SELF-STUDY REPORT

School of Computer Science
College of Engineering and Physical Sciences
University of Guelph

Bachelor of Computing (Honours) in Computer Science

Bachelor of Computing (General) in Computer Science

Bachelor of Computing (Honours) in Software Engineering

Master of Science in Computer Science

Master of Cybersecurity and Threat Intelligence

Doctor of Philosophy in Computational Sciences

May 2022

Background

The School of Computer Science (SoCS) was founded in 1971 and is celebrating its 50th anniversary. To date, it has graduated 3,000+ students, prepared them to *Improve Life* through developing and using technology in innovative ways. Throughout its history, SoCS has maintained its focus on undergraduate education — to develop strong technical and analytical skills in our students using hands-on experience in leading edge technology. However, SoCS is embracing exciting changes as well: its undergraduate programs have become increasingly popular in the last eight years; it welcomed 11 new faculty members who brought in diverse research backgrounds and strong research profiles; its historical home (Reynolds Building) received major renovations and reopened in August 2018; it celebrated outstanding achievements of our alumni for the first time in March 2019 and again in June 2021; and it was placed as the 9th out of 27 Canadian universities in the 2022 Times Higher Education ranking by Computer Science subject (see https://www.timeshighereducation.com/world-university-rankings/2022/subject-ranking/computer-science).

At the institutional level, the University of Guelph completed its strategic framework in 2016 — Our Path Forward — which describes who we are as an institution, where we will focus and how we will move forward as a University. In May 2018, the College of Engineering and Physical Sciences (CEPS) launched a comprehensive strategic planning process as well. Based on essential statistics collected and consultation with faculty members and staff, the following five college-level goals were established:

- Maintain and build on our strengths in undergraduate education, including enhancing the cooperative education and research opportunities our students receive, and increasing the percentage of international students we enroll in our programs.
- Enhance our graduate education through the introduction of new professional master's programs.
- Increase our research intensity and impact.
- Focus on issues of equity, diversity and inclusivity (EDI) in our College and ensure all our students, faculty, and staff feel valued and respected.
- Take advantage of interdisciplinary opportunities in research and teaching across our College, the University of Guelph, and beyond.

To align SoCS initiatives with goals set by the College and the University, SoCS conducted its own self-study between 2018 and 2020. Feedback was collected through several surveys and retreats by the SoCS Strategic Planning Committee, under the subsequent leadership of D. Gillis (until 2018), S. Scott (2018-2019), and M. Gong (2019-2020). A report was finalized and endorsed by the School Council in April 2020.

Continuous Improvement Resulting from Previous Review

The previous cyclical review for Institutional Quality Assurance Process (IQAP) was performed in March 2014. Key recommendations from the previous review, as well as the resulting actions and outcomes, are summarized in Table 1.

Table 1: Resulting actions and outcomes from previous review

Recommendation	Resulting Action and Outcome
Plan how to advertise the strengths and unique aspects of the school; Continue involving undergraduate and graduate students in recruitment and outreach.	SoCS created an Outreach Officer position, which was filled by L. Zweep. She managed outreach activities for engaging high school students and did a great job in involving undergraduate students. This helps to increase the number of undergraduate applicants from 1,148 in Fall 2013 to 3,387 in Fall 2021. However, since L. Zweep left University of Guelph and the position moved to CEPS Dean's Office, SoCS no longer has a dedicated staff for outreach.
Develop and launch two new programs in Mobile Computing and Human-Computer Interaction; Analyze the benefits of a new program in Game Programming.	Proposals were made for new majors in both Mobile Computing and Human-Computer Interaction, but SoCS didn't receive supports for implementing them. SoCS is also willing to explore new programs in other areas, such as Cybersecurity and AI.
Address maintenance issues in the Reynolds building; Review and address security needs of the Thornbrough building labs.	Most maintenance issues in Reynolds were addressed through a major building renovation in 2018. Controlled access was added to teaching labs in Thornbrough building. However, SoCS still lacks space for further growing our undergraduate programs and for research labs.
In all hiring decisions, consider gender representation; Establish a mentorship program to help junior faculty.	Efforts were made to enhance gender balance in faculty complement. Female faculty ratio has raised from 16% in 2013 to 23% in 2022. New junior faculty members were provided with mentors.
In any future faculty hires, give careful consideration to scholarly research record and likelihood of research funding success, in addition to teaching needs and general fit with the department.	Research record and likelihood of research funding success have been important considerations in recent hires. All regular faculty members hired after 2013 are currently supported by NSERC Discovery Grants. The number of grant holders has doubled from 6 in 2013 to 13 in 2022.
Thoroughly assess the viability of the PhD program, including the possibility of its permanent closure.	In responding to this recommendation, SoCS replaced the PhD in Computer Science program with an interdisciplinary PhD in Computational Sciences program. However, with new faculty members joining SoCS, the needs for the conventional PhD program grew. Hence, the PhD in Computer Science program was reinstated in Fall 2021. Now both PhD programs see health growth.
Hire an additional System Support person	An additional IT Analyst III position was created and filled.

Summary of Process

The 2020 SoCS self-study report provided a solid foundation. Some of the initiatives raised in the 2020 report have been implemented, whereas others are reiterated in this document. Additional efforts were made on the following fronts:

- Undergraduate curriculum mapping, led by Y. Xiang (Associate Director, Undergraduate Studies)
- Graduate curriculum mapping, led by J. Sawada (Associate Director, Graduate Studies)
- Alumni survey, led by S. Scott (Assistant Director)
- Co-op employer survey, led by D. Calvert (Undergraduate Curriculum Committee Chair)
- Student survey, led by S. Brennan and G. Klotz (Undergraduate Program Counsellors)
- Data retrieval and analysis, led by M. Gong (Director)

All faculty members contributed to curriculum mappings. Drafts of the report were discussed in November 2021 and February 2022 SoCS council meetings. After addressing constructive feedback provided by the Office of Quality Assurance and the Office of Graduate and Postdoctoral Studies, the final version was endorsed by SoCS Council in May 2022.

While this report has gone through multiple revisions between July 2021 and May 2022, the data used, including faculty and staff complement, are based on the snapshot taken in April 2022. In addition, at the time of finalization of this document, the world is still being affected by the COVID-19 pandemic, which has had strong impact on SoCS, University of Guelph, and the discipline of Computer Science (CS). It is difficult to predict how long the pandemic will last and how soon the World can fully recover both economically and societally. Thus, the long-term impacts of the pandemic on higher education (CS education in particular) are not discussed in this report, but SoCS will be prepared to adjust its action plans as needed.

A. Resource and Organization

We start with evaluating the human, physical, and financial resources that SoCS currently has, as well as its organization structure.

A.1. Faculty

As of May 2022, SoCS has 26 faculty members, including two teaching-focused tenure-track Assistant Professors, one regular tenure-track Assistant Professor, 14 tenured Associate Professors, and nine Professors. A list of all faculty members is provided in Table 2.

Table 2: List of faculty members including names, ranks, and research areas

Name	Rank	Category	Research Areas
Antonie, L.	Associate Prof.	Tenured	Data mining; Data integration
Bruce, N.	Associate Prof.	Tenured	Deep learning; Computer vision
Calvert, D.	Associate Prof.	Tenured	Classification; Neural network
Chaturvedi, R.	Assistant Prof.	Tenure-track; Teaching focused	Data mining; Predictive modeling
Dara, R.	Associate Prof.	Tenured	Privacy; Data governance
Dehghantanha, A.	Associate Prof.	Tenured	Cybersecurity; Cyber threat intelligence
Flatla, D.	Associate Prof.	Tenured	Human-computer interaction
Gillis, D.	Associate Prof.	Tenured	Risk assessment; Spatial temporal statistics
Gong, M.	Professor	Tenured	Computer graphics; Computer vision
Grewal, G.	Associate Prof.	Tenured	Data mining; FPGA
Hamilton-Wright, A.	Associate Prof.	Tenured	Decision support; Association mining
Khan, H.	Assistant Prof.	Tenure-track	Security and privacy; Mobile systems
Kremar, S.	Professor	Tenured	Deep learning; Recurrent networks
Lin, X.	Professor	Tenured	Information security; Digital forensics
Matsakis, P.	Professor	Tenured	Computer graphics; Pattern recognition
McCuaig, J.	Associate Prof.	Tenured	Interactive cognitive computing
Nikenko, D.	Assistant Prof.	Tenure-track; Teaching focused	Image processing; Human-computer interaction
Obimbo, C.	Professor	Tenured	Intrusion detection; Cryptography
Sawada, J.	Professor	Tenured	Combinatorial algorithms; Graph theory
Scott, S.	Professor	Tenured	Human-computer interaction; Interaction design
Song, F.	Associate Prof.	Tenured	Machine learning; Natural language processing
Stacey, D.	Associate Prof.	Tenured	Ontologies; Knowledge engineering

Wang, F.	Professor	Tenured	Artificial intelligence; Reinforcement learning
Wineberg, M.	Associate Prof.	Tenured	Computational evolutionary algorithms
Wirth, M.	Associate Prof.	Tenured	Pedagogy; Usability
Xiang, Y.	Professor	Tenured	Knowledge representation; Multiagent graphical models

The percentage of female faculty members has been historically low at 16%; see Figure 1. Recent hires helped to improve the gender balance, with the percentage fluctuating around 21-23% in the past three years. Figure 1 also plots the current age distribution of SoCS faculty members, which shows that the 46-55 age group has the highest number of 10 faculty members.

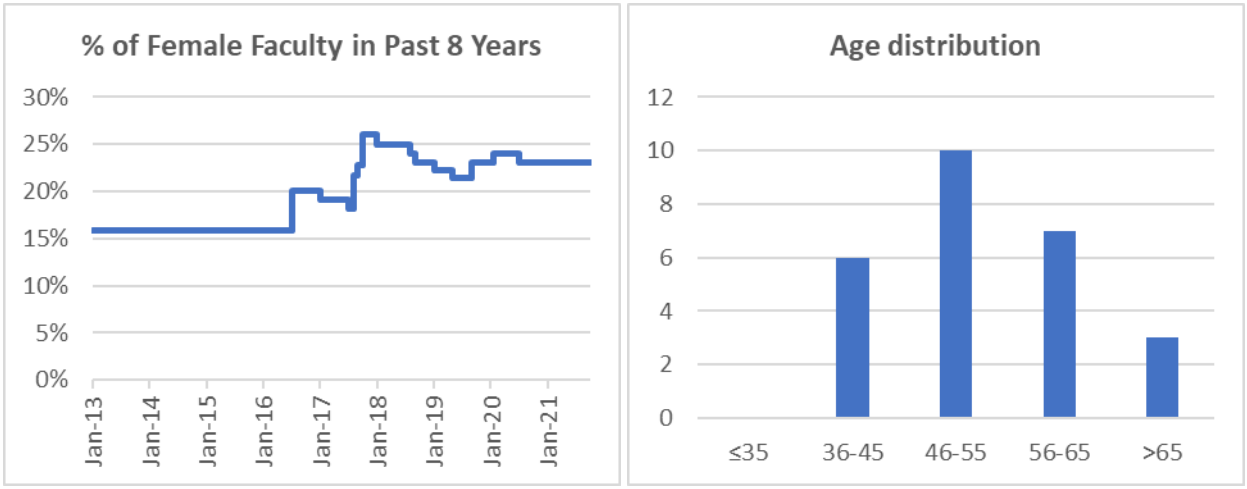

Figure 1: SoCS faculty demographics

Figure 2 further plots the faculty composition in the past eight years. It reveals that the composition didn't see any change (i.e. new hires or promotions) during the 3.5 years between January 2013 and July 2016. Compounded with the rapid increase in undergraduate student population (more on this in Section B.1), SoCS faculty members at the time felt overloaded and stressed. This trend was broken in the 2016/17 academic year, when two new faculty members joined and two existing faculty members were successfully promoted to Associate Professor and Professor, respectively. In the following year, SoCS welcomed two new regular faculty positions and two teaching-focused CL positions. In the 2018/19 academic year, two more faculty positions were added to support the new Master of Cybersecurity and Threat Intelligence (MCTI) program and a new position for the School Director was also created. A new position was later created for supporting the Centre for Advancing Responsible and Ethical Artificial Intelligence (CARE-AI) and was filled in Summer 2020. Finally, in Summer 2021, two tenure-track teaching-focused positions were filled to replace the two previous CL positions.

During the 3-year period between 2017 and 2020, four faculty members also retired. One of these positions were lost due to budget cuts, one position was used for converting an existing CL appointment into a tenure-track position, one position was filled by a new faculty member, and the last one is currently being filled.

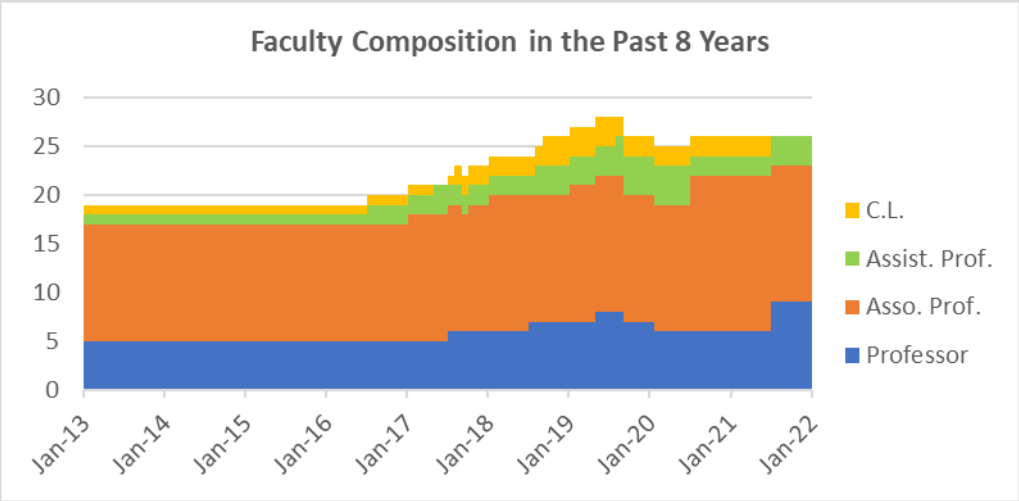

Figure 2: Faculty composition over the past eight years

While SoCS enjoys the net gain of eight new faculty positions (a 44% increase) when compared to year 2013, there is still a case to be made that the current faculty complement level is still insufficient. This is because: 1) the number of undergraduate students more than doubled during the same time period, and 2) three of the new faculty members are heavily involved in the new MCTI program and, hence, have very limited teaching capacity to support SoCS undergraduate programs. It is therefore important to reach an agreement with university administrators on the proper faculty complement level (Action Plan E.1.1).

A.2. Staff

SoCS hosts 10 staff members as of April 2022, including an Administrative Officer, two Undergraduate Program Counsellors, two IT Analysts, an Industry Liaison Officer, an Administrative and Academic Support, an Instructional Support Coordinator, and two Program Assistants, one each for the undergraduate and graduate programs.

To support the rapidly growing undergraduate programs, SoCS has been hiring Teaching Assistants (TAs) for many instructional related tasks, including grading assignments/exams, tutoring students in labs, and administrating academic integrity. Using TAs for these tasks has the benefits of low budget requirements, job opportunities for our students, and ability to quickly adapt to enrolment changes. However, it also brings high administrative overhead for planning, advertising, interviewing, and filling TA positions. The Academic Staff Hiring Committee responsible for these tasks was considered the most demanding SoCS committee. Other challenges include training TAs to better prepare them for the job, managing multiple TAs in a single course, maintaining consistency among multiple sections of the same courses, evaluating TA performances, and avoiding conflict of interests (especially for handling academic misconduct cases).

Besides the issue of TA management, the increase in the number of undergraduate students also adds heavy workload to our Program Counsellor (G. Klotz). With 850+ full-time-equivalent (FTE)

undergraduate students in 2020/21 academic year, the ratio of students-to-counsellor at SoCS is much higher than the average in CEPS.

Both issues were partially addressed in the 2019/20 academic year through the creation of two temporary staff positions, an Instructional Support Coordinator and a second Undergraduate Program Counsellor. The Instructional Support Coordinator (J. Lange) contributes greatly to the TA management process, whereas the second Undergraduate Program Counsellor (first filled by A. Nejedly and then by S. Brennan) helps G. Klotz to support the increasing undergrad student body and also takes charge of academic integrity responsibility. The Instructional Support Coordinator position has been converted into permanent position in Fall 2021, but the second Undergraduate Program Counsellor position is still temporary. Hence, securing this staff capacity for long term is important (Action Plan E.1.2).

While SoCS gained two new staff positions in the past three years, we also loss a full-time position for Recruitment and Outreach Officer in 2020. The new position, filled by L. Zalewski, reports to the CEPS Dean's Office and handles recruitment for both SoCS and three other departments. The impact of such change on SoCS student recruitment is not yet clear.

A.3. Organization Structure

Figure 3: SoCS Organization Chart

The organization structure of SoCS is shown in Figure 3. The administrative team currently consists of a Director (M. Gong), an Associate Director Graduate Studies (J. Sawada), an Associate Director Undergraduate Studies (Y. Xiang), an Assistant Director (R. Dara), and an MCTI Program Director (A. Dehghantanha). There are currently 16 standing committees; see Figure 4.

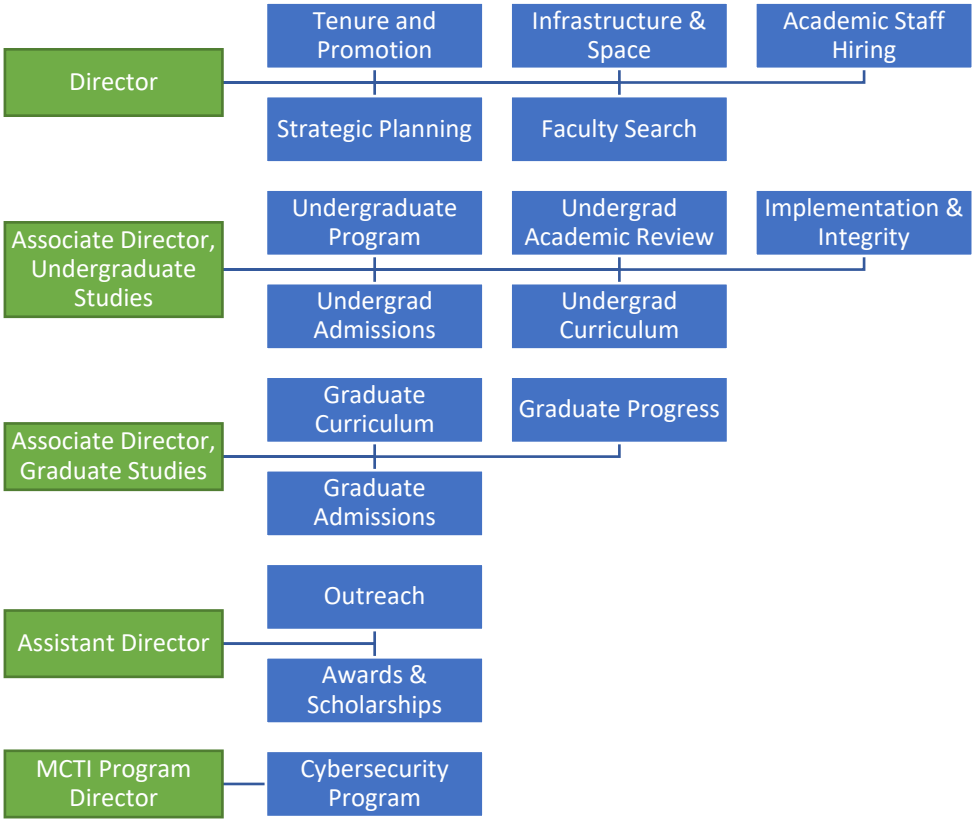

Figure 4: Organization of SoCS committees

A.4. Faculty Workload Assignment

As shown in Figure 5, most faculty members in SoCS follow the default Distribution of Effort (DOE), which is 40% teaching, 40% scholarship, and 20% service. The exceptions include the two teaching-focused positions, which have a DOE of 70%/15%/15%, and members taking on administrative roles both within and outside of SoCS.

Faculty members with 40% teaching load are expected to teach three courses per year, whereas 70% teaching load translates to five courses per year. Currently the workload differences between offering different courses are not considered. This approach, while is easy to implement, raises equitable issues for the following reasons:

- While the majority of SoCS undergraduate lecture courses have the same credit weighting of 0.5 credits, there are four courses (i.e., CIS*2170, CIS*2750, CIS*3750, and CIS*3760) have 0.75 credits for recognizing the heavier project or group work component in these courses. Added work is required for managing such a course, which is not recognized.
- In some courses, faculty are required to actively participate in weekly labs, whereas in others there is no lab component for the course.
- The efforts for developing and teaching a new course is not formally recognized.

- Preparatory work for offering an existing course for the first time is not recognized. In comparison, the Collective Agreement between CUPE 3913 and the University of Guelph clearly defines the supplemental payment for such preparatory work from sessional lecturers.
- Class size differences are not considered. Due to rapid enrolment increase, SoCS faculty members were forced to offer extra-large courses. The problem was alleviated by the Interim Director (P. Matsakis) at the time, who split most (but not all) of the courses with over 200 students into multiple sections.

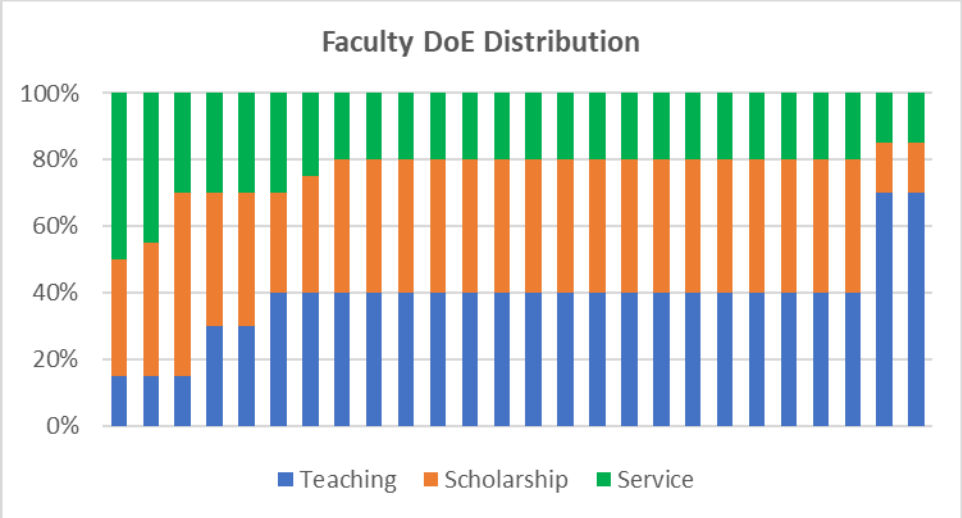

Figure 5: The Distribution of Effort (DOE) of different faculty members (one faculty member per column).

When M. Gong joined the School as a new Director, he mentioned the teaching equivalency document at Memorial University of Newfoundland, which defines the additional teaching credits for offering new courses, courses with labs/large sizes, etc. There is interest for SoCS to set up a similar practice to ensure equity among faculty members' teaching workload (Action Plan E.1.3).

A.5. Physical Infrastructure

SoCS mainly resides in the Reynolds Building, which was initially built in 1915. This historical building was extensively renovated between November 2017 and August 2018. Currently, the building has 38 offices, which host all SoCS faculty and staff members. The usage of other rooms in the Reynolds Building is listed in Table 3.

In terms of undergraduate teaching space, besides a lab in Reynolds 0002, SoCS also uses four other teaching labs: THRN (Thornbrough) 2418, THRN 2420, THRN 3401, and SSC (Summerlee Science Complex) 1303/1305. These labs are currently being used at close to capacity. In addition, the room SSC 1303 is reserved as a teaching lab for graduate students in the new MCTI program.

In terms of research space, our self-study has revealed the needs for dedicated research facilities. There are four rooms (Reynolds 2207/3307/2221/3321) set up as "graduate pods" in the newly

renovated Reynolds building, which accommodate 84 students in total. Two other double-office-sized rooms (Reynolds 2206/3306) are reserved as research labs: one as HCI Lab for conducting user studies and is shared by S. Scott, D. Flatla, and A. Hamilton-Wright; the other as Cyber Science Lab for supporting A. Dehghantanha's CRC Tier II appointment and hosting his computer servers. The graduate pods are currently at close to capacity with our current graduate students, and thus, there lacks room for additional graduate students and undergraduate students hired for either part-time or full-time research position (e.g. summer URA/USRA students).

Table 3: Space usage in Reynolds building

Room location	Room function	# of seats
Reynolds 0001	Shared TA office	23
Reynolds 0002	General teaching lab	48
Reynolds 0003	Shared TA office	20
Reynolds 0004	Postdoc and sessional office	20
Reynolds 1101	Classroom	48
Reynolds 1103	Boardroom	8
Reynolds 2224/3324	Boardroom (2)	12 each
Reynolds 2206/3306	Research lab (2)	6 each
Reynolds 2207/3307	Graduate student office (2)	15 each
Reynolds 2221/3321	Graduate student office (2)	24 each

Table 4: Lab space outside the Reynolds building

Room location	Room function	# of seats
Thornbrough 2418	Teaching lab with Bring Your Own Computing stations	48
Thornbrough 2420	Teaching lab with iMacs	40
Thornbrough 3401	Teaching lab with PCs	28
Summerlee Science Complex 1305	MCTI teaching lab	35

Due to the space constraint, existing undergraduate research students are forced to work at home, at library, or occasionally at one of the meeting rooms. This is not a sustainable arrangement and does not offer these students a high-quality research experience, which they could get when work closely with more senior graduate students and faculty members. They cannot receive mentorship on conducting research, technical problems, or general professional development in a timely manner. The lack of high-quality research experience in turn makes it hard to motivate these students to pursue further graduate studies.

Action is therefore needed to seek for additional high-quality space on campus for SoCS to support both teaching and research activities (Action Plan E.1.4).

A.6. Financial Resources

As shown in Figure 6, the total budget of SoCS has been doubled from $3.14 million in the 2013/14 fiscal year to $6.86 million in the 2020/21 fiscal year, largely due to the added faculty positions. On the other hand, the School has been carrying a debt, which started at $566K in the 2013/14 fiscal year and accounted for 18% of the annual budget for that year. Under the pressure of recovering from the debt, SoCS adopted cost-saving measures such as using less costly Undergraduate Teaching Assistants (UTAs) instead of Graduate Teaching Assistants (GTAs) in 1st and 2nd year courses. The debt has since greatly reduced to $193K in 2020/21 fiscal year.

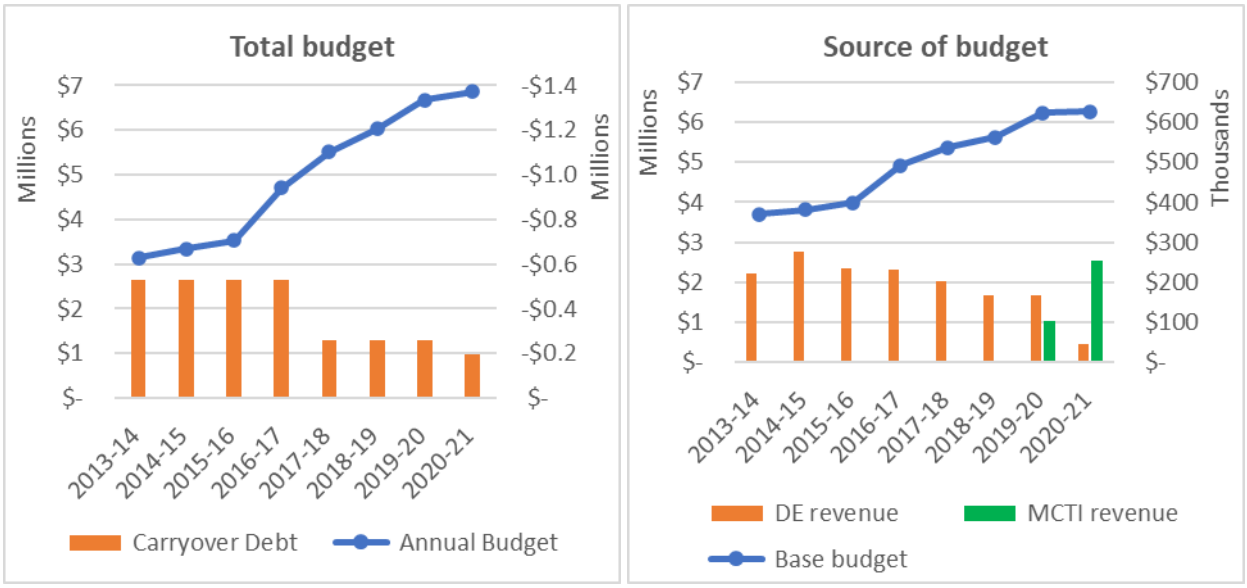

Figure 6: SoCS total budget and sources of revenue

Also shown in Figure 6, the main part of the SoCS budget is the base budget received from the University, the only other notable revenue sources for SoCS are through offering Distance Education (DE) courses and the new MCTI program. This DE revenue was $274K in the 2014/15 academic year but has since declined to $171K in the 2019/20 academic year, due to the reduction on the number of DE courses that SoCS offers. As the pandemic started in 2020 and most courses were moved to remote delivery, the University waived DE fee for registered students and hence SoCS lost almost all DE revenue in the 2020/21 academic year. On the other hand, the new MCTI program earned SoCS $102K and $254K in revenue for the 2019/20 and 2020/21 academic years, respectively, based on a tuition sharing agreement with the University for this professional graduate program.

B. UNDERGRADUATE EDUCATION

SoCS offers two main 4-year Bachelor of Computing (BComp) degree programs: one in Computer Science (BCH.CS) and the other in Software Engineering (BCH.SE). Both programs offer 5-year co-operative education degree program options (BCH.CS:C and BCH.SE:C) for eligible students (70% GPA or higher). SoCS also offers a 3-year BComp General (BCG) degree program.

SoCS students are required to create an Area of Application (AoA) in consultation with SoCS Program Counsellors. The AoA is a set of 8 courses from another discipline, such as Psychology, Business Administration, and Biology. The goal is to broaden students' skills and knowledge by studying a secondary area of their interests.

B.1. Learning Outcomes

A detailed curriculum mapping report, including Program Learning Outcomes (PLOs), alignment to University Learning Outcomes (ULOs), curriculum mapping and assessment methods is available in Appendix A. Some of the Specialization Outcomes for the three degree programs are highlighted below:

Bachelor of Computing in Computer Science (BCH.CS)

- Develop, test, document, deploy and maintain security program code to meet given specifications.
- Design, implement, and evaluate computer--based solutions to meet the needs and constraints of the client.
- Apply knowledge of computing and mathematics to a discipline outside of computing.
- Apply knowledge from at least one specialized area of computer science (Human Factors, Security, Graphics, Networks, Databases) to the design/development of software.
- Understand the use and structure of the common mechanisms for formally describing software and algorithms. Execute standard measuring and analysis techniques in the evaluation of computing algorithms.
- Demonstrate technological fluency. Evaluate and test new technologies systematically.

Bachelor of Computing in Software Engineering (BCH.SE)

- Use a variety of proven techniques when analyzing software development problems.
- Evaluate possible approaches to solving a problem and explain the benefits and drawbacks to each approach.
- Describe the broad engineering considerations that are the background for developing complex, software-intensive systems.
- Translate software specifications into well--documented designs.
- Collect, analyze, and interpret metrics for software and software development teams.
- Plan and execute software engineering processes that effectively use available technology and tools.

- Produce and interpret a variety of diagrams to represent beginning, middle and final stages of software projects.

Bachelor of Computing General (BCG)

- Examine complex real-world problems. Devise efficient, well-documented computer-based solutions for those problems.
- Analyze a software development problem. Consider a range of possible approaches to its solution and identify the most promising approaches.
- Apply a knowledge of fundamental algorithms, programming techniques, and design to create software systems.
- Design, correctly implement, and document solutions to significant computational problems.
- Apply the core areas of software development. (data structures, programming languages, computer architecture).
- Apply mathematical foundations, algorithmic principles, design of computer-based systems.
- Evaluate current techniques, hardware, software, and tools required for the production of software systems.
- Understand the use and structure of the common mechanisms for formally describing software and hardware structures and graphical user interfaces.

B.2. High Overall Demand for SoCS Programs

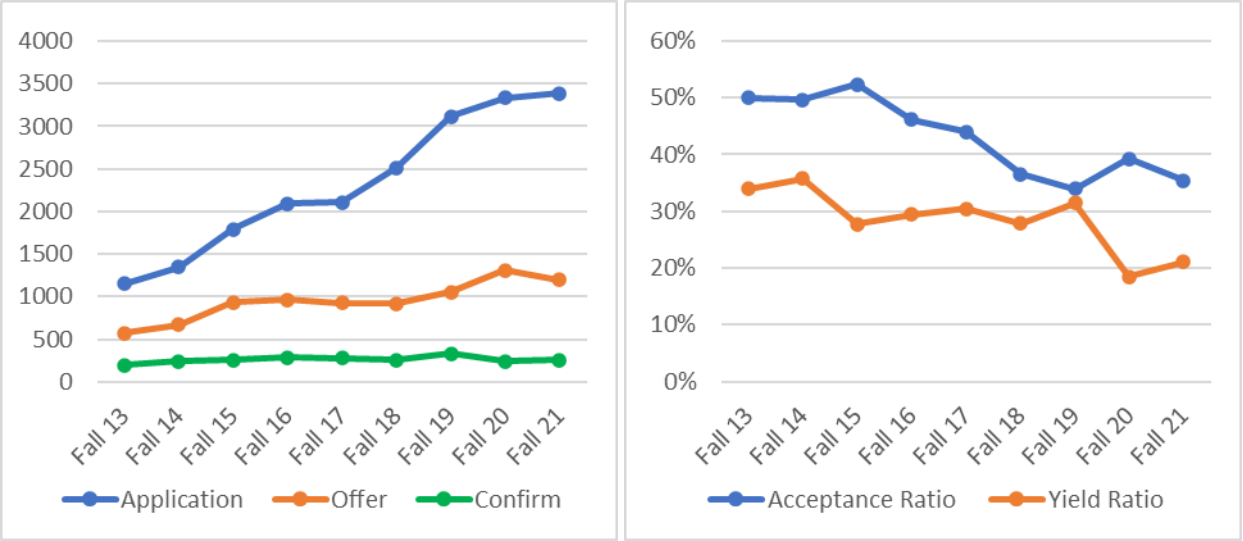

Figure 7: Growth in demand for SoCS programs. Left: number of students applied for, received offer from, and confirmed to attend SoCS; Right: the corresponding acceptance and yield (confirmed/offers) ratios.

Figure 7 plots first-year student recruitment data for the past four years, which show a strong and increasing demand for SoCS undergraduate programs. From 2013 to 2021 the number of applications, excluding transfers, has tripled from 1,148 to 3,387. The rapid increase in the number of applicants has led to a decrease in acceptance ratios. SoCS used to accept over 1/2 of its applicants in Fall 2016, but only took ~1/3 in Fall 2021. The yield ration has be relatively stable at 30%, but drops to 20% for the last two years, presumably caused by the pandemic.

To address the increased demand and rapid growth in the SoCS undergraduate program, with limited additional faculty hires, SoCS had set an enrolment target of 200 incoming students under the leadership of the Interim Director (P. Matsakis) at the time. However, this target was sometimes overshot. For example, there were 291 students confirmed to join SoCS in Fall 2019, exceeding the target by ~45%. As a result, SoCS was left scrambling to find larger classrooms and sessional lectures to accommodate the additional students within a short period. We learned from this experience and a more conservative admission strategy was used in the ensuing two rounds of undergraduate recruitment.

Given the global trend toward digitization across many different industry sectors, the industry need for software developers will continue to grow. The current interest and expected growth of artificial intelligence integration into a wide variety of application areas also calls for more CS graduates. Hence, we anticipate this high demand to continue for the short- to mid-term future. Long-term demand is less certain, however. University of Guelph is situated within hours of several top, internationally recognized Computer Science schools/departments, and competition for the top students is fierce. Providing a quality education and student experience will play a key factor for SoCS to maintain and grow its local, Canadian, and international reputation. Initiatives for fueling the long-term demand for SoCS programs includes providing more experiential learning opportunities (Action Plan E.2.1) and opportunities to learn in-depth knowledge in selected areas (Action Plan E.2.2).

B.3. Demands for Different SoCS Programs

We further compare the demands for the three SoCS degree programs and the two co-op options. Figure 8 shows that the two co-op options attracted the highest number of applicants throughout the past four years. The cutoff averages for the two co-op options are in general higher as well. This indicates that students value the experiential learning experience that SoCS offers through co-op.

Experiential learning is listed as one of the 10 metrics in the Ontario's new performance-based funding model for colleges and universities. Hence, further enhancing SoCS co-op programs has multiple benefits. On the other hand, the number of co-op placement positions is limited, especially during the summer terms. The CEPS Dean's office has led the efforts on introducing summer academic term for SoCS and the School of Engineering. SoCS fully supports this initiative. We are also exploring the possibility of making co-op training mandatory for our BCH.CS and BCH.SE programs (Action Plan E.2.1).

Figure 8 also shows that the 3-year BComp General degree is the least attractive program in SoCS. There were only 24 applicants in Fall 2013 and 82 in Fall 2021, accounts for only ~2% of the total applicants. While not being a popular option, this program can be restructured to serve as a

graceful exit route for students in other SoCS programs who run into insurmountable difficulty in completion, especially if co-op training is required for BCH.CS and BCH.SE programs.

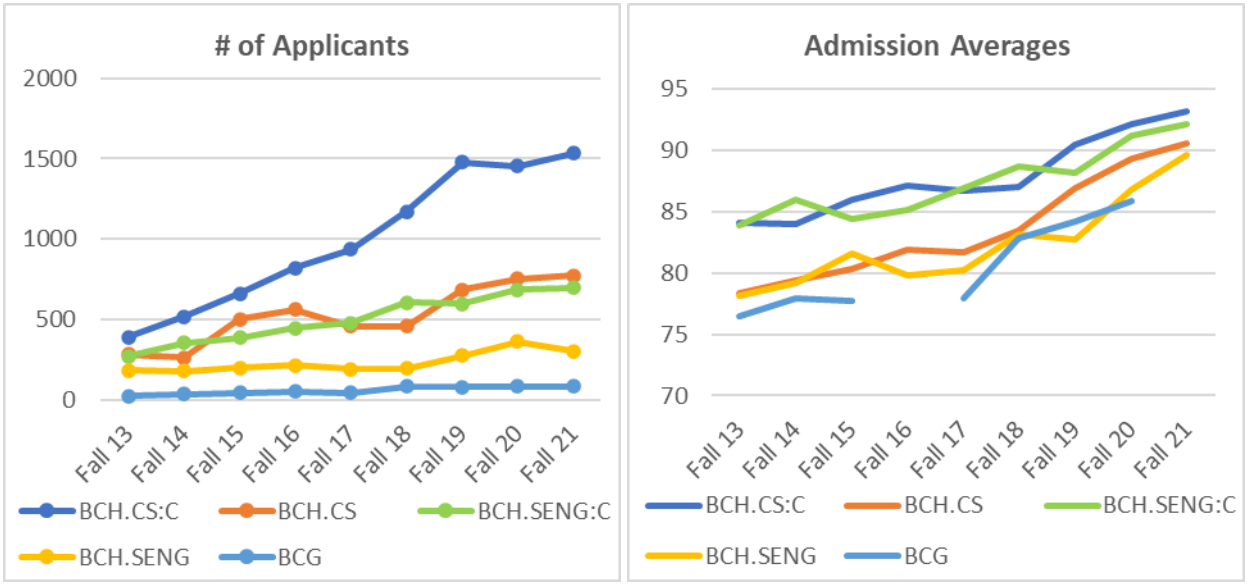

Figure 8: Comparison among different SoCS programs on the number of applications (left) and cutoff average (right).

B.4. Undergraduate Student Body

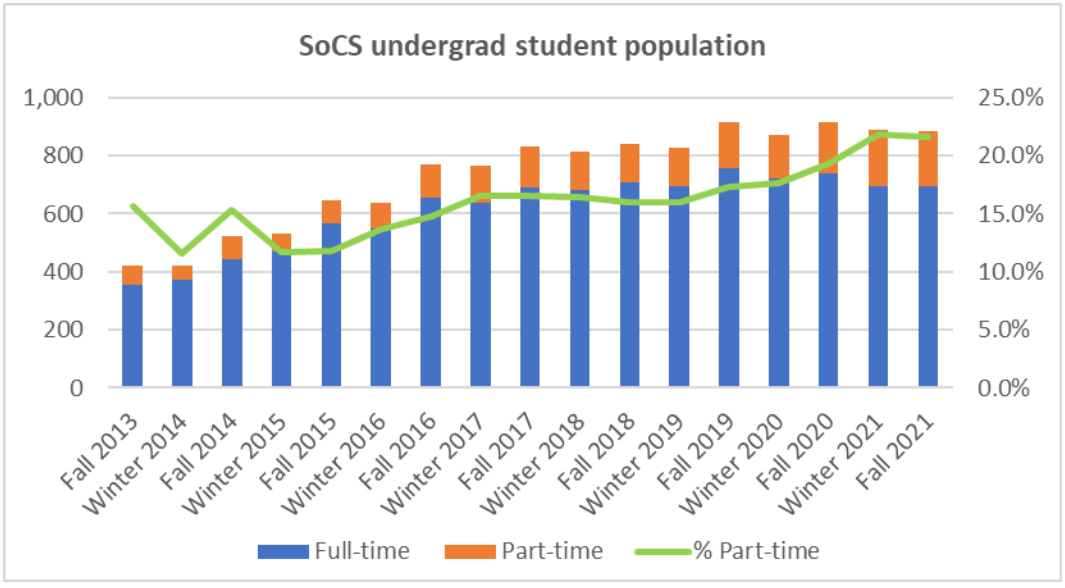

Figure 9: SoCS student headcount and part-time vs full-time student ratios

Official enrolment data retrieved from the University Data Portal show that the number of students in SoCS programs has increased substantially over the past eight years. As shown in Figure 9, there were 355 full-time and 66 part-time students in 2013/14 academic year, whereas the latest numbers have more than doubled to 734 full-time and 159 part-time. The percentage

of part-time students has been stable at ~15% between 2016 and 2019, but saw gradual increases since Fall 2020, presumably due to the COVID-19 pandemic.

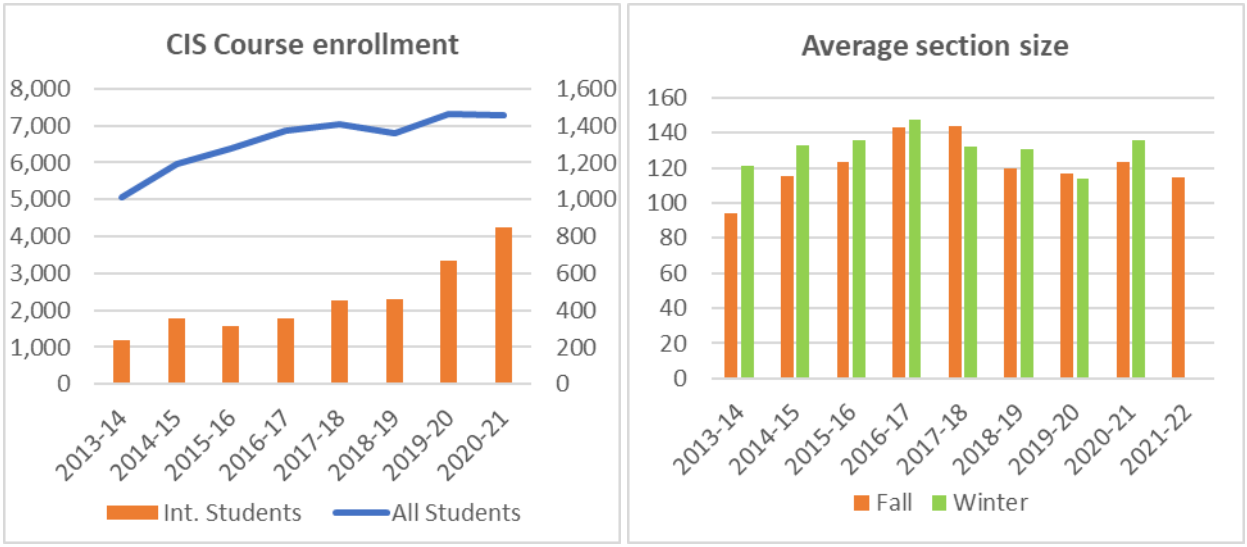

Figure 10: CIS course enrolment and average section sizes

In addition, SoCS also conducts significant service teaching both within CEPS and for the broader university community, with ~2,000 students enrolled in our introduction to computer applications, computing and introductory programming courses in recent years. As shown in Figure 10, the total course enrolment increased from ~5,000 in 2013/14 to >7,000 in 2020/21. Among them, the number of course registration from international students has more than tripled from 239 to 847. The average class size has been quite stable at around 130 students per section in Fall and Winter terms.

B.5. Undergraduate Student-to-Faculty Ratio

On the other hand, as mentioned in Section A.1, the number of SoCS faculty members didn't catch up until 2017/18 academic year. As a result, the full-time equivalent (FTE) undergraduate student-to-faculty ratio dramatically increased from 16:1 in January 2013 to peak of ~38:1 in both September 2016 and September 2017; see Figure 11. The new positions created helped to reduce this ratio to ~30:1 in Summer 2019, but the high incoming student enrolment in Fall 2019 pushed it up to >35:1 again. If we consider service courses provided by SoCS, the ratio is even higher.

In addition, since some of the new hires were dedicated for supporting the new course-based MCTI program and hence cannot contribute to undergraduate teaching, the overall undergraduate student-to-faculty ratio does not show an accurate picture. If we remove the faculty members needed for offering the seven courses for the MCTI program, the ratio only saw a modest drop to ~35:1 in Summer 2019 and now is sitting at ~37:1, even after the filling of two teaching-focused faculty positions; see Figure 11.

Feedback collected during our self-study consultation activities found that many faculty and staff feel unable to provide a high-quality teaching experience or enough support for undergraduate students in their classes, as the size of their classes have grown. A specific concern was the impact

on the BCH.SE program, which was intentionally designed as a "boutique" program that offers students intensive team-based, project focused learning. This type of course design demands significantly more hands-on management from faculty than more theory-based courses. Another concern, valid for both the BCH.CS and BCH.SE programs, is the impact on the student experience in upper year technical electives that teach in-depth, advanced technical skills and knowledge. Providing meaningful, quality experiences in large classroom contexts for these demanding courses is extremely difficult and time-intensive.

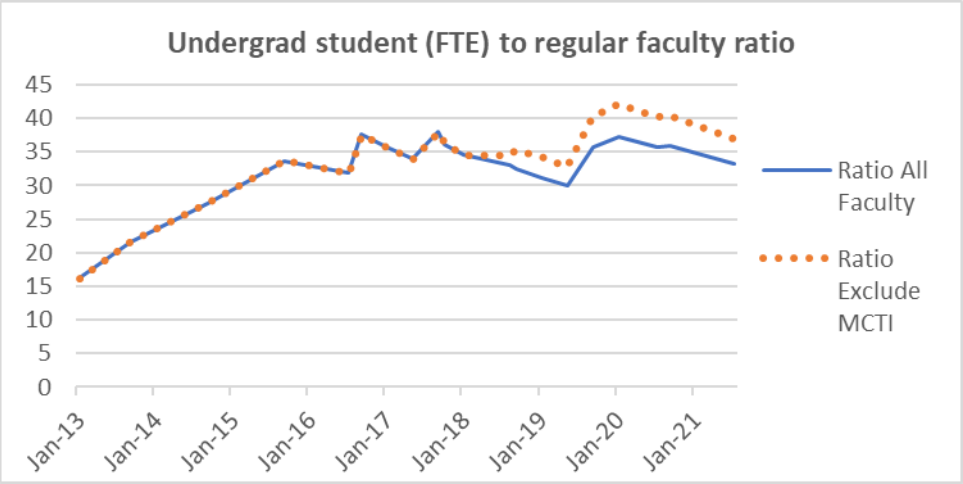

Figure 11 Undergraduate student (FTE) to faculty ratio

High undergraduate student-to-faculty ratio also causes issues beyond undergraduate education, because it demands faculty's immediate attention from multiple aspects, including more out-of-class student consultations, more time mentoring and managing larger numbers of TAs, and developing new course content delivery and assessment strategies to accommodate large (including team-based and project-focused) classes. These additional efforts have substantial impact on the amount of time and energy faculty members have for maintaining active research programs that support thesis-based graduate students; more on this in Section C.3.

To address this issue, it is imperative that SoCS work together with the College and University to resolve the currently inadequate staffing levels (faculty and staff) to appropriately support our high enrolment levels (Action Plans E.1.1 and E.1.2). As discussed above, providing students with a high-quality learning experience is critical for maintaining the reputation and long-term demands of our programs.

B.6. Increases in International and Female Student Ratios

Besides the increases in the total number of students, SoCS undergraduate programs are also becoming increasingly diversified. As shown in Figure 12, there were a total of 14 international students in SoCS programs in Fall 2013, which accounts for 3.3% of student population at the time. Today, this number has increased by nine times to 127, which accounts for 15% student population. In addition, despite the challenges brought by the COVID-19 pandemic, 40+ international students joined SoCS in each of the past two Falls, which accounts for over 20% of

the incoming cohorts. This trend aligns well with both the College's and University's strategic mandate towards internationalization.

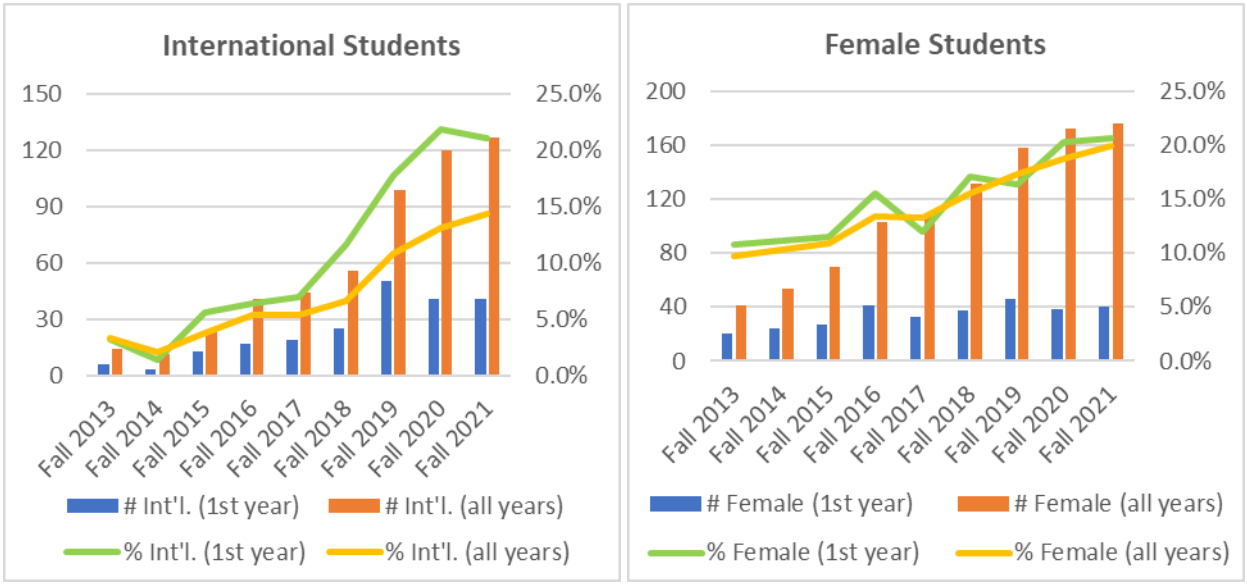

Figure 12: Composition of SoCS students in terms of international (left) and female (right) students

This increase in international students brings opportunity to help grow the global reputation of SoCS degree programs and to generate additional tuition income for the University. It also introduces new challenges as we welcome these new students to SoCS, Guelph, and Canada. Sufficient resources and supports are needed to ensure a successful acclimation and integration into our programs. To address this issue, one of our initiatives will be to secure resources for actively recruiting and better supporting international students (Action Plan E.5.3).

Figure 12 also shows the number and percentage of female students over the past eight years. There were a total number of 41 female students across all our BComp degree programs in Fall 2013. Today, there are 176 female students in SoCS. The percentage of female students enrolled also increased slowly but steadily, from <10% in Fall 2013 to ~20% in Fall 2021.

The College has stated an overall target of reaching 20% female enrolment in all programs by 2022. SoCS has just met this goal but still has more work to do. One of our initiatives will be targeted recruitment and retention for female students (Action Plan E.5.4).

B.7. Retention and Graduation

There are cases that students switch between co-op and non-no-op options, but the overall retention ratio is quite high. Figure 13 shows the number of undergraduate degrees awarded in the past nine years. It shows that a total of 185 students graduated in 2021, which is 8.8 times of the graduation number in 2013.

The plot also shows that the graduation rates have increased in recent years. For students from the 2010 cohort, ~40% graduated in 5 years (on-time for co-op options) and 47% graduated in 6

years. These two rates have increased to 60% and 70%, respectively, for students in the 2014 cohort.

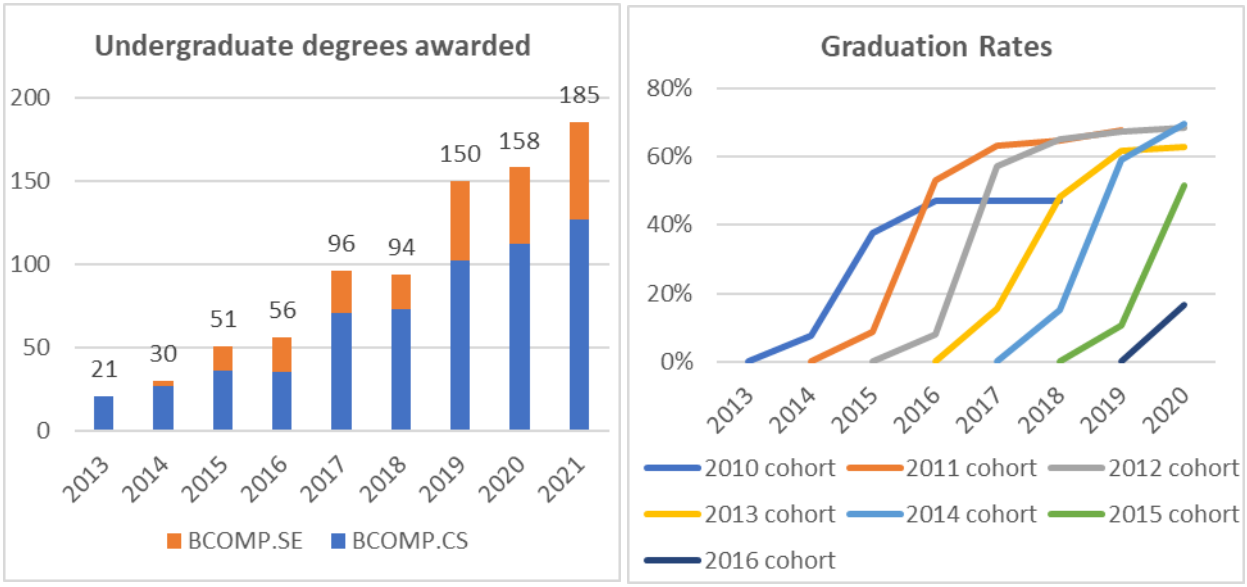

Figure 13: Number of undergraduate degrees awarded and the graduation rates for different cohorts.

B.8. Student Survey

Both alumni and current undergraduate students were surveyed for this self-study. The alumni survey was conducted in August 2021. Invitations were sent to 574 alumni who graduated between 2017 and 2021. 115 responses were received (65 from BCH.CS, 33 from BCH.SE, and 17 from BCG); see Appendix B. The undergraduate student survey was conducted in January 2022. 380 senior undergraduate students were invited. 69 responses were received (44 from BCH.CS, 23 from BCH.SE, and 2 from BCG); see Appendix C.

A great majority of survey participants found that the PLOs are met. They are satisfied with their overall experience in BComp degree programs and with overall quality of teaching in CIS courses. In response to questions on the main strength of the BCH.CS programs, representative alumni feedback include:

- "Good variety of courses to pick and choose." "The breadth of knowledge learned."
- "Learning low-level languages early on in my academic career…" "I appreciate that C is the main language taught, as it provides a very solid foundation for learning other languages."
- "The program overall put a strong emphasis on the core studies, and the theory…"
- "The community and environment within the program is a lot healthier, friendly, and supportive than other schools…" "Many of the profs were very welcoming and I had an amazing time learning under them."

In response to the question on the main weakness of the BCH.CS program, representative alumni feedback include:

- “It would have been nice if there could be more courses specific to fields we might be interested in.”
- “NOT Learning modern programming languages, sticking to strictly C for the majority of courses set me back in my career.” “Focus on C should stop after second year once students have a strong base, classes should then focus on tools used on jobsites. This includes Java, Python, C++, AWS, cloud computing services.”
- “Co-op and non co-op streams being so mixed, caused many to come in with lack of knowledge.”

In response to the question on recommended changes, alumni provided the following feedback:

- “Teach with languages currently being used in industry.” “Consult industry professionals on how day-to-day software development is done on an organic level without so much concern for how things are done by the book.”
- “Stop forcing students to take so many courses outside of Comp courses as an ‘area of app’.” “Create streams for AI/ML/DS, web development, mobile development, infrastructure, cybersecurity, and more.”
- “More courses, perhaps dropping the AoA requirement completely.” “Have the courses be offered in both fall and winter. And please have some summer courses!!!”

For the BCH.SE programs, the main strengths that participants identified are:

- “Learning to break down large problems into solvable chunks, and the foundations of programming.”
- “The main strength of the Software Engineering program was the Software Design stream of courses.”
- “The experience of working within a team to prepare us for working in the real world.” “The group work projects were great experiences.” “Heavy focus on teamwork and design process.”
- “Co-op placements are far and away the most beneficial experience that I gained during my degree program.” “Work term experience doing real-world software development both for learning and as a reference on a resume.”

The main weaknesses identified are:

- “A focus on foundations and theory and a weakness on modern software projects, stacks, and workflows.”
- “A lot of course content overlapped, mainly in the Software Design courses.” “We kind of went overboard with the 5 design courses, 3750, and 3760.”
- “Area of application focused most of the elective credits onto a single discipline and could be difficult to coordinate alongside co-op work terms which made scheduling courses tricky sometimes.”

Recommended changes to the program include:

- "Add streams to the program that provide more in depth teachings to different sectors of the computing word, i.e. security, AI, UI, etc. streams."
- "Each of these Software Engineering core courses (at least after the first) should have a tangible project or portfolio piece developed within them."
- "Make a modern corporate development course. Drop the students in 3rd year into a huge project that's partially complete and TEACH them how to contribute to it's development, and how to learn to read complex code they did not write."
- "Have professors interview alumni currently in the software engineering industry to ask about modern technologies, methodologies, and cultural practices in the workplace."

Despite the concerns raised, we would like to emphasize that the overall survey feedback is highly positive. In addition, some weaknesses identified (e.g., the focus on C programming language) are considered as strength by many others. While SoCS cannot tailor our curriculum based on individual comments, we like to carefully consider what changes can be made and what additional resources are needed. These include introducing summer academic term (Action Plan E.2.1), offering Streams or Areas of Emphasis (Action Plan E.2.2), better exposing students to modern programming languages (Action Plan E.2.3), and better differentiation between different software design courses (Action Plan E.2.4).

B.9. Co-op Employer Survey

The Co-op option in computing is very popular with demand outpacing the number of available positions. The majors in Computer Science and in Software Engineering both have the Co-op option. Students are required to take the COOP*1100 course in preparation for their first work term. This course focusses on the professional skills and expectations that will be necessary to succeed in the competitive process that will lead to employment.

The Co-op program requires five years and students normally complete five work terms during this time. Each work term is four months in length. This program is supported by two Co-op coordinators in the Experiential Learning Hub. Approximately half of the students in the Bachelor of Computing program pursue the Co-op option. A survey of students indicated that they were happy with the current requirement of five work terms.

In a recent survey of Co-op employers, 93% were extremely or somewhat satisfied with the Co-op students from the program and that they were likely to hire students from the Guelph Co-op program in the future. None of the employers indicated they were unsatisfied with the program. A total of 44 employers responded to the survey.

The employers in the Co-op program come from a variety of industries and such as NCR, RBC, Manulife, The Co-operators, The City of Kitchener, Tulip, and TAMVOES Health Inc.

In response to the question "Do you have any other suggestions to improve the Computer Science Co-op program that would help the school direct their program and plan for the future?" the employer's responses included:

- “University of Guelph, has one of the best Computer Science program. Most people know Guelph for veterinary or animal or bio tech sciences. U of Guelph, can market their great computer science program better as it is a genuinely great program.”
- “I am very happy with the program and the quality of the students that we hire.”
- “We've employed over 70 UG co-op students since 2017 and have hired at least 8 former UG co-op students fulltime once they graduated. We are extremely pleased with the co-op program at UG and generally feel that the calibre of students is as good if not better than UW. We find the UG students have more hands-on experience and more experience working in groups than those from UW (which tends to focus more on individual assignments and theoretical learning). Keep up the great work to build the soft and technical skills in your students that are actually needed in the market. At this time, I don't have any recommended changes but will reach out if I think of anything.”

The area that employers most commonly identified as one which could be improved was both written and oral communications skills. The Software Engineering major identifies communications as one of its primary objectives. The feedback we have received from the Co-op Coordinators is that this emphasis has been successful and these students are in general more easily employed. Due to limitations associated with class and lab size the Software Engineering major is limited to approximately 40% of the intake to the Bachelor of Computing program so we are unable to expand the number of students who receive this education.

C. GRADUATE EDUCATION

SoCS currently offers four graduate degree programs, a Master of Science degree in Computer Science (MSc.CS), a professional Master in Cybersecurity and Threat Intelligence (MCTI), a conventional Doctor of Philosophy in Computer Science (PhD.CS), and an interdisciplinary PhD in Computational Sciences (PhD.CSCI).

The MSc.CS is a 2-year program that requires completion of five graduate courses (1 core, four elective), a public seminar, and a thesis. The MCTI program is newly launched in Fall 2019 as SoCS's first course-based Master program. It is a one-year (3 semester) program that requires completion of six courses and a project with an industry partner or eight courses without project. The PhD.CSCI is a 3-year interdisciplinary program that requires one supervisor in SoCS and one supervisor in a relevant Application Discipline (AD) outside of SoCS. Students must complete a core course, a qualifying exam, two public seminars, and a dissertation. It is fairly new and began admitting students in 2016. Prior to that, SoCS offered a traditional PhD in CS, which was discontinued in 2014/15 but successfully reinstated in Fall 2021. Currently the PhD.CS is a 4-year program that requires completion of 3 courses and a dissertation.

SoCS also participates in two collaborative specializations. The Collaborative Specialization in Artificial Intelligence (CSAI) is available for thesis-based M.Sc. students, whereas the Collaborative Specialization in One Health (CSOH) is available for both thesis-based M.Sc. and Ph.D. students.

C.1. Learning Outcomes

Appendix D provides an analysis of the alignment to the University Learning Outcomes (ULOs) and program requirements for each of the graduate programs (MSc.CS, MCTI, PhD.CS and PhD.CSCI). Some of the learning outcomes for each of the four programs are highlighted below:

Doctor of Philosophy in Computer Science (PhD.CS)

- Be capable of conducting high-quality research in an ethical manner.
- Have a deep understanding of their research domain within computer science.
- Have the potential to make significant contributions to the Academy and in the private sector upon completion.
- Display excellent technical communication skills, both written and oral.
- Apply independent critical and creative thinking.
- Apply logic principles after significant inquiry and analysis.
- Solve problems with a high degree of innovation.
- Demonstrate the breadth knowledge of the discipline.

Doctor of Philosophy in Computational Sciences (PhD.CSCI)

- Be capable of tackling emerging problems in science and humanities through investigation and application of current computer technologies.

- Study computing within the context of another discipline commensurate with their interests and career goals.
- Communicate scientific and technological findings effectively to professionals working in other research areas.
- Apply independent critical and creative thinking.
- Apply logic principles after significant inquiry and analysis.

Master of Science degree in Computer Science (MSc.CS)

- Be capable of conducting quality research in an ethical manner.
- Have a deep understanding of their research domain within computer science
- Have the potential to make complete a higher degree and contribute to the private sector upon completion.
- Display strong technical communication skills, both written and oral.

Master in Cybersecurity and Threat Intelligence (MCTI)

- Possess a solid knowledge base and practiced lab-based skills to fill the growing need in the field of cybersecurity, cyber threat intelligence, and digital forensics.
- In Security Management: Plan, implement, and upgrade security measures and controls; Protect information systems against unauthorized access, modification, and/or destruction; Conduct internal and external security audits and forensics examinations; Recommend and install appropriate tools and countermeasures to monitor and track existing and emerging threats in different cyber environments
- In Analysis of Software and Data Analytics: Maintain data for analysis and monitor security access; Analyze security breaches to conduct root cause analysis; Anticipate security alerts, incidents, and disasters and reduce their likelihood; Conduct vulnerability testing, risk analyses, penetration testing, and security assessments; Manage and develop indications of compromise and indications of attack on network, intrusion detection, and prevention systems
- In Security Architecture: Develop security roadmaps and strategic plans to manage and govern enterprise cyber security; Design and architect security solutions in correspondence with existing and emerging threats to the enterprise; Recommend security technologies and compensating controls and intelligence tools, tactics, and procedures

C.2. Strong Demand for SoCS Graduate Programs

Like our undergraduate programs, the number of applicants for SoCS graduate programs has increased dramatically in the past five years as well; see Figure 14. The total number of applicants jumped from <100 in 2016 calendar year to 550+ in 2020. Correspondingly, the acceptance rates for the M.Sc. program dropped from 23% in 2016 to merely 3% in 2020. The new MCTI program also becomes very competitive. Its acceptance rate was 35% in the program's inauguration year, which quickly dropped to 12% the year after.

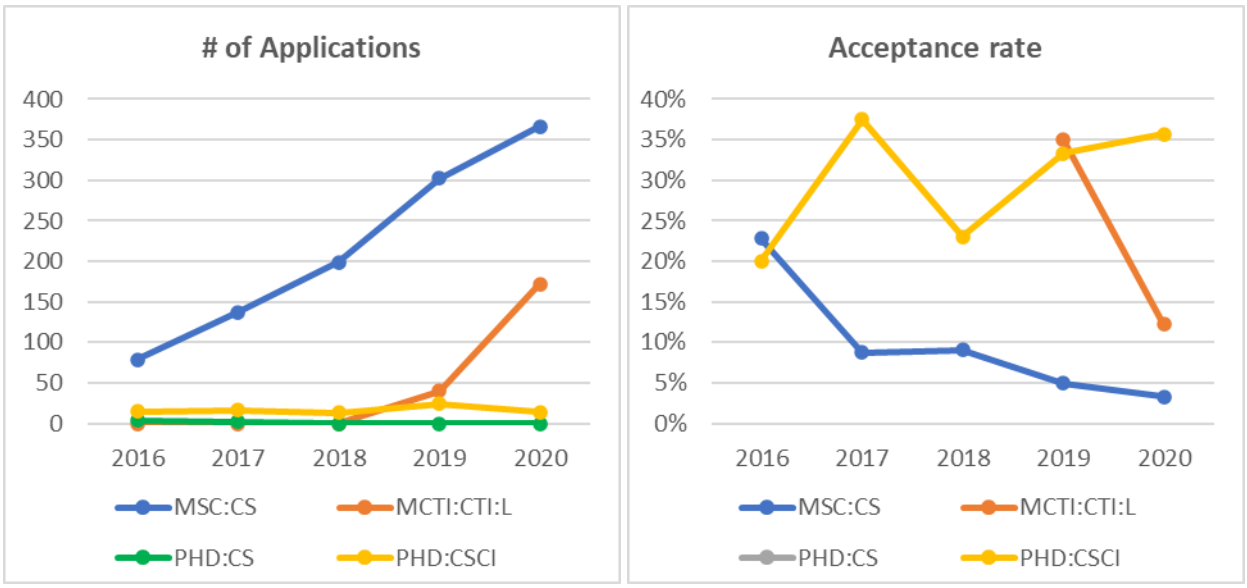

Figure 14: Number of applicants and acceptance rates for different SoCS graduate programs.

The high international student percentage presents both opportunities and challenges for SoCS to grow our graduate programs in the future. The current reality in Canada is that undergraduates from technical fields (computing, engineering, etc.) are in extremely high demand. These students can obtain well-paying jobs directly out of their bachelor's degrees. Thus, it is difficult, even for top computing and engineering schools in Canada, to recruit domestic students into graduate studies. Exceptions include certain areas such as Artificial Intelligence, Cybersecurity, and Bioengineering, where such topics are currently largely taught at the graduate level. Thus, we believe that our newly introduced MCTI program will help attract both domestic and international graduate students.

The large number of applicants introduces high workload for screening them. SoCS only has one Graduate Program Assistant (J. Hughes), who oversees the progress of ~90 existing graduate students on top of processing the applications. Hence, she does not have the capacity to provide detailed evaluation on the large number of applicants. Only those whom faculty members express interest to recruit are carefully reviewed and hence some high-quality applicants could be rejected without being known to faculty members. Discussion on how to better screen graduate applicants is therefore needed, especially for applicants of the course-based MCTI as they do not have supporting faculty members (Action Plan E.3.4).

C.3. Growth in Graduate Student Body

The graduate programs at SoCS have historically been small. As shown in Figure 15, there were 23 graduate students in 2014, 16 of which were PhD.CS students and 17 were MSc.CS students. The substantial growth of the undergraduate program at the time was a significant factor for this low graduate student-to-faculty ratio. Faculty members were overwhelmed by undergraduate teaching and had less time to conduct research, recruit high-quality students, write grants to obtain research funding, supervise graduate students, write papers to demonstrate productivity

for grant reviewers, and attend conferences to promote and raise the visibility of research outcomes.

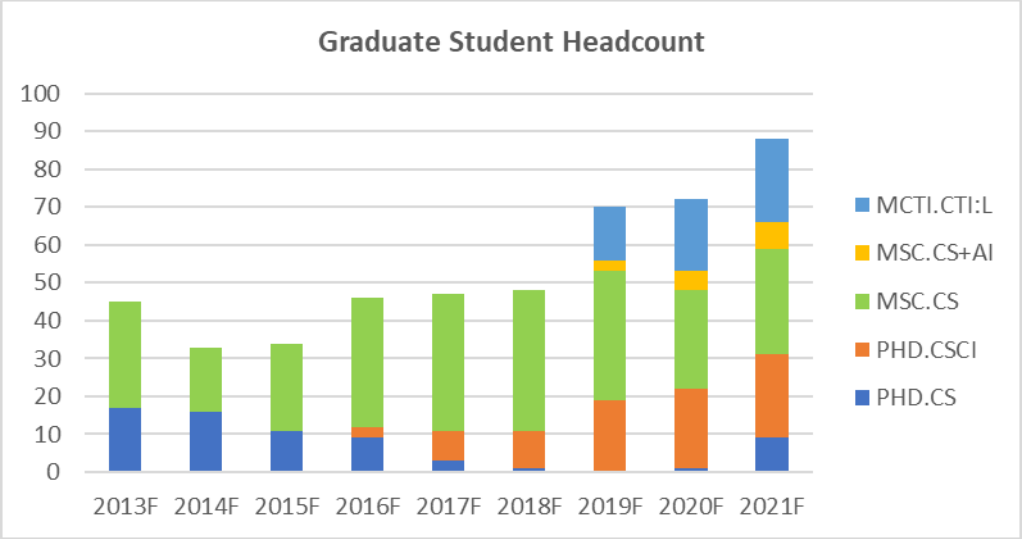

Figure 15: Number of graduate students in SoCS programs.

In responding to concerns raised to the PhD.CS program, the School chose to replace it with an interdisciplinary PhD.CSCI program in 2016. Since then, the PhD.CSCI program has seen a healthy growth to 22 full-time students this year. While it has attracted many high-quality students with diverse backgrounds, prospective PhD students interested in pursuing an academic position in CS departments may feel that it could be underappreciated by the hiring committees. The lack of freedom for independently supervising PhD students also drives some SoCS faculty members to supervise PhD students outside the University of Guelph. These two factors motivated SoCS to reinstate its PhD.CS program, which welcomed the first cohort of nine students in Fall 2021. The total number of PhD students was therefore boosted to 31. The PhD students per faculty member ratio reached 1.19, which is higher than the CEPS average ratio of 1.08.

SoCS is also the home of a thesis-based MSc.CS program and its collaborative specialization in AI variant (MSc.CS+AI). The total number students in these two programs has been around 35 in the past six years. With a total of 66 research-focused graduate students in Fall 2021, the graduate student-to-faculty member ratio is 2.54. This ratio is relatively low for a CS department in a research-intensive university.

Finally, the course-based MCTI was inaugurated in Fall 2019 with 14 students. It has gradually grown to 22 in Fall 2021 and can easily reach its designed capacity of 35 students, thanks to the large number of applicants (170+ for Fall 2021) we have.

Overall, we currently have a modest graduate program that has tremendous potential to grow and strengthen. However, this growth requires dedicated attention and commitment from the School, in balance with its much larger and demanding undergraduate program.

C.4. Limited Graduate Course Offerings

This self-study revealed that SoCS has been struggling to offer an adequate number of graduate courses on a regular basis. As shown in Figure 16, the number of regular graduate courses (excluding special topics and MCTI courses) that SoCS offered in each of the past eight year varied from 2 to 5. For example, during the 2015/16 academic year, only two regular courses from the graduate calendar were offered, one of which was on technical communication and research methodology (CIS*6890) and the other was an introductory course on image processing (CIS*6320).

To help students access relevant courses, faculty members frequently offer special topics courses (CIS*6650) and direct reading courses (CIS*6660). The latter ones are often restricted to one or two students and are not counted toward faculty members' teaching loads. Moreover, some of the courses listed in the graduate calendar are outdated and do not reflect the research focus of current faculty and the research training that these faculty members need their students to have. From a marketing perspective, this does not effectively communicate to our existing and prospective graduate students what courses they could take when they are in our program. To address this issue, the Graduate Curriculum Committee, led by the Associate Director Graduate Studies (J. Sawada), developed a major modification to our graduate program in the 2020/21 academic year. Six inactive courses were removed, whereas three new ones were introduced. This helps to reduce the need to offer courses as special topics, but additional efforts to review and modernize our graduate course offerings are still needed (Action Plan E.3.1).

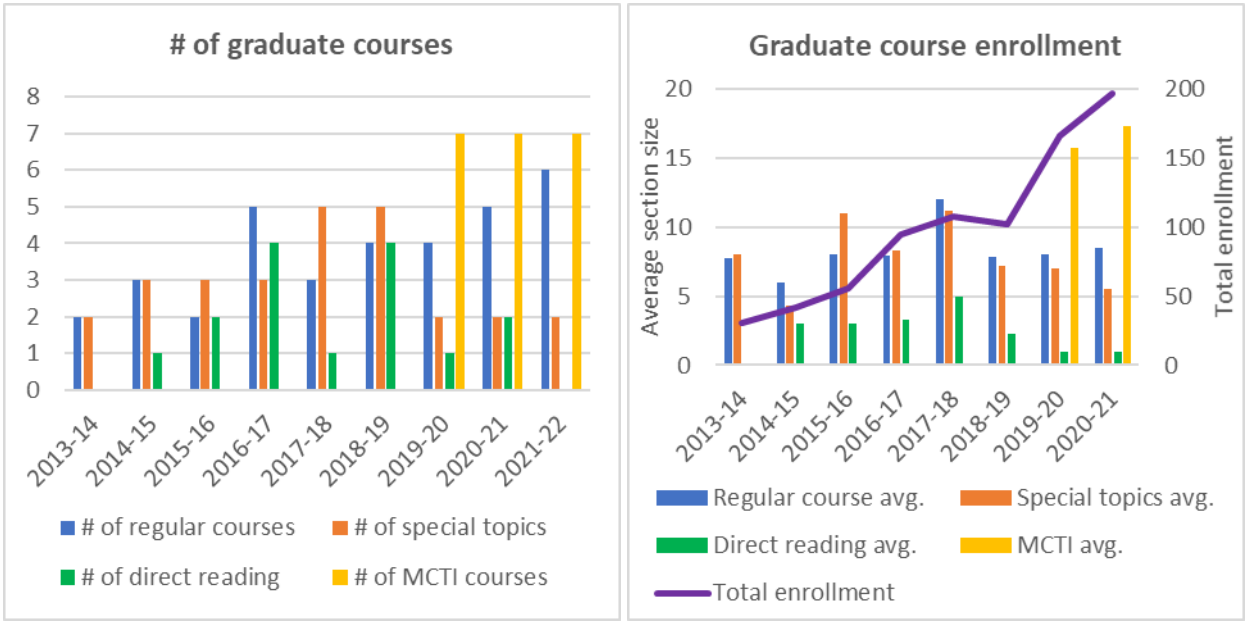

Figure 16: Number of graduate courses and course enrolment.

The lack of regularly offered graduate courses is also a resource issue, as large undergraduate courses need to be staffed before small graduate courses. Introducing a course-based MSc route could be a potential approach to address this problem (to be discussed in Section C.7).

C.5. Limited Funding Support for Graduate Students

The level of funding support plays an extremely strong role in attracting and retaining high-quality research-based graduate students. Figure 17 shows the current level of funding supports for both MSc and PhD students in SoCS. This funding can come in the form of scholarships, GTAs, Graduate Research Assistantships (GRAs), and paid internships, such as research-based industry partnerships through Mitacs Accelerate grants. A challenge for SoCS faculty is that very few scholarships are available to international students, which are the main source of our graduate program due to reasons mentioned above. The number of GTAs and GRAs that SoCS can offer is also limited due to the pressure for reducing deficit in SoCS annual budget (Section A.6) and the lack of research funding (more on this in Section D.2).

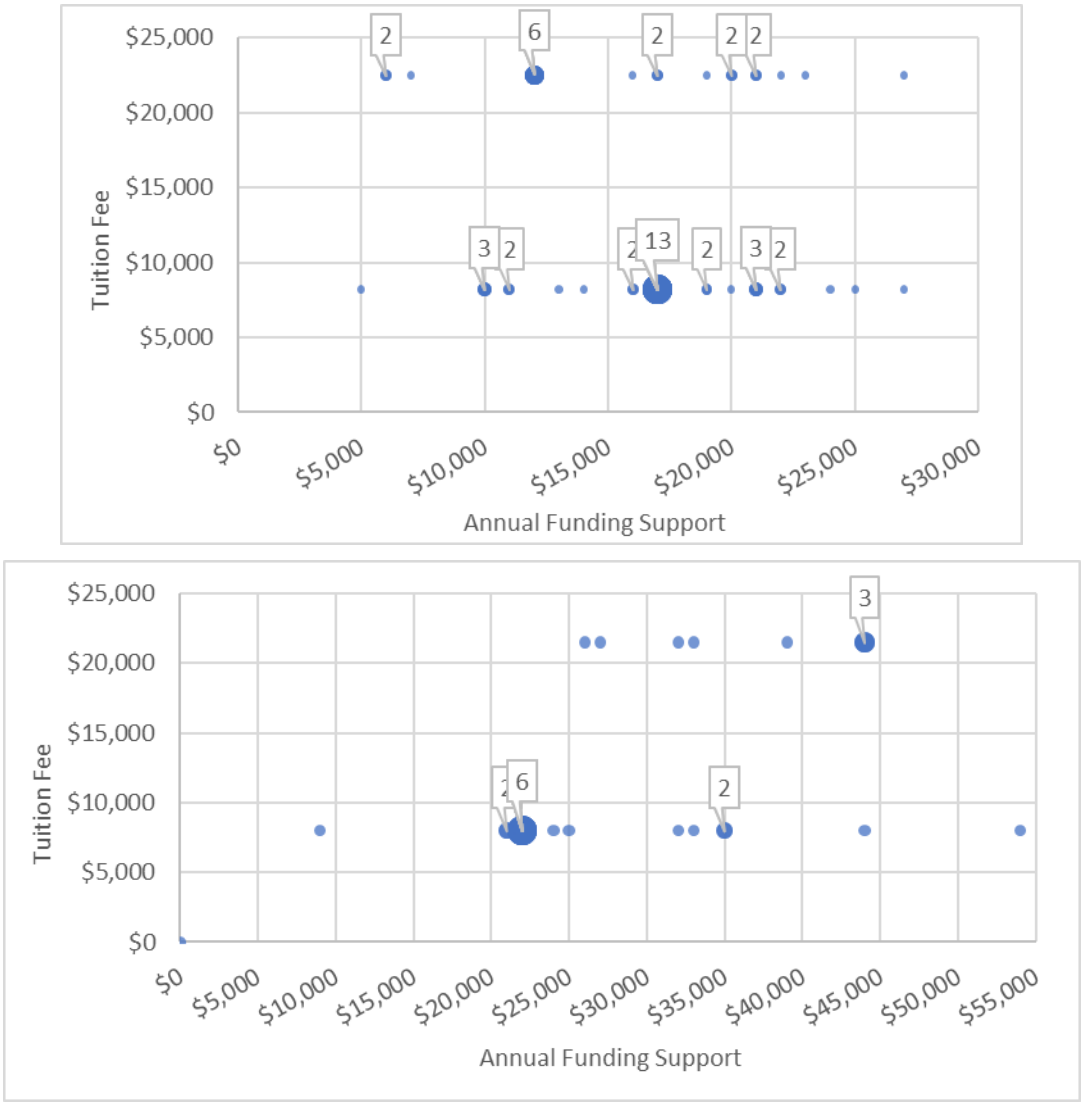

Figure 17: Funding support for MSc (top) and PhD (bottom) students started on or after Winter 2018. Each student is represented by a dot and multiple students with the same tuition/funding package are clustered into a bigger dot. All PhD students have funding support covering their tuitions, but some MSc students do not.

There are two recent changes in funding requirement for graduate students. First, the Office of Graduate and Postdoctoral Studies (OGPS) introduced the International Doctoral Tuition Scholarships (IDTS) in Fall 2018, which is valued at $12,500/year. IDTS is available for international students with an admission average of A⁻ or higher or once a candidate admitted with a lower admission average successfully completes their Qualifying Examination. It bridges the difference between international and domestic student tuitions (currently at $6,560 and $2,330 per term respectively) and hence makes supporting international PhD students easier. Secondly, a new graduate funding policy came into effect in Winter 2020 within CEPS and from OGPS. This policy mandates the minimum funding levels to be $16,500 for research-based MSc students and $21,500 for PhD students. According to the data presented by the Associate Dean of Research and Graduate Studies (L. Brown) in Fall 2019, only three of the 16 MSc students in SoCS MSc program at the time were being funded at $16,500 or higher. Hence, this policy has strong impacts on SoCS faculty members' capability for recruiting MSc students.

To maintain and increase the number of graduate students under the new CEPS funding policy, securing adequate funding supports is the key. To facilitate faculty members, SoCS adjusted its GTA funding policy in Fall 2020 and started to offer two guaranteed GTAs for all incoming students. Faculty members are also encouraged to seek industry partnerships such as Mitacs Accelerate grants, which generally have high success rates. Once SoCS operates under better financial conditions (debt cleared and additional revenue generated), we will consider providing more GTA opportunities and/or offering school scholarships to top students (Action Plan E.3.2).

C.6. Retention and Graduation

Figure 18 plots the number of students graduated from our graduate programs in the past eight years. It shows that SoCS has gradually graduated its PhD.CS students who were admitted before the program was transformed into the PhD.CSCI. It also graduated the first two PhD.CSCI students in 2020. On average, the number of MSc.CS students graduated in the past four years is 50% more than the average of previous years.

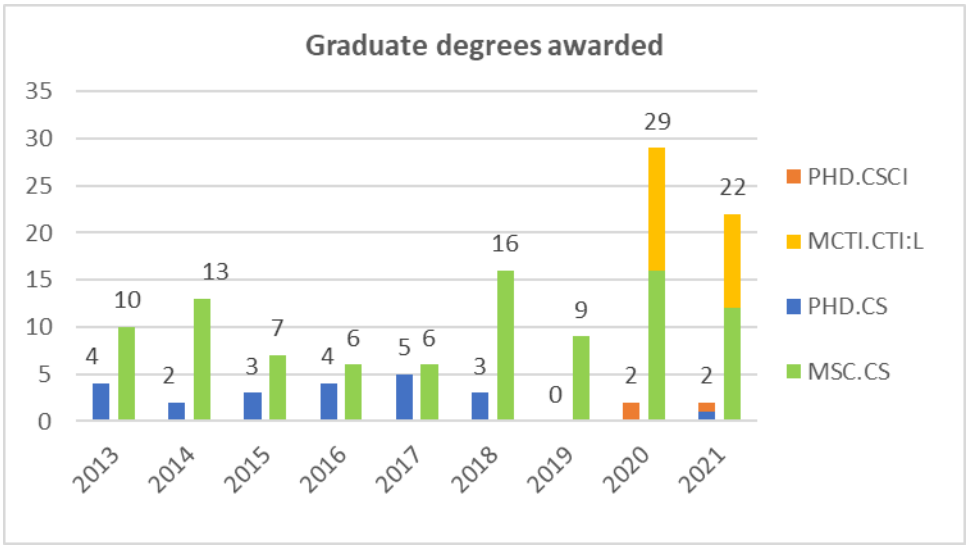

Figure 18: Number of graduate degrees awarded in the past eight years.

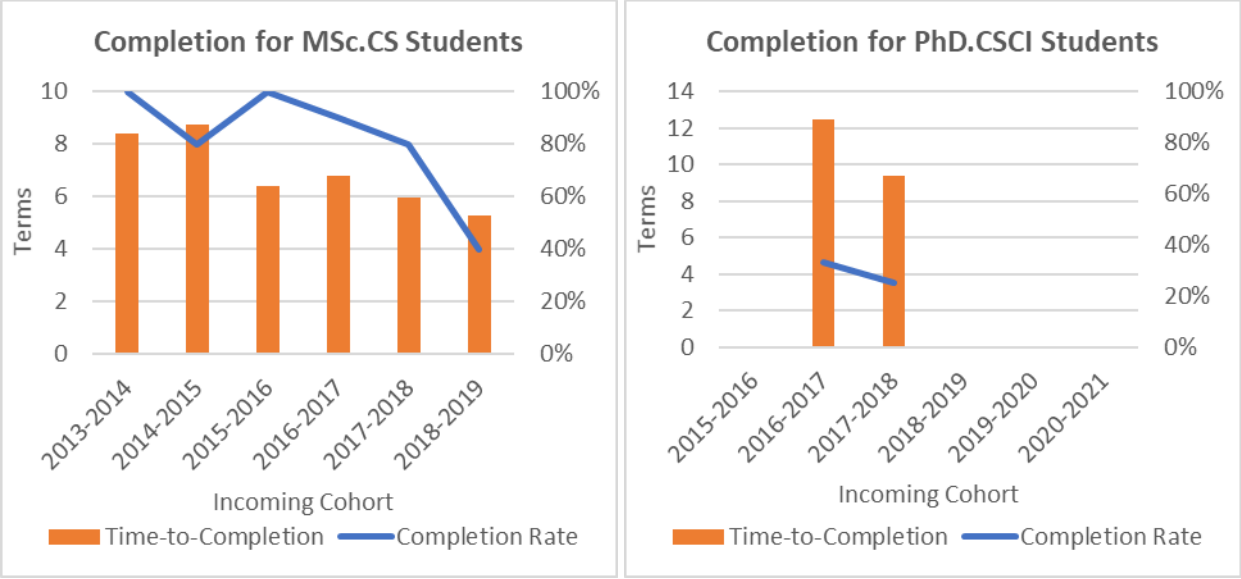

Figure 19: Completion rates and time-to-completion for graduate students.

Figure 19 further shows the graduation rates and time-to-completion for each cohort of MSc.CS and PhD.CSCI students. For MSc.CS students admitted on or before 2017/18 academic year, ~90% of students were graduated, with the average time-to-completion being 7 terms. About 40% of students admitted in 2018/19 academic year have graduated at the time the data was collected (September 2021). Since the designed time-to-completion for MSc.CS program is 6 terms, we consider the result satisfactory.

As mentioned above, two PhD.CSCI students graduated in 2020. Figure 19 shows that they were admitted in 2016/17 and 2017/18 academic years, respectively, and represent ~30% of students admitted in the respective years. They took on average 11 terms to complete the program, while other students in the same cohort haven't graduated yet. This suggests that the designed program duration for the PhD.CSCI program (9 terms) may be too aggressive and may need adjustment.

C.7. Opportunity for Course-based MSc Option

Even though we cannot accept more thesis-based MSc and PhD students due to limited funding support, the large number of MSc applicants still offer a good opportunity for growing our graduate program through introducing a general course-based MSc route (Action Plan E.3.3). As discussed above, SoCS only accepts 3% of the MSc applicants in year 2020. Recent research on the internationalization of Canadian graduate studies programs also indicates that a key goal of many foreign students to is supplement their existing educational background and, sometimes

their industrial experience, with Canadian academic credentials[1]. Hence, such a course-based MSc option is expected to be popular among international students.

The initial design for the course-based MSc is a 2-year program with 4- or 8-month internship term. This differentiates it from the existing 1-year MCTI program and offers international students with opportunities to access the Canadian job market. Students in course-based MSc can transfer to the thesis route if they can find supporting supervisors. The program is expected to be funded by a tuition revenue share model like the MCTI program. The anticipated benefits to SoCS include:

- Bring tuition revenue to the School so that we can offer more graduate courses, as well as courses in summer terms.
- Provide faculty members with opportunities to teach graduate courses in their area of interests, which helps them to reduce workload on teaching.
- Faculty members who supervise projects for course-based MSc students receive both credits for HQP training and funding support to their general-purpose accounts.
- Have a large pool of graduate students available on campus, from which faculty members can identify strong candidates for recruiting into the thesis-based MSc program, reducing the needs for evaluating international candidates on papers only.
- By allowing thesis-based MSc students to transfer to course-based route as well, we provide a graceful exit route for thesis-based MSc students who have difficulty with their research program.

On the other hand, several questions need to be carefully addressed before we move forward. These include how many graduate courses SoCS can support with its current faculty complement level, how to ensure the quality of the undergraduate courses not being affected, and how to avoid the new course-based MSc program undermining the MCTI program.

C.8. Interdisciplinary Graduate Programs

With many different disciplines embracing digitization and artificial intelligence, CS research becomes increasing interdisciplinary. SoCS has participated in the Collaborative Specialization in Artificial Intelligence (CSAI) since its inception. The CSAI is a joint specialization with the School of Engineering and Department of Mathematics and Statistics. To complete the CSAI program, students must be enrolled in a thesis-based MSc program in CS, Engineering, Mathematics and Statistics, or Bioinformatics, and complete additional, program-specific courses (for a total of 5.5 courses instead of five courses). More recently, SoCS joined the new Collaborative Specialization in One Health, which is being led by the Department of Population Medicine, Ontario Veterinary College. SoCS is also supporting the new professional Master of Data Science (MDS) program led by the Department of Mathematics and Statistics, which was inaugurated in Fall 2021. These

[1] Kyra Garson, 2018, "Internationalization, Inclusion, and Intercultural Understanding? What are Students Learning?" Keynote talk at the 31st Annual Teaching and Learning Conference, University of Guelph, May 1-2, 2018.

interdisciplinary graduate programs help boost collaborations between SoCS and other disciplines on campus.

We are also active collaborating with other academic units for developing new graduate programs. For example, discussions with the Gordon S. Lang School of Business and Economics are underway for a professional Master of Cybersecurity Leadership. This initiative is being led by our MCTI Program Director (A. Dehghantanha).

C.9. Student Survey

Current graduate students were surveyed in January 2022. Invitations were sent to 73 students who have studied three or more terms at SoCS. Appendix E shows the 23 responses that were received. Overall, students are satisfied with their experience in our graduate programs and with the quality of teaching in CIS graduate courses.

In response to questions on the main strength of the graduate degree programs, representative student feedback include:

- “The flexibility of the masters program”
- “The main strength of my degree program is the interdisciplinary nature of the work, the networking opportunities and the support that I have from faculty including (but not limited to) my advisor.”

Recommended changes to the program include:

- “I think summer courses would be beneficial to the program.”
- “Increase course offerings. Especially courses like data science and machine learning/AI.”

Several concerns are also raised. For example, 45% of the participants felt that the space for working on campus is lacking and 27% concerned about insufficient funding support.

D. RESEARCH

SoCS faculty actively engage in research in several theoretical and applied research areas. SoCS also has a long history of conducting interdisciplinary and applied computing research, as reflected in the emphasis of our Computational Sciences PhD program discussed above.

D.1. Research Profiles

It is generally difficult to profile the research conducted by an academic unit and to identify research clusters. Hence, here we utilize the data from the CSRankings.org, which publishes a metrics-based ranking of Computer Science for institutions around the world. We acknowledge the limitation of this approach as the website only counts publications appeared at the very top conferences in 26 selected research areas. Neither top journal articles, nor high-quality publications in interdisciplinary and niche areas are included.

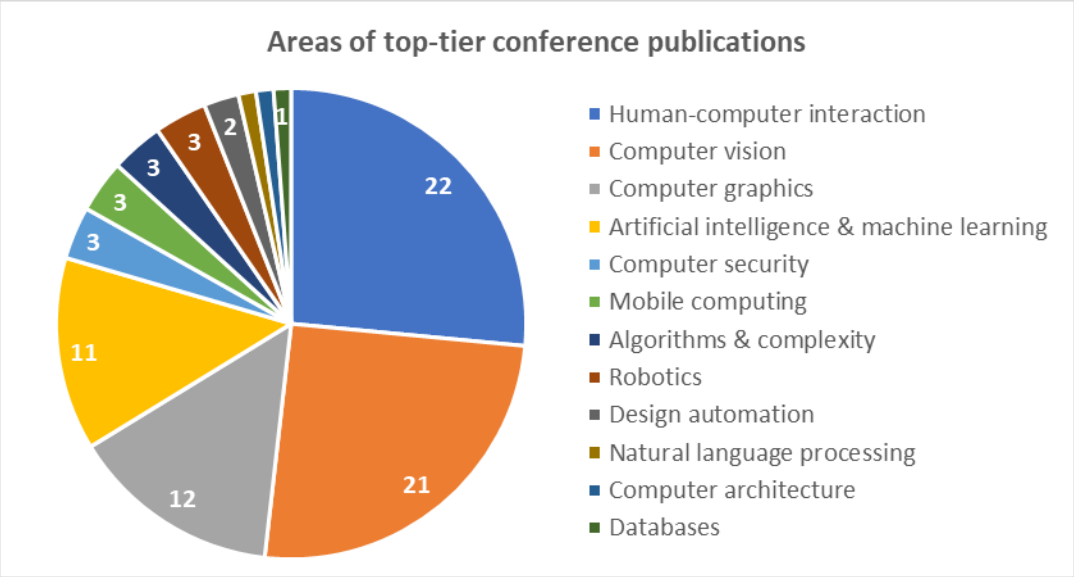

Figure 20: Number of publications that SoCS faculty members have contributed to top-tier conferences, as indexed by CSrankings.org.

Figure 20 shows the number of top conference papers published by SoCS existing faculty members in different areas. It suggests that SoCS has strong research profile in areas such as Human-Computer Interaction, Computer Vision, Computer Graphics, and Artificial Intelligence & Machine Learning. It also has made notable contributions to the fields of Computer Security, Mobile Computing, Algorithms & Complexity, and Robotics.

Although SoCS may not yet have a strong research reputation among CS departments in Canadian universities, in recent years it has celebrated many research excellence achievements among our faculty members. These include:

- NSERC Discovery Accelerator Supplements (DAS) award, S. Scott, 2017
- Multi-million-dollar Mitacs funding, D. Gillis, 2018

- NSERC Canada Research Chair (CRC) Tier II appointment, A. Dehghantanha, 2020
- Section Chair appointment for NSERC Computer Science Evaluation Group, J. Sawada, 2021
- Technical Recognition Award by the IEEE Communications and Information Security Technical Committee, X. Lin, 2021
- Multiple best-paper awards in top conferences.

One problem we have is that we are not doing an adequate job of communicating the outcomes and values of our research both internally across campus and externally. To address this issue, one of our initiatives will be to create a strategy to promote and celebrate our research activities and successes to key stakeholders, such as university administrators, funding agencies, and potential students (Action Plan E.4.3).

Another direction for improving our research profile is to host regular seminars for both our own faculty members and external researchers to showcase their work (Action Plan E.4.4). University of Guelph is surrounded by several internationally recognized Computer Science schools/departments, which is a disadvantage for us in terms of attracting and retaining top students. However, we can also take advantage of this by bringing in nearby strong researchers to SoCS. Such research seminars will help boost collaborations both within and outside of the School, as well as to broaden the knowledge of our graduate students. If budget allows, we would also like to fund a SoCS Distinguished Lecture Series to attract high profile researchers. This will help put SoCS in the spotlight of respective research communities.

Besides promoting research of faculty members, we would also like to showcase research outcomes from students, both graduate and undergraduate. A possible direction is to create an annual Research Forum (Action Plan E.4.5). Both graduate students and undergraduate students registered for CIS*4910 (Computer Science Thesis) would be required to present their work.

D.2. Significant Growth in Research Funding

The level of research funding support for SoCS was historically low at under $400K per fiscal year between 2013 and 2018; see Figure 21. However, we have observed significant funding growth in the past three years. The total amount has reached over $1.12M in 2020-21 fiscal year, a threefold increase over 2017-18. With our 24 regular (excluding teaching-focused) faculty members, the funding amount per faculty member is $46.8K.

Besides the total funding dollars, the amount of support secured from the NSERC Discovery Grants is also an important metrics, since this amount is used by both the TriCouncil and internally at Guelph to enable additional funding allocations and quotas for research support funding such as NSERC USRAs, CFI infrastructure grants, etc. As shown in Figure 22, the total amount of NSERC Discovery Grants awarded in year 2016 was $87K. The amount has since quadrupled in 2022 to $404K. During this five-year period, the number of grant holders was also tripled from 4 to 13, which now accounts for more than 50% regular faculty members in SoCS. The support from the CEPS Dean's Office on internal funding review, led by Associate Dean Research (L. Brown), should be credited for helping both new and returning faculty members to secure their Discovery Grants.

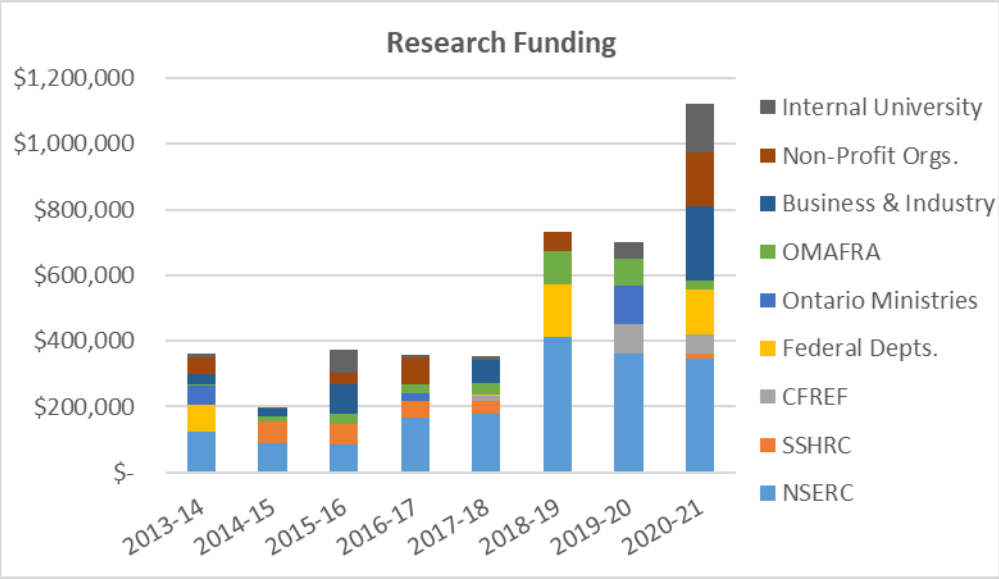

Figure 21: The amount of research funding in the past eight years.

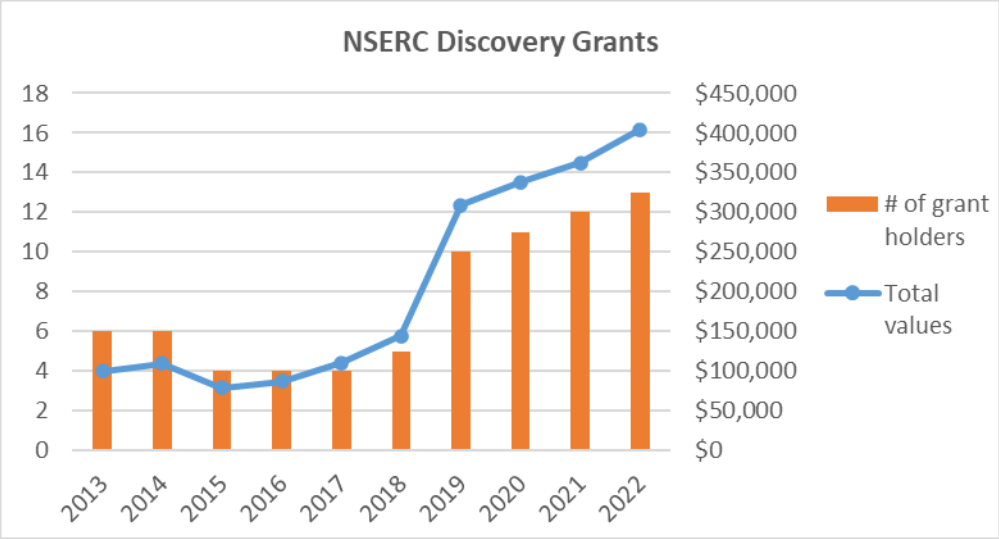

Figure 22: Number of NSERC Discovery Grants and the total values.

The contribution of new MCTI program to the growth of research funding also worth highlighting. The number of MCTI industry projects for Summer 2020, 2021, and 2022 are 6, 7, and 10, respectively. All these projects are match-funded by MITACS. Due to increasing number of projects and the needs for short turn-around, our MCTI program developed a rigorous internal review process through an agreement with MITACS. This process is not replacing MITACS review, but funding decisions can be made based on the results of internal reviews. All project proposals are developed in collaboration between the industry, the faculty member in charge of the project, and the MCTI intern. These proposals are first reviewed by the MCTI Director (A. Dehghantanha) and the CEPS Associate Dean of Research and Graduate Studies (L. Brown), who provide feedbacks. In the second round, proposals are anonymously reviewed (single blind peer

review) by two faculty members in the field or in closely related areas for funding decisions. MITACS regularly examines the review process and funded proposals are randomly selected for further review. This internal review process reduces funding decision time from 2-3 months to 3-4 weeks, which made MCTI project partnership a very attractive option for industry.

While the data show very positive trends, to achieve the College's goal of increasing research funding by 50% still requires additional efforts. Strategies on how to improve grant application success will be developed and implemented (Action Plan E.4.2).

D.3. Drastic Increase of Research Citations

Most SoCS faculty members publish regularly at reputable venues, including refereed journals and conference proceedings. Since the research methodology used can vary dramatically, it is hard to evaluate and compare the research productivities and impacts across different fields in CS. Nevertheless, the Google Scholar citation counts and the corresponding h-index numbers are reported here, as researchers nowadays often include them in grant applications.

Figure 23: Faculty research impact in terms of total citation count (left) and h-index number (right). Note that some data are missing as not all faculty members have Google Scholar user profiles set up.

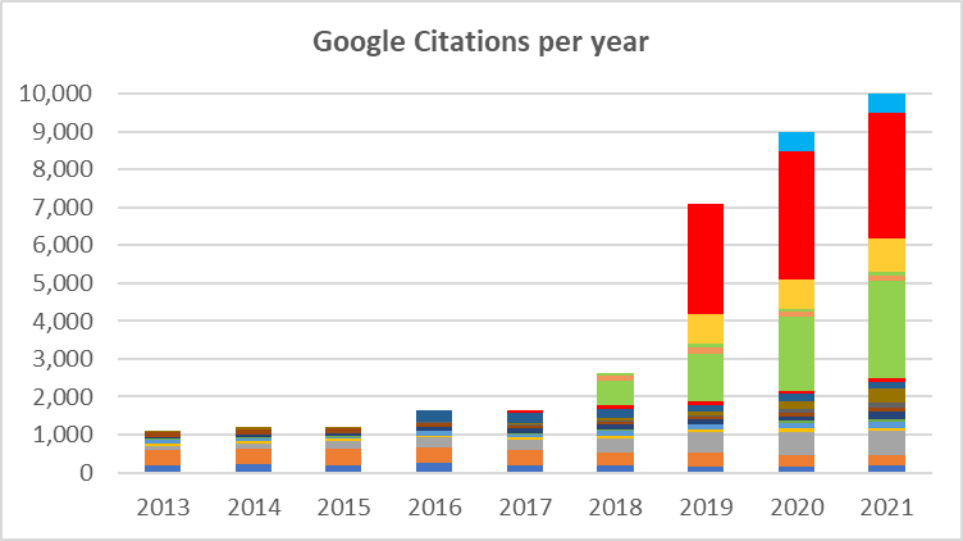

Figure 24: Google citations per year for SoCS. Each color represents a faculty member. For members joined after 2013, only the citations after their starting years are included.

Figure 23 plots the data for all SoCS faculty members who have Google Scholar user profiles set up. To fairly compare faculty members in different stages of their academic career, the number of years passed since they gained their PhD are used as the X-axis[2]. As expected, more senior faculty members generally have higher research citations and h-index numbers.

Another trend can be observed from the figure is that faculty members hired in the past five years have higher citations than their peers who joined earlier. This is related to the fact that SoCS faculty members were overwhelmed by undergraduate teaching before 2016, as discussed previously in Section C.3. Some faculty members lost their research momentum due to the lack of time for research, leading to slower progress on building up research impacts. In comparison, faculty members who worked at other institutes first and joined SoCS in recent years were able to devote more time on research.

Figure 24 further plots the total annual citations during the past eight years, where different colors represent different SoCS faculty members. It shows that the total citation count has dramatically increased from ~1,100 in 2013 to >10,000 in 2021.

The above observations suggest that, because SoCS welcomes strong researchers and is also attractive to them, its research profile has improved quickly through recent investments on new and replacement faculty positions, and through providing senior faculty members time and resources to rebuild their research programs. One evidence is that University of Guelph is currently ranked as 12th out of 29 Canadian universities by http://csrankings.org/, which is based on research publications only, and ranked the 9th among Canadian universities in the 2022 Times Higher Education ranking by Computer Science subject, which gave us high score on citations. However, if student-faculty-ratio continues to rise and faculty members become overloaded with

[2] Date of 1st PhD is used for researchers with more than one PhD degrees. Potential interruptions in the academic career, such as parental leaves or industry experiences, are not considered for simplicity.

undergraduate teaching again, recently hired faculty members will experience the same difficulties as senior faculty members faced before 2016. The School will also lose its attraction to strong researchers. Hence, prioritizing research time for faculty members is of high importance. (Action Plan E.4.1).

E. ACTION PLANS

Here, we discuss the planned actions for SoCS in the next five years, as well as how these actions support the goals listed in the Strategic Plan for CEPS — "Inspiring Excellence (2018-2023)". These actions are grouped into five areas: resources and organization, undergraduate education, graduate education, research, and outreach and fundraising. The planned actions under each category are ordered by their priorities.

E.1. Resources and Organization

E.1.1. Lobby for the Proper Faculty Complement Level

Given the high undergraduate student-to-faculty ratio and rising demands for SoCS undergraduate programs, SoCS needs to proactively determine the proper faculty complement level for supporting different incoming student enrolment targets (e.g. 200 vs. 250 vs. 300), additional stream options, and potential summer academic terms. The number of additional courses/sessions needed for supporting more students will be investigated by the Undergraduate Curriculum Committee and then consulted at the SoCS School Council. Efforts will be made to secure the resources needed before agreeing to increase the enrolment target.

The action plan aligns well with College GOAL A.1 (strategic additions to the faculty complement) in the CEPS Strategic Plan. Progress of this action plan will be measured using the undergraduate student-to-faculty ratio, with the goal of lowering the ratio to <30:1 from the current 35:1 by year 2023.

E.1.2. Ensure Sufficient Academic, Administrative, & Instructional Staff Support

The rapidly increased undergraduate body calls for additional staff capacity for academic, administrative, and instructional supports. The Instructional Support Coordinator position established in Fall 2019 has effectively lowered the workload of the Academic Staff Hiring Committee. The second Undergraduate Program Counsellor position helped to bring SoCS student-to-counsellor ratio closer to the average ratio in CEPS and to manage academic misconduct cases.

While the first staff position has been converted to permanent in Fall 2021, the second position is still temporary. Demonstrating the importance of the second position for SoCS undergraduate programs and adding it to SoCS base budget are therefore needed. We would like to advocate the needs for a dedicated Recruitment and Outreach Officer and additional staff capacity for supporting our growing graduate programs.

E.1.3. Create Equitable Workloads for Faculty Members

Currently there is no formal policy at SoCS for recognizing the workload difference in teaching new vs. existing courses, courses with different sizes and credits, and courses with vs. without lab components. Efforts will be made to create a teaching equivalency document that recognizes the additional workloads. The Undergraduate Curriculum Committee led by D. Calvert has already investigated this issue and drafted a document. However, more work is needed to develop a sustainable solution.

E.1.4. Acquire or Build Additional Space

The Reynolds Building, home of SoCS, is being used at its capacity. Should the university decide to increase the enrolment number of incoming undergraduate students, additional teaching labs are needed. Research labs are also needed for conducting research, as well as for facilitating interactions among postdoctoral researchers, PhD and MSc students, and undergraduate research assistants who work in the same field. When the Reynolds Building was renovated, there was plan for building an extension. It is unfortunate that the plan wasn't carried through.

SoCS recognizes that building new infrastructure is a major investment and requires long term planning. Hence, in the short term, we will also explore the possibility of finding and utilizing office and lab spaces elsewhere on campus.

E.2. Undergraduate Education

E.2.1. Make Co-Op Mandatory and Offer Summer Academic Term

An important goal in CEPS Strategic Plan is to enhance the experiential learning experience (GOAL B.3). An action plan on this front is to introduce a summer academic term, which allows co-op students to be placed throughout the year. With the capacity to place more co-op students, we can make co-op training mandatory for our BCH.CS and BCH.SE programs. Such an action will address both concerns raised by alumni on mixing co-op and non co-op students and suggestions raised on offering more courses in Summer terms. In addition, the undergraduate student survey also indicates that 77% of students who are currently in the non co-op programs would choose the co-op program if they were given the choice.

The Undergraduate Curriculum Committee, led by D. Calvert, has already started investigating the additional resources needed to support a summer academic term. Progress related to this goal will be measured annually by the number of SoCS co-op students who receive co-op placements each year.

E.2.2. Offer Area of Emphasis within SoCS

As mentioned above, SoCS students are required to select AoA, which consists a set of 8 courses from another discipline. Multiple comments from alumni survey spoke about the desire of having streams as alternative routes for AoA. SoCS believes that it is important to broaden students' skills and knowledge outside of CS, which is a common practice for Bachelor degrees. However, with SoCS building up its strength on areas such as Cybersecurity and Artificial Intelligence, it makes sense to offer our undergraduate students the option to study in-depth knowledge, on top of the breadth requirement specified through AoA. Their efforts will be recognized through degree designation in form of either Stream or Area of Emphasis. In the undergraduate student survey, 91% of the student indicated that they would take Area of Emphasis, if available.

Implementing this action is resource demanding as it requires more courses in selected fields to be developed and offered regularly. Thus, this activity must be done carefully in conjunction with proper faculty and staffing levels. Once implemented, progress related to this goal will be measured by the number of students enrolled in these programs.

E.2.3. Expose Students to Modern Programming Languages

Several alumni survey participants commented our programs' focus on the C language. Although designed to teach students the fundamentals, our undergraduate curriculum does expose students to model languages, including Java (CIS*2430) and Python (CIS*2750). In addition, students can complete many senior level courses with any programming languages of their choice. Nevertheless, our Undergraduate Curriculum Committee will investigate the feasibility of converting an existing elective course, CIS*3190 Software for Legacy Systems, into a course on vocational languages. The goal of this new course is to provide students with a working knowledge of a variety of high-level programming languages. When given a wide range of languages with which to solve a particular problem, students will be able to choose the most appropriate language for implementing the solution.

Implementing this action will not require extra resources. Once implemented, progress related to this goal will be measured by the number of students taking the new elective course.

E.2.4. Highlight the Focus of Each Software Design Course

Regarding the concerns raised about software design courses being repetitive. SoCS' perspective is that such repetition is necessary for students to truly master the complicated software design process. Nevertheless, the Undergraduate Curriculum Committee plans to work with instructors of different software design courses to better coordinate these courses, to identify unique focus of individual courses, and to emphasize the needs for repetitive training in these courses.

E.3. Graduate Education

E.3.1. Review and Modernize Graduate Course Offerings

Eleven new faculty members have joined SoCS in the past five years, accounting for 45% of SoCS faculty population. Many of them work in different areas of research than existing faculty members, expanding the research expertise in SoCS. Hence, reviewing and modernizing our graduate course offerings is needed. There is a need to offer more graduate courses every year and at least one graduate course during the summer. In addition, we also need to consider the breadth of graduate courses being offered, so that students doing research in different areas can all find suitable courses. In the Graduate Student Survey, 41% of students felt that SoCS does not offer sufficient and relevant courses for either preparing you for your research or broadening your knowledge.

The Graduate Curriculum Committee has already proposed a major modification, which added three new graduate courses in Fall 2021. The committee is expected to lead further development of a revamped set of graduate courses for our graduate programs.

E.3.2. Increase Funding Supports for Graduate Students

As previously mentioned, to address outstanding debt, SoCS previously cut the number of GTA positions to save TA budget. This, however, limited the ability for SoCS faculty members to recruit graduate students and required the Academic Staff Hiring Committee to interview all graduate applicants to determine individual GTA funding level, which adds administrative workload and

delays the admission process. To support SoCS faculty members recruiting graduate students under the new CEPS minimum funding policy, SoCS has provided two guaranteed GTAs to each incoming graduate student, starting Fall 2021. Policy for providing additional funding support in form of either GTA or scholarship will be discussed.

Progress toward this goal will be measured by the total funding support for graduate students each year.

E.3.3. Introduce Course-based MSc Route

Given that SoCS only accepts <3% of international MSc applicants, there is a strong opportunity for us to offer a course-based MSc option to address this demand. Through discussions with B. Bradshaw, Assistant Vice-President Graduate Studies, we learned that such a program can be introduced as a major modification to our existing MSc program, i.e., adding a course-based route for completion. Only internal approval is needed, which can be done relatively quickly. However, we will proceed with caution to ensure that 1) the course-based route option will be well funded through a tuition revenue share model; 2) the new option will not compete and undermine our 1-year MCTI program; and 3) it won't unduly increase faculty workload.

This planned action directly supports the GOAL C.1 (offer new masters programs) in CEPS Strategic Plan. Progress related to this goal will be measured by the success in establishing the course-based MSc route and how the revenue generated helps other SoCS graduate programs.

E.3.4. Develop a Better Screening Procedure for Graduate Applicants

SoCS now receives 550+ applicants for our graduate programs each academic year, for which careful evaluation of each application is infeasible by our single Graduate Program Assistant. If SoCS decides to introduce a course-based MSc route, we need to screen all applications to these professional Master programs. This workload can be carried out by either the Graduate Admission Committee or an additional Graduate Program Assistant.

The best strategy for graduate applicant screening will be discussed. Implementation of the new screening procedure will be led by the Associate Director Graduate Studies.

E.4. Research

E.4.1. Prioritizing Research Time for Faculty Members

The overwhelming undergraduate teaching and administrative responsibilities during 2013 to 2019 academic years have already resulted in some SoCS faculty members losing their research momentum. It is therefore important to reverse this trend by protecting faculty members' time for research. The aforementioned action plans on ensuring proper faculty complement level (E.1.1), increasing the capacity of Instructional Support Staff (E.1.2), reducing administrative responsibilities, enforcing undergraduate enrolment target, and providing more GTA supports (E.3.2) all help to achieve this goal. Additional initiatives that can help to achieve this goal will also be discussed and implemented.

E.4.2. Increase Research Funding

The CEPS Strategic Plan GOAL D.1 aims to increase our research funding by ~50% by 2023. To support this goal, SoCS will encourage and facilitate faculty members to seek funding from various sources and programs. SoCS has established policy for assigning each major grant proposal a second reader, who provides valuable comments and helps to identify what the grant applicant(s) may have missed. We will continue this practice, as well as encouraging our faculty members to utilize the internal review system and grant development support offered at the College level. Collaborative efforts for applying to large group grants will be encouraged and supported. In addition, to help faculty members without funding to rebuild their research programs and to brace the impact of the new graduate funding policy, strategies for engaging all faculty members in graduate supervision/co-supervision will be investigated.

Progress towards this goal will be measured by the amount of overall research funding and Tri-council funding.

E.4.3. Celebrate Research Excellence

Some of the important research activities and achievements in SoCS are not made visible to our stakeholders, such as university administrators, funding agencies, and potential students. Hence, a new strategy is needed for making SoCS research more visible. Faculty and graduate students will be encouraged to leverage the research communication supports at the College level. Students will be encouraged to participate in the planned Annual Student Research Forum (E.4.5) to celebrate and raise the visibility of SoCS research. Additionally, promoting research excellence should also be part of the outreach and marketing efforts (to be discussed in Action Plan E.5.2 below).

E.4.4. Host Research Seminars Regularly

Research discussions and collaborations are important both for exploring potential topics and for promoting outcomes. To facilitate collaborations and boost research activities in the School, SoCS will set up regular seminars for both our own faculty members and external researchers to present their work. Policy for engaging graduate students will be discussed and implemented. Feasibility for funding and hosting a SoCS Distinguished Lecture Series to attract high profile researchers will also be explored.

Progress related to this goal will be measured by the following annual performance indicators: 1) the number of seminars hosted at SoCS; and 2) the attendance rate of graduate students and faculty members.

E.4.5. Create an Annual Student Research Forum

Right now, both MSc and PhD students in SoCS are required to give seminars on their research. However, these seminars are scheduled scattered throughout the academic year and are not well-attended. Undergraduate students working on their undergraduate projects (CIS*4900) or thesis (CIS*4910) are not required to present their work. Creating an annual Research Forum and requesting all these students to present together in a mini conference format can help them to

learn from each other on different research topics and presentation skills. It can also help to engage undergraduate students in various research opportunities.

This planned action directly support the GOAL B.6 (enhance the research experiences of our undergraduate students) in CEPS Strategic Plan. Progress will be evaluated by the number of students participated in the Research Forum.

E.5. Outreach and Fundraising

E.5.1. Develop Fundraising Priorities and Strategies

SoCS needs to work with Alumni Affairs and Development (AA&D) on developing fundraising priorities and strategies. The current 50th anniversary is a great opportunity for SoCS to gain funding support from its alumni. Areas that can benefit from fundraising campaigns include:

- Scholarship support for targeted student groups, e.g. female students or students from specific geographical regions.
- Funding for supporting a SoCS Distinguished Lecture Series, which invites world-class researchers to Guelph.
- Funding for additional space to host SoCS.

This planned action supports the CEPS Strategic Plan GOAL E.6 (work with AA&D to steward existing partnerships). Progress toward this goal will be measured by the amount of funds raised each year.

E.5.2. Revisit Outreach and Team Building Strategy

On one hand, the dramatic increases in number of undergraduate applicants for SoCS programs is a strong indication of our success on outreach. On the other hand, the self-study activity suggested that we need to get more faculty members to engage in outreach activities. In addition, the outreach effort at the graduate level has room for improvements.

In 2020/21 academic year, an Outreach Committee was established and outreach was added to the mandates of Assistant Director. This facilitated the communication with the CEPS Dean's Office, especially with the Associate Dean External Relations. However, with the Recruitment and Outreach Officer now reporting to the Dean's Office and supporting other academic units, how to collaborate with the Dean's Office with the role of Associate Dean External Relations being vacant, to develop focused outreach activities, and to market SoCS programs at both undergraduate and graduate levels require careful discussions.

E.5.3. Secure Resources for Recruiting and Supporting International Students

The CEPS Strategic Plan GOAL B.2 aims to increase international student enrolment in all CEPS programs to a minimum of 15% by 2022. International students, however, generally require more resources and support to ensure a successful acclimation and integration into our program. Plans for increasing resources for international students, such as tuition revenue sharing, are being investigated at both University and College levels. SoCS will work with the higher administration to secure resources and to actively recruit and better support international students.

Progress toward this goal will be measured by the percentage of international students in undergraduate SoCS programs, as well as the additional resources secured for supporting these students.

E.5.4. Actively Recruit and Retain Female Students

The CEPS Strategic Plan states the goal of having a minimum of 20% women enrolled in first year for all CEPS programs by 2023. SoCS recently met the expectation, but active and targeted recruitment for female students is still needed. The Action Plan E.5.2, if successfully implemented, can help toward this goal. In addition, SoCS will also encourage and support our existing female students to attend the annual Canadian Celebration of Women in Computing (CAN-CWiC) conference. This conference helps to connect our local students with the broader female student community, encouraging them to stay in SoCS programs.

Progress toward this goal will be measured by the percentage of female students in undergraduate SoCS programs, as well as retention and graduation ratios of female students.

F. CONCLUSIONS

Overall, this self-study shows very positive trend for SoCS. The demand for our undergraduate programs has been steadily growing in the past five years. We are attracting better and more diverse undergraduate students. Both research funding and publication impacts saw dramatic increase in the past three years. The School inaugurated its first professional MSc program and reinstated its own PhD program in the past three years as well. With more resources and time, we are very confident that the School can grow even stronger.

There are, of course, also concerns. SoCS does not have sufficient staff to support our undergraduate students, especially the growing international student body. We are not offering enough graduate courses for our graduate students. SoCS is also running out of space for hosting our students and research labs.

Since most of the concerns are resource related, the School feels that SoCS is locating at a crossroads to continue building up its research profile and further enhancing its teaching excellence, or to lose this momentum once again by burning out faculty members with high teaching and administration loads. The level of supports at higher administration plays an essential role on which direction SoCS will be heading in the next eight years.