ACCELERATING THE SMOOTH ADOPTION OF SMART SYSTEMS & DIGITAL TECHNOLOGIES VIA WORK-INTEGRATED LEARNING AND INDUSTRY-MUNICIPALITY-ACADEMIA NETWORKS

An Evaluation Report for FSC

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SEPT, MCMASTER
Hamilton, ON

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FSC is a forward-thinking centre for research and collaboration dedicated to preparing Canadians for employment success. We believe Canadians should feel confident about the skills they have to succeed in a changing workforce. As a pan-Canadian community, we are collaborating to rigorously identify, test, measure, and share innovative approaches to assessing and developing the skills Canadians need to thrive in the days and years ahead. The Future Skills Centre was founded by a consortium whose members are Toronto Metropolitan University, Blueprint ADE, and The Conference Board of Canada

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Executive Summary

The purpose of this report is to provide an in-depth evaluation of the “ACCELERATING THE SMOOTH ADOPTION OF SMART SYSTEMS & DIGITAL TECHNOLOGIES VIA WORK-INTEGRATED LEARNING AND INDUSTRY-MUNICIPALITY-ACADEMIA NETWORKS” project funded by the Future Skills Centre. This project has been caried out over a period of three years starting on April 1, 2023, and ending in August 2023.

Problem and Opportunity Addressed

The digital transformation is already underway due to the emerging technologies, including robotics and automation, IoT and IIoT, machine learning, autonomous driving, 3D printing and artificial intelligence (AI), known as the Fourth Industrial Revolution (Industry 4.0) and COVID-19 has accelerated the use of these technologies. Since the inception of this project AI applications have significantly advanced and have found their applications in almost every business sector. This combination of applications using Industry 4.0 technologies and AI based application development has created a pathway to Industry 5.0. These advances continue to provide opportunities for growth in the industry as well as pose challenges for adoption due to the pace of advancing technologies. As industrial and business organizations continue to adopt these technologies and equally, they face the following challenges: lack of talent with skills and capabilities to adopt and manage complex Industry 4.0 applications, lack of knowledge of available digital technologies and how it can help their business operations, lack of basic digital infrastructure for implementation of IT and OT technologies, and not being able to upskill their current workforce due to financial and other constraints. As recently the Canadian Manufacturing Coalition have outlined four priorities, they wanted to be addressed in the 2023 federal budget. These include Support industry by attracting the workers and skills it needs through increased and targeted immigration and enhanced training supports; Drive innovation, investment, and the adoption of advanced technologies and automation; Increase domestic manufacturing production and exports; Help manufacturers adapt to and advance Canada’s climate change plan. Educational organizations such McMaster University and other universities and colleges can provide the talent needed for the adoption of these technologies. It is in this light this project was proposed to accelerate the adoption of these technologies.

Goals and Objectives

The following goals and objectives were framed during the start up and after a few months of implementation phase of this project:

1. Build Industrial Municipalities SEPT (IMS) Network for the Adoption of Digital Technologies
2. Engage IMS Network Partners for Work Integrated Learning (WIL) for Solving Partner’s Challenges
3. Support the Building/Testing of the Prototypes by the Students Engaged in WIL
4. Develop IoT, IIoT, Industry 4.0 Learning Modules and Prototypes
5. Document WIL Processes
6. Support Students in All M.Eng. SEPT Streams - WIL Projects
7. Support Students in B.Tech. Automation, Automotive , and\ Smart Systems Capstone Projects

8. Support Campus Wide Digital Technology Projects/Groups
9. Support the design of curriculum and hands-on lab development for the new Systems & Technology M.Eng. program and Smarts Systems option in the existing B.Tech. Automation program.

Key Accomplishments

Over the course of this project more than 120 WIL projects sponsored by the IMS Network partners have been secured and 90 projects have been completed.

More than 20 tutorials have been prepared for sharing with IMS partners, as well as course material for student self-learning, and for future workshops to be offered by SEPT.

The use of Industry 4.0 maturity index as a guideline for the implementation of IoT/IIoT technologies was prepared and shared with some faculty members and WIL partners.

Completed 16 advanced application prototypes for demonstration of different aspects of digital technologies, some in collaboration with IMS partners, and others for future adoption in labs and courses.

Offered 12 workshops attended by SEPT and engineering undergraduates and newly arrived graduate students.

Supported 5 campus teams that had a total membership of 281 engineering students.

Three special individual group teams also got support from this project.

WIL processes implementation document has been prepared and shared with FSC that can enable others to implement their own WIL projects.

More than one hundred and one lab experiments and prototypes have been developed.

All Systems and Technology and Smart Systems option in the Automation program received on going support in the design and implementation of hands-on labs.

The enrolment in the S&T program, the focus of this project, has gone from 21 students in the first batch to 109 students accepted for this fall with a waiting list of 50 more students. This is a testimonial to the success of the S&T program supported by FSC funding.

Nineteen papers were presented by the students at the three SEPT BRIC Symposiums.

Published 6 professional papers and a chapter in a book on IoT applications. Two other draft papers are ready to be published.

Received international recognition: Swaleh Owais, 2021 mechanical engineering grad and Yang Cheng, industrial designer, supported by the FSC funding , have won the prestigious 2022 James Dyson Global Sustainability Award for Polyformer; and Prototyping for Humanity Global Award

A new design of a low-cost continuous bed 3D printer adopted for use in Rwanda and built by many other international teams.

Wheelchair WIL project completed, more than 25 students participated, in co-operation with Burlington Rotary Club provided the foundation and resources to build 100 wheelchairs in Uganda.

The NEUDOSE satellite was launched into space aboard a SpaceX rocket bound for the International Space Station, where it was deployed by astronauts after one month of the launch. Our collaborators have secured new funding from Canadian Space Agency for the design and development of the next generation cube satellite.

Key Evaluation Questions and Findings

The following criteria proposed in the project proposal was used to evaluate and monitor the success of this project: the number and types of projects undertaken; the number of students engaged in Industry 4.0 projects; assessment of technology transfer; the feedback from the network partners engaging the students for solving their challenges and Industry 4.0 module use; the number of co-op positions offered by the network member organizations; and student career placement successes. It can be stated that we have surpassed all these expectations that were provided for the project funding application. All these aspects are discussed in this report.

The overall specific question of Industry 4.0, including AI, knowledge transfer from academia to industry in the context of education and training is how to support the accelerated adoption of these digital technologies in various sectors, manufacturing, health care, transportation, smart cities, and other sectors impacted by new technologies. SEPT has adopted various strategies to address this question and in specific terms this project has supported all those major elements as illustrated in this report and exemplified in various quarterly reports that have been submitted. These models and approaches are described briefly in this report.

This leads to a general overriding question "What academic programs and processes can be designed, developed, and supported that can accelerate the adoption of Industry 4.0 and Smart Systems in the Canadian industries and communities?" A following question is "How to best asses these programs and processes for their learning outcomes and successes?" This report addresses these questions as well in the context of this project.

In addition, this report addresses all questions posed in the evaluation guidelines provided by FSC.

Recommendations

Industrial organizations and SMEs not having a solid understanding of evolving digital technologies, including rapidly advancing AI technologies, need much support in evaluating their impact/implications and adopting them in the workplaces.

Academic institutions need to design and or modify and implement programs, that include WIL and provide, hands-on Industry 4.0 technological skills and capabilities to the students that are in high demand. This is where FSC funding has been able to provide the necessary support for hands-on experience to the students in their classrooms and WIL project implementations.

Financial, technical, physical facilities for the campus teams. Most campuses provide limited resources for these teams, but a lot more needs to be done as the experience provided by these team activities goes beyond the classroom experience and prepare them well for their future careers in industry and academia.

There are no readily available tools for assessing the digital technology competencies of the employees followed by developing upskill plans and associated training resource materials, that can be followed by the adoption of IoT, IIoT, Industry 4.0, machine learning and AI technologies by these employees.

The use of Industry 4.0 maturity index and corresponding assessment tools as a guideline for the implementation of IoT/IIoT technologies can be further expanded for the design of training and academic programs to support the adoption of these technologies.

The SMEs, with fewer employees, and start-ups need nurturing and technical support for accelerating their progress in digital technology implementations. They often have great ideas and have developed their products and offerings but there remain some roadblocks in fully implementing them that need extra technical and financial resources. Their efforts are more devoted to their day-to-day operations just to stay active in their business. This project has made significant contributions to several WIL partners in this regard.

1. Introduction

Stakeholders and Evaluation Goals (as articulated by partners and key stakeholders) a) Who were the stakeholders for the program undertaken with FSC? b) How has the purpose and use of this evaluation been articulated? Provide details on any work done to articulate how this evaluation's findings were envisioned to have been used by partners, key project stakeholders, and other external stakeholders. If possible, describe any relevant processes undertaken to develop and validate these goals (i.e., design workshops, 1:1 consultations, etc.)

These excerpts from the FSC Evaluation Guidelines have been addressed in the following pages along with other details and findings.

2. Industrial Municipalities SEPT (IMS) Network Steering Committee

During the first year of this project an Industrial Municipalities SEPT (IMS) Network Steering Committee comprising of the following was set up for informal consultations as well as to get input regarding the goals of this project:

Andrea McKinney, General Manager, Corporate Services, Town of Orangeville

Cyrus Tehrani, Chief Digital Officer, City of Hamilton

Gina Suchi, President, Westhill Innovation Inc.

Joshua Lombardo-Bottema, Founder/CEO, GoWench Auto

Karen Linseman, Director of Operations, Innovation Factory

Remy Audel, Control & Diagnostics Development Engineer, General Motors

Rob McCann, Founder, Clearcable Networks; President, Hamilton Technology Centre

Members from SEPT: Ishwar Singh, Salman Bawa, Zhen Gao

Regular Zoom meetings were held as the university was closed for on campus activities. After first year of these meetings, it was then relegated to informal discussions based on any issue that needed to be addressed.

3. Who were the stakeholders for the program undertaken with FSC?

- Industrial Municipalities SEPT (IMS) Network for the adoption of digital technologies. SEPT has a community outreach program to develop partnerships and collaboration with industrial, municipal, and other community groups such as hospitals, professional organizations, rotary clubs, startups, and relevant campus units. This outreach was extended to expand the collaboration to invite more partners for the implementation of this FSC project.

- IMS Network Partners for Work Integrated Learning (WIL) for solving partner's challenges.
  One key aspect of collaboration with SEPT IMS partners is to offer them opportunities to bring forth their digital technology challenges that can be addressed by the students in the M.Eng.. programs as a part of WIL program requirements. These partners or their representative participate actively in the WIL project meetings and mentoring the students.
- The Students in SEPT M.Eng.. Programs Engaged in WIL Projects and Taking Smart Systems Courses
  SEPT M.Eng. programs offer two options to the students; one is course based only and the second is course and WIL project based. The new Systems & Technology (S&T) program, supported by this project offers both options to the students. The students also have an option to go on a paid co-op work term for 4 to 12 months. The students in other M.Eng. streams interested in digital technology related courses and WIL projects are also included in this project.
- SEPT B.Tech.. students in automation, and automotive programs working on capstone projects.
  SEPT offers seven undergraduate B.Tech.. degrees. The students in automation and automotive program must complete a capstone project as a part of their degree completion requirements. This FSC project was extended to give these students opportunities to work on WIL projects as well.
- The following student groups on campus engaged in special projects: Mar's Rover, Neudose Satellite, Robotics & ROS, McMaster Rocketry Team and a few Special Project teams.
  At McMaster University there are over 70 engineering clubs, committees, and teams that the students can join to enhance their technical and non-technical skills. The teams listed here were supported by the FSC project as they met the criteria of enhancing the digital technology skills of the student involved.
- SEPT faculty engaged with WIL and capstone projects.
  The M.Eng. students who have opted for the WIL projects and undergraduate students undertaking the capstone class, working on the WIL project are registered in their respective courses which are supervised by a SEPT faculty member. In addition, each WIL team is to be supported by another faculty lead who is expert in the field of WIL project topic. These two activities are crucial for the success of the WIL project.
- FSC/SEPT Employees to Support above activities.
  This is a group of students who have been hired during this project to support the development of IoT, IIoT, Industry 4.0 learning modules, lab experiments, tutorials, and support the development of special projects identified in consultation with others.

4. How has the purpose and use of this evaluation been articulated?

The purpose and use of this evaluation has been articulated based on the goals of the project, relevant Outcomes from FSC Common Outcomes Framework/Network Indicators, survey evaluations instruments development in consultation with BluePrint, and key successes and challenges in the program design and delivery.

5. Learning-focused Background and Description of the Project

a) Project Need/ Opportunity:

i) Why was this project needed?

The digital transformation is already underway due to the emerging technologies, including robotics and automation, IoT and IIoT, machine learning, autonomous driving, 3D printing and artificial intelligence, known as the Fourth Industrial Revolution – and COVID-19 has accelerated the use of these technologies. But only a quarter of businesses were using IoT technologies in 2019, according to McKinsey(https://www.mckinsey.com/industries/private-equity-and-principal-investors/our-insights/growing-opportunities-in-the-internet-of-things), up from 13% in 2014. Currently there are more connected devices than people in the world, according to the World Economic Forum's State of the Connected World report (https://www3.weforum.org/docs/WEF_The_State_of_the_Connected_World_2020.pdf) and it is predicted that by 2025, 41.6 billion devices will be capturing data on how we live, work, move through our cities and operate and maintain the machines on which we depend. It was reported in 2017 that these merging technological developments and advancements are likely to bring widespread automation and irreversible shifts in the structure of jobs and capability requirements, presenting major challenges in labour markets and for policymakers to consider these factors for promoting the adoption of Industry 4.0 required skills for employment. New jobs will require new competencies and new skillsets. The mix of skills needed to perform in modern societies has become increasingly complex and will keep evolving as technology-enhanced work environments evolve, requiring future generations of workers to develop digital ability and lifelong learning capacities at an early age. Soft skills such as self-organization and understanding self-motivation, problem-solving capabilities, management, teamwork, or communication skills are of equal importance in the emerging technological era. The inequalities and social cleavage that may potentially arise from these emerging technological changes can be of major concern (See discussions, stats, and author profiles for this publication at: (https://www.researchgate.net/publication/322109884
Industry 4.0: New Challenges and Opportunities for the Labour Market
Article in Foresight and STI Governance · December 2017, DOI: 10.17323/2500-2597.2017.4.6.8).

To address these challenges a B.Tech.. program (McMaster-Mohawk Partnership) in automation was launched in 2006/2008 after extensive consultation with industry and community partners. This program addressed the growing need of the marketplace for more grads for implementing basic automation in industry. There were only 20 to 30 students graduating in early years with both supply side and demand side led the enrolment increase to between 80 to 90 students and the success was based on graduation rate, co-op placements and full-time job opportunities and feedback from employers and past graduates. Industry 4.0 term was first used in 2011 at Hannover Messe trade fair. By 2015 Europe was leading the implementation of Industry 4.0. In 2015 this author conducted extensive research and noted that Canada was way behind in considering Industry 4.0 implementation and there was not a single undergraduate or graduate program in Canada that supported educational programs and training in this emerging technology, even the term Industry 4.0 was not well known to academics and industry partners. The author proposed a smart system stream in the B.Tech. Automation program and consider offering an M.Eng.. program. At that time SEPT did not exist to offer such a program, but there was a graduate department called school of engineering practice that offered a few practices based M.Eng. degrees. Soon the undergraduate and graduate departments were combined to move forward to meet the educational challenges and opportunities to address the adoption of Industry 4.0 in Canada. An extensive review of the job opportunities related to Industry 4.0 showed very clearly that there was a need for an advanced degree in this field that would also provide a pathway for the undergraduate students in the existing automation program and the proposed smart systems stream. In a similar fashion SEPT faculty developed curriculum road map to be implemented in these programs. The undergraduate and graduate industrial advisory committees, industry partners, former grads all supported this well needed program.

Even recently Canadian Manufacturers Call for Urgent Action in Budget 2023 (Ref 1, Appendix V) to “Support industry by attracting the workers and skills it needs through increased and targeted immigration and enhanced training supports.

- *Drive innovation, investment, and the adoption of advanced technologies and automation.*
- *Increase domestic manufacturing production and exports.*
- *Help manufacturers adapt to and advance Canada’s climate change plan;”*

This project was proposed to support the design, development and delivery of the undergraduate and graduate programs in smart systems in ***Accelerating the Smooth Adoption of Smart Systems & Digital Technologies via Work-Integrated Learning (WIL) and Industry-Municipality-Academia Networks*** for providing graduates with the skills in demand.

As discussed in detail below the program will provide opportunities for the graduates who are looking to change their careers with employability skills needed in the current job market. Most of the graduates are already working in the industry where they are implementing the skills they learned and thus aiding companies to adopt the innovative digital technologies.

It was expected that this program will improve the employability of the graduates and directly/ indirectly influence employers to accelerate their adoption of new technologies as supported by the feedback that we have received.

ii) Who are the populations that this project aimed to serve (be as specific as possible about demographics, geographical locations, occupations, and sectors)?

This project aimed to serve the following groups either working or recent graduates in engineering and technology in mechanical, manufacturing, electrical, mechatronics, software, automation, automotive and vehicle technology undertaking to complete a masters in engineering in one year, who wanted either to enhance their career aspirations or acquire knowledge in these emerging technologies. This project was also designed to create pathways for new immigrants and international students looking for a hands-on practical M.Eng.. program in smart and digital technology systems that can be finished in one year and offers opportunities for co-op experience as well, so they can start their careers for employment in Canada.

Because of the changing employment landscape many engineering and technology graduates find themselves without jobs in the Industry 4.0 growth areas. To provide opportunities for these graduates an extremely flexible M.Eng.. program in Systems and Technology was launched as reported in the project proposal. This has been bourn out very clearly in the background degrees of the students enrolled in this program.

The demographic data for the students joining the M.Eng.. programs supported by FSC project is provided as an attachment to this report.

iii) To what extent were these needs being addressed before project implementation? What was known about what needed to be improved and/or expanded?

McMaster-Mohawk B.Tech.. partnership programs were fully launched only in 2008 & setting up a SEPT LF in 2017 to address the Industry 4.0 and digital skills needs and needs of other sectors for engineering technology graduates. The B.Tech.. automation was the only main program directly supporting some aspects of the Industry 4.0 paradigm. In the currently M.Eng.. existing programs (prior to application for this funding) had just introduced the concept of work integrated learning (WIL). There was no program in the M.Eng.. streams that directly supported the adoption of Industry 4.0 paradigm. The manufacturing M.Eng.. stream needed to be streamlined to support the introduction of Industry 4.0 concepts. In addition, the WIL processes were not documented and streamlined for adoption by other streams. This question is being further addressed in the section on Academic Program Design & Model for Supporting the Accelerated Adoption of Industry 4.0 Technologies in the Workplace

b) Theory of Change/ Logic Model/ Hypothesis

i) What was being tested in this project?

An overriding question for us is *"What academic programs and processes can be designed, developed, and supported that can accelerate the adoption of Industry 4.0 and Smart Systems in the Canadian industries and communities?"* A following question is *"How to best asses these programs and processes for their learning outcomes and successes?"* This report addresses these questions in the context of this project.

However, this project was more about the transfer and use of knowledge in the emerging technologies as articulated above to solve the problems and challenges of the community partners. It was also a goal to develop learning resources, prototypes and learning modules, for the smart system programs in SEPT. In addition, we added another goal during the first stages of this project to support campus students to gain knowledge and hands-on experience for emerging capabilities required by the industry to adopt and implement Industry 4.0 concepts.

The overall specific question in the context of education and training is how to support the accelerated adoption of the digital technologies (Industry 4.0 etc. as said above) in various sectors, manufacturing, health care, transportation, smart cities, and other sectors impacted by these new technologies. SEPT has adopted various strategies to address this question and in specific terms this project has supported all those major elements as illustrated below and exemplified in various quarterly reports that have been given.

There are 7 traditional engineering departments and SEPT (some time referred to as Engineering Practice) that constitute the McMaster Engineering. The traditional engineering degrees mainly focus on the specific chosen field of studies such as civil, electrical, mechanical, chemical, materials and engineering physics. The focus of SEPT M.Eng.. programs are a multidisciplinary blend between academic theory, engineering practise, hands-on, and understanding how to leverage technology to create solutions and produce value for society. The S&T program and the Smart Systems stream choice in the automation program are the latest addition to the SEPT degree offerings. The S&T degree can be finished in 1 to 2 years of studies while traditional M.Eng.. degrees require 16 months. SEPT M.Eng.. programs are based on course work with hands-on labs wherever needed, WIL, and co-op options. The WIL option is not available to McMaster's traditional M.Eng.. programs. SEPT vison has built in mechanism to offer courses and programs that can quickly respond to the evolving skills and capabilities needs of the various fields of employment sectors. The S&T program is an example of this response to help guide Industry 4.0 into the future by its graduates. This master's program is the only one of its kind in Canada that delivers specialized training in digital manufacturing, automotive, automation and smart connected systems.

ii) How did project partners think the project would work and address stated needs?

Out of the six stages of the Industry 4.0 development path, a vast majority of most advanced companies are still at level 2. A vast majority of SMEs, some start-ups, and municipalities face many misperceptions, obstacles, challenges, and lack of skills in implementing Industry 4.0 and may get left behind. Many of the companies we have dealt with recently are not even at the first level of computerization. SEPT IMS-Network will accelerate the adoption of Industry 4.0 technologies by engaging the industry/community partners by providing them human resources with skills and capabilities to kick start their projects on to a digital transformation path. These projects will be carried out by the students, in undergraduate and graduate programs with Industry 4.0 skills, as part of their degree completion requirements at no cost to the partners and if required, further supplemented by co-op placements with the partners. In return these students will gain valuable experience in solving real problems and ready for full-time placement in accelerating adoption of these technologies. This is an innovative radical solution that SEPT has developed for helping industry/community partners for the adoption of other newer technologies as well.

Our early feedback from the IMS-Network Steering Committee was taken into account during the implementation of this project that involved contacting start ups, some individuals, and some organizations, taking their proposed challenges to the students and in one case providing technical support to one the partner companies, Westhill Innovation, (http://www.westhillinnovation.com), in the procuring and use of 3D printer. They have been involved with SEPT in supplying many WIL challenges. One of the early projects was in the development and testing of solar powered trailer as a substitute for the energy supplied to the cooling units by the truck's diesel engine. One of SEPT M.Eng.. student was involved in the development and testing of this system as a part of his WIL project and then hired by them full time to implement it for commercial applications as described on their website that states " *With Loblaw testing the trailer system on grocery deliveries around the province this winter, Succi (CEO) expects to gather valuable performance data about the unit, which was built at Mohawk College's Stoney Creek campus with the help of McMaster University masters students from the W Booth School of Engineering*." In addition, 3 other projects were handled by the WIL students who were also hired by this company. Westhill needed to understand the use of 3D printing technology as they built a solar powered golf cart for SEPT students. In the early stages of the FSC project we provided support for 3D printing and more recently demonstrated various 3D printer models so that they could adopt one for their daily use. We shared guidelines for 3D best printing and loaned them a 3D printer for their everyday use. In addition, Westhill is collaborating with two SEPT faculty for us of AI technology for automated regulation of refrigeration system as the trailer goes from one climate system to another while traveling from east to west. WIL students have been offered to work on this project as well.

This above case fully illustrates how the WIL projects have led to the adoption and development of new digital technology applications by an innovative Ontario company with limited technical and manpower resources.

A second case also illustrates how WIL projects can influence adoption by proving what students equipped with these skills can do for a business. CareGO , A Leader in Material Handling Metals has supplied several WIL projects that have been supported by this FSC project. One such WIL project that uses AI technology to develop an automated customer support system to replace their manual system. It was decided to develop NATURAL LANGUAGE PROCESSING model that AUTOMATES CUSTOMER SUPPORT. This WIL project was guided by this author and his colleague Dr. Fortuna. The aim was to develop an intelligent software application that can categorize external voice messages and automatically relay them to the appropriate department within Carego. When implemented, the application will streamline communication and reduce the reliance on company staff to manage after hours calls.

A systems and technology M.Eng.. student spearheaded the project and employed skills in machine learning and natural language processing to deliver a custom-built solution for in house testing. The student has since been hired by Carego as a Machine Learning Specialist.

This student's testimonial is included in the SEPT 2021 annual report attached with this report.

On another note, several tutorials were prepared to offer as lunch and learn to CareGo employees that was started with basic introduction to IoT and Applications in an industrial setting. However, it was said that it is very difficult to motivate current employees, under the current COVID-19 climate, to undertake advantage of learning new technologies and their impact. Nevertheless, we offered all groups the opportunity to get support from this project by contacting us in addition to their WIL challenges.

There are two other cases where students working on the FSC project started their own companies: AXIBO & ARVI (https://www.axibo.com/)and Archocell (https://archocell.ca/).

Two testimonials from two student founders of these companies received help from working on the FSC projects are attached with this report.

All the WIL project results are presented in the following two documents: 2021 ANNUAL REPORT Community-Engaged Project Learning and 2022 WIL Projects. These two documents are attached with this report as well as submitted as a part of the FSC activity report.

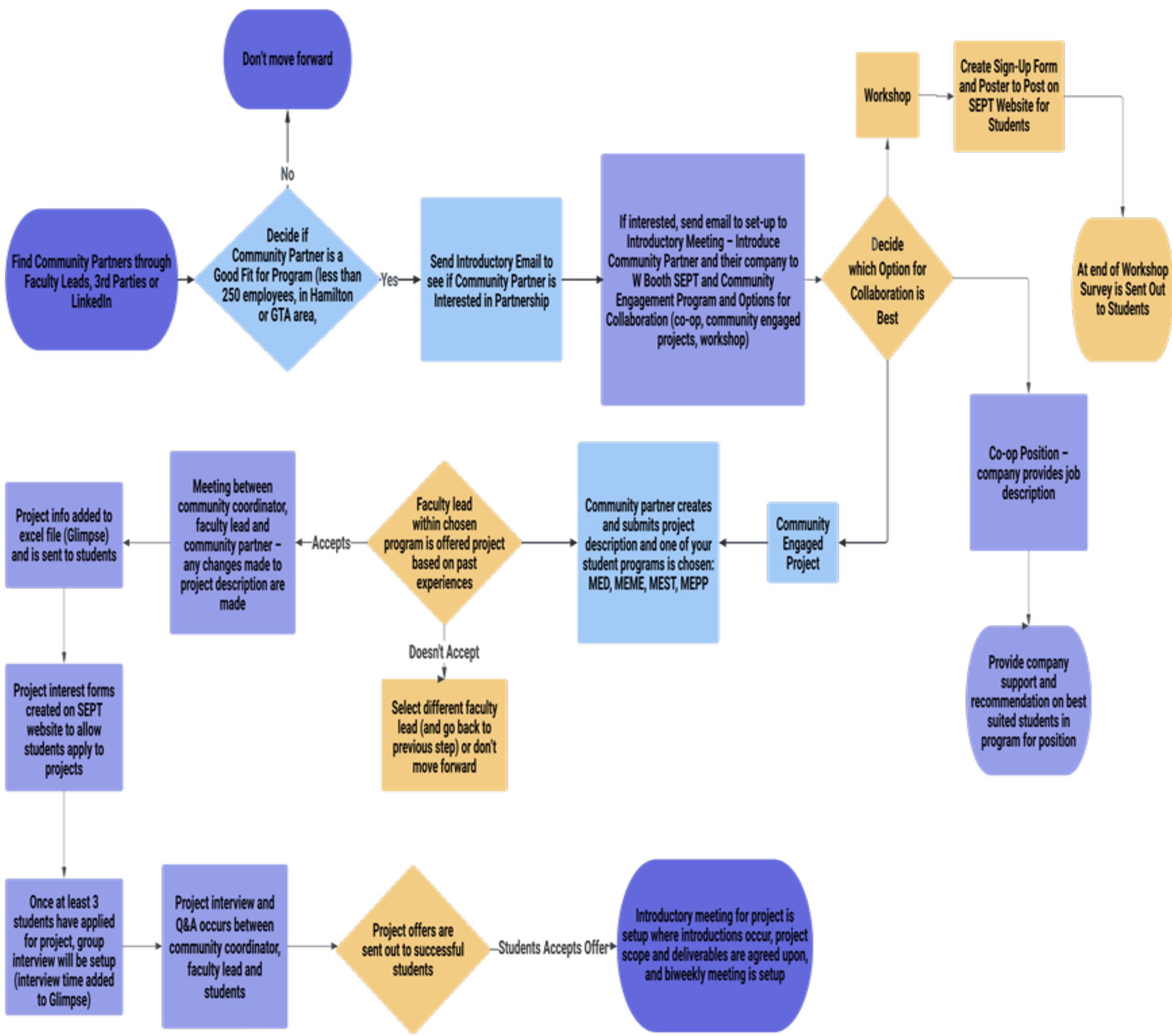
6. *Process:* How were the resources/ inputs to be used to deliver activities and outputs?

Given below is the process flow diagram that shows how the students will be engaged to solve the challenges (WIL Projects) proposed by the IMS Network Partners.

In case of the student's groups on the campus project teams, they will articulate their learning and project implementation goals to receive the needed resources to design and build their prototypes.

Similarly, the students employed via FSC funding will get their resources support based on the leaning modules they are developing.

As most student projects were done remotely as they needed small prototype components, microcontrollers, sensors, mechanical parts, software access. Two mechanisms were used to provide these supplies: either the student groups will buy the items and submit their receipts, or the SEPT will place the order directly and have the items shipped to the students addresses.



Process flow diagram that shows how the students are engaged to solve the challenges (WIL Projects) proposed by the IMS Network Partners. Once the student accepts the project the next steps are bi-weekly meetings, a mid term report, final report and presentation followed by faculty evaluation with input from WIL partner. This process occurs over a period of two semesters. The details of this process are all documented in the WIL Processes Document attached with this report.

7. *Outcomes:* What did project partners anticipate to be the result of delivering the project as planned?

The expectation was to deliver a project mid-term and final reports to the community partners along with any prototype developed for the project. A sample final report along with a power presentation by the students to the community partner is attached with this document.

In case of the students' groups on the campus project teams, including the FSC employed group, they will design, develop, test and document the prototype and publish reports to be shared with others. These reports are available if needed.

Outputs (ie, number of WIL projects, # of modules developed)

A total of 81 WIL projects have been completed and there are 25 in different stages, 101 modules for hands-on laboratory experiments, 20 tutorials and 25 special projects completed. In addition, 10 workshops were delivered, and a total 7 papers presented at 2021 SEPT BRIC Symposium and 11 papers at 2022 BRIC Symposium. Further details and references to the BRIC Symposium are provided later in this document.

This is an addition to documenting WIL processes for future implementation in SEPT as well as a guideline for others to adopt to implement their WIL programs. A copy of SEPT WIL processes has been given in a previous report to FSC.

Outcomes (graduation numbers, employment data)

The number of graduates completing the M.Eng.. degrees in the SEPT are given in the table below (Degree Awarded). A significant point to note in this context is that in the fall 2020, 27 students registered for the S&T M.Eng.. degree and that this September 2023, we have 109 students who accepted our offers so far for S&T program. There are another 50 applications awaiting reviews (we can only select top-notch ones for the remaining applications). The total applications are more than 300. This is a new record of applications that shows higher popularity of this new program supported by FSC funding. It will well test out our limit of capacity. The graduation number increase in the table is solely due to the increased enrolment in the S&T program. Please note that it is difficult to directly co-relate the graduation numbers with the enrolment numbers as at different times the number of students on co-op is different. As well some students are on co-op work term for 4 months, some on 8 months and others on 12-to-16-month co-op.

SEPT M.Eng.. enrolment is the highest in the in the engineering faculty at McMaster University due to the practice based, co-op enabled, and WIL based offering and has increased due to the enrollment in S&T program as noted above.

Degree Awarded
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			2022	2021		2020		2019	
Student Career	Student Faculty	Education Level	2023 Winter	2022 Winter	2022 Spring/Summer	2021 Winter	2021 Spring/Summer	2020 Winter	2020 Spring/Summer
Graduate	Faculty of Engineering	Graduate Master's Degree	3	49	37	28	31	18	12
Grand Total			**3**	**49**	**37**	**28**	**31**	**18**	**12**

Employment Data: 94 per cent of McMaster engineering graduates (provincial average of 93.1) are employed within six months of graduation and 96 percent after two years. The graduate student placement record across university is not available currently and McMaster SEPT is considering started collecting this information.

As seen in the SEPT Meng Enrolment Co-op Placement Data attached to this report, shows the high success rate of the S&T (also referred to asl MEST) students. In addition, it should also be noted that the MEME program WIL projects that have been supported by the FSC funding is also high in co-op placement numbers. The MEME program also prepares the students in the use of digital technologies related to manufacturing particularly CAD, 3D printing, Manufacturing Processes, and Lean Manufacturing etc.

As mentioned above two major documents describing the M.Eng. WIL Projects are attached with this report.

8. What assumptions were initially made about the project to achieve its objectives? (Example: participant recruitment, involvement of key stakeholders, etc.).

It was expected that there will be more than 30 IMS partners engaged with the WIL students and completing 60 projects addressing the digital technology challenges of these partners. More than 30 learning modules and 20 technology papers on topics described above will be developed and distributed to IMS partners for accelerating the adoption of IoT, IIoT and Industry 4. It was expected that 40 students will be enrolled in the S&T program each year and about 20 to 25 students enrolled in the undergraduate smart systems option in the B.Tech. automation program. We also expected to hire two post-docs to work on the Industry 4. protype type development components of the project and a community engagement assistant to support the delivery of these programs.

* Did you recruit the kinds of/ numbers of students you had initially envisioned?

The enrolment started with 27 students in 2021, with diverse academic background, registered for the S&T M.Eng.. degree has since climbed steadily for this September 2023; we have 109 students who accepted our offers so far for S&T program and 50 on the waiting list. More details of enrolment covered in an earlier section and the data is attached with this report as well.

* Did the anticipated interest among employer WIL partners emerge? why or why not?

We now have a total of 60 WIL partners including McMaster faculty-initiated community-oriented supporting WIL projects and secured 120 projects. This list is constantly changing as some WIL projects come on board and others are finished. We have more projects than the number of students opting for WIL projects.

9. What contextual factors were anticipated that might affect how the project is delivered?

It is possible that we may have more projects than the number of available students in the new programs due to the COVID-19 issue. In this case, efforts will be made to get students from existing programs with identified matching capability requirements of the network members' project. Another challenge maybe if the students do not have transportation to regularly visit the site of the network partners' workplace. In such a case a special arrangement will be made.

This report includes the WIL projects attempted by the undergraduate students to address this issue.

10. How was success initially articulated for this project?

The following criteria will be used to monitor the success of this project: the number and types of projects undertaken; the number of students engaged in Industry 4.0 projects; assessment of technology transfer; the feedback from the network partners engaging the students for solving their challenges and Industry 4.0 module use; the number of co-op positions offered by the network member organizations; and student career placement successes.

11. What did we learn about how the program is being implemented?

a. **How can we improve uptake of new frontier technologies in firms and generate sufficient WIL program projects for students?**
   The first step in establishing IMS Network was to make new contacts and set up an introductory meeting. At this meeting we describe SEPT programs, faculty expertise, SEPT labs and learning resources, and the goals of the WIL projects. The potential net work partner is given the opportunity to describe their

business and the type of collaboration they are exploring. Many such clients will request for another meeting with their technical experts or managers for further follow up. Not all the contacts that have been made have led to securing WIL projects from them. An important part of this process is to emphasise the mutual benefits and for the partners to understand that the type of project they can provide is not the one they need to have it done according to their timetable instead of the academic schedule as well as the risk involved and the time commitment on their part for mentoring the students and participating in the meetings. We have learned that these are very important conversations for the success of the WIL engaged projects.

Outcomes: i) This effort has resulted in more then 40 IMS Partners/Collaborators; ii) and there are 15 other potential collaboration with whom discussions have taken place, but they have not submitted their challenges yet.

b. **How can we support engagement, information, sharing and collaboration between academic leads, industry partners and students?**
After the initial discussions the potential IMS partner is sent a project proposal template (a copy is attached with this report) and if required an example of a previous proposal as a reference point for developing their challenge. These proposals form a basis for developing a glimpse of projects that is shared with the students and faculty. A prior step in this process is matching the expertise of the faculty with each project and consent obtained for faculty to supervise the project. The next step involves setting up an interview styles meeting with each group of students who have are interested in the project, with the interested faculty and community engagement person. At the end of the meeting an email is sent to the students who are considered suitable for the project they have shown interest and students given a deadline to acknowledge if they will accept the project. The next step involves a series of biweekly meetings attended by the students and IMS partners, faculty and community engagement personnel. At the end of the semester the students presented their solution and submitted a detailed report which was evaluated by the faculty involved with some input from the community partner.

Outcomes: Over the last two years of this project, we had a maximum of 105 projects that formed the basis of the project glimpse shared with the students.

Evaluation: The IMS Partners engaged in WIL projects were requested to provide their feedback on the WIL processes. Some of the key questions answered by them are as follows:

c. **What resources are required to meet the expectations of WIL partners and for students to sufficiently demonstrate their competencies when using new technologies?**

An important element of this project has been the resources needed to support the building and testing of prototypes by the students engaged in WIL projects. These resources have been made available using the FSC funding. The students select WIL projects over the course-based M.Eng. degree to gain hands-on experience in solving community partners challenges. This answer is repeated over and over, during the interviews with the faculty and community engagement personnel, by the student why they choose to work on WIL projects. Based on the requirements of the project each group of students need different prototype components and often are related to the latest technology implementation. Most of these projects have been listed in the quarterly reports but do not state the outcomes of each project. A detailed list of these projects illustrating the challenges and the outcomes will be made available at the end of this project. All projects that needed funding support were quite successful in achieving the learning/goal outcomes and demonstrating the prototype to the community partners. Some projects involved hardware and software others required only software and other were of design nature.

Outcomes: Number of WIL Projects Completed and Underway

Start Date	End Date	Number of Projects
Jan 2021	August 2021	18
May 2021	Dec 2021	7
Jan 2022	August 2022	40
May 2022	Dec 2022	16
Jan 2023	August 2023	15
May 2023	Dec 2023	24

Evaluation: The students engaged in WIL projects were requested to provide their feedback on the WIL processes. Some of the key questions answered by them are as follows:

d. **How do we develop stronger employer interest in new learning modules and prototype projects in new technologies?**
One of the original goals of this project was to design , develop and test IoT, IIoT, Industry 4.0 leaning modules for hands-on experience by the learners. It was also stipulated that these modules will be shared with community partners for their colleagues to get a hands-on experience in understanding these digital technologies of the new era and put them on to learning path for implementation of these concepts in their workplace. In addition, these modules will form the basis of Systems and Technology lab courses. Only a very few community partners participated in this part of the program due to mostly

COVID-19 related issues at the workplace and in other cases they did not have enough human resources to take advantage of this offer. In other cases, the community partners were involved to see what they can learn about the new technologies from these WIL projects. Some of these modules have earned international attention as reported in quarterly reports. We encouraged our community partners to take advantage of the IoT/IIoT learning resources we have developed. Two companies did take advantage of our offer listed in the outcomes below.

These learning resources have also been used to deliver various virtual workshops that have been reported in the quarterly reports as well as have formed the basis of many smart system courses listed in the outcomes section.

<u>Outcomes:</u>

I. Here we report two cases where learning modules and knowledge was shared beyond the scope of the Wil projects: CareGo has been very supportive of the WIL program and over the last two years they have provided many of their challenges that they want to solve for implementation at their workplace. In collaboration with them we developed the following plan to deliver lunch time learn and engage program with their employees. i) IoT Communication Protocols; ii) IoT Open-Source Resources; iii) Introduction to Data Analytics; iv) Data Analytics and Machine Leaning; v) Power BI Introduction; vi) Power BI Advanced. The first of these workshops was delivered on Oct 5,2021 and was attended by 22 persons with very positive feedback. The main goal for the CareGo was as follows: " As discussed our interest lies in workshops to spark ideas with our staff, not how to implement but what technologies are out there so that we can incorporate then into our R&D and Product Development programs."
II. The second case involved in helping a community partner in the selection of a 3D printer and how to optimize their 3D printing processes and models.
III. More than ***<u>one hundred and one lab experiments and prototypes</u>*** have been developed.
    a. A list labs and prototype models along with a sample lab is attached.
IV. We supported a high school teacher with IoT labs along with a class set of home automation kit for his computer course.
V. Special Topic Tutorials: 4-20mA current loop (6), IEC62443 Cybersecurity(9), Micro 820(5), Sinking & Sourcing(7), MacIoT Board, PCB Development, React, Solenoid Valve CAD Design etc. More details are given later in this report.

<u>Evaluation:</u>

e. How to support the development of technical and soft skills (problem solving, teamwork, etc. among students).

Initially the program was designed to support and establish the newly launched SEPT Systems & Technology program. COVID-19 impacted a quite a bit as all the programs and courses in SEPT were moved to the on-line format which resulted in students working on their projects remotely with out access to the on-campus lab resources as well as access to the community partner's workplace for WIL projects. The projects chosen by the students required different type of resources that were easily available to be shipped to the students' homes or they required more software type of resources that were easily downloadable from the commercial sites. As well as several students from other M.Eng.. stream approached for a similar support to the S&T students. The M.Eng. students in the following streams were all offered the opportunity to get the support from FSC team of students and funding for the prototype development and testing: manufacturing, engineering design and entrepreneurship. Some of the highlights of these projects are listed in the outcomes below.

<u>Outcomes:</u> The students in the manufacturing, design and entrepreneurship programs received technical support as well resources for building and testing their prototypes. Some of the salient outcomes are as follows:

- ***I.*** Supported the vision of a Canadian SME GoWrench to DISRUPT AUTONOMOUS VEHICLE INDUSTRY by putting together a multi disciplinary team of manufacturing and systems technology students working on the WIL projects. (Faculty Leads: Dr. Moein Mehrtash and Dr. Ishwar Singh)
- ***II.*** Firefighters risk exposure to hazardous materials, including chemicals linked to various forms of cancer. It's important that they thoroughly decontaminate themselves, their gear and equipment following a fire event. The Orangeville Fire Department engaged SEPT design students and faculty to help ensure this routinely happens at its facilities. (Faculty Leads: Dr. Robert Fleisig and Dr. Marjan Alavi)
- ***III.*** Two groups of manufacturing and engineering design students delivered prototypes of wheelchairs and special components for the Burlington Rotary Club:
  - ***a.*** Uganda Wheelchairs: 5 wheelchairs manufactured and assembled (Faculty Lead: Dr. Ishwar Singh and Community Partner Mr. Peter French)
  - ***b.*** Design of a Propulsion System for Uganda Wheelchairs. (Faculty Lead: Dr. Robert Fleisig and Dr. Ishwar Singh, Community Partner Mr. Peter French)
- ***IV.*** Supported Emergency Responders Association to Promote Smart Technologies. Two groups of engineering design stream of students worked on this project. The use of drones for such tasks was considered and demonstrated as an option for these projects.
- ***V.*** Supported the student teams in the entrepreneurship Proof of Concept course. These students received support for the following purposes: background in technical knowledge, support to identify and purchase prototype components, weekly meetings, and final evaluation and feedback.
  - ***a.*** Major Support to Team Daton: RBC EPIC Business Model Canvas Competition Made the Semi Final: https://www.youtube.com/embed/fa3G6OG0jQ0
    Project Demo:https://drive.google.com/file/d/1OJHkWeaUDR2VUQnHiAi_KtJbcksPhK5L/view?usp=share_link

b. Major Support to Team ThunderVolt: Portable Battery which is Safe, Durable, Easy to Navigate and Long Lasting Navigate & Long Lasting. This team received $5000 funding from McMaster University
c. Minor Support: Team Micelle: Ophthalmic Drug Delivery Prototype
d. Minor Support: Team NOBLE : Development of Neonatal Laryngoscope Prototype
e. Minor Support: Team S-13: RBC EPIC Business Model Canvas Competition Made the Final and Won the People's Choice Award: https://www.youtube.com/embed/fa3G6OG0jQ0

Evaluations:

I. The students in 1 to 5 projects passed their WIL project course with excellent marks. The students in line item 6 above passed their proof-of-concept course and were evaluated as follows: Was known knowledge articulated? Was new knowledge articulated? Were gaps (i.e., risks) articulated? What are the gaps (i.e., risks) to move from known knowledge to new knowledge? Was the bridge (i.e., a proof-of-concept plan) articulated? Was the journey (i.e., actual proof of concept work done) articulated? Was success shared? Were struggles/failures and lessons learned shared? and Were next steps articulated?
II. These students were included in the program feedback survey results along with the students' projects reported above.

f. How to support the development of technical and soft skills (problem solving, teamwork, etc. among students)?

One of the risk factors that was considered in the early stage of this project was to anticipate what could be done if there were more WIL projects then the number of students in the M.Eng. program opting for these projects. This is precisely what happened early in the program that we had 105 projects and were not all selected by the M.Eng. students. This led to opening WIL projects to the B.Tech. undergraduate students in Automation, Automotive, and\ Smart Systems Capstone as well. There were several differences in working with the undergraduate students as compared to the students in the M.Eng. streams. A key difference being these students are on a different semester schedule as compared to the graduate students. The B.Tech. students will work on Part A of the project during the months of Jan to April and then go on a co-op work term from May to August and then come back to work on the Part B of the project from Sept to Dec. In addition to this difference these students' capabilities and approaches to the WIL projects needed a much closer supervision and support. These students undertook to work on WIL projects that are listed here in the outcomes below.

Outcomes:

I. Prototype developed for IoT Carbon Monoxide Detector in Collaboration with Longan Vision Wil Partner
II. Prototype Developed for Sunshade Control System in Collaboration with Jans Awning Wil Partner
III. CAD Model Developed for 6-Axis Robot and 3-Axis Robot in Collaboration with AXIBO
IV. Completed SEPT-Axibo Cheetah Capstone Project
V. Completed Smart Home for Aging-in-Place (SHAPE) Project
VI. Completed a prototype of Portable CNC

g. How to Support Campus Wide Digital Technology Projects?

The B.Tech. programs are known for hands-on labs, current curriculum based on the capabilities required by the employers, co-op placement for 12 months supported by teaching tack faculty members, a dedicated support staff and industrial advisory committee for each program, and a state-of-the-art learning factory. The students in the engineering program often apply for working in the learning factory to gain more hands-on experience with the newer digital technologies. In addition, they join or start a new campus wide student team to tackle a challenging problem, participate in a competition with the aim of gaining hands-on experience and teamwork in the use and adoption of new technologies. Such groups were supported to enhance the impact of this project on a larger body of students to prepare them for the accelerated adoption of smart systems and digital technologies in the workplace after their graduation. The groups that have been supported by this project are McMaster Neudose, Mars Rover, Rocketry, ImaginAble Solutions, and AutoPlow and miscellaneous group of student teams.

Outcomes:

I. AutoPlow team has been established by Yuxiang Guan (connecting with Dr. Ishwar Singh to design and build a spray robot for disinfection during the COVID-19) to build an autonomous sidewalk snow plowing robot and ROS training and learning modules. https://sites.google.com/view/autoplow/home?authuser=0
II. ImaginAble Extended their Design for use of their product by different special need populations and provided training to new students joining the volunteer group.
III. Rocketry Team Fueling Innovation: We are a student run team based at McMaster University in Hamilton, Ontario, Canada. We design, build, and launch rockets and innovative payloads. Recently, we had a successful launch to 3km (10,000ft) in altitude at the inaugural Launch Canada Competition! We are now working on building an improved solid rocket for 2023 competitions and developing a hybrid rocket for 2024 with funding support from FSC project.
IV. Mars Rover
V. McMaster Neudose

a. https://www.cbc.ca/news/canada/hamilton/mcmaster-satellite-neudose-launch-1.6773542
b. https://brighterworld.mcmaster.ca/articles/mcmaster-satellite-lifts-off-from-kennedy-space-center/

12. Tutorials

More than 20 tutorials have been prepared. Some of them have been prepared for workshops, others at the request of community partners, and to be shared with students, faculty and other users for their upskilling or for classroom use. The details of these tutorial are available from the author of this report. A simple tutorial is submitted along with this report and will be shared with the annual report. Table below provides the list of these tutorials.

No	Tutorial Topic	No	Tutorial Topic
1	Printed Circuit Board Design -1	11	Machine Learning - Python
2	Printed Circuit Board Design -2	12	IoT Implementation - Applications
3	MacIoT Board - Junior	13	PowerBI Introduction
4	MacIoT Board - Advanced	14	PowerBI Advanced
5	Lora & LoRaWAN	15	OpenCV Research
6	Zigbee technology & Applications	16	Predictive Analytics-Visualization
7	Webot & Bilby Rover Robot	17	Machine Learning at Edge Node
8	Microcontrollers and Electronics	18	Introduction to Drones
9	Basic Python Coding	19	Li-Ion Batteries - Portable Charger
10	AI and Machine Learning	20	3D Printing

13. Special Projects- Application Prototype

More than 16 special project-application prototypes have been developed. These protypes have been developed to demonstrate the applications of digital technology for different applications and are available for education and training examples. The details of these special projects are available from the author of this report. One such project is submitted along with this report and will be shared with the annual report. Table below provides the list of these projects. All these projects have a great potential for future applications, some of them have already been recognized internationally as mentioned below.

No	Project Title	No	Project Title
1	CityLab-Cellular Video Streaming	9	Digital Twin
2	Smart Safety Seat	10	IoT/IIoT Integration Platform
3	OpenBelt 3D Printer	11	Cybersecurity Tools

4	OctoBot-Robot for 3D Printing	12	Ventilator Redesign
5	AXIBO Robot Arm: A Lightweight 3D Printed Robot	13	PolyFormer: Recycling PET bottles into filaments for 3D-printers
6	Virtual Doctor Platform	14	Kafka -
7	Robot Joint Design	15	Autonomous Driving
8	Smart City Platform	16	Manufacturing Execution System

Smart Safety Seat is designed to safe lives in vehicle accidents and has been entered for two international awards: Dyson and Prototype for Humanity.

OpenBelt 3D Printer: An Open-Source Conveyor Belt 3D Printer: A Continuous Bed 3D Printer: Swaleh Owais started this project with the author in 2018 in the LF and lately finished the final prototype with FSC funding support. This has been made into an open-source project: https://hackaday.io/project/114738-automatic-infinite-3d-printer This project has enabled Swaleh to go to Kigali, Rwanda and help them in establishing a 3D printing facility supported by international funds. This project was presented to our students in a FSC workshop on 3D printing organized last year. The Automatic Infinite 3D printer was well received by the 3D printing community. The project won several awards and the demo video received hundreds of thousands of views on YouTube: https://youtu.be/E_RvnqVHbnA Future Skills Center (FSC) Support: This project was generously supported by the Future Skills Center (FSC) federal program, via McMaster University. Complete documentation links along with this YouTube, Swaleh acknowledge this in this video link that provides detailed instruction for making it. https://www.youtube.com/watch?v=gruBm8ppwgY&t=67s

PolyFormer: Open-source machine recycling PET bottles into filaments for 3D-printers Recycling Waste Plastics into 3D Printer Filament: this FSC funded project has been developed by Swaleh in co-operation with Reiten Cheng (project designer) a student.This project has won the following awards: **Hackaday 2022 3rd Place Award: this 3rd place award ($15,000)** was presented to Swaleh and Reiten at the Hackaday Supercon 2022 , Pasadena, CA. This link below at 18.57 minutes shows the presentation of this award: https://www.youtube.com/watch?v=IqhjMuHKeGc. This project also won 2022 **James Dyson Award: Global Sustainability Winner awarded to Canadian entry Polyformer** *:* this award of ~$50,000 is shared equally by Swaleh and Reiten. Here is the link to the press release:https://www.dysoncanada.ca/en/newsroom/overview/press-release/2022-james-dyson-award-sustainabilitywinner In addition this project was awarded Global Grade Show Travel Award: please see links below:
https://www.globalgradshow.com/
https://www.prototypesforhumanity.com/project/3d-plastics/

This project has been made into open source and is now active in 10 countries. We are now working on a mini version of this machine.

Virtual Doctor Platform: This project demonstrates how internet technology can be leveraged to provide a virtual doctor platform for any physician with out the use external internet resources and is the first of its kind for real-time monitoring of a biomedical parameters.

Cybersecurity tools: this is one topic where there is lack of teaching material, based on cybersecurity standards, badly needed for education and training. Every day one comes across news either there has been a cyberattack at corporation website/infrastructure or lack of cybersecurity talent for different organizational needs. We have prepared in-depth leaning material on this topic and lab experiments.

14. WORKSHOPS FOR TECHNICAL SKILLS - Fall 2021

I. Learn basic python commands and applications. Topics include variables, loops, functions, arrays, libraries and more. Workshop 1: October 12th,2021, 3-6pm

II. Learn about computer modelling as well as 3D printing with live demonstrations followed by presentations by 3 experts in the 3D printing industry. Workshop 3: October 14th,2021, 3-6pm

III. Learn how to use sensors, software, and other technologies to exchange information between physical objects. IoT is the future of manufacturing! Workshop 2: October 13th, 2021, 3-6pm

IV. Learn how to use computer software to analyze data and predict future outcomes. You will learn important information regarding Artificial Intelligence. Workshop 4: October 15th, 2021, 3-6pm

V. SEPT Workshop: Workplace Culture and Career Trends - Insights from a Canadian Perspective: January 29, 2022, 10:00 AM-11:30 AM

15. WORKSHOPS FOR TECHNICAL SKILLS - Fall 2022

The following workshops were offered in the fall of 2022:

I. **Internet of Things (IoT)/Industrial Internet of Things (IIOT) for Smart Systems :** Learn how to use sensors, so�-ware, and other technologies to exchange information between physical objects. IoT is the future of manufacturing! The presentation will be followed by two project demos.

II. **Python and Machine Learning:** variables, loops, functions, arrays, various ML & AI libraries and more. Also, data set mathematics and statistics will be covered as an application of Python modules in AI & ML

III. **MacIoT** - A Hands on Workshop Learn how to program a MacIoT Learn how to program a MacIoT board using C++ in this hands-on workshop. The MacIoT board can be used in numerous sensor and communication applications. We will be giving out 20 MacIoT boards to undergrad and 20 to M.Eng. students.

IV. **Microcontrollers, Arduino and Electronics:** Learn the basics of microcontrollers and microprocessors , Arduino platform and options, digital and analog sensors and electronics, and IoT sample application.
V. **ROS 2 Platform:** Learn what is ROS, what are the different ROS distributions, ROS 2 basics, what are the difference between ROS and ROS 2, and ROS applications. This was a specific request by the McMaster Rocketry Team, AutoPlow group, and ArchoCell (a new startup company).
VI. **LoRaWAN Hands-On :** In this seminar an overview of various wireless technologies was presented along with introduction to LoRa and LoRaWAN. This was a specific request by the McMaster Rocketry Team.
VII. **Workplace Culture and Career Trends - Insights from a Canadian Perspective:** January 28, 2023, 10:00 AM-1PM

About 54 students registered for the first 3 workshops and 25 students completed the surveys. The key findings from this survey are:

i) 5 students were from the engineering program (3 from mechatronics, and 2 from software), 9 students were from the bachelor of technology program (7 from automation, and 2 from automotive and vehicle) and 11 students were from a SEPT Graduate program (one from design, one from manufacturing and 9 from systems and technology)

ii) 2 students identified as Caucasian, one student identified as African American, 14 students identified as Asian, 3 students identified as Hispanic, 4 students identified as Middle Eastern and only one student with disability.

iii) 16 of the students surveyed attended the workshop out of interest, 2 attended the workshop as a seminar, 5 students attended the workshop as a part of their Masters in Engineering Project, one student attended the workshop as a part of their Bachelor of Technology Project, and 4 students attended the workshop as a part of their Extracurricular Project

iv) 17 of the 25 students surveyed had a positive or neutral opinion of the program in relation to its effectiveness in preparing the student for the digital era

v) 23 of the 25 students surveyed were satisfied with the program

vi) 21 of the 25 students surveyed agreed that the program has/will help them advance in their career

vii) 23 of the 25 students surveyed were likely to recommend someone else to the program

Feedback for the last two workshops was very positive:

16. Impact on New & Revised Courses

Graduate Courses: One of the core courses for the S&T is the Cyber-Physical Systems to support this course 15 labs were developed on a robotics platform designed in collaboration with AXIBO. This platform and course material has been shared with faculty and students for their hands-on experience in use the ROS applications. This platform has a flexible design to accommodate new sensors and new single board computers as well. In addition, a class set of 3D cameras have been supplied and other supporting equipment. These cameras can be used in a new course Visual Perception for Autonomous Vehicles. This plat form has been used by two groups of S&T M.Eng. students for their WIL projects.

The IoT and IIoT resources materials developed, along with hardware components acquired, have been shared with the professor teaching the Internet of Things (IoT) and industrial Internet of Things (IIoT) Systems course. Currently we are working with the instructor to design a LoRa and LoRaWAN hands-on lab. For the Advanced Robotics and Automation course a class set of robotic car kits have been provided. These kits have already been used by 3 groups of students , over the last year for their in-class special project at the end of the course. These small portable kits allow the students a platform to apply their knowledge gained in this course and other supporting courses to develop their hand-on skills and capabilities. For the Industrial

Automation courses a set of Factory IO platform have been provided. Factory I/O is a 3D factory simulation for learning automation technologies. Designed to be easy to use, it allows to quickly build a virtual factory using a selection of common industrial parts. Factory I/O also includes many scenes inspired by typical industrial applications, ranging from beginner to advanced difficulty levels. The most common scenario is to use Factory I/O as a PLC training platform since PLC are the most common controllers found in industrial applications. This platform is very useful for teaching an on-line PLC course as well for providing experience prior to performing hands-on labs. This platform has been consistently used since the launch of this project.

A key offering for the S&T is the Sensors and Actuators course. For this course a set of 6 hands-on lab experiments listed in the labs document have been developed and used every year in two offerings of this course. Currently the robotics platform described above is also being used in this course for a basic introduction to autonomous driving using Lidar data.

Undergraduate Courses: IoT, Industrial Networking, Smart Cities

17. What will we learn about how to use resources more efficiently to achieve the desired outcomes?

- Use open-source software platforms that do not cost anything.
- Use videotelephony software programs for all meetings and for some specific events and a few courses that fit the remote learning criteria.

- Hire students and train them to be your partners in the delivery of your programs.
- Provide opportunities for volunteer work in support the delivery of your program by providing volunteers an opportunity to learn new technologies as well.
- Explore hiring students who are eligible for OSAP as this provides an opportunity to get funding support in the for of wage subsidies. This is also a vehicle to help the students coming from low-income groups to advance their career aspirations.
- Effective use of the internet leaning resources and free cloud platform access for the students and faculty.
- Develop partnerships with small start up companies as they generally trying to develop products and services using the cutting-edge technology. The students working on their projects will benefit from their experience.
- Increase the in-kind contribution by exploring synergies within your organization in supporting the achievement of mutual goals.
- Define and limit the amount of funding resources that will be provided to each team based on their project proposals.
- Use low-cost learning kits to provide opportunity for in and outside class for hand-on experience.

18. Causal Attribution: To what extent will we learn about the extent to which any outcomes can be causally attributed to the project intervention? What information (qualitative or quantitative) would improve our confidence in the role the project played in achieving outcomes?

Just prior to this project approval the Systems and Technology M.Eng.. program had been approved but the internal funding to support the design and delivery was not certain due to the uncertainty that normally occurs when a new program is launched. Other existing SEPT programs that had WIL component had very limited access to the funds for prototype work for each project and there were also less opportunities for hand-on type of projects and hands-on lab development etc. The wheelchair project was started in 2017 by students enrolled into the manufacturing and engineering design streams. But there were no resources for supplies and lack of hands-on opportunities to work on very expensive manufacturing equipment that was available in the department. So, for several years the students refined the designs and proposed manufacturing methods such as a “Factory in a Box” concept described in an earlier M.Eng.. report. It is only after this funding was approved that we were able to not only support the main goal of this project but extend support to other existing M.Eng.. programs as well. Another example that can be used to illustrate the impact of this funding is the SHAPE House Project above. Prior to this funding several M.A.Sc students working on the project could only do a lot of design, conceptual work and very limited prototyping. This funding provided the resources to install all the basic sensors and actuators , networking infrastructure, smart energy monitoring, water leak detection, and data base storage system. The team of four undergraduate students working along with the author of this report and Dr. Feng sponsor of the project prepared a conceptual plan, material resources selection and procurement, installation of the wiring and switches and routers.

Another significant factor has been the support to design new hands-on labs for the new S&T M.Eng. and some smart systems courses for the B.Tech. program as shown in the section of Impact one New and Revised Courses.

The learning resources that have been developed would be available for use by the upcoming groups of students and faculty.

19. Co-op Placement and Impact on WIL Projects

20. WIL Project Learning Evaluations

In this section we consider various methods of evaluating WIL projects and their impacts. It is important to note the differences between the graduate and undergraduate WIL schedules. In the case of the undergraduate students, they start they complete part 1 of the project from Jan to April, and then they go on for a summer co-op work term and finish the second part of the project in Dec of the same year. Community partners have the option to hire undergraduate students to continue to work on their challenge during the paid co-op work term them. These students receive two main evaluations one for each part from the professor in charge of their capstone project with some input from the community partner and other faculty advisor associated with the project. In the case of all these undergrad WIL projects reported here the author was the associated professor working on the FSC project. The students receive a grade in this course based on McMaster's standard grade assignment scale. A copy of final presentation and report is distributed to all involved in this process.

The WIL schedule for the graduate program is different then the undergraduate schedule. They spend two consecutive semesters working on the WIL projects and go on to their co-op work term before or after completing the WIL project. If the students attempt their WIL project before the completing courses that provide them sufficient background and foundations to attempt the WIL project, they can face technical challenges that may be difficult for them to address while working on the project. The challenge faced by all involved is to give flexibility to the students in selecting their project timeline and the student be prepared well to meet the goals of the WIL project. The WIL project evaluation method in each of the M.Eng. streams is different. The engineering design program uses an evaluation scheme based on a rubric for assigning a grade between 1 and 10, which then is used by the professor to assign a final grade based on McMaster Scale. The community partner is also given the opportunity to complete the rubric and grade form with any written feedback that is given to the students if they need to revise any aspect of the report. The manufacturing stream on the other hand uses a satisfactory or unsatisfactory criteria for the report along with written feedback to the students. The final course grade is assigned by the professor in charge of the course. The S&T program started jut prior to obtaining this grant is the latest in the M.Eng. stream offerings and uses a scheme where the grade is totally assigned by the professor in charge of the class. The community partner has very little involvement in this process. This is one of the issues that will be brought forth for future discussion with the program lead of the S&T program.

21. Academic Program Design & Model for Supporting the Accelerated Adoption of Industry 4.0 Technologies in the Workplace

The highly successful SEPT B.Tech. 4-year undergraduate program in Automation, along with Automotive and Vehicle Technology, and Biotechnology, was launched in 2006 has the following key elements in its operational model: a proper balance of theory and practical curriculum based on the needs of the employers for adopting automation, that is validated by the industrial advisory committee, 12 month compulsory co-op, teaching only faculty with industrial experience, and above all hands-on labs supported by state of the art equipment, laboratory and networked computer infrastructure. This model was jointly designed and developed by McMaster and Mohawk B.Tech. Partnership. The B.Tech. students can use labs for their hands-on work at both campuses. This model offers a very efficient use of laboratory resources between the two institutions. In terms of the Industry 4.0 maturity index this program is between above level 2 and beginning of level 3 on the 6-scale maturity index (referred as "6 Stages in the Industry 4.0 Development of Path"). To offer programs that enhances the curriculum content to stages 3 and beyond, the author of this report, proposed a smart system stream at undergrad and grad level programs, during engineering dean's 2015 summer retreat. Consequently, a smart system stream in the B.Tech. program and S&T were approved and launched. This project funding was made available just in time to support these programs on-going development needs and supporting WIL projects as discussed here in this report. The M.Eng. S&T model provides a fast-track degree with the following elements built into the program structure: co-op placement, hands-on labs, course based or WIL project option. In this program the students have a lot of flexibility in choosing the list of courses to complete their academic requirements. This flexibility has opened admission to students coming from different undergraduate degrees. This program is particularly well suited for applicants with backgrounds in Electrical, Software and Mechatronics Engineering, Computer Science, Physics, Mathematics, and Automation Systems. Students from other engineering and science disciples who are comfortable with writing solution procedures as software code, and who wish to refocus their careers on automation or data science, are also invited to apply. This is one of the very few degrees that opens doors for the students who are looking for a change in career and move forward with their advanced credentials in digital technologies for the new era.

The success of this model and program is born out as discussed in the co-op placement data.

In terms of the industry 4.0 maturity index, it is difficult at this stage to assess the overall program level. However, the list of courses covers material up to maturity level 5 with some basics for level 6.

22. Learning From Supporting Campus Team Students and Projects

In this section we examine why and how to support campus teams for providing the skills and capabilities for the current and future workforce requirements. There are hundreds of campus clubs at universities and colleges, but the number of Engineering and Technology (E&T) teams is quite limited. These E&T teams can prepare students for the workplace and connect them with employers and build meaningful ties with the community beyond campus. Campus clubs and teams are mostly overseen by student unions and the level of oversight, support, training and funding differs tremendously from campus to campus. It is not easy to start a new technology team as they must go through several steps that may take one to two years as experienced by the students working with this author and not eligible for financial support immediately. The engineering and technology teams need financial resources to build their prototypes and achieve their stated goals. On many campuses there are some professors who have research funding that helps the to support some technical teams but that is not the case for most other technical teams who start their teams based on their future technology vision. All teams that have been supported by the FSC funding had very limited resources. They would not have accomplished their goals in the time required to participate in a competition tat offer tremendous learning opportunities.

"A mix of both small-scale qualitative and large-scale quantitative studies have concluded that participation in all kinds of campus clubs is correlated with success factors like improved critical thinking, personal development, academic and affective growth, leadership skills and ultimately postsecondary persistence. Club participation also encourages cross-cultural and cross-racial interactions between members. This improves members' knowledge and awareness of diversity and social justice issues" (https://www.universityaffairs.ca/features/feature-article/campus-clubs-offer-profound-subtle-learning-experience/).

These teams have also provided opportunities for the development of soft skills such as self-organization and understanding self-motivation, problem-solving capabilities, management, teamwork, and communication skills. As seen on the website of each of the teams supported by this project, they ,except for AutoPlow, have an organization structure along with the technical leads for different engineering and technology areas, updates on their activities and diversity of the membership involved. These websites also recognize the support provided by FSC project funding. The author meets regularly with these team members to help the with any issues at hand.

As discussed in this report these teams have a lot of success stories that validate above assertions.

23. Discussion and Implications

I. Is there a need to expand the program or project to reach new population groups or different geographies? Why or why not?
Based on the demographic data of student enrolment we have seen this program can be extended to other regions of the country. This fast-track M.Eng.. degree, supported by WIL projects and optional co-op placement can provide opportunities to the international students as well as to the graduates in the country who want to upskill, and/change their field of studies that will enhance their career goals with the digital skills in demand. This unique M.Eng. S&T program can be offered fully on-line to reach graduates in other provinces.

II. Are opportunities for other organizations serving the populations in question to adopt elements of what was being explored here?
The Academic Program Design & Models for Supporting the Accelerated Adoption of Industry 4.0 Technologies in the Workplace discussed above can certainly be adopted not only for the S&T M.Eng. degrees,(as well design engineering and manufacturing) but also the undergraduate degrees in automation and smart systems. A few common key elements of these programs are practice based theory, hands-on labs and projects, co-op placement opportunities and supported by WIL projects as a part of the degree requirements. These program models provide opportunities for continual curriculum renewal based on the current and future job prospects.

III. Did the project in question attract additional investment or partnership support over the course of the FSC engagement? If so, what factors might have contributed)?
The community partners (SMEs, New Startups, Municipalities and other groups) provided tremendous support to the students in mentoring them and providing their challenges while knowing very well that there was a risk as they may not get the results they were expecting. This support had an impact on securing co-op placement for the students and in many cases hiring them for full-time job opportunities. It is important to note that such programs do require more administrative and operational support as well. To facilitate the implementation of the WIL program, the services of a community engagement co-ordinator and assistant are required. This is where the FSC project had a huge impact in the delivery of the new program discussed in this report.
The factors that contribute to the community partners providing their challenges and support to the students are: small companies and community organizations have many R&D ideas but not enough technical support at their sites; therefore they welcome this opportunity for WIL projects; in other cases they have ideas but not

enough industry 4.0 foundational knowledge to implement their projects at their site; they also see that young people need mentoring support and are willing to commit their time to support these activities; and of course there is an expectation that a product or prototype is delivered to them at the end of the project. Some of our partners have been providing WIL challenges year after year.

IV. What larger lessons for service delivery did this project provide?

a. How to Solicit WIL projects and engage with potential WIL partner?
b. How to manage WIL processes and projects?
c. Explore collaborations for assisting IMS partners for accelerated adoption of Industry 4.0 beyond WIL project.
d. Engage the students in the selection of WIL projects.
e. Process steps involved in interviewing students for WIL projects.
f. Arranging and attending biweekly meetings attended by faculty lead and WIL community partner and FSC team member(s).
g. Technical consultation and advising beyond classroom experience.
h. Reviewing of reports; and providing feedback methods.
i. Use of different project evaluation models.
j. Selection and sourcing of appropriate parts for protypes.
k. Arranging lab space for prototype work.
l. Providing IT support.
m. Intervention processes to resolve technical and non-technical issues.
n. Support to campus teams for enhanced hands-on learning and training needs.
o. Support to individual group of students seeking support for their project learning.
p. Providing support for facilities services when required by a project, for example where to locate a solar desalination model for experiments by the students.
q. Students working on WIL projects needing financial support during the project.
r. Guiding the students for improving their communication, report writing and presentation skills.
s. Guiding students for professional interaction with the WIL partners including teamwork.

V. What larger lessons for policies at various levels of government should be discussed?

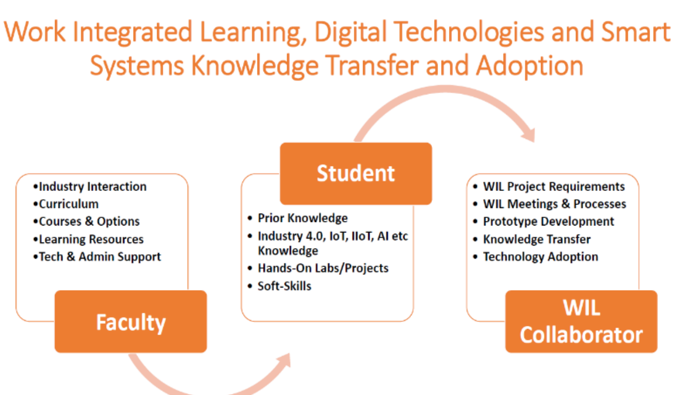
a. Nature of academic programs and models, including the curriculum, for the preparing the undergraduate and graduate students in supporting the industry providing appropriate skilled workforce for the adoption of digital technologies, beyond the soft skills.
b. How to support the implementation of different WIL models for the academic institutions?
c. Budget implications and financial resources for providing hands-on education and training. Often this is a very arbitrary decision at a local academic department and not given any attention at all. This author is one of the founders

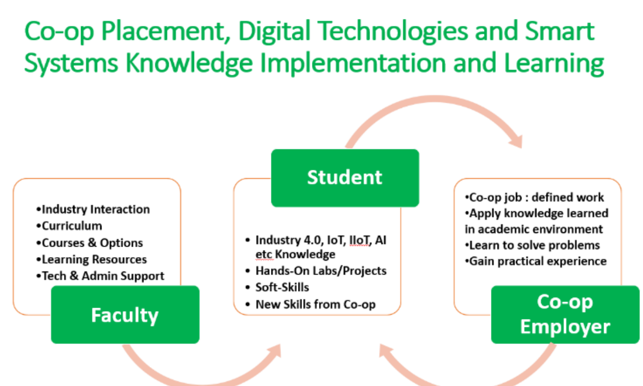
of the McMaster-Mohawk partnership and insisted during the MOU development process that 10% of the total budget every year be set aside for the development of hands-on labs and related projects. It is this policy that has seen the hallmark of success of the B.Tech.. programs (particularly the automation program in this context). This is the only program in Canada that fully supports the adoption of Industry 4.0 technology curriculum and hands-on state of the art laboratories and projects. However, when the M.Eng.. program, built on the top of B.Tech.. programs, was launched this was not the case as this program is not governed by the partnership. This is where FSC funding has been able to provide the necessary support for hands-on experience to the students in their classrooms and WIL project implementations.

d. Financial, technical, physical facilities for the campus teams. Most campuses provide limited resources for these teams, but a lot more needs to be done as the experience provided by these team activities goes beyond the classroom experience and prepare them well for their future careers in industry and academia.

24. Summary

The demand for professionals skilled in automation and smart systems, AI, accelerated computing, and high-performance computing, machine learning, and related digital skills such as Internet of Things (IoT) and cybersecurity continues to increase, leading to a significant gap in talent in these areas. SEPT B.Tech.. program in automation was launched in 2006 to address some of these gaps. In 2015 two smart systems/IoT technology programs, one at graduate level and second at an undergraduate level were proposed at a Dean's spring retreat. These two suggestions were implemented in 2019/2020 in the form of a smart systems option in the B.Tech.. automation program and a brand-new Systems & Technology SEPT M.Eng.. program offerings. A key element of this program is the availability of Work Integrated Learning (WIL) option that is designed to support the adoption of these technologies by SMEs, new startups, municipalities, and other sectors of society such as hospitals, and community organizations needing the deployment of digital technology platforms. These organizations often lack resources for experimenting and adopting these new technologies to enhance their product offerings, services, and improve their operations using digital technologies. The S&T program has been developed and





delivered, over the last two years, with FSC funding support to address the skills gap experienced by these organizations. The WIL and co-op model deployed for this program is depicted in Figure below.

Over the course of this project more than 120 WIL projects sponsored by the IMS Network partners have been secured and 81 projects have been completed. More than 20 tutorials have been prepared for sharing with IMS partners, as well as course material for student self-learning, and for future workshops to be offered by SEPT. We have also completed 16 advanced application prototypes for demonstration of different aspects of digital technologies, some in collaboration with IMS partners, and others for future adoption in labs and courses. We offered 12 workshops attended by SEPT and engineering undergraduates and newly arrived graduate students. We supported 5 campus teams that had a total membership of 281 engineering students. In addition, 3 special individual group teams also got support from this project. A very comprehensive WIL processes implementation document has been prepared and shared with FSC that can enable others to implement their own WIL projects. This document was tested by a new employee hired in the second-year operation of this project.

More than one hundred and one lab experiments and prototypes have been developed.

The enrolment in the S&T program, the focus of this project, has gone from 21 students in the first batch to 109 students accepted for this fall with a waiting list of 50 more students. This is a testimonial to the success of the S&T program supported by FSC funding.

18 papers were presented by the students at the two SEPT BRIC Symposiums and published 6 professional papers and a chapter in a book on IoT applications.

A very large number of students in the S&T program as compared to other SEPT M.Eng.. streams also secured co-op positions mostly with SMEs and big corporations looking for supporting their digital technology projects. This presented a challenge in managing some of the WIL project schedules.

The students who take advantage of the WIL projects along with co-op placement opportunities often secure full-time earlier than other students and many times with their co-op employers.

The feedback from the students, faculty and WIL partners has been very positive and samples are attached with this report.

The curriculum is designed for the S&T and smart systems option for B.Tech.. students based on IoT, IIoT, and Industry 4.0 are at the core of all activities related to the implementation of this project. During the interaction with IMS partners, it became very clear that organizations did not have a clear understanding of these technologies and needed much support for adopting in their workplaces.

There are no readily available tools for assessing the digital technology competencies of the employees followed by developing upskill plans and associated training resource materials, that can be followed by the adoption of IoT, IIoT, Industry 4.0, machine learning and AI technologies by these employees.

The SMEs, with fewer employees, and start-ups need nurturing and technical support for accelerating their progress in digital technology implementations. They often have great ideas and have developed their products and offerings but there remain some roadblocks in fully implementing them that need extra technical and financial resources. Their efforts are more devoted to their day-to-day operations just to stay active in their business.

Acknowledgements

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Appendix

I. Documents Attached with This Report

a. SEPT M.Eng.. Demographic Data
b. WIL Projects in SEPT 2021 Report
c. WIL Projects 2022
d. SEPT M.Eng.. Enrolment & Co-op Placement Data

II. Industry 4.0 Key Terms

Industry 4.0 is the preliminary result of a development that began almost 200 years ago. A brief review of the four phases of the industrial revolution:

Industry 1.0 1830-1871: Steam engine.

A greater amount of goods and products can be manufactured in mechanical production plants.

Industry 2.0 1871-1969: Electricity.

Assembly line and series production. Production is divided into individual, self-contained work steps. Globalization begins.

Industry 3.0 1970-End of the 20th century: Rationalization and automation.

First programmable controllers. Human labor is increasingly replaced by machines.

Industry 4.0 Digitization.

Robots manufacture alongside humans. Extensive networking of robots and machines with each other, with work pieces, as well as with customers and companies.

Industry 4.0 Related Terms

- **Enterprise Resource Planning (ERP):** Business process management tools that can be used to manage information across an organization.
- **IoT:** IoT stands for Internet of Things, a concept that refers to connections between physical objects like sensors or machines and the Internet.
- **IIoT:** IIoT stands for the Industrial Internet of Things, a concept that refers to the connections between people, data, and machines as they relate to manufacturing.
- **Big data:** big data refers to large sets of structured or unstructured data that can be compiled, stored, organized, and analyzed to reveal patterns, trends, associations, and opportunities.
- **Artificial intelligence (AI):** Artificial intelligence is a concept that refers to a computer's ability to perform tasks and make decisions that would historically require some level of human intelligence.
- **M2M:** This stands for machine-to-machine and refers to the communication that happens between two separate machines through wireless or wired networks.
- **Digitization:** Digitization refers to the process of collecting and converting different types of information into a digital format.
- **Smart factory:** A smart factory is one that invests in and leverages Industry 4.0 technology, solutions, and approaches.
- **Machine learning:** Machine learning refers to the ability that computers must learn and improve on their own through artificial intelligence—without being explicitly told or programmed to do so.
- **Cloud computing:** Cloud computing refers to the practice of using interconnected remote servers hosted on the Internet to store, manage, and process information.
- **Real-time data processing:** Real-time data processing refers to the abilities of computer systems and machines to process data and provide real-time or near-time outputs and insights continuously and automatically.
- **Ecosystem:** An ecosystem, in terms of manufacturing, refers to the potential connectedness of your entire operation—inventory and planning, financials, customer relationships, supply chain management, and manufacturing execution.
- **Cyber-physical systems (CPS):** Cyber-physical systems, also sometimes known as cyber manufacturing, refers to an Industry 4.0-enabled manufacturing environment that offers real-time data collection, analysis, and transparency across every aspect of a manufacturing operation.
- **Network Infrastructure:** Consider connectivity and scale, AI-powered automation, security, flexibility, and agility, and/or employ as a service.
- **CAD/CAM Systems:** They are modern manufacturing and design tools. 3D model for visualization and digital twining.

- **Generative Design:** Generative design is a design exploration process. Designers or engineers input design goals into the generative design software, along with parameters such as performance or spatial requirements, materials, manufacturing methods, and cost constraints. The software explores all the possible permutations of a solution, quickly generating design alternatives. It tests and learns from each iteration what works and what doesn't.
- **3D Printing/Additive Manufacturing**: It is one of the pillars of Industry 4.0 like other digital technologies. This technology has transformed the traditional patterns of production methods. The use of 3D printing /additive manufacturing combined with other technologies including 3D CAD Modeling allows to quickly model a project and even finalize it.
- **Robots/Cobots**: Industrial robots emerged at the dawn of Industry 3.0, along with computerized control and automation, and have evolved over many years, becoming specialized for various industries and processes. Robots are designed for mass production; they are solitary, working in relative isolation on specific tasks. With the emergence of Industry 4.0, cyber-physical systems, and the Internet of things (IoT), some robots evolved into collaborative robots, called cobots. Cobots interact with their environment, including people and other robots, and support flexible manufacturing and mass customization.
- **3D Vision Systems/Machine Vision:** Machine vision is an indispensable component of every automated environment. This is true for hardware - such as in robotics - and in software for image analysis purposes or for training artificial neural networks (Deep Learning).
- **Digital Twins:** A digital twin is a digital representation of a physical product, system, or process (a physical twin) that serves as the effectively indistinguishable digital counterpart of it for practical purposes, such as simulation, integration, testing, monitoring, and maintenance.
- **IT/OT Integration/Convergence:** IT/OT convergence describes the merging of information technology (IT) and operational technology (OT). While these departments have traditionally been siloed, IT/OT convergence integrates the tools businesses use to collect data (IT) with the tools it uses to control processes (OT).

Industry 4.0 Implementation Checklist

1. Select and implement technologies that enable data collection and analysis for obtaining insight from the collected data. A key step in this process is to define the following parameters for the data to be collected and analyzed: Kind of Data; Amount of Data to be Collected and Stored; How to store the Data; Data Store Time Frame; Format of Data; Data Location and Infrastructure Required; and Methods to Access Data.
2. Assess the digital skills of employees for the above task. Set up a training program based on this assessment and to introduce Industry 4.0 concepts for implementation in your specific workplace.
3. Capture and digitize all design, planning and operational the knowledge and experiences acquired by process designers, operators, and managers. The goal is to be able to use this knowledge to develop deeper insights for future decision.
4. Use decision-support systems based on analytics and AI support for operational decision-making.

5. To implement above tasks consider using available open-source tools or commercial products such as Manufacturing Execution Systems (MES)
6. Implement cybersecurity. This has become a critical requirement for modern organizations be small or big.
7. Consider adopting Industry Standards/Regulations based on your specific operations.

Information Sources:

https://www.epicor.com/en-ca/blog/what-is-industry-4-0/

https://www.arubanetworks.com/assets/eo/eBook_Network-Modernization.pdf

https://www.google.com/search?client=firefox-b-d&q=regenerative+design

https://www.digikey.com/en/articles/robots-evolve-to-cobots-in-industry-4-0

https://www.baslerweb.com/en/vision-campus/markets-and-applications/what-is-the-role-of-computer-vision-for-industry-4-0/

https://www.emnify.com/iot-glossary/it-ot-convergence

III. Industry 4.0 Maturity Index

A PowerPoint Presentation is attached with this report.

IV. B.Tech.. Capstone Projects-Evaluations

Evaluations:

I. IoT Carbon Monoxide Detector in Collaboration with Longan Vision Wil Partner

This project is an example of a basic IoT set up and had the scope of connecting to the cloud to visualize the data being transmitted from the site of the equipment location thus meets one of the criteria of the Industry 4.0 implementations. Due to time limitations, as well lack of student's knowledge in using real-time operating system on a single board computer, the students could not implement the solution on a single board computer specified by the community partner. An intervention was made to help the students struggling with this task; however, all the goals could not be achieved due to time limitation as well. On other hand the students also brought to our attention the fact that the community partners were not quick in responding to their technical questions and support. An important lesson learned from this project is that the students background and motivation are two critical requirements for the success of the WIL project. In this case the motivation was not an issue at all. This element of proper matching needs to be addressed as the SEPT moves forward with new projects. This project has helped us to identify a gap in students background that has to be addressed in future curriculum revisions.

II. Sunshade Control System with IoT in Collaboration with Jans Awning Wil Partner

This project is an example of how an outdated legacy control system that has been in use is in the need of a modern controller based on Industry 4.0 concepts. This is one of the key challenges that many industries all over the world are facing how to migrate to the newer digital technologies. So, the students proposed a digital solution based on low cost RPi single board computer. The final solution of the control system includes the Raspberry Pi, a custom PCB board and transmitter with a special 433.42MHz oscillator to communicate with Somfy devices. The custom PCB board has relays to control a linear actuator and LEDs.

The proposed prototype solution achieves the required functions within the constraints and satisfies all the objectives as specified. The community partner, Jans Awning Products, has been extremely pleased with the prototype as well as its quick reaction to voice commands. Future goals include ability to make the control system commercially available.

The overall cost was only $150 of components but the implementation required knowledge in digital electronics, PCB making, operating system, programming, databases, wireless communications, communication protocols and trouble shooting skills. This project has provided opportunity to solve a real legacy problem using the modern tool and prepared these two students for implementing digital technologies in the workplace.

III. 6-Axis Robot Project

There is not a single company in Canada (https://tracxn.com/explore/Industrial-Robotics-Startups-in-Canada) that makes an all purpose 6-axis industrial cobot/robot. The AXIBO, a new start up, is trying to develop one for their applications as described in the student's report. Robot design is quite a complex task not to talk of building one that has its own challenges in the design of joints and selection of motors for these joints. The focus of the project was shifted to the design of a 3-axis robot as due to the complexity of the original goal of the project. At the end two main items were delivered to the community partner: 3D CAD model of the 6-axis robot design and 3D design model of the 3-axis robot. The prototype could not be developed to due to supply chain issue of getting the correct sized motors on time.

These students honed their capabilities in 3D CAD design, selection of appropriate motors, and as well as understanding the limitations of their knowledge for such a complex challenge. However, these capabilities match with CAD design capabilities required in the workplace.

IV. SEPT-Axibo Cheetah Capstone Project

Axibo's goal is to make a cost-effective modified quadruped robot and commercialize it to be used in the film industry. The Unitree GO1 quadruped was chosen to be the basis for this project as basis to understand its capabilities. It is a commercially available quadruped that retails for $2,700 USD. It is being used as a platform to jump start the development of the quadruped and focus on the programming aspect of the quadruped.

The final solutions to achieving our goals were different to how we set out to tackle them, however we were able to reach the functionality in the end. This includes having an effective vision script, capable simulation running, and quadruped software that is being understood. The integration process to make all the control systems work together was successful. There were many components that needed to communicate and work together, and we were able to establish working communication protocols between them all. The entire development process of our capstone has been documented along the way with screenshots, notes and descriptions of the progress made. All this information is available on our capstone website to make it easily accessible to upcoming capstone groups and for our community partner, Axibo, in the future.

This group of students have demonstrated a full understanding of Industry 4.0 concepts and have developed the capabilities for advancing their careers rapidly and implementing smart digital technologies in the workplace. Their skills in programming, internet communications, hardware and software, applications of vision systems and AI are an asset as related to the Industry 4.0 maturity index described in this report.

V. Smart Home for Aging-in-Place

“The Smart Home for Aging in Place Project (SHAPE) is definitely one of the best projects these years in Automation program. Vincent and his team did 1-hour presentation (normal duration of a talk is 15 ~ 20 mins, but there was no reason to interrupt them) and live demoed their work; they also prepared an ultra-high quality video demo with 1 GB. In my section throughout the past 8 years’ capstone classes, it is the top 2 (or top 1, the other outstanding one is Simran Nijjar and his team’s YuMi CoBot). I think we can contact Karen (our Communications & Engagement Coordinator) for promoting this team’s work to motivate more students. Thanks so much Qiyin and Ish for providing our students such an excellent project.” Dr. Zhen Gao, Faculty Lead, System & Technology Program, SEPT, McMaster

“I'm very happy to hear the project presentation went well. The team has been working very hard and thank you for giving us the opportunity (and funding) for this project. It would be a great demonstration site to the community as well.” Dr. Qiyin Fang, Professor and Co-ordinator SHAPE House, McMaster

This group of students implemented this project between level 5 and 6 Industry 4.0 Maturity Index. They deployed the following technologies: IT/OT Integration, Home Automation, Network Infrastructure, Database and Visualization, Wireless Communications, Protocol Integration, Environmental Monitoring, Water Safety Shutoff and Smart Sensors.

VI. Portable CNC

CNC machines are the workhorse of the manufacturing industry and with modern digital technology capability are becoming part of the IoT ecosystem. But these machines are quite expensive. A group of undergraduate students have designed and developed a low-cost version of CNC that can be very useful to SMEs for their small part making capabilities.

V. Campus Teams Supported Projects-Evaluations

I. AutoPlow Team

II. ImaginAble

The ImaginAble Solutions team have witnessed the talent and passion of BTECH and engineering students during our project. Provided the proper guidance and resources, the students applied their knowledge in class towards a meaningful project that can impact the lives of people living with a disability. Moreover, we have furthered our learning about the engineering design process as we worked on various iterations of our assistive device. We presented the students with real feedback and suggestions from health clinicians and patients across North America. The students then gathered this information and went through the engineering design process repeatedly to create an enhanced version of our product that met the needs of patients living with limited hand mobility. Our team will continue to enhance our product through our thorough understanding of the engineering design process and prototype iterations required to create a successful product. This in turn will help us create a product that can help impact the lives of patients and health clinicians across North America.

As the CEO of ImaginAble Solutions, the project has inspired me to continue using 3D printing technology to create products that can meaningfully impact our customers. The possibilities are endless, and our team has grown exponentially through the help of Dr. Ishwar's team and the Future Skills Centre (FSC) Project funding. We are extremely proud to say that through this project funding we have successfully launched a formal research study with people living with a spinal cord injury across Canada, sold our product Guided Hands across North America and Singapore, as well as created a working prototype for Guided Hands 2.0.

III. Rocketry Team

Participating in the rocketry project has improved my skills in multiple aspects. Through the hands-on experience, I have gained deeper technical understandings in areas such as electrical engineering, embedded systems, and programming. In many cases, I had to figure out what exactly that we want to do, so that I can come up with the right questions to research for possible solutions. Then, the processes of making decisions and trade-offs, adapting research findings to our use cases, and iterating solutions helped me gain insights in how real-world engineering can be done. In addition, my involvement in the teamwork environment has enhanced my collaboration and communication abilities. Taking a leading role in a group, I have been practicing my project planning skills, while also engaging in solving specific problems with others. This role helped me see the importance of having an overarching goal, great and challenging enough yet achievable, to motivate everyone and push the team forward.

I hope to use what I have learned in rocketry to build more complex projects and take leading roles in them. I will build on top of the technical knowledge I have gained in the project, while generalize those non-technical skills to help myself tackle problems that I will face.

Things I learned from my participation will for sure be beneficial for my future career. I have been able to elevate my job-search objective through this experience. Alan Ding, Team Lead, Flight Control

IV. *Mars Rover*

Samee Syed: I learnt various real life engineering skills, like being able to design for manufacturing, this can only be taught by experiencing it own your own, and MMRT gave me the opportunity to learn.

I plan to use these skills in my career after i graduate, we use a lot of engineering standards and practices that are used by many companies outside of university and this team has helped me prepare for it.

Participating in this team has helped me a lot, I managed to gain many connections and build relationships with employers. I even was hired before I graduated because of my work at MMRT.

Ethan McAuliffe: I've learned how to use ROS and how man features must be implemented to make a robot which is capable of driving, navigating, manipulating objects, etc. I've also learned a lot of non-technical skills about working as a part of a team and managing tasks, deadlines, people, etc.

I intend to use this knowledge in my career (both the technical and non-technical knowledge). This project has helped me advance my career goals.

Elston Almeida : Hardware design, architecture development, project scoping and management, team management, multi-disciplinary problem solving yields the best results, and understanding my own ambitions.

Already had the chance to use many of the skills in my workplace from board design, debugging, project management, etc. I plan to continue leveraging the skills originally procured on the team in my career as an electrical hardware designer and personal projects.
Yes, it most definitely has! From leveraging my skills to find jobs to developing various skills required by my future ambitions.

Mohit Aasi: I have learned what it takes to create a team/company from the ground up. Putting time in both the administrative as well as the technical discussions has made me a well-rounded individual. Leading meetings for the future steps and decisions to have the team running functionally, I have gained valuable experience.

I intend to work in a field where I can help multiple teams reach a common goal.

It has helped you in advancing your career goals. I have learned from experience on how to tackle different situations in its most efficient manner.

V. McMaster Neudose

Aaron Pitcher: Being a part of this project for many years (holding many different roles in the project), there are countless things I have learned from the opportunity. Here is a brief list of what I have learned:

•Team and project management skills relating to a large multi-year long project to successfully complete the construction of this Ground Station

•The process behind the project life cycles (project scope definition, design of the s system, refinement of the system and completion of the project)

•Software programming and testing of the radio frequency (RF) and microwave hardware

•Printed circuit board (PCB) design for custom controllers and components to the system

•Autonomous satellite tracking and controllers are required for pointing the antennas

•Large scale assembly of an interdisciplinary project involving RF, electronic, mechanical and software integration

•The process of obtaining RF licensing for the Ground Station and the necessary certificates to operate the system

Communication protocols and network topologies (modulation, packetization, forward-error correction, encryption, OSI models, etc.)

•Server management and ethernet networking for local and external internet access

•Managing a large team (10+) of undergraduate and graduate students

The knowledge and skills attained during this project have helped me in my pursuit of a career in satellite communication systems. This opportunity has allowed me to apply my technical expertise in radio frequency (RF) and microwave design to aid and assist in the development of our McMaster NEUDOSE Ground Station located on the McMaster campus. This project has assisted in my professional/education development and will continue to encourage new individuals into the field of RF design. The project has also made it possible to obtain all the valuable scientific information expected to be captured during the McMaster NEUDOSE mission. This will have an ever-lasting effect on all the students associated with the greater NEUDOSE project.

This project has been instrumental in advancing my career goals. Projects like this ground station provide students with opportunities to apply their educational knowledge to real-life scenarios. This is of great importance to employers as it shows the students have taken what they have learned and can re-apply it. This project has also provided learning opportunities not typically found in the classroom. My role in this project has opened many career opportunities in my field, specifically co-op opportunities along with full-time employment when I graduate.

Daniel Tajik: I have learnt an enormous amount through the course of this project, including but not limited to:

- programming software-defined radios to communicate with satellite technology
- constructing ground station hardware capable of tracking satellites and communicating with them
- protocols for attaining licensing and permits for construction and operation of large antenna hardware
- design and construction of PCBs for rotor controlling technology
- communication techniques including modulation, packetization, FEC, encryption, networking, and many more
- embedded system programming
- managing a team of 10+ individuals

I am exploring a career in space communications, of which all my learnings from this project will directly contribute to. The ability to apply my theoretical background in RF and microwave engineering to a practical hardware projection is very enticing to employers and has led to multiple promising job interviews and offers. This is true not only for internship and co-ops, but also full-time positions post graduation. I look forward to advancing Canada's aerospace industry!

Absolutely! I will be starting at MDA in several months following the completion of my degree, and I credit this project for giving me the experience necessary to be hired there. Thank you very much for providing funding for this exciting and ground-breaking work!

VI. Publication List

List of Publications -Ishwar Singh, Students and Faculty Collaborators-During The FSC Funding Phase

1. Implementing IIoT and Industry 4.0 technologies in a Remote Learning Mode Using PLCs paper, co-authored with Centea and Gao was presented at Rev2022 conference.

2. Design, Development and Use of AGVs in the SEPT Learning Factory Paper Authored by Dan Centea Reiner Schmidt, Luis Caballero, Anoop Gadhrri, and Ishwar Singh, has been accepted to be presented at the ICL2022 conference.
3. The key to surviving Industry 4.0 revolution is to adopt and lead. This requires businesses to be aware of the disruptive elements of this technology and develop a plan to have a talent pool that can make the most of it. AI is among the top ten technologies that are shaping the global economy. The goal of this workshop is to provide the participants with tools to kick start their learning journey in this fascinating field of AI technology. We have developed a 4-step plan to facilitate this learning journey. This two-hour workshop on learning AI in four steps will cover the following topics: Section 1. Artificial Intelligence and Machine Learning Basics, this section will cover what is AI and introduction to AI levels, brief history of AI, types, and examples of AI applications. Section 2. Python for Machine Learning, in this section will present the reasons to use Python for ML, and how to use various Python modules such as: NumPy, Pandas, SciPy, and MatPlot Lib. Section 3. NN and CNN, Reinforcement Learning, Transfer Learning, RCNN, GAN, Transformer, Graph NN. Section 4. Open-source AI frameworks, and applications and limitations of AI. Workshop Organizer and Presenters: Ishwar Singh, Zhen Gao, Hamidreza.
4. Brain-Robot Interface Based on Artificial Intelligence, Ayodeji Onipe, Amiel Dominic Gozon, Eric Yang, Ishwar Singh, and Zhen Gao*Published in: Sensors & Transducers, Published by IFSA Publishing, S. L., 2022,
5. Remote Learning: Implementing IIoT and Industry 4.0 Technologies Using PLC Zhen Gao, Dan Centea, Ishwar Singh McMaster University, 1280 Main Street West, Hamilton, ON L8S 0A3, Canada.
6. TOWARDS DEEP LEARNING VISUAL SLAM IN AUTONOMOUS
   VEHICLES Oussama Saoudi, Hamidreza Mahyar , Ishwar Singh
   Department of Computing and Software, 2W Booth School of Engineering Practice and Technology, McMaster University, Canada
7. APOLLO 360 THE MODULAR 3D PRINTER S. Syed, I. Mosare, I.Singh
   W Booth School of Engineering Practice and Technology, McMaster University, Canada
8. OCTOBOT: A ROBOT FOR AUTOMATING 3D PRINTERS. S. Owais, P. Patel, Z. Wang, S. Veldhuis,I. Singh, W Booth School of Engineering Practice and Technology, McMaster University, Canada, Department of Mechanical Engineering, McMaster
9. 5G IOT BOARD: BRINGING 5G CAPABILITY TO MCMASTER J. Dorland , V. Lombardi , I. Singh
   1W Booth School of Engineering Practice and Technology, McMaster University, Canada.
   Email address: dorlanj@mcmaster.ca, lombav1@mcmaster.ca, isingh@mcmaster.c
10. SPATIAL AI POWERED COMPUTER VISION FOR AUTONOMOUS
    VEHICLES Ko Long Rocco Lee, Ishwar Singh
    W Booth School of Engineering Practice and Technology, McMaster University, Canada
    Email addres isingh@mcmaster.ca, leek104@mcmaster.
11. HIGH AUTONOMOUS DRIVING PRINCIPLE AND TECHNOLOGY
    Tong (Andrew) Lu, Luke Meng, Tianchi Chen, Changrong Li, Moein Mehrtash, Ishwar Singh
    W Booth School of Engineering Practice and Technology, McMaster University, Canada
12. ELECTRIFIED-FOLDABLE AUTONOMOUS VEHICLE
    Sai upamanyu Perumalla , Nitish kumar Mathuri , Syed Shujaat Raza Zaidi ,Moein Mehrtash, Ishwar Singh
    W Booth School of Engineering Practice and Technology, McMaster University, Canada,

13. TRAFFIC LIGHT CONTROLLER BASED REMOTE LAB FOR EMERGENCY VEHICLES, Dr. Marjan Alavi, Amreen Mander, Dr. Ishwar Singh, W Booth School of Engineering Practice and Technology, Integrated Biomedical Engineering & Health Sciences, McMaster University, Canada.
14. INDUSTRIAL COBOT COMMUNICATION INTEROPERABILITY AND RESPONSE TIME REDUCTION Timothy Reinhart, Ishwar Singh,W Booth School of Engineering Practice and Technology, McMaster University, Canada, Global Manufacturing Engineering, Automation Group, Dana Corporation, USA
15. INDUSTRIAL ROBOTIC VISION GUIDED PICK AND PLACE, Timothy Reinhar, Zhen Gao, Ishwar Singh, W Booth School of Engineering Practice and Technology, McMaster University, Canada, Global Manufacturing Engineering, Automation Group, Dana Corporation, USA
16. CRITICAL SAFETY SYSTEMS TESTING AUTOMOTIVE, Josh Dorland, Ishwar Singh, W Booth School of Engineering Practice and Technology, McMaster University, Canada
17. IOT COMMUNICATION: SECURITY AND BEST PRACTICES, V. Lombardi, I. Singh, W Booth School of Engineering Practice and Technology, McMaster University, Canada
18. A NEW ERA IN DIGITAL TWINS ON-LINE LEARNING AND THEIR DEVELOPMENT FRAMEWORK, Zahraa Khalil, Ishwar Singh, W Booth School of Engineering Practice and Technology, McMaster University, Canada
19. DEVELOPMENT OF COMPACT ROBOT JOINT DESIGN FOR LOW COST 6-AXIS ROBOT, Xiaoyu Jiang, Ishwar Singh, W Booth School of Engineering Practice and Technology, McMaster University, Canada
20. BIOMEDICAL SENSOR DATA MONITORING SYSTEM, ChihYung Wu, Ishwar Singh, W Booth School of Engineering Practice and Technology, McMaster University, Canada
21. SEPT [1] IOT-CONNECT: DEMONSTRATING MODERN WEB DEVELOPMENT PRACTICES A. Sokacz, I. Singh, W Booth School of Engineering Practice and Technology, McMaster University, Canada
22. SEPT MIT DOG DESIGN MODIFICATION AND APPLICATION, Ethan Cho, Ishwar Singh, W Booth School of Engineering Practice and Technology, McMaster University, Canad
23. PERSONAL EXPERIENCE WITH SELF, DIRECTED LEARNING, Danial Noori Zadeh, Ioannis Papaspyridis, Ishwar Singh, W Booth School of Engineering Practice and Technology, McMaster University,Canada
24. IoT Applications Computing, IntechOPen, ISBN 978-1-83968-690-0, Editor: Ishwar Singh, Carmine Massarelli, Co-Editor: Zhen Gao, January 7th, 2022, Total Chapter Downloads: 4493: Abstract: The evolution of emerging and innovative technologies based on Industry 4.0 concepts are transforming society and industry into a fully digitized and networked globe. Sensing, communications, and computing embedded with ambient intelligence are at the heart of the Internet of Things (IoT), the Industrial Internet of Things (IIoT), and Industry 4.0 technologies with expanding applications in manufacturing, transportation, health, building automation, agriculture, and the environment. It is expected that the emerging technology clusters of ambient intelligence computing will not only transform modern industry but also advance societal health and wellness, as well as make the environment more sustainable. This book uses an interdisciplinary approach to explain the complex issue of scientific and technological innovations largely based on intelligent computing.
25. IIoT Machine Health Monitoring Models for Education and Training, Ishwar Singh, Sean Hodgins, Anoop Gadhrri and Reiner Schmidt, DOI: 10.5772/intechopen.99032, 2021

<u>Publications Details Available from: isingh@mcmaster .ca</u>

VII. Industry References

Canadian Manufacturers Call for Urgent Action in Budget 2023

Ottawa, March 24, 2023 – The undersigned members of the Canadian Manufacturing Coalition (CMC), a group of Canada's leading manufacturing sector associations chaired by Canadian Manufacturers & Exporters (CME), call on the federal government to support the manufacturing industry in Budget 2023 with measures that will help attract and train workers, support investment, and accelerate their transition to net zero production.

In addition to implementing a comprehensive industrial strategy for Canada, the members of the Canadian Manufacturing Coalition have outlined four priorities they want addressed in the March 28 budget.

These include:

"Support industry by attracting the workers and skills it needs through increased and targeted immigration and enhanced training supports.

- Drive innovation, investment, and the adoption of advanced technologies and automation.
- Increase domestic manufacturing production and exports.
- Help manufacturers adapt to and advance Canada's climate change plan;"

The industry is under pressure because of chronic labour shortages, "Buy American" protectionism, declining investment, weak export performance, competition from the U.S. Inflation Reduction Act, and massive costs associated with net-zero transition.

"Canadian manufacturers need urgent action on all these fronts to combat the threats posed to their competitiveness," says CMC Chair Dennis Darby, President and CEO of Canadian Manufacturers and Exporters. "Investing in our sector will not only enable our manufacturers to overcome these challenges, but to thrive, and to continue to play the important economic role they have always played."

The Canadian Manufacturing Coalition is composed of over 30 manufacturing sector trade associations and combined represents all 90,000 manufacturing companies across Canada.

The manufacturing sector accounts for nearly 10 per cent of Canada's real gross domestic product and 2/3 of Canada's goods exports.

Manufacturers employ 1.7 million people in Canada.

Total manufacturing sales hit a record high of $718.4 billion in 2021 (https://cme-mec.ca/blog/canadian-manufacturers-call-for-urgent-action-in-budget-2023/)

Industry 4.0 & Canada's Digital Future in Manufacturing

A new CME report identifies three broad but interconnected issues that are limiting Canadian manufacturers' innovation and technology adoption.

HIGH PURCHASE COSTS & UNCERTAIN ROI

New equipment and technologies are expensive and, the way they fit into existing operations is not always obvious.

RECOMMENDATIONS

Introduce a shared 20 per cent investment tax credit on the purchase of new machinery, equipment, and technologies, including software.

Support the creation and delivery of a nation-wide government-led SMART program that offsets the cost of technology assessment, diagnostic services; and provide support for SMEs.

Develop an awareness campaign that demonstrates the benefits of technology adoption.

LACK OF INFORMATION & TESTING OPPORTUNITIES

Businesses are not always aware of what technologies are available, what their benefits and capabilities are, and how they would fit into (or disrupt) existing operations.

RECOMMENDATIONS

Provide financial support to facilitate technology demonstration tours and site visits that showcase cutting-edge machinery, equipment, and technologies.

Fund a series of technology demonstration and testing hubs across Canada that give manufacturers the opportunity to learn about and test new technologies.

Develop an online technology adoption roadmap.

LABOUR & SKILL SHORTAGES

When businesses cannot find workers with the specialized skills needed to assess, operate, and maintain that equipment, it limits they ability to adopt technology.

RECOMMENDATIONS

Encourage more youth to choose a manufacturing career.

Bring together major employers, their supply chains, and local secondary and post-secondary institutions to discuss workforce needs, and drive curriculum planning.

Extend and make permanent the Atlantic Immigration Pilot to the rest of Canada.

Developing closer business/post-secondary ties for curriculum development and work-integrated learning programs. (https://cme-mec.ca/initiatives/industry-4-0-canadas-digital-future-in-manufacturing/)