Map My Career: Connecting University Curriculum with Employment

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Abstract

Often universities are criticized for not generating qualified graduates to supply to the job market, because of the mismatch between the higher education outputs and industry demands. The fast-changing skills and competence requirements make it difficult for students to understand the specific skills required for specific jobs. The research aims to propose a model called 'Map My Career' to improve the fit between university curriculum and the job market, which can reduce the university-industry skill gaps. The model is implemented as a software application using text mining and data analytics that can be used by university students to match the skills that can be achieved by completing their subjects and the required skills of particular career options. The paper examines the effectiveness of the application by evaluating its functionalities from the perspective of the prime beneficiaries of graduate employability: students, employers and universities.

Keywords: graduate employability, skill mapping, work-ready graduates.

1. Introduction

Universities play a big role in preparing students for employment in the fast-changing job market. Students have frequently cited that employment is the main motivation for pursuing a university degree [6], [11], [19]. On the other hand, the outlook of the job market for university graduates has changed more frequently over the last two decades and the university graduate employment figures are falling [3]. Graduates are not assured employment by virtue of successfully completing a university degree [12]. Recent reports show that the graduate employability rates are the lowest they have been in twenty years [22]. This results in an increased pressure for the universities to produce graduates with high employability skills. Yorke and Knight [25] define employability as the achievements of attributes that make individuals more likely to gain employment and be successful in their chosen occupations, which benefits themselves, the workforce, the community and the economy.

The problem universities facing is the inability to generate qualified graduates to supply to the job market, because of the mismatch between the education output and industry demands [10]. Education-job mismatches are indicated by comparing the acquired skills from university's curriculum with the level and type of skills considered most appropriate for a job [1]. Research states that generally university graduates lack requisite skills for the modern workplace [23]. Universities need to provide students with not only adequate theoretical-practical knowledge in their field but also the necessary abilities and competencies to carry out their job assignments [10]. This finding is supported by Tomlinson [20], which identifies that generic skills alone are not adequate for graduate employability.

University curriculum and job market have become more difficult to align because of the dynamic nature of work environments and the diversified needs of labour market in response to the emergence of new technologies. In fact, graduates are often uncertain at the initial stage of job searching, hence they wastefully spend resources in applying for inappropriate jobs. On the other hand, employers want graduates with relevant subject-specific skills and knowledge [8]. Most employers hiring graduates are small and medium-sized businesses and they do not offer the same training and development opportunities as do the larger, traditional employers of graduates [6]. These employers need to attract skilled graduates who can work competently from the first day rather than spending money to develop their employability skills. [6]. So an employer-driven approach needs to be adopted for closing the gap between university and labour market.

Students come to university to study with expectations in terms of the skills and knowledge that they will acquire, and the career opportunities that will open up to them as a consequence of completing their course. For a student, it is essential that they understand the opportunities that are available to them in relation to their career of interest [8]. The integration of acquired skills with the skills that are required for relevant job positions is necessary in order to make accurate and informed decisions [7], [15].

The research aims to identify the mismatch between the skills required by the job market and the skills acquired through university curriculum. We argue that given proper information and guidance, students attending universities are better prepared for their career, choose majors aligned to their interests and skills, and develop reasonable career expectations. This is the main motivation of the research. The paper proposes a career-focused educational system to improve the fit between university curriculum and the job market, which can reduce the university-industry skill gaps. The research is implemented as an application that can be used by university students to match the skills that can be achieved by completing their subjects and the required skills of particular career options. The effectiveness of the application is evaluated by assessing its functionalities from the perspective of the prime beneficiaries of graduate employability: students, employers and universities.

2. Related Works

The need to reduce the skill gap between university curriculum and the labour market requirements has stimulated numerous research studies that explored the views of multiple stakeholders including university students, graduates, faculty and employers. Yorke and Knight [25] propose USEM model of employability consist of four inter-related components namely understanding (U), skills (S), efficacy beliefs (E), and metacognition (M) which components should be embedded into a curriculum. This study also acknowledges that the needs of students, employers and other stakeholders must be taken into account.

Dacre Pool and Sewell [8] propose CareerEDGE model, which highlights that there are five underlying components for graduate employability, namely career development learning, experience (E), degree subject knowledge (D), generic skills (G) and emotional intelligence (E). These five components upon reflection can generate self-efficacy, self-esteem and self-confidence that can play a major role in employment.

Bridgestock [2] suggest that the skills on how to manage a career should be introduced early in the student's university experience. He proposed an employability conceptual model which extends beyond the generic skills and stresses the importance of career management skills, career building skills, discipline-specific skills, self-management skills, underpinning traits and dispositions.

Lee and Han [16] conducted an empirical study on the skill requirements for entry-level programmer/analyst jobs in the Information Systems (IS) field by analyzing job ads posted on Fortune 500 corporate websites for three years and found a gap between the curriculum contents and the requirements of the industry. Their research suggests that the IS curriculum need to put more emphasis on developing application development skills, software skills, business skills and general problem-solving skills.

There are many other theoretical models and concepts that provide underlying concepts of graduate employability and analyze the skill mismatch principally by means of graduate surveys and interviews [10], [20], [23]. Even though domain-specific skills are very important in the recruitment process of university graduates, most research in this area is concentrated on generic skills rather than domain-specific skills.

The fast-changing skills and competence requirements make it difficult to adjust the specific skills for jobs manually. Therefore there is a need for automatic or semi-automatic methods to update such knowledge bases. The feasibility of this approach have been tested and exemplified using several data mining techniques [26]. The results are encouraging and will be used to support decisions in professional development. Often universities and private job recruitment websites and platforms provide the functions of information release and information search. However, the traditional search engines cannot fully satisfy the needs of information discovery and recommendation because frequently it is difficult for university graduates to select appropriate keywords to describe particular skills. In addition, the keyword-based information search is not complete in many cases. High-quality job recommendation engines should have the capabilities to provide personalized and intelligent employment recommendation service for individual graduates [18]. There is an increasing demand for a system to assist students to develop graduate attributes which can help them secure future employment [12].

3. Proposed *Map My Career* Model

Students need to have a realistic picture of how their chosen course and the academic skills they develop through a course can help achieving their objectives and career. Based on this view, we propose *Map My Career* model. The model presented here (see Fig. 1) provides a conceptual framework which connects university and industry using a map and gap analysis of required job-specific skills and acquired subject-specific skills.

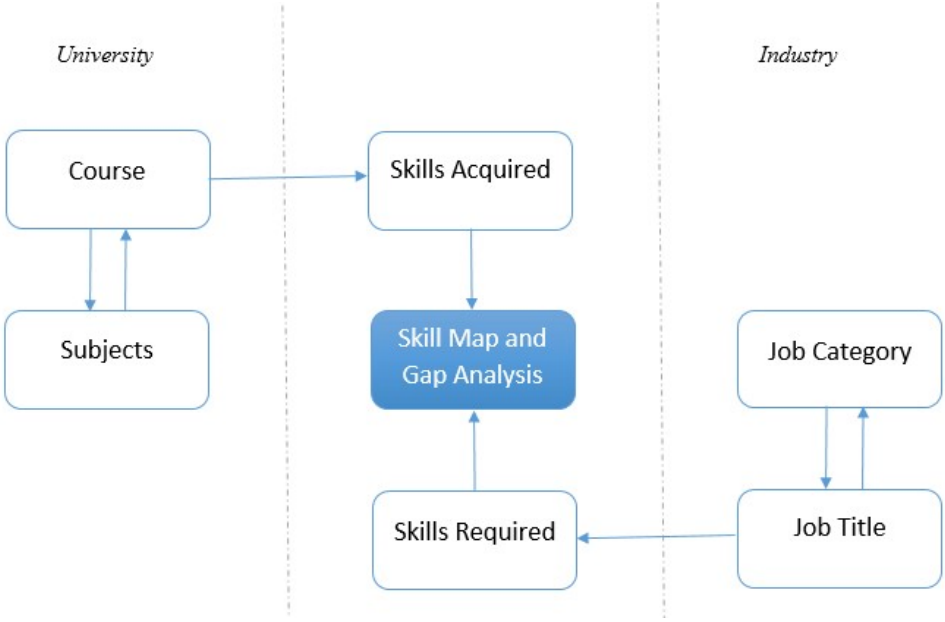

Fig. 1. Map My Career Model.

By comparing the skills from the subjects within a course with the skills required in the job description, the skill gap and map analysis are performed. This highlighted component, which is shown in the middle of the model, matches up the skill attributes from subjects within a course with the skill attributes of a particular job to identify the matching skills and gaps profile by quantifying the relevance of skills using text mining and data analytics.

Based on *Map My Career* model, we develop a tool which gives students, universities and employers a forward-looking analytical tool. The tool can serve as a navigational system which helps in the matching process between course, subjects, skills and jobs through quantitative treatment of data. The tool also assists students who need additional education or training in order to develop the skills required for the position by emphasizing technical specificities of a job profile. The data collection, analysis, methodologies and implementations of these components will be discussed in the following sections.

The challenge now is to gather and analyze data that can be used to validate our model and implement the application with a real-world dataset. In recent years, online job advertisements have become a popular job-search model as these data strongly correlate with job openings and demand [4]. Students, graduates, employers, researchers, universities and curriculum developers now view online job postings data as a practical source to explore the nature of today's dynamicity of the job market. Online job advertisements can show the relative demand for different types of skills for specific jobs. Real-time job market indicators can be particularly useful in aligning education curricula with workforce needs in emerging or rapidly changing industries, such as healthcare and information technology (IT) [4].

3.1. Skill to Job Map Analysis

A list of skills has been created by extracting the skills from the job advertisements. Using a frequency-based ranking approach, we quantify the relevance of a set of skills on a number of job titles in a particular domain. For this study, the selected domain is IT. A set of job descriptions from advertisements of similar job titles are combined and the pre-processing of text is done in order to clean the dataset. Following that, the skills required for a job are extracted from the job description by matching the skills with the list of skills that we have created.

We have investigated several weighted schemes including the latent semantic indexing and Word2Vec model. After assessing a sample of the weighted scores produced by different schemes, TF-IDF approach is proved to be efficient for matching skill terms with the job description. *Map My Career* model uses weighted scheme by considering the local and global weights to score the skills to relevant jobs. The local weight depends only on the frequencies within the document and not on the inter-document frequencies. In the case of jobs, since the skills can be different for different jobs, this weighting scheme alone is not sufficient. On the other hand, global weighting gives a weight to each term in the corpus. The TF-IDF weight score is calculated by including both local and global weights.

A term-document matrix is created using the list of skills for each job title. Considering each job title as a document and each skill as a word, TF-IDF measures the relevance of each skill to the job title. The TF-IDF is calculated by multiplying the term frequency (how often a skill appears in a job title) with the inverse document frequency (how rarely a skill appears in the whole set of job titles). Some skills that are more important to a job title occur in that job title much more frequently than they do in most other job titles.

Job advertisements consist of a set of job titles values $J = (j_1, j_2 j_3, \dots \dots j_n)$. The number of job advertisement having job title j that requires skills s is represented as(s, j). Our aim is to find the skills weight for any given job title. The skills are weighted based on a function that maps each skill s with job title j. The skills are represented as $\mathrm{S} = (s_1, s_2, s_3, \dots s_n)$ and job advertisements as $\mathrm{A} = (a_1, a_2, a_3, \dots . a_n)$.

The weight $(s, j) = f(s, j)$ which means for any job title j_1, we sort skills by $f(s, j_1)$, since more frequency a skill is required under that title, the more likely the skill is an essential skill for that title. In order to calculate the weight of skills for each job title we use TF-IDF approach. The simple term frequency is calculated as shown in Eq. (1). In reality, the number of skills for each job title varies. Therefore, the experiments are conducted with a variant of term frequency called normalized term frequency as shown in Eq. (2), where N is the total number of skills associated with each job title.

The inverse document frequency is calculated with some smoothing techniques as shown in Eq. (3), where t_s is the total number of job titles that requires skill s and T is the number of all unique job titles. Using the normalized TF-IDF method, we compute $TF' - IDF_{(s,j)}$ for all the valid (s, j) pairs in the dataset as shown in Eq. (4).

$$TF\ (s,j) = \ f(s,j) \tag{1}$$

$$TF'\ (s,j) = \frac{TF\ (s,j)}{\mathrm{N}} \tag{2}$$

$$IDF\ (s) = \ \log_2\left(\frac{|1+T|}{t_s}\right) \tag{3}$$

$$TF' - IDF_{(s,j)} = TF'_{(s,j)} * IDF_{(s)} \tag{4}$$

$$TF' - IDF_{(S,j_1))} = \sum_{i=0}^{n}(TF' - IDF_{(s_i,j_1)}) \tag{5}$$

$$W_{(si,j1)} = \frac{(TF\prime - IDF_{(s_i,j_1)})}{\sum_{i=0}^{n}(TF\prime - IDF_{(s_i,j_1)})} * 100 \tag{6}$$

Once the $TF' - IDF_{(s,j)}$ value is calculated for each job title–skill pair, for a job title we list the skills in the descending order of $TF' - IDF$ score so that the skills having a higher weight for a job title come first. The total $TF' - IDF_{(S,j_1))}$ score for n skills for a job $j_1$is calculated in Eq. (5). Finally the $TF' - IDF_{(s,j)}$ value for each skill of each job is converted to weight percentage score $W_{(si,j1)}$. The weighted score $W_{(s_i,j_1)}$ of a skill i for a job title $j_1$is calculated as shown in Eq. (6). The skill weighted scores for all jobs are then rounded and are represented as a matrix as shown in Table 1.

Table 1. Skill Weighted Scores.

	Skills				
Jobs	s_1	s_2	s_3	.	s_n
j_1	$w_{(j_1,s_1)}$	$w_{(j_1,s_2)}$	$w_{(j_1,s_3)}$	.	$w_{(j_1,s_n)}$
j_2	$w_{(j_2,s_1)}$	$w_{(j_2,s_2)}$	$w_{(j_2,s_3)}$	.	$w_{(j_2,s_n)}$
j_3	$w_{(j_3,s_1)}$	$w_{(j_3,s_2)}$	$w_{(j_3,s_3)}$	.	$w_{(j_3,s_n)}$
.	.	.	.	.	.
j_n	$w_{(j_n,s_1)}$	$w_{(j_n,s_2)}$	$w_{(j_n,s_3)}$	.	$w_{(j_n,s_n)}$

3.2. Skill Gap Analysis

A key element in reducing the skill gap is by accurately identifying the mismatch between the skills expected by employers and those possessed by graduates. Our fundamental goal is identifying which skills students have mastered, which skills they have not, and which skills they are in the process of mastering. A skill gap analysis is an outcomes assessment method which is calculated based on the weight gap between the adequacy of skills required by the work environment and the skills acquired from their chosen course. The skill gap analysis for a job $j_1$is calculated in Eq. (7).

$$100\ - W_{(s_i,j_1)} \tag{7}$$

3.3. Subject to Skill Map Analysis

For every subject within a course, we extract the acquired skills based on the subject learning outcomes description. In some cases, this information is only available in a semi-structured format. We need to model it in a more structured manner by parsing the documents and extracting the skills with reference to the skills taxonomy that we have created.

The output of this phase will be a list of subjects annotated with the skills that could be potentially learned by completing each subject. The skills are represented as $S = (s_1, s_2, s_3, \dots s_n)$ and the subjects are represented as $U = (u_1, u_2, u_3, \dots u_n)$. Each subject corresponds to many skills and each skill can be developed by many subjects. Also, the skills acquired in a subject can be in various levels depending on whether the subject is an introductory or a more advanced subject.

4. Implementation of *Map My Career* Application

Map My Career model is implemented as a web-application using PHP and MySQL database running on Apache server. All the data analysis and text processing are done using R. For generating visualizations and validations, we use JavaScript, jQuery and Ajax. The application user interface interactively provides information for students about their course and career and thereby, improve their awareness of the important skills required for certain job positions. The application also provides a structured view of each course in regards to the generated skills with intuitive visualizations, which according to Constantinov et al, [5] is important in course evaluation. The interface facilitates self-reflection on current skills in comparison to job market demand and identifies potential gaps. Also, this application can provide students with a snapshot of their academic track through graphical visualization of the current state, the outcomes of their course and the possible career options.

4.1. Data Collection

In this study, we use jobs and subjects from IT domain based on four reasons. First, IT is currently one of the fastest growing sectors. Second, all economic sectors worldwide are experiencing a shortage of workers with good ICT knowledge and skills [14]. Third, this sector has a very dynamic nature with frequent development of new roles, hence students need to adapt to the new skill requirements to meet current needs as well as future ones [6]. Finally, student dropout rate in IT courses is high in comparison with other fields [13].

First, we extracted 300 job advertisements in IT domain from career advertising websites including Seek (seek.com.au) and Indeed (au.indeed.com), two of the more popular job-seeking website in the country. Following that, we use text analysis to extract the skills from the job advertisements to create a list of skills with the help of domain experts. In the second stage, we extracted 1,200 jobs in IT from the same websites using pre-defined specific job titles in order to analyse and perform the skill gap and map analysis. Every job title is satisfied by many job advertisements. In terms of the university course data, we use two different courses (Bachelor of Computer Science and Master of Information Technology) offered by the Department of Computer Science and IT in an Australian university. The course data is collected from the course guide. Then the data from the course guide is processed to extract the skills for each subject taught within that course.

4.2. Skill Mapping Interface

Skill mapping interface connects the subjects within the course to job titles through a set of skills. The implementation of skill job mapping with the weighted score is shown in Fig. 2 and Fig. 3.

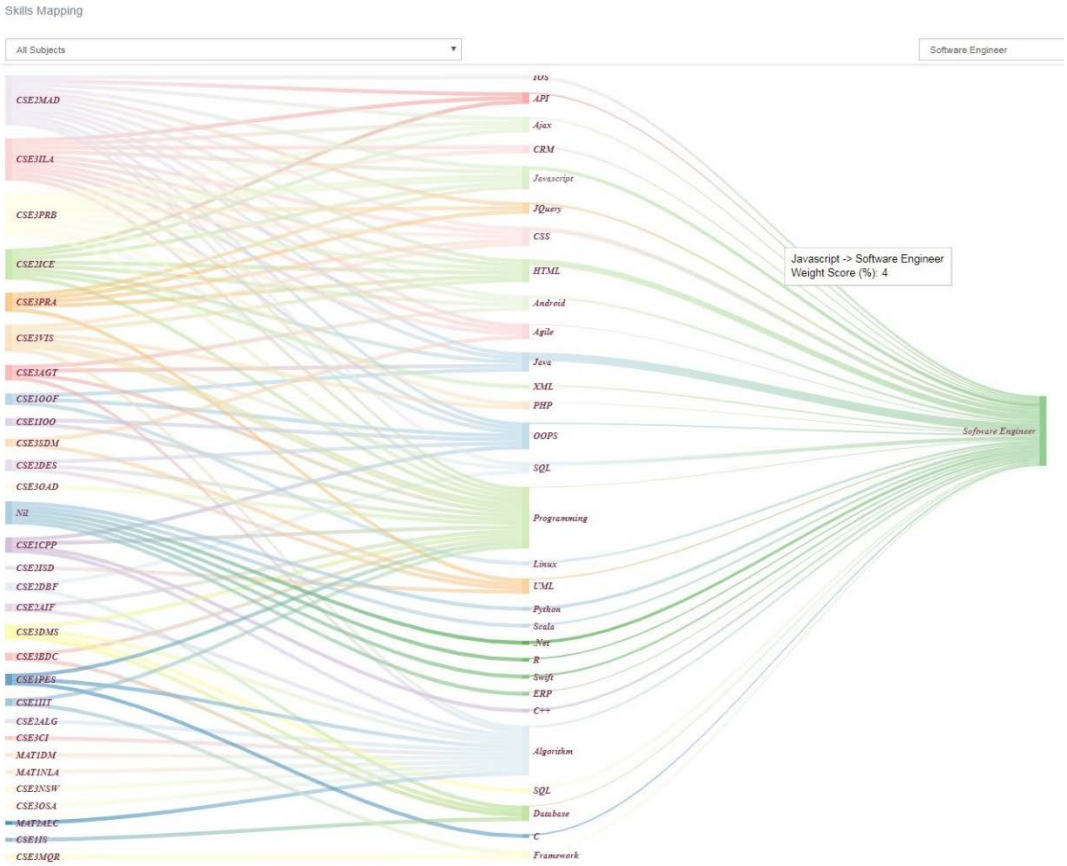

Fig. 2. Skill Mapping Interface 1 – A List of Subjects to a Job Position.

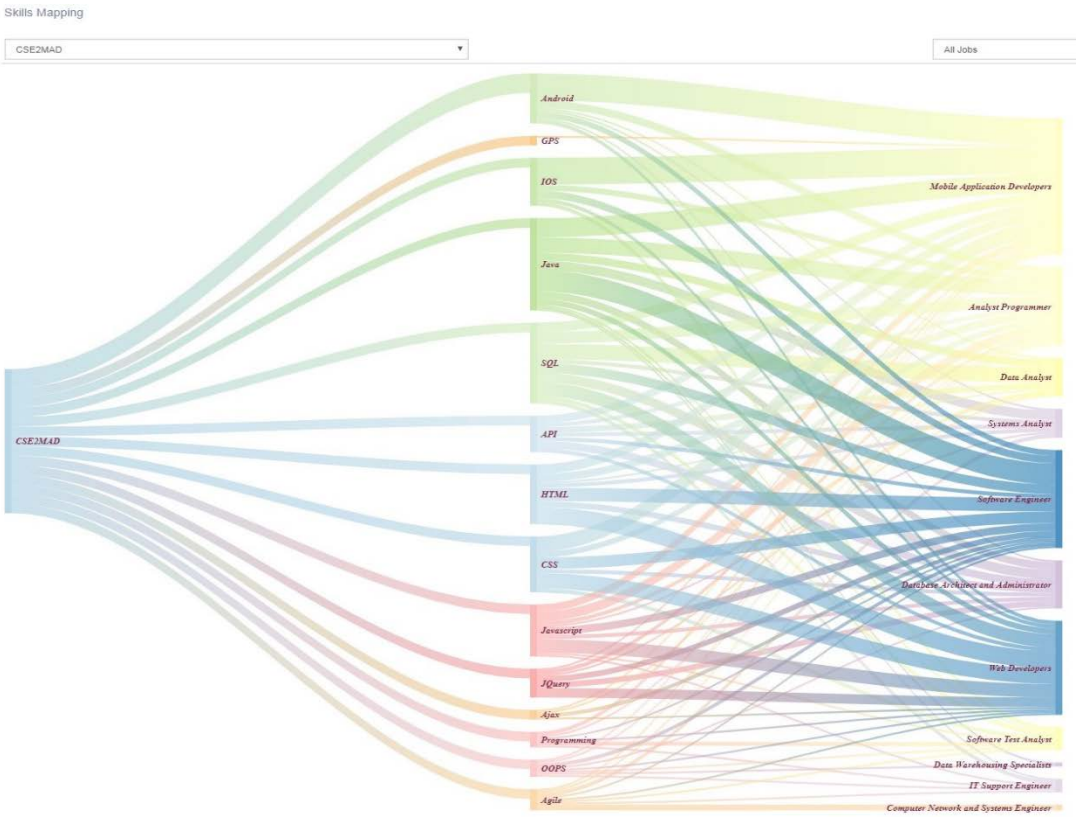

Fig. 3. Skill Mapping Interface 2 – A List of Job Positions to a Subject.

In Fig. 2, the subjects in a course will be mapped to a chosen job and in Fig. 3, the jobs are mapped with the chosen subject. The mapping line width is based on the weighted score which is calculated using Eq. (6) and a sample of the weighted score for 10 IT jobs with a limited number of skills is shown in Table 2.

Table 2. Skill Weighted scores for 10 IT jobs.

	Skills (%)															
Jobs	***Javascript***	***JQuery***	***SQL***	***Python***	***Android***	***IOS***	***Scala***	***Linux***	***Java***	***.Net***	***R***	***C++***	***API***	***HTML***	***CSS***	***Swift***
Software Engineer	4	3	5	4	3	4	3	3	11	7	2	4	2	5	4	3
Mobile Application Developers	7	2	3	1	13	14	0	0	6	5	0	3	4	5	8	5
Web Developer	7	5	7	4	2	2	1	3	3	4	1	0	2	9	8	0
Data Analyst	2	1	8	11	1	0	4	2	4	1	12	1	3	1	0	0
Database Architect &Administrator	2	3	12	4	1	0	3	4	4	3	1	2	4	3	2	0
Software Test Analyst	2	3	7	0	1	1	0	2	4	6	0	1	3	9	4	1
Data Warehousing Specialist	0	2	11	1	1	0	3	2	4	2	0	0	2	3	1	0
IT Support Engineer	3	3	8	2	6	4	1	7	6	3	1	2	1	4	2	0
Computer Network and System Engineer	1	0	3	1	1	0	0	3	4	1	0	1	1	1	0	0
Network Security Engineer	1	0	4	2	0	0	0	4	5	1	0	0	1	0	0	0

The visualization shows the skills which are developed by a student upon completing a course, based on the selected subjects and how well the students fit into a particular job title. The student can also use this visualization to plan their subject selection. The tool also enhances students' awareness as to which skills are valuable to their aspired career. Due to space constraints, we could only show one skill mapping interface (see Fig 2) for Software Engineer job. Using reverse engineering, the skills required by this job are mapped in the skills list. The skills list is then matched with skills acquired by different subjects within a course. It can be seen there are several skills that are not developed by any of the subjects. This input is also useful for the university in order to further improve their course and subject offerings.

4.3. Skill Gap and Map Analysis Interface

Skill gap and map analysis provides an option for users to choose subjects and target jobs as shown in Fig. 4. The application compares the score of the different job profiles from our weighted model as described in Section 2 and displays an overall picture of the matching score with each job chosen by the user as shown by charts in Fig. 5. The charts represent the skills match (in percentages) of each chosen job title with the selected subjects by computing the skill weight score. Another component in this line of analysis is an interactive pie chart representing the match and gaps of skills with its relevant weight scores. Each section in pie chart represents a skill and on mouseover will show the skill name with its relevant score for that job title. Also, the skill gaps are made stand out as shown in Fig. 5.

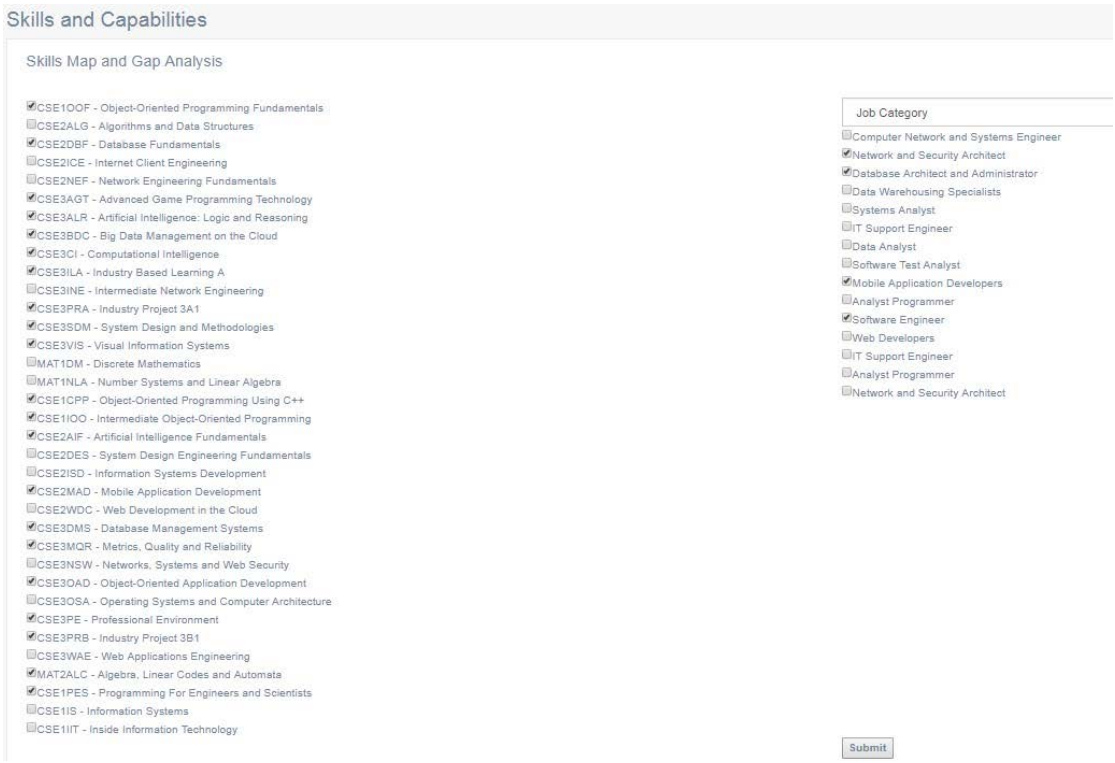

Fig. 4. Subjects Selection and Job Selection Form.

Fig. 5. Skill Map and Gap Analysis.

5. Discussion

Map My Career is developed as a career planning tool, and thus, this study examines the effectiveness of the model and application by evaluating its functionalities from the perspective of the important stakeholders and prime beneficiaries of graduate employability: students and graduates, employers and universities. We use literature to support our discussion.

Students. This proposed model and application assist students to plan their future career. Students view their employability as a measure of their potential to secure and undertake future employment [21]. The work environment has changed and a respectable degree or soft skills alone is not sufficient to secure a job, rather, graduates must possess the hard skills tailored for each position. Today's higher education students want choice, personalization, efficiency and relevance leading to maximal outcomes, including employment [12]. Understanding their career options can help them to plan their career.

The application guides students to choose a course or subjects within a course with respect to their desired career. Most of the time employers tailor their job advertisements to include the skills that employees need. Having modelled relevant job profiles with skills gained through their course enables the application to assist students in their career planning. The weighted skill map and gap analysis with graphics and visualization provide clarity to students not only on how each skill and what percentage of each skill that they develop in their subjects related to a different career but also help them to identify their skill gaps in achieving their desired career.

Universities. Universities can attract and retain students by placing emphasis on identifying and meeting student's needs and expectations [9]. Designing a course with job market demand help universities to produce more employable graduates. Wiseman et al. [24] found that the aspiration to engage in higher education is positively correlated with the extent to which graduate jobs are visible to young people. The clarity of a career path and the available employment opportunities play an important role in the decision-making of young people and is strongly correlated to the degree awarded [11].

Often universities have dedicated career team to guide students, however, in many cases, these professionals do not have enough time and resources to address the needs of all students. Frequently students are not comfortable to talk to others regarding their career aspiration. As the application provides a clear explanation on how each course or subjects relate to each different career option, this will help to avoid issues such as students changing courses or dropping out of university, to a large extent. Sometimes the course syllabus might unintentionally overlap especially in universities that have a flexible curriculum with a large number of elective subjects. Together with modelled relationships between the skills gained to the skills required for the targeted career, clusters of similar job profiles as well as weighted relationships between skills can be detected.

Moreover, by using frequently updated workforce data to measure the demand for different job titles, the application helps students in making decisions about which course or subjects to add, modify or discontinue. The curriculum alignment should start with data analysis to keep student learning relevant to the skills and competencies demanded by industry. Therefore, this tool will help in the design of curriculum which reflects the job market by monitoring the skills required in the labour market and mapping them with the skills offered by the subjects within a course. Furthermore, it will increase graduate employability which will increase the overall reputation of a university.

Employers. Often it is harder for employers to find the best talent for their vacancies. Employers spend billions of dollars advertising job openings, evaluating candidates, and hiring new employees each year [17]. Many employers perceive university education as being very theoretical, with a large gap between the skills acquired through university studies and the skills required in the workplace [10]. Even though many researchers in higher education stress the importance of collaborating with employers in designing curriculum to avoid skill mismatches between university education and job market needs, the practicality of doing this is always a question and some argue that the learning outcomes of university subjects might be too specific to a particular employer [6], [8], [10].

Map My Career model is a solution by which we can close the gap between university and industry to ensure graduates are better equipped for the workplace. From an employer's perspective, this application enables domain-specific skilled graduates to be tailored to specific positions. Since employability is translated into skillsets, with the correct knowledge of job responsibilities and the tasks required for a position, the graduates can apply their skill and expertise in terms that employers understand. The employers will no longer have to seek and then train graduates but will get work-ready graduates having job-specific skills and this may give employers a significant advantage of reducing the hiring cost. Moreover, skilled graduates are a valuable asset to a company.

6. Conclusion

Without proper guidance or direction, it is difficult for students to make sound courses and career choices. On the other hand we cannot ignore the fact that there exists mismatch between university education and jobs available in the industry. Many students, especially those with little or no work experience, often make life-altering decisions under a cloud of uncertainty about how their postsecondary education choices will affect their employment outcomes, the path needed to reach those outcomes, the likelihood of success, and whether their career will line up with their abilities, preferences, and interests. Students need a system that will guide them to make the right course and career decisions.

This research has proposed a mean to bridge the gap between university and industry by outlining a conceptual model and implementing a real-time web application using data analytics and text mining techniques to identify the most relevant jobs in the job market as well as most relevant subjects in line with the desired job profile. In addition to the focus on careers, students also sense the skills they develop throughout their course and subjects. The combined knowledge of both the skills students developed and how they relate to their potential career path helps to build confidence, a positive attitude towards learning and successful engagement with the course.

In this paper, we have focused mainly on the Information Technology domain with limited available data. This is an ongoing research study and in the future, the model will be improved by adding more courses and jobs from different disciplines. The model will be further improved by adding soft skills that can be acquired by other activities including placement and work-integrated learning, along with discipline specific hard skills. Currently, we have evaluated the functionalities of our model with the support of literatures. In future, we plan to evaluate it directly with students, universities and employers using surveys and interviews.

Map My Career model and application help students to explore different career options, develop their skill set and encourage them to take ownership of their employability development from the start of their university journey till their entry to their desired career. It facilitates students' awareness of their desired career in advance and enables them to explore more job options. It offers an integrated approach by providing students with clarity about what is expected of them, and what skills they need to develop, how they need to learn, how to progress, and the understanding they need to succeed. Students can develop realistic aspirations based on sound information that can prepare themselves for employment in industries and achieve the outcomes they desire.

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