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Renewal of an information systems curriculum to support career based tracks: A case study

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RENEWAL OF AN INFORMATION SYSTEMS CURRICULUM TO SUPPORT CAREER BASED TRACKS: A CASE STUDY

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Abstract:

The pace at which technology redefines traditional job functions is picking up rapidly. This trend is triggered particularly by advances in analytics, security, cloud computing, Artificial Intelligence and big data. The purpose of this paper is to present a case study on our approach to renewing an undergraduate IS Major curriculum to align with the needs of the industry. We adopt a survey based approach to study Information Systems (IS) graduate skills requirements and re-design the curriculum framework for the IS program at our school. The paper describes in detail the process, the redesigned IS curriculum, the impact of the new curriculum on student enrolment across the different career tracks, and some lessons learned when trying to re-design the curriculum to align with industry needs. The work reported in this paper provides one pathway for Information Systems and Computer Science schools to re-engineer their curriculum design.

Keywords: Information Systems curriculum, Industry needs, national level job skills requirements, survey findings, curriculum framework

I. INTRODUCTION

Designing a curriculum for an undergraduate IS program is challenging and involves significant effort and resources. Many research works that describe approaches to developing IS program curriculum design follow the survey methodologies (Amadi 2012, Al-Hashimi et al. 2020). The objective of surveys is to identify IS graduate skills and the participants are the IT stakeholders such as employers (Leonard et al. 2019), graduates (Al-Hashimi et al. 2020) and faculty (Sahin et al. 2020). In our project, to gather IS re-design strategies, we analyse IS curriculums from top schools, industry Information Technology (IT) demands, and national level job skills requirements.

Study of national level job demands and skills requirements is crucial to help plan the policies and processes in the education, training, and support for the emerging manpower requirements. Infocomm Development Authority (IDA[1]), is a statutory board of Singapore Government which produces survey reports on manpower projections, computing technology skills projections, and Singapore trends in computing technology needs. Analysing these reports enables the curriculum designers to curate the graduate learning outcomes. Further the employment survey reports by the government, Joint-Autonomous University Graduate Employment Survey (JAUGES[2]) provides statistics about industry sectors where graduates

[1] https://www.imda.gov.sg/
[2] https://www.moe.gov.sg/

are hired. The survey reports enable the study of emerging jobs in the industry and develop relevant career paths within the curriculum.

In order to align with the new demands from industry and the national job skills framework, School of Information Systems, Singapore Management University channeled efforts to revamp the IS undergraduate curriculum. As the first step in this process, the curriculum management team comprising SIS faculty and staff combined the analysis from the above surveys to gain insights required for the re-design of IS curriculum. Furthermore, to ensure alignment with best practices, the team analysed IS curriculum from top IS schools around the world. Finally, we held focus group discussions with industry professionals in Singapore to validate their understanding of local requirements. In this paper, we share the renewal process and the resulting revamped IS curriculum design from these efforts. We believe the design process described provides a resource for Information Systems and Computer Science schools seeking to examine and modify their respective curriculum models.

The remainder of this paper is organized as follows. Section II presents a literature review of related work. In Section III, we introduce the survey based process of our curriculum renewal efforts. In Section IV, we present the findings from our surveys and the analysis based on the findings. In Section V, we describe the re-designed curriculum in terms of learning outcomes, curriculum framework and courses. Finally, we conclude in Section VI by highlighting some of the key lessons learned and the next steps.

II. RELATED WORK

Designing a curriculum for IT professionals is challenging and involves significant effort and resources. Schagaev et al. 2010 propose 'return the results of education to society' as a basis for designing computing curriculum. This approach considers various components of the program and according to this method, the cycle of education is completed when its outcome has been returned back to society. Plice et al. 2007 propose an appropriate strategy to align IS curriculum with the needs of industry by placing emphasis on communications and teamwork skills while maintaining a balance between business and technical content.

Current research in identifying IS graduate skills are mostly achieved by surveying IT stakeholders. Jones et al, 2008 researched skills for entry-level IS positions. The important hard skills identified include Microsoft Office, database/data warehouse/SQL, and knowledge of security, while the most important soft skills include willingness to learn, critical thinking, and attitude. Their approach helped to identify the different software tools that are to be integrated into the various IS courses. Amadi 2012, surveyed IS managers to identify the required skills. His findings include the expectation that IS graduates need to have some understanding of business fundamentals, although the expected depth or level of understanding varied with the IS graduates' job roles, responsibilities, and positions.

Leonard et al. 2019 identified gaps in the current IS curriculum by surveying IT professionals and list them as security, programming, system development, database, and project management. Al-Hashimi et al. 2020 surveyed alumni for skills gap analysis and their findings indicate that mostly these include the technical and tool-specific skills. For example, using project management (MS project, etc.), programming in PHP, and creating flowcharts. Sahin et al. 2020 analysed IT industry skills using a survey approach. Their study indicated that IS undergraduate curriculum must place emphasis on personal and non-technical skills. The study also suggested that establishing multiple learning tracks in the IT curriculum would equip students with specialized knowledge and skills.

Makkonen & Skaniakos (2015) use student career paths as a guide to help design the curriculum. Traditional approaches to career paths are quite generic namely consultant, developer, business analyst, etc., and do not take into consideration specializations in various technology and domain areas.

Going forward, new IS graduates must have both foundation skills and more in depth skills in a chosen technology or domain area which help them progress along specific emerging

career roles such as data analyst, digital transformation consultant, etc.[3][4] Our study focuses on both technical and professional skills required by IS graduates to embark on emerging career roles in IT industry. Professional skills refer to soft skills such as leadership, adaptability, communication, etc., required for working effectively in teams.

III. CURRICULUM RENEWAL PROCESS

The curriculum renewal process is presented in Figure 1 and it was executed over a two-year period between 2016 and 2018. Since technology and market demand keeps changing this is an ongoing process over several years until the program is retired.

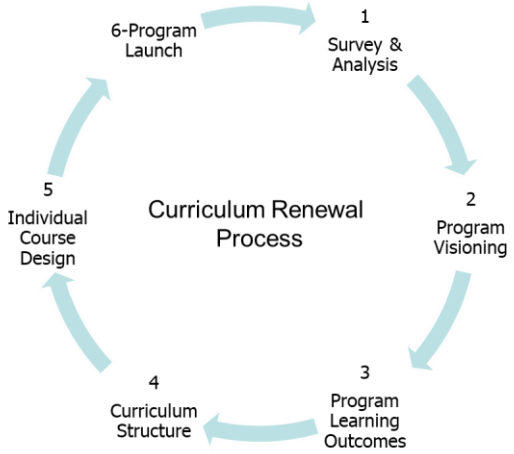

Fig. 1 Curriculum Renewal Process

Phase 1: During this phase, the team has to decide what information and who to consult in order to determine what changes will help improve the curriculum and align it to the needs of the industry. The subsequent phases rely on this phase to make well-grounded decisions about the curriculum. The surveys are conducted from both primary and secondary sources. The details of the survey methodology is described in the next section.

Phase 2: Using the survey analysis findings, the program vision is defined. The purpose of this phase is to help articulate the program's identity, which contributes to the creation of program learning outcomes and set the overall focus of the curriculum.

Phase 3: During this phase, the Program Learning Outcomes (PLOs) are defined using the program vision statements. This helps to articulate the specific expectations of a student graduating with an IS Major. The PLOs aid the curriculum renewal team to have a clear understanding of "what a student should know and be able to do by the time they graduate". This has to be aligned with the technical, professional and career skills as identified by the industry employment surveys.

Phase 4: In this phase, the curriculum renewal team prepare the overall curriculum structure that will help to deliver the PLOs. The curriculum structure needs to ensure that the student completes the required number of course units to obtain a degree within the stipulated time period of four years. The structure is divided into university core, IS core and IS electives aligned to career tracks.

Phase 5: The detailed design of each course involves the definition of Course Level Outcomes (CLOs) that are mapped to the PLOs. Once the CLOs are defined, the appropriate course content and hands-on labs are designed to deliver the outcomes.

[3] https://www.ecompetences.eu/ict-professional-profiles/
[4] https://www.skillsfuture.sg/

Phase 6: This phase involves various approval processes followed by outreach and administrative processes to launch the program ad individual courses. An important aspect of this phase is the continuous monitoring of the program along with feedback from students and industry partners on completion of student internships and finally graduate employment surveys.

In order to execute the renewal process, different workgroups were formed that included faculty and staff. The curriculum head was the project manager and each workgroup had its task leader. Periodic discussion sessions where held were the individual workgroups presented their findings and collective decisions were made with support from the senior management. Special focused session meetings were held with industry professionals to ensure alignment with market needs.

Curriculum Renewal Objectives

The key objective of the curriculum renewal effort is to conduct a systematic review of the positioning of the BSc (IS) degree program and formulate plans to enhance the program over the next 2-3 years. The key tasks of the project are to:

i. Conduct survey-based analysis of:
    a. Relevant IS schools' curriculum to gain insights on curriculum structure and best practices followed by other institutions
    b. National manpower needs and job skills requirements to understand the current skills demands
    c. Singapore industry needs in terms of IS graduates to help design career paths and define learning outcomes for each path
ii. Develop program vision, program learning outcomes, curriculum structure and design individual courses that align and map with the evolving industry demands.

Survey Based Approach

During the survey analysis phase, three surveys were conducted: IS curriculums survey, industry & SIS graduate employment survey and industry focused group sessions. For curriculum survey, we first studied ranking reports from the following Information Systems schools ranking institutes/bodies: US News and World Report[5], College factual[6], USA Today[7], Study.com[8] and QS ranking 2015[9]. Based on the analysis of the rankings, we analysed the IS curriculum from three universities around the world. For the industry demands survey, recall that we focus on surveys from Singapore based national employment body IDA. For SIS graduate employment survey, we use the employment survey from JAUGES as well as Singapore Computer Society. The industry focused group sessions included representatives from IT consulting firm management and technology heads, financial services IT heads, and entrepreneurs.

[5] http://colleges.usnews.rankingsandreviews.com/best-colleges/rankings/business-management-information-systems

[6] http://www.collegefactual.com/majors/computer-information-sciences/computer-information-systems-cis/rankings/top-ranked/

[7] http://college.usatoday.com/2014/12/29/top-ranked-schools-for-a-degree-in-computer-information-systems/

[8] http://study.com/articles/List_of_Top_Schools_with_Information_Systems_Programs.html

[9] http://www.topuniversities.com/university-rankings/university-subject-rankings/2015/computer-science-information-systems#sorting=rank+region=+country=257+faculty=+stars=false+search

IV. FINDINGS FROM SURVEYS

The present the approaches, results, findings, and discussions of phase 1 in this section.

IS Program Curriculum Survey Findings

An initial survey was conducted to identity 20 top schools based on various ranking reports and to gain a broad understanding of their respective IS programs. For further in-depth study of the curriculum, we choose three schools with contrasting criteria namely the focus of IS program offered (e.g. management vs. technology focused); size (e.g. large, medium) and positioning of the school (e.g. situated within management faculty);

University 1: Curriculum IS Major is rather similar to the BSc (IS) at SIS, including a group project with a real client similar to the SIS capstone project course. Compared to SIS, this IS Major has a "soft skills" slant, probably because it's based in College of Humanities and Social Science. In contrast, the SMU SIS curriculum has an "enterprise" slant, with courses such as Enterprise Integration, Enterprise Web Solutions, and Process Modelling and Solutions Blueprinting.

University 2: The curriculum at University 2 is less focused on the IS technology and more on management areas. The courses focussing on IS technology are similar to the SIS foundation courses. Compared to the SIS curriculum, there are no advanced IS courses. The broad career paths offered within the curriculum enable the students to choose courses that can lead them to specific career choices such as security, project management, IT consulting, enterprise IS, and system analysis and design.

University 3: This University offers 3 different bachelor programs in the area of information systems; ranging from those in management to those with technical depth. SIS curriculum is similar to its program in Web and IS major. The career choices are very generic and no specific career paths are defined.

In summary, SIS curriculum is comparable with that of those from the relevant IS schools across the globe. Many of these schools offer more choices to students either in terms of different programs or specializations within a single program. From this study, we established the main gap within the IS program, i.e., lack of opportunity to gain depth aligned to specific career paths within the program. The next step was to decide the relevant career paths that are likely to be in demand in Singapore and the region.

Industry & SIS Graduate Employment Survey Findings

We first present the industry findings where the reports provide statistics on predicted areas of employment. We then present the Singapore Ministry of Education (MOE), graduates employment survey findings.

Industry: The total demand for Infocomm professionals was 198,200 in 2016 and demand is projected to grow by another 42,300 in the next three years (2017–2019). The Infocomm job vacancies as of 2016 were 18,200. The computing staff account for 145,000 jobs under Infocomm and the remaining jobs are related to non-IT job roles. The computing staff account for 70% of total Infocomm staff and the key roles are depicted in Table 1. Table 2 depicts the demand in the specialization jobs.

Table 1. Key roles for computing staff

Roles	% of staff	Job vacancies	Demand in 3 years	Example roles
IT Development roles	51%	10,000	27,400	Software/application manager, Software/application developer, business analyst, UI Designer, Multimedia developer, etc.

Network & Infrastructure related job roles	16%	2900	3400	IT infrastructure manager, systems administrator; Network engineer, etc.
Critical Emerging Tech specialists	6%	700	2700	IT security specialist, Data analysts/Data Scientists, Machine Learning/Artificial Intelligence Engineer, Infocomm R&D, etc.

Table 2. Statistics and projections related to critical emerging tech specialists

Specialization	**Demand in numbers**	**Demand distribution for 11800 jobs**
Research & Development	5600	47.5%
Cyber Security	4100	34.7%
Data Analytics	2100	17.9%

From Table.1 and Table 2, we observe that IT development has the requirements for the highest number of computing staff. Most of the roles indicated are suitable for the Information Systems graduates. In terms of specialization, R&D has the most number of jobs, and cybersecurity & data analytics are other fast-growing specializations.

SIS graduate employment: Table 3 shows the statistics from JAUGES graduate employment survey for 2017. We study the top sectors that recruit most IS graduates as well as the top of companies in each industry.

Table 3. Top 3 sectors where IS graduates found jobs

Sector	**% of IS graduates employed**
Information & Communication	37%
Financial and Insurance	34%
Public Administration and Defence	9%
Legal, Accounting and Auditing	4%
Logistics and Supply Chain Management	2%

Table 3 indicates that many IS graduates take up jobs in companies under Information & Communication and Financial & Insurance sectors. These include consulting e.g. Accenture), banks (JP Morgan) and technology (e.g. IBM) companies. From the data taken from the SMU office of career services we observe that this is also true for the internships undertaken by IS students.

In summary, based on the analysis of IDA and JAUGES surveys the priority order for skills development within the curriculum should be; Application Development, Data Analytics, Cyber Security, and IT Solution Consulting. The priority of industry domain focus should be; IT Technology, Consulting and Financial & Insurance, firms.

Industry Focus Group Session Findings

We invited the industry professionals for a workshop and conducted the focus group discussions on the IS major curriculum and its alignment with industry needs. The summary

of findings from the industry focus group sessions is shown in Table 4. We have classified the findings into two categories: Technical and Professional skills. Potential industry employers mostly emphasized technology foundational and soft skills for job excellence. Some also mentioned specific technologies required for the development of business solutions that are likely to be in demand.

Table 4. Summary of employers' survey analysis

Technical Skills	Professional skills
The students should • Be able to program (e.g. Python, Java, .NET etc.,) and have a good understanding of the related frameworks • Have a good understanding of how to integrate applications using service oriented architecture and have foundational understand of networking principles • Be able to model and analyse structured and unstructured data • Have an understanding of 2-3 enterprise platforms (e.g. SAP), understand cloud computing and be able to build applications using a cloud platform (e.g. AWS). • Have UI building experience • Be able to use RAD platforms (e.g. Alpha)	The students should • Have critical thinking and problem solving and design thinking skills • Have an understanding of business continuity • Have an understanding of management and business context • Know how to define problems, understand business and apply skills to solve the problems • Be able to help the client to explore what they can do more by suggesting innovative solutions and asking the right the questions • Have good oral and written communication skills • Have a good team working skills

In summary, the key takeaways from the focused group sessions are that the curriculum design should ensure that the IS graduates are equipped with a good balance of technical skills and soft/professional skills aligned with the industry needs. Additionally, various tools and techniques proposed by the industry professionals should be considered when designing the individual course content and labs.

V. DESIGN OF THE NEW CURRICULUM

Based on the inputs from surveys and focused group session findings and further discussions within the SIS curriculum design team, we move to the next phases. In this section, we describe the proposed curriculum in terms of program positioning, learning outcomes, and the re-designed curriculum framework. Due to space constraints, we shall not describe the detailed course designs.

Program Positioning

Recall that phase 2 is about establishing the vision of IS program. The IS major is positioned to focus on *innovative solutioning*, with emphasis on:

i. *Value Creation (for business and society):* Identifying opportunities to create value by addressing business and user needs.
ii. *IT & Business Innovation:* Innovating to create value by going beyond current industry practices, to exploiting the possibilities offered by emerging technology and market trends, and synthesizing knowledge across domains.

iii. *Solutioning*: Building applications through harnessing computing and information technologies to effect innovation.

Program Learning Outcomes (PLOs)

In phase 3, we work on deriving the learning outcomes of IS major. Table 5 shows IS PLOs designed by the curriculum team based on the survey and skills analysis which includes both the technical and professional skills. Compared to the earlier curriculum the new curriculum lays more emphasis on new digital technologies and innovative solutioning skills. The PLOs include both technical and professional skills. We also depict the IS courses that contribute the most to the given PLOs.

Table 5: PLOs of new IS curriculum (Technical and Professional PLOs)

IS Program Outcome	Courses
Understand business and society context through modelling of organizational processes, people and data	Data Management, Business Process Analysis & Solutioning (BPAS), Interactive Design Prototyping (IDP)
Select and apply appropriate programming languages, tools, techniques and architectures for solving a given problem	Web Application Development, Intro to Programming, IDP
Design, build and manage innovative IT solutions in an enterprise context	Enterprise Solution Design, Enterprise Solution Management (ESM), Digital Business Technology & Transformation (DBTT)
Apply effective project management and change management skills to deliver impactful IT solutions	Software Project Management (SPM)
Demonstrate commitment to a continuous and life-long learning process by adapting to changing technological environment	Information Systems & innovation, DBTT, ESM, Capstone project
Ability to communicate and work in groups with an understanding of professional and social responsibilities	SPM, BPAS, ESM, Capstone project
Understand and apply knowledge of advanced and specialised information technology theories and models to meet desired needs	Career tracks courses and electives

Curriculum Framework

Recall that in phase 4 and phase 5, we design the curriculum structure and the corresponding courses based on the findings from the previous surveys. As described earlier, the program emphasizes three areas namely value creation, business innovation, and solutioning. In order to achieve this, the curriculum needs to ensure that the graduates have agile and social skills, IS discipline foundation skills and domain-specific career skills. The revamped curriculum provides students with strong foundational skills in Information Systems and career tracks designed to offer depth courses in alignment with national and global job market trends. The new curriculum aims to produce well-balanced graduates equipped with both cross-discipline expertise and deep discipline expertise. The students complete the university and IS core courses in the first two years and subsequently in years 3 and 4 they do the career track courses.

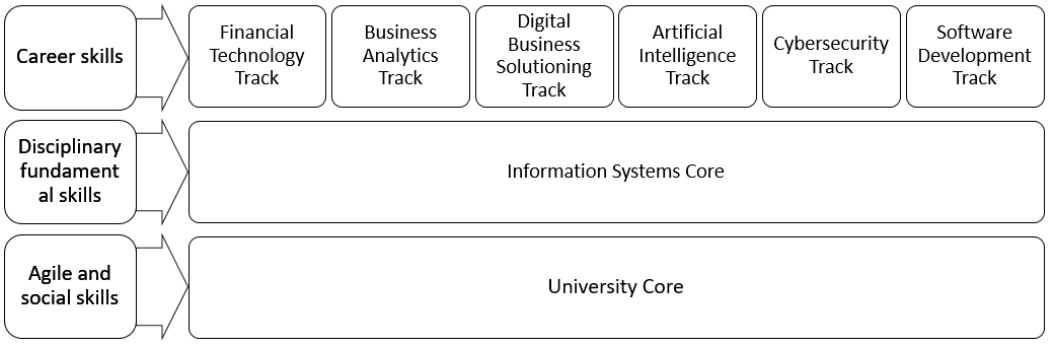

Fig. 2 IS Program Curriculum Framework

Agile & Social skills

The university core curriculum will serve to nurture a generation of adaptive and adroit graduates who are technically competent and agile, socially conscious and adept in their communities, and inspired by the timeless puzzles and challenges confronting humanity[10]. Courses in the university are depicted in Table 6.

Table 6. Sample University core courses

Pillars of skills	Courses
Capabilities	Statistics Computational Thinking Managing Writing & Reasoning Internship
Communities	Economics & Society Technology & Society Cultures of the Modern World Community Service
Civilisations	Ethics & Social Responsibility Big Questions Global Exposure

Disciplinary fundamental skills

Information Systems core curriculum prepares the graduates with the disciplinary fundamental skills in information technology required to design, implement and manage solutions for real-world projects. The courses are shown in Table 7.

Table 7. Information Systems core courses

Pillars of Skills	Courses
Innovation, business solutioning and management	Information Systems & Innovation Business Process Analysis and Solutioning Enterprise Solution Development Enterprise Solution Management Digital Business Technology and Transformation
Software development and management	Introduction to Programming Software Project Management Web Application Development I Web Application Development II Interaction Design and Prototyping
Information management	Data Management

[10] https://www.smu.edu.sg/programmes/core-curriculum

Career Tracks

Each career track requires students to do a total of four compulsory and elective courses.

Digital Business Solutioning (DBS) Track: Students doing the DBS track will learn how to ideate, design, and develop IT solutions that will leverage digital technologies (like cloud computing, big data and analytics, mobile networks, social media, Internet of Things) to enhance operational excellence, integrate information-processes-people, and drive product and process innovation.

Business Analytics (BA) Track: The BA track aims to provide students with the concepts, methods, and best practices of data analytics through working on real-world use cases and practicum. Students are equipped with skills to design and develop analytics solutions for business decision making process.

Financial Technology (FT) Track: The FT track covers the foundations of enterprise architecture in banking, as well as the functional domain areas, such as retail & corporate banking, digital payments & innovations, and financial markets. Students…

Cybersecurity (CS) Track: The CS track aims to produce high-quality security practitioners with a solid theoretical and practical foundation. The courses in this track have a full-spectrum coverage on various aspects of security fundamentals, including (but not limited) to network security, data security, and software security.

Artificial Intelligence (AI) Track: The AI track covers an area that aims to augment or substitute human intelligence in solving complex real-world decision making problems. AI models help build systems that think for themselves and improve over time. The courses in this track will equip students with core concepts and practical know-how to build innovative AI applications that impact business and society.

Software Development (SD) Track: Students doing SD track will be equipped with the technical skills to develop web or mobile applications to solve business problems and to leverage technology effectively. Computational literacy lends a skill advantage to anyone who wishes to contribute effectively to the economy. It also helps to improve the way your brain works; as well as improve your ability to be more meticulous and to think about the causes and effects of everyday problems.

Discussions

In phase 6, we study the outcomes of the program launch. The renewed curriculum was launched in August 2017. Table 8 shows the enrolments for the career-based tracks in the first and second run. The curriculum also provides a path for undertaking dual tracks in order to further enhance job opportunities. We observe that IS students are more inclined towards the BA, DBS, and SD tracks which also aligns with the industry manpower demands described in Section IV. .

Table 8: Student enrolment statistics in the career tracks

Career track	2017 Intake	2018 Intake
Artificial Intelligence	5%	8%
Business Analytics	50%	47%
Cybersecurity	7%	8%
Digital Business Solutioning	16%	13%
Financial Technology	7%	6%
Software Development	15%	18%

In 2018, School of Information Systems introduced a new degree in Computer Science and after much analysis, the more technical tracks such are Cybersecurity and Artificial Intelligence were parked under Computer Science major. IS Major students keen to gain deep

technical and mathematical skills must choose to do a second major and a respective track from the Computer Science degree.

The following are some key takeaways from our work.

a. Curriculum design should consider both national level skills for identifying skills in demand and specific industry sector technology needs. The national level skills provide general directions for the university in terms of program planning intending to fill the manpower skills gaps. Whereas, the industry input provides more in-depth insights that help to design career paths and course-specific skills.
b. Learning outcomes should be designed considering both technical and professional skills. The technical skills prepare the students for specific job roles and prepare them to complete the job-related tasks. The professional skills aid the students to effectively handle the workplace environment and for their professional growth.
c. Course design should not only consider the concepts and theories but also the technology tools that are in demand in the industry. Curriculum managers usually aim at high level learning outcomes for their program and usually leave the course details to the course managers. This may result in individual course designs that satisfy partial competencies required by the industries resulting in a lack of industry skills alignment for fresh graduates. Therefore, the course managers should consider industry specific technology demands to ensure graduates are job-ready.

VI. CONCLUSION

In this paper, we present a curriculum renewal process for IS curriculum based on analysing national level skills, global best practices, and industry needs. The first launch of the career based IS curriculum by the School of Information Systems was well received by the students. The capstone projects were also aligned to the career track and there has been an overwhelming response from industries sponsoring the capstone project. We have also observed more students taking up internships in their respective tracks thus helping them to establish the network required for securing a job when they graduate.

VII. ACKNOWLEDGEMENTS

The authors would like to thank the faculty and staff of the School of Information Systems, Singapore Management University, who have supported this project over the years. Most importantly, we would like to thank the core members of the curriculum redesign project and the industry professionals who have directly contributed to the renewed IS Major curriculum.

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Dr. Kyong Jin Shim is an Assistant Professor of Information Systems (Practice) in the School of Information Systems at Singapore Management University. Her research focuses on large scale social sensing in popular social network platforms and multi-player video games. Using statistics, machine learning and social science theories, her research investigates how people connect, collaborate, mentor, exchange and spread information across large social networks, build long-term relationships, and form communities. Her research seeks to capture and analyze social conversations about a wide range of social topics such as politics, health, economy, entertainment, sports, etc. She is an industry practitioner with 15 years of experience in Software Development and Data Science in a wide variety of domains such as computational biology, computational social science, healthcare, legal, video gaming, marketing, logistics and supply chain management.