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Mapping Information Systems Student Skills to Industry Skills Framework

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***Abstract*— SFIA skills framework is widely popular among education institutions and ICT industries. The framework provides ICT skills profiles which can be a valuable resource that supports the career planning of a student. However, currently a student does not have a method or approach to exploit the SFIA framework to align his or her competencies that he or she has acquired during the education program, to the skills defined in the SFIA framework. In this paper, we present a solution model for generating a skills report based on individual's competencies and experiences. In particular, we focus on Information Systems students' profiles. Student skill generator takes in curriculum and LinkedIn profile's data as an input and generates student's skills report which is aligned with SFIA framework. Moreover, the system also generates a list of recommended jobs in ICT sector that match the student's skills. We evaluated our solution model on an undergraduate core curriculum; Bachelor of Science (Information Systems Management) degree program BSc (ISM), offered by the School of Information Systems (SIS), Singapore Management University (SMU) and LinkedIn profiles of student from year 3, year 4 and alumni.**

Keywords—Competencies, SFIA, Industry skills, LinkedIn profiles

I. INTRODUCTION

One of the key outcomes of doing an Information Systems (IS) program is employability, which is the capacity of a graduate to find a first job and then also be able to progress in their career, by moving to other jobs. A good curriculum plays a key role in employability of students by providing a vital link between the students and industry. Within the curriculum, students acquire skills from academic courses taught at the University as well as external activities such as internships, projects, industry clubs and industry relevant extra courses. In order to ensure employability, skills acquired in the curriculum must be aligned with skills required by the industry [1], [3], [4] [6]. Competencies are often used to define "transferable skills" acquired by the student on completing specific courses and the overall program. Therefore, mapping student competencies to the industry skills helps the students to prepare a profile and plan their career path.

SFIA skills framework is widely popular among ICT industries and education institutions [1], [2], [5], [7], [8]. The framework provides ICT skills profiles which are invaluable resources in support of career planning for an individual.

SFIA skills framework defines a collection of ICT skills which provides common language of communication among academics, employers and students. Currently, many employers and education institutions use SFIA framework for supporting IT professionals and curriculum designs. However, there are still many gaps that need to be addressed. One such gap that we are focusing in this paper is aligning students' skills to industry skills framework. University students do not have a systematic method to exploit the SFIA framework to identify his or her competencies aligned to the SFIA skills framework. Often students fail to exploit SFIA skills framework during the course selection or job application or even in the resume preparation. This leads to three related problems, firstly, students are unable to make informed decisions in choosing their career path and in preparing their resume. Secondly, employers have to manually examine the student resumes and map their skills to the required job skills, which can be a tedious and painstaking process. Thirdly, increasingly, students choose to use independent platforms such as LinkedIn profiles, e-portfolios, Facebook, etc., to present their skills and overall learning journey [10], [11], and in order to market them better, the student skills and experiences from other platforms needs to be consolidated and aligned with the industry skills framework.

Recent surveys show that most of the employers are inclined towards LinkedIn profiles for job recruitment process [12]. LinkedIn is one of the popular social media platforms, which is created mainly for business purposes. It allows users to input their academic and personal information on the web as well as allowing business connections to be shown among social users or business entities. In fact, according to current research [13], Information Systems students benefit from LinkedIn profiles, and universities encourage the students to create and maintain LinkedIn profiles.

Therefore, there is a need for an integrated tool that can build an individual student competency report based on the information from platforms such as LinkedIn, and at the same time, align the competencies to the industry framework, SFIA skills framework. The tool should be capable of summarizing the skills from university courses as well as skills achieved by the students from external activities. This skills summary representation can also support the employers in recruitment process. In this paper, we study two relevant problems; skills generation and job recommendation.

Skills generation: In this task, our objective is to generate the SFIA skills for an Information Systems student. The inputs to the task are IS curriculum course competencies, LinkedIn profiles and SFIA framework. The output of the task is a visual representation of mapped SFIA skills of a given student.

Job recommendation: In this task, our objective is to generate list of recommended ICT jobs for an IS student. The inputs to the task are student skills generated from the previous task and ICT job roles with SFIA skills matrix [6]. The output of the task is the list of job roles.

One of the major challenges in student skills mapping task is that the curriculum, LinkedIn profiles and the industry skills frameworks are majorly expressed in text and unstructured in nature. However, the emergence of analytics techniques that leverages vast amounts of data sets to gain insights from the data which is both structured and unstructured opens new possibilities for automating this process.

In this paper, we present a solution model for generating a skills report based on a student's competencies and learning experiences and describe the Student Skills Generator (SSG) System. In particular, we focus on information systems students' profiles and their curriculum. Student Skill Generator takes in curriculum data and LinkedIn profiles as inputs and generates student's skills report which is aligned with SFIA framework. Moreover, the system also generates a list of recommended jobs in ICT sector defined by Australian Computer Society [14]. We evaluated SSG System on an undergraduate core curriculum; Bachelor of Science (Information Systems) degree program BSc (IS), offered by the School of Information Systems (SIS), Singapore Management University (SMU) and LinkedIn profiles of students from year 3, year 4 and alumni.

The rest of the paper is organized as follows. In Section II, we discuss closely related work on methods to process the competencies into structured information, as well as usage of skills frameworks in the IT industry and state our novel research contributions in context to the related work. Section III presents the details of the proposed solution, the technology and the techniques implemented. In Section IV, the experimental setup for evaluation of SSG System is presented along with the dataset used and an analysis of the results. The key conclusions drawn from this research work along with proposals for future work is presented in Section V.

II. RELATED WORK

Skills Framework has been rapidly adopted by various educational institutions, companies and countries to evaluate their current employees and potential future employee candidates [6] [7] [8] [9] [22]. Similarly, digital resumes are popular among students when applying for jobs and during career planning process [18] [19] [21]. In this section, we review the existing works related to both these aspects.

A. SFIA Skills and Job Roles

SFIA (Skills Framework for the Information Age) is a framework which groups 96 skills into 6 categories: Strategy and Architecture, Business Change, Solution Development and Implementation, Service Management, Procurement and Management Support, and Client Interface [17]. With 7 levels of responsibility associated to each skill/knowledge, it matches the skills of the workforce to the needs of the business. For more details the reader can refer to [9].

As shown in Figure 1, SFIA benefits key stakeholders of ICT industry namely students, employers and academics [33].SFIA enables employers of IT professionals to carry out a range of HR activities against a common framework. These activities include; skill audit, planning future skill requirements and development programs, standardization of job titles and functions, and resource allocation.

SFIA allows students to plan the professional development and enhance their employability prospects.

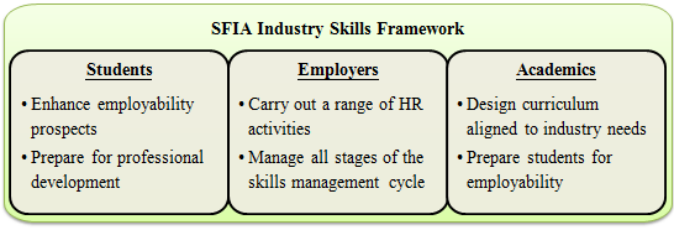


Fig. 1. SFIA key stakeholders and benefits

In an earlier work [9], the authors demonstrate how to generate SFIA competencies from LinkedIn profiles, using SFIA skills framework, Blooms's taxonomy [16], and information retrieval techniques [15]. For more details on this work, the reader may refer to [9].

Given the popularity of SFIA, Australian Computer Society (ACS) has conducted a survey and has defined 25 common ICT job profiles. Further, ACS identified SFIA skills for these ICT jobs. Sample jobs and the corresponding SFIA skills are shown in Table I. For complete list, refer to ACS project [14].

TABLE I. ICT PROFESSIONAL PROFILES AND SFIA SKILLS

Job Role	SFIA Skills
ICT Consultant	Business analysis, Business process improvement, Consultancy, IT governance, Solution architecture
Software Engineer	Database/repository design, Programming/software development, Software development process improvement, Systems design, Testing
Chief Information Officer	Enterprise and business architecture development, IT governance, IT Management, Portfolio management, Stakeholder relationship management, Supplier relationship management

In our current research work, we adopt the ACS matrix [14] of job roles and SFIA to recommend jobs for students.

B. Mapping Competencies to Industry Skills Framework

Mapping competencies for jobs and education has been studied by several works. Bowman provided a research on understandings of generic skills across Australia's education where skills are mapped to the curriculum by various Australian universities [25]. Bound and Lin's study investigated Workforce Skills Qualifications (WSQ) programs that included some form of workplace learning with the purpose of understanding learning processes, barriers and constraints to workplace learning and how to support

workplace learning [26]. Recently Australian skills council studied the mapping of the major qualifications against jobs, competencies and qualifications against ACS, CompTIA (Information Technology (IT) Industry & Association) and SFIA [27]. The council also provided a diagram for each qualification which outlines how each skill intersects with ACS, CompTIA and SFIA. Ala-Mutka has combined ICT and digital media to define digital competence which is the set of knowledge, skills, attitudes (thus including abilities, strategies, values and awareness) that are required in ICT sector [28]. Over 15 frameworks for teaching are developed in this context [29].

In terms of ICT curriculum design, Konsky et al. provided a model for designing and managing higher education programs in Information and Communications Technology (ICT) based on SFIA framework [30]. SFIA framework has been extended to other domains as well. Health informatics competencies mapping to SFIA framework was studied by Hovenga and Grain [31]. Grant studied various frameworks for competencies and stresses on the need for software to support or integrate e-portfolios with competence frameworks [24]. Our work reported in this paper is aligned with Grant's vision and is directed towards developing automated software that maps the competencies to the industry skills framework. In particular, we focus on the students' competencies.

C. Digital Resumes, Jobs and SFIA

Online portfolios, e-Portfolios, have been shown to help significantly in a job search [18]. E-Portfolio consists of more than an electronic storehouse or a resume. It includes a self-learning process to help students identify gaps in their current portfolio. The students can define their existing skills, competencies and experiences. In this way the students can identify their current skills and those required for a particular job, and then work towards narrowing the skills gap for getting their dream job. E-portfolios demonstrate students' learning and competency, yet higher education has not persuaded many employers to use them in recruiting and selecting employees [10]. Recently, LinkedIn resumes are becoming more popular among the employers [19]. LinkedIn helps establish connections with pre-existing contacts: professors, college peers, and previous or current employer [20]. Such connections will offer students the opportunity to maintain a professional network that extends beyond their close circle of friends and takes advantage of the strength of weak ties [21]. With the growing popularity of LinkedIn profiles among employers, our solution reported in the next section leverages the LinekdIn profile data.

SFIA framework is also widely used by the job sites [22, 23]. Employers refer to SFIA framework in defining the job positions and skills requirement based on SFIA framework. Such definitions enable the employers and the job applicants to have a common language of understanding on the needs and skills match. However, the mapping of skills is still a manual process [31].

In this paper, we propose an automated approach to map the student's profile to SFIA skills using text analytics approach. In particular, we study LinkedIn profiles to generate the mapped SFIA skills.

III. SOLUTION

The solution architecture of the Student Skills Generator is presented in Figure 2. It uses the Curriculum Industry Mapper (CIM) and Job roles–SFIA skills matrix (see Table I).

The Curriculum Industry Mapper (CIM) automatically generates the alignment of curriculum competencies with industry skills framework. It also generates visuals that enable educationists and students to measure the alignment and discover the insights and gaps of a curriculum. For more details on the CIM, the reader may refer to [9].

In the first step, the LinkedIn profile of a student is fed into CIM which pre-processes the textual content and generates two outputs; SFIA mapped curriculum skills and SFIA mapped student skills which are based on the student's LinkedIn profile. In the second step, SFIA mapped job profiles, which are obtained from UK government are provided as inputs to generate job recommendations. The SFIA skills in jobs are matched with the student skills and a report is generated with a list of jobs that are recommended for a specific student. The details of each stage are explained in the following sub sections.

A. Student Skills Generation

The LinkedIn profiles are textual in nature and hence are first processed using text mining techniques built in CIM. We then apply Bloom's verbs (e.g. classify, analyze, explain) on the LinkedIn content to generate skill levels. After pre-processing the data, the retrieved information is indexed and vector of each document is stored in the created search engine. LinkedIn information will represent as a search query for the search engine, and using the vector space model cosine similarity score [34], the similarity scores of the query will be computed against all SFIA skills. With the threshold set on the score, the mapped SFIA skills will be generated for the student. CIM also generates the mapped SFIA skills for the given Information Systems curriculum as explained in [9]. Both the SFIA mapped curriculum skills and SFIA mapped student skills are exploited for the job recommendations which are explained in the next sub section.

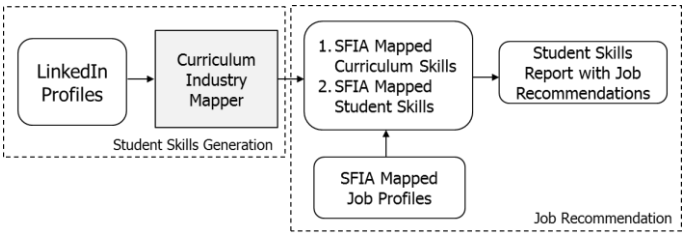


Fig. 2. Student Skills Generator Architecture

B. Job Recommendations

In this step, the focus is on generating matching job roles based on SFIA skills. This is a straight forward process where we combine the two SFIA mapped skills namely, SFIA mapped curriculum skills and SFIA mapped student skills and generate the list of jobs (Column 1 in Table 1). Finally, a report is generated for each LinkedIn profile. The report is organized into four sections; the mapped SFIA skills from the processed

information of LinkedIn profile, the mapped SFIA skills from the curriculum, the combination of generated SFIA skills with both competencies and LinkedIn profile, and the recommended jobs. These four sections are selected because they have the most impact when presenting the report to users.

IV. EXPERIMENTS

A. Dataset

For our experiments, two dataset groups are used. For curriculum competencies, we used the undergraduate core curriculum courses from School of Information Systems (SIS), Singapore Management University (SMU). The data statistics are as shown in Table II. Each course has been identified based on its entry requirement and difficulty level, where basic stands for the foundation courses and advanced stands for advance level courses which test the higher order comprehension and understanding and require knowledge of foundation courses. In total there are 398 competencies across both basic and advanced courses.

For industry skills framework, we used SFIA 5 skillsets obtained from the SFIA website after obtaining an individual license. A total of 96 IT skills with 344 skill level descriptions are used. Following the SFIA given skillset list, not all skills have written description for level 1 to 7 therefore if we look at 96 IT skills, we only have 344 skill level description data rather than the full 672.

TABLE II DATA STATISTICS

Courses	14 (Basic = 7, Advanced = 7)
Total Competencies	398
SFIA IT Skills	96
SFIA IT Skill Level Descriptions	344
SMU, SIS student LinkedIn Profiles	70 (Year 3: 15, Year 4: 45, Alumni: 10)

For student dataset, we retrieved 70 School of Information Systems, students' LinkedIn profiles. In SMU, the students are strongly encouraged to create LinkedIn profiles. We acquired year 3 and year 4 students' profiles as they are likely to contain information on internships and projects. We also incorporated alumni profiles in our datasets. LinkedIn provides APIs and external libraries to retrieve the segments of LinkedIn profile information that is required. The other pre-processing techniques from [32] served to clean and break down the large collection of terms within the datasets. It must be noted that the information in LinkedIn varied in content length and quality as the information is per user's discretion.

B. Experimental Setup

LinkedIn profiles are first categorized into their academic years as the curriculum courses completed by students vary by year. For similarity matching, the threshold for the cosine similarity level was set at 0.2 based on work done in [34]. We first generate a students' skills report for all LinkedIn profiles using Student Skills Generator (SSG). We then sent the individual report to owners of the LinkedIn profiles through electronic mail with an attachment of their generated reported and a link to a Google survey form for gathering the students' feedback.

Our experiments and analysis are done in three phases.

1) In the first phase, we perform a LinkedIn profile analysis to study the feasibility of LinkedIn profile to provide SFIA skills.

2) In the second phase we perform SSG analysis to study the outcomes of SSG.

3) In the final phase, we study the usability of the skills report by performing the student survey study and analysis.

C. LinkedIn Profiles Analysis

In this experiment, we study the significance of utilizing LinkedIn profiles to provide new SFIA skills for a particular student. We evaluate the significance by measuring the number of returned SFIA skills from the retrieved LinkedIn profile information.

From our analysis, we observed that number of SFIA skills generated by SSG varied across LinkedIn Profiles and by academic year. The total number of LinkedIn profiles that had positive results (return at least 1 SFIA skill) is 50 out of the datasets of 70 profiles (71%). Additionally, we observed that the number of skills returned had a large gap between the rich profiles and the average profiles. The rich profiles are those with more details in the form of projects, internships etc., and are linked to large number of SFIA skills.

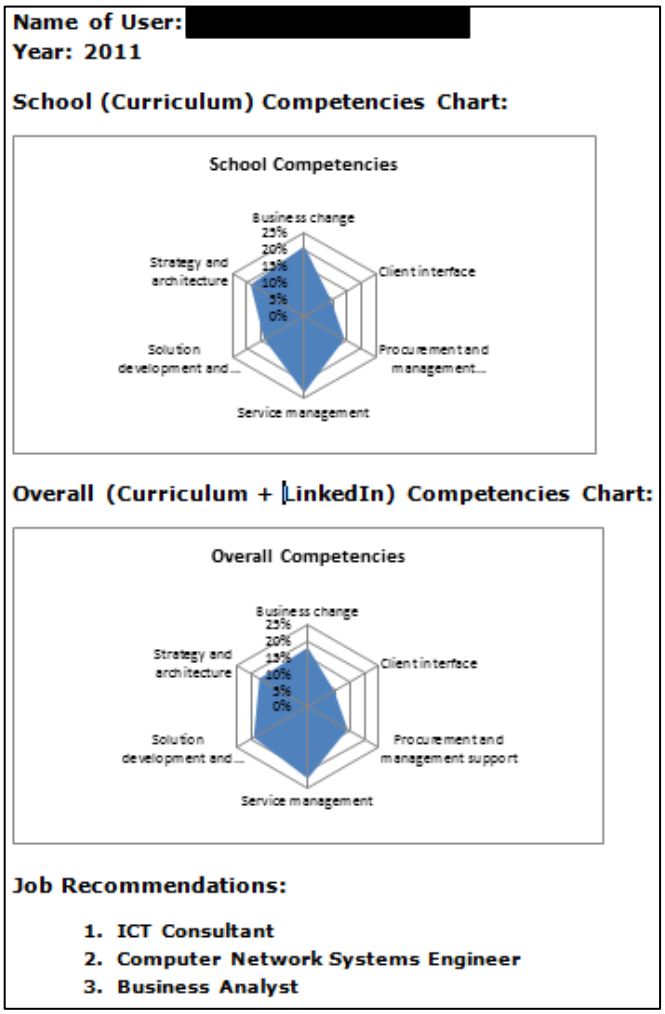
In our analysis, we observed that the content quality – writing style, terms and words used, and number of repetitive terms, affected the number of skills returned. Therefore, users with good content quality and experiences were able to have more SFIA skills from the mapping process.

We also observed that Year 3 students had lower numbers of SFIA skills. We can attribute this to two reasons. One, they might not have completed the internships or other external activities and second, they might not have spent additional effort in completing their profiles, as these students are not yet in a rush for searching a job. As we looked at the results for academic year 4 and alumni, we saw the best results for year 4 students with around 10 skills being mapped to SFIA, and average results for the alumni with around 7 skills being mapped to SFIA. This result was a bit puzzling since one is expected to see more SFIA skills in the working alumni compared to a current year 4 students. We attribute this discrepancy to the fact that probably most alumni profiles were are not updated over a period of time.

B. Student Skills Report

In this phase, we study the outcomes of SSG. We run all available 70 LinkedIn profiles to generate skills reports. Three outputs are produced for each student. The first output is the competency chart that shows the mapped SFIA skills with the retrieved information from LinkedIn profiles. The second output is the competency chart that shows the mapped SFIA skills with the curriculum competencies. The third output is the recommended jobs based on the overall SFIA skills. Figure 3 shows a sample student skills report generated by SSG. The figure shows that based on the school curriculum

competencies, a student enrolled in Singapore Management University, School of Information Systems, BSc (IS) degree



course, is well balanced across the six different SFIA skill areas. However, we also observe that the competencies have a greater emphasis on SFIA service management skills compared to the other SFIA skills.

Fig. 3. Sample Student Skills Report Generated by SSG

As we move further down the report, overall competencies chart which is a combination of curriculum competencies and the student LinkedIn profile skills, we observe that the student has additional SFIA skills from LinkedIn profile which are categorized into "Software Development" sub-category under SFIA "Solutions Development and Implementation" category. These additional skills can now be visualized in the second radar chart and one can see an increase in the skills under "Solutions Development and Implementation" compared to the first radar chart.

The report presented in Figure 3 aids both the educational institutions as well as the students. An educational institution may want to gather such results to analyze the curriculum with respect to the industry skills. The students can plan their professional development and seek skills or courses to complement their curriculum. A student may also utilize the report in exploring his or her strength and weakness identify suitable job roles or industries, and even the relevant improvements or changes to be made for a dream job.

Job recommendations are generated as the final section of the report for students' ease of use. In our analysis across 70 LinkedIn profile, we observed that ICT consultant was one of the top recommended job role for 92% of the profiles used. The curriculum mainly equips the students with ICT consultant skills and therefore it is not surprising that this job role is always on the top for all SIS student profiles. During this analysis we also found that the profile write-ups in LinkedIn profiles can be further improved to have more variations and the career office can help the students with further refining their LinkedIn profiles.

Additionally, the job recommendations model can be improved with more data on from the industry and we leave this as a future work.

C. End User Survey

In this phase, we studied the usability of the report by conducting a survey of the students. Our questionnaire was based on three main aspects of the skills report, namely usage, completeness and accuracy. Out of the 70 LinkedIn profiles, only 40 responded to the survey questionnaire and completed the survey.

We observed that in general there was a positive reaction to the report presented to the LinkedIn profile users. For questions such as "it provides a clear and simple format to advertise my competencies and accomplishments" and "it helps to communicate my assets in writing to an employer" achieved more than 75% positive answers (slightly or strongly agree). This shows that students are fond of the idea of skills report, which indicates that the approach to visualize the information was well received.

Questions that asked about the accuracy and relevancy of the results such as "it provides the summary of competencies gained in school and out of school" received a more positive result of 70% agreement on the report data. However, 65% of the positive results were only "slightly agree".

Another observation we had is a strong negative response to the question "whether does the report fully describe one's capabilities". The results showed a 54% of disagreeing that the report fully showed what they are capable of. This can be due to the fact that most of these users have taken subjects or courses from other schools within SMU and the competencies from these courses were not included in our study. It is also possible for a student majoring in the BSs (IS) program to have more than 15 business or non-IS related courses which could have a substantial amount of skills which were omitted. Future work will be aimed at including skills acquired from non-IS courses into our study.

Another notable observation we gathered from the survey, was for the response to the question "to the report helped me plan courses to achieve my dream jobs". This question received a 74% in disagreement. When we explored further through investigation with the survey subjects, we concluded that most of the disagreement resonated from an unknown dream job. In

fact most of the students surveyed did not have a dream job in mind.

V. CONCLUSIONS

Curriculum plays a key role in employability of students as it provides the students with the necessary skills to get industry relevant jobs. Therefore mapping competencies from curriculum to the industry skills helps the students to prepare a profile and plan their career path. Additionally, students' also increasing use LinkedIn profiles to seek job opportunities. In this paper, we proposed an automated student profile generation system that captures curriculum competencies and skills from LinkedIn profiles and map them to an industry standard skills framework. Additionally, the system also recommends relevant job roles that map to a specific student's skillset. Future work will be aimed at adding more job variations and including skills obtained from non-IS courses which are studied as a part of the program.

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