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Survey of Information Technology Undergraduate Degree Programs in Canada

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***Abstract*—A survey of Information Technology (IT) undergraduate degree programs in Canada is presented. IT Bachelor degrees have not been very popular in Canada although they have existed for a number of years in other parts of the world, including the United States (US) and the European Union (EU). This survey is looking into the current status of IT undergraduate degree programs and their curricula.**

***Index Terms*—Information technology, computing, curriculum, IT baccalaureate program, IT programs demand**

I. Introduction

A task group of the Association for Computing Machinery (ACM) and IEEE Computer Society (IEEE-CS) developed Curriculum Guidelines for Undergraduate Degree Programs in Information Technology [2], which was published in 2017. ACM and IEEE defined the term Information Technology as follows: "Information Technology is the study of systemic approaches to select, develop, apply, integrate, and administer secure computing technologies to enable users to accomplish their personal, organizational, and societal goals."

Universities have started to tailor their existing and create new programs in one of the fastest growing disciplines in undergraduate and graduate education today.

II. Information Technology Program Features

Very few programs in Canada have a focus on IT, a discipline which began to emerge in the late 1990s to fill the gap that other computing disciplines did not adequately address. Other computing disciplines certainly share a common terminology with IT, but often their courses do not focus enough on the application, selection, integration, or security of technology. For example, computer science courses are often having a theoretical rather than an applied focus, and information systems courses are frequently too focused on business value rather than technology or security.

The intended purpose of the programs in IT is to prepare graduates who will improve the prospects for excellence in the computer-based delivery of services and information. The IT programs can also provide a platform for further work leading to graduate studies in IT, as well as careers in fields such as business, law, medicine, management and others.

III. Where Do IT Programs Belong?

There is a source of much confusion in relation to Computing / ICT (Information and Communication Technologies) due to variation in terminology, as pointed out in [16]. Even nowadays, programs are hard to be identified since they are not always titled "IT" and they are housed in various colleges and schools, including computing, engineering, business [13].

An important question is whether IT programs should belong to science, engineering, or business/management areas.

Undergraduate degree programs in computing–related disciplines began to emerge in the 1960s. Originally, there were only three kinds of computing-related degree programs in North America: computer science, electrical engineering, and information systems.

Computing curricula and focus [2] include:

- **Computer Science (CS)**: 60s; creating new knowledge, theory and tools development;
- **Information Systems (IS)**: 60s; integrating IT solutions and business processes to meet the information needs of businesses and other enterprises;
- **Computer Engineering (CE)**: Mid 70s; infrastructure of computer-based systems;
- **Software Engineering (SE)**: 80s-90s; designing and building reliable large software systems;
- **Information Technology (IT)**: Late 90s; the youngest, the most integrative.

The closest disciplines to IT are CS and IS. However, they are fundamentally different although there exists some overlapping content. While CS programs typically focus more on theory and tools development, IT programs usually focus more on applications and operation. IT programs are frequently mistaken with IS programs, which focus more on the interaction between organizational concerns and computer-based systems.

IV. The Birth of the Academic Field of IT

What happened in the 90s? In 1994, the United States government privatized the internet backbone. Commercial firms took over the job of carrying long–distance internet traffic, allowing the government–funded NSFNET to be decommissioned [7]. By 2000, almost half of Americans were on the internet. The rapid increase of IT innovations has marked the

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birth of the academic field of IT in 2008 [3]. These innovations include: web services; emergence of mobile computing; social media; high-speed wireless networks; and expansion of data centers. A decade later, IT capabilities have become embedded in everything around us. The increased importance and global reach of computing technology in all aspects of todays society was the basis for the emergence of the IT discipline [2].

A report in the computing curricula series "Cybersecurity Curricula 2017" became available on December 31, 2017, representing an expansion of the ACM education initiative to include the first set of global curricular recommendations in cybersecurity education at the post-secondary level, see [4].

V. IT Curriculum

There are many ways to build an undergraduate curriculum for IT. Distinctive features would be influenced by the institutional missions and visions as well as accumulated expertise in existing programs. The applied focus along with the academic degree option of such programs has the potential to attract students willing to complete a degree allowing them to obtain jobs directly close to and upon graduation.

BSIT programs can receive support from professional organizations such as the Institute of Electrical and Electronics Engineers (IEEE), Information Systems Audit and Control Association (ISACA), Canadian Information Processing Society (CIPS), Alberta Association of IT Professionals, International Information System Security Certification Consortium $(ISC)^2$. These well-known organizations can support IT programs with expertise and members of advisory committees.

A. Essential and Supplemental Domains

According to the ACM-IEEE Curriculum Guidelines, an IT degree program should build both technical and business skills / soft skills grouped in essential and supplemental domains. The essential domains refer to the minimal competencies that all students in all information technology degree programs must achieve. The supplemental domains reflect the purpose and goals and the mission of program.

B. Delivery Methods

Typical program methods of delivery are designed to build technical knowledge, with the requisite soft, communication, and teamwork skills, as well as ensure students gain as much hands-on experience as possible, which is essential for information technology. Well-designed IT programs allow students to gain academic credit if they are engaged in an internship or work–study programs. These experiences can develop important soft or professional skills that are so valuable in the workplace. Obtaining experience along while studying at a university provides a necessary component to help students decide on future career goals. IT programs usually have a professional advisory board assisting with developing a strong industry connection by bridging the professional experience gap between academia and industry. The IT industry in Canada has many opportunities for hands–on part–time or even full-time work for students.

Undergraduate IT degree programs are academic programs with the emphasis on building technical and soft skills, and teamwork. The opportunities to work in teams should start early in the curriculum. Later on, there need to be significant projects of a complex task, in which a small team undertakes the design and implementation. The last year of the study, the programs require students to work on major capstone projects for the undergraduate experience. The well-designed IT curriculum also includes coursework with emphasis on writing and oral presentations for skills to communicate ideas effectively in both written and oral forms.

C. Learning Methodologies

The program curricula include mathematics with content that focuses on discrete structures and selected supplemental subjects: probability; statistics; financial mathematics, data analytics, linear algebra and calculus. Students enrolling in the IT program should be encouraged to take science courses (physics, chemistry, etc.). If students work in the technological field they need to develop strong analytical and critical thinking skills as well as to acquire empirical and experimental learning skills.

Learning and teaching methodologies for undergraduate programs in IT should assist students in acquiring technical knowledge, critical thinking, problem solving, communication and research skills. They include traditional and modern approaches such as classroom lectures incorporating inquiry based learning, discussion, practice by doing, problem-solving. Course assignments and other type of examination test what students learned in way that combines tests with experience. IT is a laboratory discipline with formal, scheduled laboratories included in many courses. Building soft skills and teamwork is achieved through project-based work. Students are asked to present their work, thus, students can build and enhance their presentation skills.

Work–integrated Learning (WiL) is beneficial for students in technology and other professional programs. Examples of appropriate undergraduate WiL in IT programs include internship, required professional practice, capstone projects developed with industry, and co-ops. Alberta's Ministry of Advanced Education requires and even gives preference to programs that include more than one WiL component. It appears that companies lack employees with specific IT skills; the programs need to include ways of building these skills and competencies. Employers need IT specialists at any levels, from junior level to senior level positions; therefore, there are opportunities for students in all years of their undergraduate study to gain WiL experience while studying

D. Accreditation

There are various organizations dealing with accreditation of IT programs. One such organization is ABET, a U.S. based, which can conduct an accreditation review outside the U.S. only with explicit permission from all applicable national education authorities in that program's country or region, as noted on their website: https://www.abet.org. Presently, there is

no computing program in Canada accredited by ABET. ABET is a nonprofit ISO 9001 certified organization that accredits college and university programs in applied and natural science, computing, engineering and engineering technology.

The most recent criteria, reflecting the published in December 2017 guidelines [2], require that the curriculum for IT and similarly named computing programs include coverage of fundamentals and applied practice in three areas [1]: the core information technologies of human-computer interaction, information management, programming, web systems and technologies, and networking; system administration and system maintenance; and system integration and system architecture.

VI. Demand

There are a few university degree programs in Canada (none in Alberta) focusing on information technologies; there are only diploma and certificate programs in somewhat close areas offered by institutes of technology. At the degree level there are programs that are related to IT. Namely, programs in Information Systems are available in Alberta, such as the Bachelor of Computer Information Systems of Mount Royal University in Calgary, administered by the Department of Mathematics and Computing and jointly offered with the School of Business, and the Bachelor of Science in Computing and Information Systems at Athabasca University.

VII. Labour Market Demand and Initiatives

In its 2017 Compensation Guide for Tech Professionals [10], the tech recruiting company Modis indicated that the need for these professionals is generally high across all (tech) industries, and that they are seeing especially strong competition for: agile specialties; security professionals; managed services; project management; health IT; web development; database administration. Bachelor of Science in IT degree holders can be successful in any these occupations. Modis Compensation Guide shows relatively high starting salaries for IT specialists, which along with anticipated demand makes the IT profession very attractive to individuals.

A. Government of Canada

Recent Government of Canada (GC) initiatives include "Government of Canada Information Technology Strategic Plan," published in June 2016 [5], which "outlines the key activities to ensure they provide secure, reliable, responsive and innovative IT services that contribute to better programs and services to Canadians."

The first update of this plan is the "Government of Canada Strategic Plan for Information Management and Information Technology 2017 to 2021," published in [5]. A larger digital policy and strategy, called "Digital Operations Strategic Plan: 2018-2022" [6], followed the update of the IT strategic plan. The government needs to change following the fundamental changes happening in the world over the last 20-30 years.

In its Express Entry Year–end Report 2017, [11], Immigration, Refugees and Citizenship Canada of the Government of Canada listed the number of invitations issued to candidates by occupations. The top three ranked number of invitations in 2017 and 2016 were issued to: 1. Information systems analysts and consultants; 2. Software engineers; 3. Computer programmers and interactive media developers.

The following unit groups of the National Occupational Classification 2016 version [12] contain "information technology" in their job titles, namely: information systems analysts and consultants; computer and information systems managers; and computer engineers (except software engineers and designers). IT trained individuals may also hold jobs with titles under the software engineers and designers occupation, such as: telecommunications software engineer; embedded software engineer; software design verification engineer; software testing engineer, among others.

B. Government of Alberta

In 2018, Alberta projected a labour shortage of computer and information systems professionals by 2025, as well as a shortage of software designers, programmers and developers. To address this shortage in Alberta's high–tech sector, the Government indicated willingness to work with post–secondary institutions and industry partners in order to develop, train and graduate highly–skilled workers in key areas such as artificial intelligence, quantum computing, health innovation, big data and clean and renewable technology. Consequently, Alberta's Bill 2 Growth and Diversification Act was introduced March 2018 and passed June 5, 2018.

The Talent Advisory Council and Technology (TACT) was established to assist the government with adding new and expanded seats to the post-secondary institutions in the province. They developed guidelines and priorities, as well as approved million of dollars investment approach to post–secondary programming.

VIII. Issues

In the context of undergraduate computing education, developing curriculum guidelines for IT presents multiple challenges. Because IT is relatively new as a discipline, institutions sometimes offer IT baccalaureate degree programs within a previously established discipline. For example, an IT degree program could exist within an already established IS program or within an established CS program. In fact, because of institutional convenience, an institution might even offer all IT courses as simply subsets of an existing discipline.

IX. Overview of Existing IT Programs

Information Technology refers to undergraduate degree programs that prepare students to meet the computer technology needs of business, government, healthcare, schools, and other kinds of organizations. It focuses on ensuring that the organizations infrastructure is appropriate and reliable.

Information Technology undergraduate degree programs have been established lately, including in Canada as well as in the United States. Examples are programs offered by the following universities: University of Southern Maine (United

States); Arizona State University (United States); Charles Sturt University (Australia); University of Pretoria (South Africa).

The University of Cincinnati created a successful Bachelor of Science of Information Technology program in 2004. They considered a networking track specialization for their IT degree program while developing it, see [15].

Several foreign universities discovered the niche in the Canadian post-secondary education; consequently, they started to offer IT programs in Canada:

- National American University offers online Bachelor's degree in IT specializing in various field of interests: application development; web development; cyber security and forensics; management information systems; game software development; network management Microsoft.
- Fairleigh Dickinson University Vancouver offers Bachelor of Science interdisciplinary curriculum focusing on Information Technology and Computer Science.

Presently, examples of Canadian post–secondary institutions offering Bachelor degree in IT programs include:

- Carleton University in collaboration with Algonquin College offers Bachelor of Information Technology with four distinct programs: Information Resource Management; Interactive Multimedia and Design; Network Technology; and Photonics and Laser Technology, School of Information Technology.
- Bishop's University: Bachelor of Arts in Information Technology, Faculty of Arts and Science.
- York University: Bachelor of Arts – Information Technology, with a strong technical orientation and Bachelor of Commerce – Information Technology, which adds more business depth, Liberal Arts & Professional Studies.
- University of Ontario Institute of Technology Bachelor of Information Technology (Honours) degree offers three program majors: Game Development and Entrepreneurship; Networking and Information Technology Security; Technology Management, Faculty of Business and Information Technology.
- Kwantlen Polytechnic University: Bachelor of Technology in Information Technology, School of Business.

The above IT degree programs differ with respect to curricula, administrative units, degree type, and focus. They are housed in different faculties: science; business; arts; technology; professional studies.

Almost all programs include senior project courses or thesis. Available to selected students, a co-operative education option gives them the opportunity to apply the skills gained during academic study in paid, practical work experience semesters. The co-op option helps students build contacts for both summer and future employment.

In Europe, there is strong emphasis on the IT and CS education, both at the high school level and at the university level. That is why there are many undergraduate and graduate degree programs in ICT. Programs may have narrow focus on software engineering, web design, cybersecurity, among others. At the same time, there exist interdisciplinary programs [14] combining IT with other discipline. In many cases this programs are in a professional area other than Computing, such as Economics, Management, and Physics. Another modern trend is the need of programs focused on Computational Science (e.g. Computational Biology), which have something in common with IT programs including the necessity for analytical skills and thinking in other science discipline.

X. Conclusion

This paper provided a survey on the status of the evolving baccalaureate discipline of Information Technology in Canada. IT programs in Canada may increase in near future, given that such programs are quite popular in other parts of the world and there is a high demand for IT professionals.

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