The Impact of Hands-On Workshops

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Emma and her grandfather, Jacob, walked into a café on a fall Saturday morning and ordered pancakes. While they waited, she pulled out her laptop and a box containing parts for her project for Halloween night. Unlike in previous years, she was more concerned with developing an M&M© sorting machine to "save the red ones for last" than which costume she was going to wear. So far, her prototype consisted of a microcontroller reading a luminosity sensor to determine the color of the candy. She had attached an RGB LED and programmed it to display the same color from the sensor to confirm it was functioning correctly.

Jacob, a retired accountant, had recently attended an IEEE workshop at the public library to learn about electronics in an effort to reconnect with Emma. Although her project went beyond the introductory knowledge of microcontrollers and sensors, it was enough for them to converse, learn, and experiment with embedded systems together.

Both were deeply engaged in the conversation when the waiter arrived with the chocolate chip pancakes. As he placed the food on the table, he looked at the small development board connected to a breadboard through a mess of colorful jumper wires and asked Emma, "What are you building?"

Let's pause here for a moment and consider this scenario. Can you spot the fictional element?

Photo: David Lipnowski

Degrees Restaurant, U. of Manitoba (Feb. 4, 2017).

The made-up component is the welcoming environment of a local coffee shop for people working on electronics. This public space is often associated with chatting, reading, or editing an essay on a laptop. The rest of the story is based on real events from an IEEE workshop held at the Winnipeg Public Library.

Opening a project box with small circuit boards connected through colorful wires can be a cause for concern in today's hyper vigilant society. For this to change, STEM education needs to reach audiences beyond the classroom to not just teach new concepts, but also remove fears, demystify what engineers and scientists do, and, ultimately, encourage a sense of experiential life-long learning.

This article shares the experience from a group of dedicated IEEE volunteers from the Winnipeg Section who have delivered over 60 workshops in embedded systems and other topics. These initiatives have significant impact in the community engaging high school students and teachers in STEM subjects, challenging university students to experiment outside the classroom environment, helping hobbyists work on their home automation projects, providing professional development activities for practitioners, and even bringing a grandfather closer to his grandchildren over a discussion on Arduinos.

How it all began

Historically, the IEEE Winnipeg Section had organized many embedded systems workshops with microprocessors going back to the 1980s when Prof. Witold Kinsner ran events at the first Microelectronics Centre in Western Canada. Later, during the 2000s, the emphasis was on Matlab for use in university labs and web applications for the trending World Wide Web phenomenon. For the most part, these events were usually ran as a seminar where a presenter would go through slides and live demonstrations, but the onus was on audience members to follow along. Many ideas were entertained to incorporate small development boards like those used in labs, but these did not materialize due to a combination of financial and logistical reasons. The lack of workshops did not prevent ambitious students like Mark Roy from experimenting as he built an LED Desktop Clock [2], but there was an untapped opportunity to engage more students in experiential learning opportunities.

In the Winter of 2011, a group of University of Manitoba (UofM) students were working on assignments in the IEEE McNaughton Centre and stumbled upon the Texas Instruments MSP430 LaunchPad—a small development board that included software and cables to get started for only $4.30 [3]. They began reading about the board, sharing ideas for projects, and started filling out a form to order them. The buzz in the room was contagious and more people gathered around to learn about the potential from this exciting product. Even with all the excitement, there were some engineering students hesitant to get involved, as their experience with electronics was limited to the safe confines of the university labs. This combination of excitement and anxiety lead to the impromptu decision to organize a workshop.

The buzz in the room was contagious and more people gathered around to learn about the potential from this exciting product

Within a span of four hours, a group of IEEE student members put in an order for more than $500 for development boards, breadboards, LEDs, resistors, and other components from various retailers around the world. Surprisingly, the breadboards became the most expensive component for the workshop when compared to the inexpensive development boards. In retrospect, the team should have called a meeting with the Student Branch executive and approved the budget expenses, however, as Grace Hopper wisely stated, sometimes "it's easier to ask forgiveness than it is to get permission." Before wrapping up the activities for the day, they talked to the branch counsellor, Dr. Kinsner, who offered lots of advice on how to manage the logistics, but more importantly, emphasized many of the pedagogical elements to consider during the workshop. In particular, he emphasized the importance of not just doing, but understanding the principles behind it by linking to the theory taught in the classroom and challenging the audience with questions to entice them to build on the examples and try out things by themselves.

By the end of that day, the UofM IEEE Student Branch was committed to its first hands-on embedded systems workshop. Since some of the parts were purchased from online overseas retailers, the dates for the workshop were not set until all the packages arrived. By then, the student branch executive had helped with many logistical elements

and a group of six instructors was formed: Dario Schor, Troy Denton, Frank Serafin, Matthew Sebastian, Matthew Woelk, and Benjamin Bergman—a combination of undergraduate and graduate students with previous embedded systems experience through courses, student group involvement, and their own projects. The team met a few times to try out the boards, developed a few examples, and noted common problems that participants might experience. In parallel, they secured funding from a few different sources including the IEEE Winnipeg Section, UofM Student Union, and the UofM Dept. of Electrical and Computer Engineering to cover the cost of food and advertising.

The "Hands-On Embedded Systems" workshop was scheduled for Sunday, March 27, 2011 from 10 a.m. to 3 p.m. in a classroom at the UofM. The cost of $20 per student included the hardware to take home, breakfast, snacks, and lunch. The 25 spots available filled up in less than 24 hours and a waiting list was created. The group consisted of electrical engineering, computer engineering, mechanical engineering, physics, and computer science students ranging from first year through masters students.

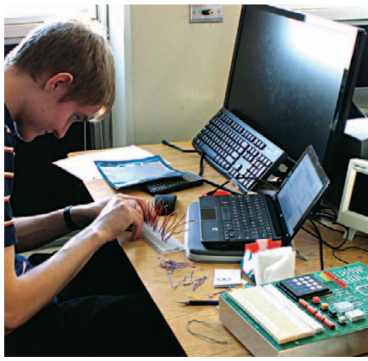
On the day of the workshop, the participants arrived, registered, and picked up their components. All participants were instructed to bring their own laptops or use one of the desktop computers from the student group. The first hour was dedicated to installing the development environment, soldering header pins onto the MSP430 boards, and eating some snacks. Already the activities were behind

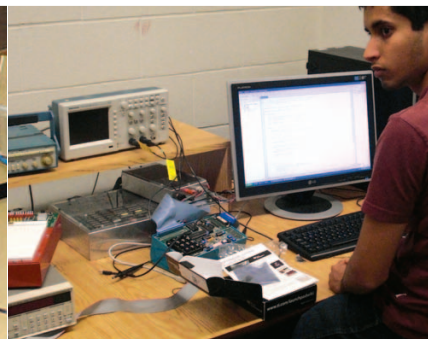
The team grew as we incorporated some attendees from the first event and other students who had lots of good ideas to contribute

schedule. There were many different versions of Windows, MacOSX, and Linux operating systems to deal with, thus requiring longer to install the development tools. Furthermore, it was surprising to see how many students were soldering components for the first time. This is something that was not taken lightly, so the instructors spent some time going over safety procedures, showing what a good solder joint looks like, and guiding students through the process.

The instructors took turns delivering content and helping students one-on-one. They started with a basic blinking LED example and moved through more complex material. The goal was to build a system that would connect all the boards from every participant together in a circle, such that they would receive an interrupt, blink an LED, and send a signal to trigger an interrupt for their neighbour's board—much like watching people do a wave at a sporting event. This proved to be too ambitious and wrongly assumed everyone would complete all the exercises by the same time. The scheduled 3 p.m. end-time would come and go. The group was so immersed in the experience that they stayed an extra 2-3 hours working. The evening ended with a large pizza order for all of those that were still around for dinner.

After the event, a survey was emailed to all participants and the results were very positive. There were some constructive comments to (i) reduce the amount of time associated with setting up the development environment, (ii) separating activities for audiences based on experience, (iii) adjusting the amount of content delivered to make the goals more achievable in the allotted time, (iv) improving the slides and making them available to students along with sample code to avoid re-typing unnecessary code, and (v) opening the event to non-UofM students. Overall the message was clear: the experiential learning objectives were met; and, most importantly, there was a yearning for more.

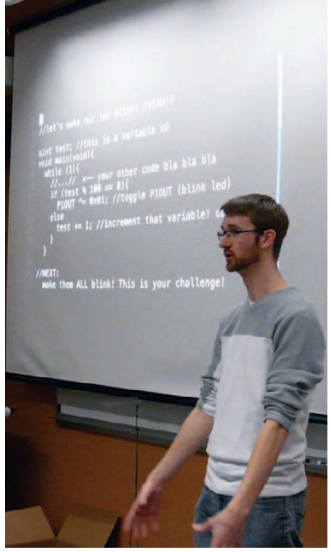
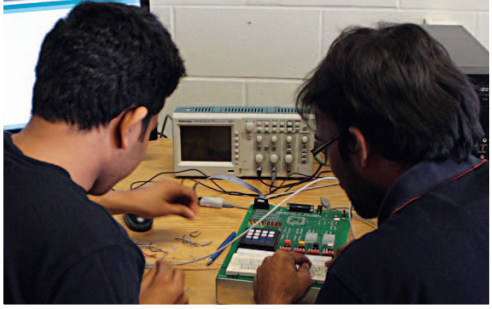
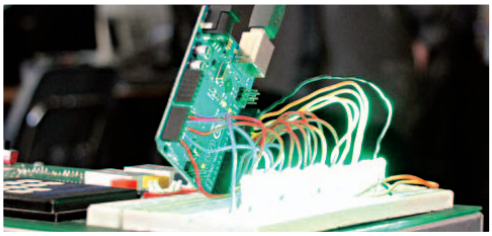


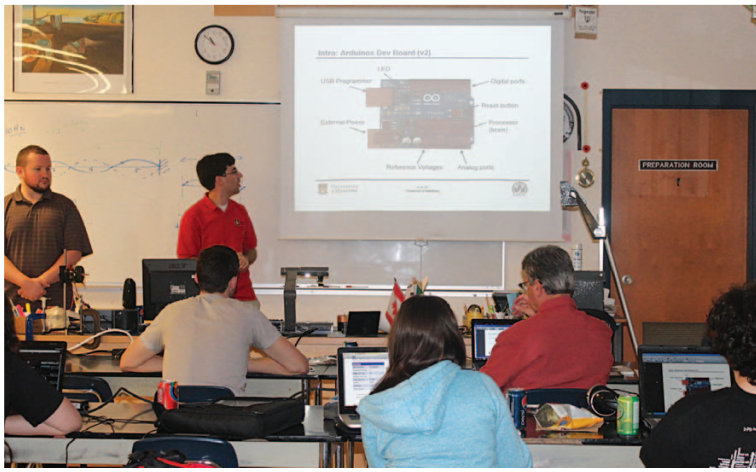


The Workshop Fever that Followed

The first workshop was not even finished and the group of attendees and instructors already began talking about the next phase. Wisely, the decision was to take time over the summer months to plan activities, develop material, and secure funding to improve the overall experience in future offerings. The team grew as we incorporated some attendees from the first event and other students who had lots of good ideas to contribute. Furthermore, there was an increased camaraderie and collaboration with other student groups including Society of Automotive Engineers (SAE), UofM Amateur Radio Society (UMARS), and UofM Space Applications and Technology Society (UMSATS), who requested specific topics to be covered to help in their respective projects.

From 2011 through 2016, there were more than 60 offerings of workshops using different development platforms including MSP430 [3], Arduino [4], and Raspberry Pi [5], and hosted by different venues around the city including the UofM, Red River College, the Winnipeg Public Library, and many high schools. In addition, there have been many collaborations with other organizations including WISE Kid-Netic Energy, UMARS, and UMSATS. Most workshops are now split into different sessions for beginner, intermediate, and advanced audiences with different prerequisite knowledge depending on the activities to be completed. The setup time has been reduced by pre-installing all the necessary tools in a computer lab where the workshop is being hosted and providing links to instructions to those wishing to install compilers on their personal computers.

WISE Kid-Netic Energy Workshops

*By **Nusraat Masood***

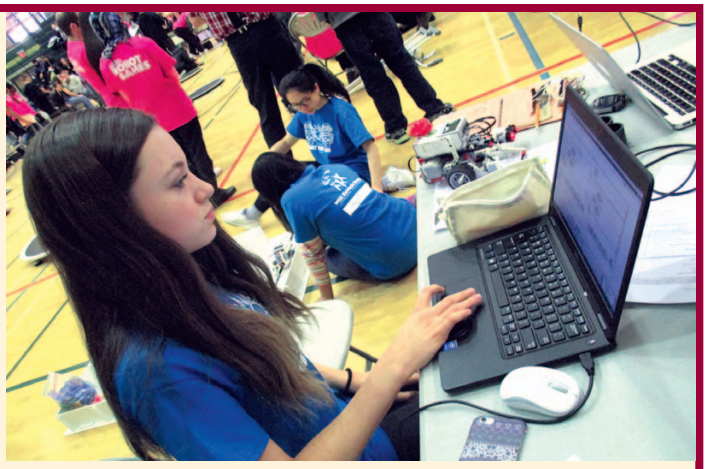
WISE Kid-Netic Energy is an outreach program established in 1990 at the University of Manitoba and a member of Actua. We serve all of Manitoba, including First Nations reserves, northern communities, southern communities and the city of Winnipeg. Annually we engage between 25,000 to 35,000 youth depending on funding levels. We are a not-for-profit. Whether it is summer camps, workshops, girls clubs or special events, all of our activities support STEM (Science Technology Engineering Math) learning through fun, messy, experiential activities. WISE stands for Women in Science & Engineering.

We engage all youth but have specific initiatives to target underrepresented groups like girls, Indigenous youth and youth facing socio-economic challenges. We hire undergraduate students pursuing degrees in STEM to deliver our outreach. This year we are offering over 20 workshops for in-classroom exploration. We follow the Manitoba science curriculum and are an excellent resource for teachers. In fact this year we received a STAM (Science Teachers' Association of Manitoba) award.

We have a workshop for grades 4-8 wanting a great first exposure to coding. The workshops is called "Codemakers" which is a nod to our funder Google.

We bring tablets and Dash robots and go through simple coding concepts like if/else and loops. Another great workshop for grade 9 is our "Solder Shop" where students solder electrical components on a printed circuit board to build a blinking LED device. For all of our workshops we bring in trained staff, materials and clean up afterwards.

If you're looking for extra-curricular activities for your girls we have some great options. This year we are running our "All Girls Robot Fight Club." It's an eight-week, 4-hour long training prep series for the Manitoba Robot Games LEGO Mindstorms competition. All participants use our LEGO Mindstorms to prepare and compete. We have a Computer Science student, Valorie Plataro, an UMSATS member and ECE student Jenica Woitowicz training the girls this year. This summer we will also be offering an all-girls intro to coding camp. The dates are July 18-20 and August 1-3. The girls will be exposed to learning apparatus like littleBits, Arduino, Dash, LEGO Mindstorms and Snap Circuits.



If you would like to learn more please see our website: wisekidneticenergy.ca

Nusraat Masood is the Program Administrator for WISE Kid-Netic Energy. She has a Bachelor's and Master's degree from the Faculty of Engineering at the University of Manitoba (UofM) in Electrical and Computer Engineering. For her Masters she designed and fabricated a lab-on-a-chip device that non-invasively manipulated dielectric beads using dielectrophoresis. After her graduate degree she worked at a start-up in Kanata, Ontario. For the past five years she has led the STEM outreach not-for-profit WISE Kid-Netic Energy program for the Faculty of Engineering at UofM. She recently spoke about how all youth are capable of pursuing STEM careers in a TEDx talk. Ms. Masood is the interim Director of UofM's Internationally-Educated Engineers Qualification program.

The Beginner workshops introduce basic concepts and are designed under the assumption that the participants have never built a circuit or programmed before. These workshops have been adapted for grade 7 classes, through university students, and beyond. For the most part, they start with a high-level description of development tools and then jump right into an example to make an LED blink. There is an unwritten goal for every student to complete the first activity and see the LED blink within the first half hour of the workshop to prove to them that they can do this. The half-hour goal is even more important for high school visits and younger audiences where many participants have preconceived notions of electronics and their strengths that have to be overcome with a positive experience before presenting them with challenging new material. For example, at a workshop held at the UofM with International Baccalaureate grade 10 students from across the province, there was a young lady that spent part of the time on her cellphone (thinking the instructors did not notice) and openly stated that electronics was way outside her interest in biology. However, she was the first to complete the hands-on example, giving her the confidence to get up from her seat to help others, alter her perception of engineering, and leave with a new perspective on her own capabilities.

Over the years, the workshops became more popular, the students involved in the activities transitioned to Young Professionals, and there was a natural opportunity to expand the activities beyond the University of Manitoba

After completing the first example, the breadboards, passive components, and other peripherals are integrated into subsequent activities. Depending on the length of the workshop, students will be provided with more complex examples that include sending messages in Morse code using an LED, reading an analog sensor, converting readings to engineering units, and printing messages to standard output. Most of the time, the final example introduces students to a rudimentary closed-loop control system where an LED represents a heater that is turned on/off depending on the readings from a thermistor. This requires students to integrate all the elements discussed into a single example that is something they can intuitively understand from their thermostats at home.

Shaftesbury High School Workshop

*By **Robert Striemer***

In 2010, the Shaftesbury High Altitude Robotics Project (SHARP) launched its first high altitude balloon (HAB) from the Erickson aerodrome in western Manitoba. The balloon reached an altitude of 107,000 feet and travelled more than 200 km before making a parachute landing just 18 kilometres from Shaftesbury High School in Winnipeg. The excitement created by this flight led to five more flights and collaboration with a growing number of schools. In April of 2016 six schools launched HABs from the playing field behind Carman Collegiate. Yearly HAB flights are now coordinated by the Manitoba Association of Physics Teachers (MAPT).

Students design and build payloads that have reached altitudes of more than 36 km. To date, fourteen payloads have flown to the stratosphere and all have been recovered. It does help that southern Manitoba is relatively flat and treeless. HAB payloads carry science and engineering experiments as well as video cameras.

Students use their electrical skills to build a payload power distribution system. Arduino microcontrollers are a very common component of HAB payloads. MAPT organized an Arduino workshop for school teams (students and teachers) in March. The University of Manitoba's department of Electrical and Computer Engineering and IEEE ran the workshop. Arduinos are used to log sensor data and control circuits such as the payload release circuit. The Arduino in the payload release circuit receives input from a GPS receiver. At a programmed altitude, the Arduino sends current to a thermal knife which cuts the line between the payload and the balloon. The payload containing experiments and cameras returns to Earth by parachute. Students analyze their data and make presentations and may enter their project in science fair competitions. Amateur radio beacons inside the payloads are used for real-time tracking. Many students take amateur radio certification courses learning about electronics, transmitters, receivers and antennas. Some students use their own ham radios to help coordinate the flights.

Shaftesbury High School hosted the first Manitoba Schools HAB Symposium in October of 2016. The symposium, sponsored by MAPT, allowed students to demonstrate their work. Their projects were discussed and information was shared in the Proceedings. Collaboration between schools has helped teams improve in all areas from flight theory, launch and tracking operations to experiment and payload design. This year about a dozen Manitoba schools are working on HAB projects. Spring floods permitting, most HABs will take to the air together sometime before the end of June 2017.

__Robert Striemer__ has been a public high school physics and science teacher for the past 33 years. Receiving his B.Sc. degree and Certificate in Education from the University of Manitoba, his classroom skills and dedication to students were recognized by a Prime Minister's Award for Teaching Excellence in 2012. He is a member of the Radio Amateurs of Canada, the Manitoba Repeater Society and the Winnipeg Amateur Radio Club in which he serves as Chief Instructor, delivering amateur radio certification courses to the community including school teachers and their students.

Glowing softly in the early morning light, a high-altitude balloon and payload are readied for lift-off roughly 250 km upwind of Shaftesbury High School.

The intermediate and advanced workshops assume that the participants have experimented with a development board before and are at least familiar with the environment. On average, about 75% of participants sign up for all three workshops, so the instructors tend to know the level of knowledge and what is expected. For those that sign up to multiple workshops, one assumes they have tinkered with the boards in the weeks in-between sessions. These workshops introduce more peripherals like different types of sensors, seven-segment displays, serial interfaces, and even the use of interrupt signals. One of the goals is to help people become more independent as they progress through different workshops. This is accomplished by providing the participants the theory behind the components and terminology they may encounter when reading about the subject. In addition, some time will be dedicated to putting datasheets on the screen and highlighting key information like operating conditions, maximum ratings, and how to interface the device to a microcontroller. Essentially providing enough knowledge to interface with simple components. Finally, the more advanced workshops have small interrelated examples that lead to a project to be completed during the session. A more grandiose end-goal keeps the interest from participants throughout the session and challenges them to think of how all the parts will fit together. Some of the most ambitious hands-on projects are described in the next section.

Regardless of the audience, there is a significant amount of effort associated with developing materials in advance of the workshop. Most of the instructors are used to working with state-of-the-art commercial software available through the university or place of employment. Initially, these were used to develop the material for the workshop, but many participants asked for open-source equivalents that they could try at home. Thus, there has been a trend to move towards open-source tools for all the materials unless specifically advertised as part of the workshop goals, like the case of the printed circuit board (PCB) workshop where students designed an Arduino shield using Altium Designer. The slides are developed in Google Slides and a link to view the files is shared with all participants at the beginning of the workshop. The advantage of this system is that it allows one instructor to continue presenting material while another person annotates the slides as needed based on feedback from participants. In the first few events, the code examples were distributed through the websites for student groups, however, more recently there was a transition to GitHub repositories to track changes during development and subconsciously promote good habits for configuration management. Finally, the diagrams and schematics have been developed in Fritzing to allow students to jump back and forth between schematics, vector graphics of the breadboard layouts, and even PCBs if desired. The vector graphics include everything from the development board, breadboard, passive components, sensors, and jumper cables. Thus, it is easy to make a high quality image that has improved legibility over an annotated photograph. Finally, handouts were developed on rare occasions for advanced workshops where text descriptions were easier to follow than bullets on a slide.

There have been many approaches used for handling workshop components and costs. Nominally, at the UofM and RRC, students register online in advance of the workshop and select whether they want to purchase any parts at cost through the student branch. This is often preferred as the bulk orders are often eligible for educational discounts. At the end of the workshop, the students get to take home all the components to continue experimenting. Any funding obtained by the student branches is only used to cover the cost of refreshments or equipment that will be kept by the branch for future activities. This is very different for high school workshops where either the school purchases parts for a physics or computer science class or the instructor signs out a set of development boards used for outreach activities by the UofM Faculty of Engineering. In contrast, the library purchased components as part of a Makerspace initiative and makes them available for short term loans.

Over the years, the workshops became more popular, the students involved in the activities transitioned to Young Professionals, and there was a natural opportunity to expand the activities beyond the University of Manitoba. These included joint workshops with the Red River College student branch, followed by high school visits coordinated by WISE Kid-Netic Energy, workshops for teachers through the IEEE Teacher In-Service Program (TISP), and other initiatives. The activities were customized for different audiences and delivered by a growing number of instructors working with anywhere from 15-25 participants per session.

Examples of Workshops

Outside the introductory workshops already described, there are many special events that show the potential for these events within the community. The following are six examples that give an overview of the range of activities in Winnipeg.

GPS Receivers at Shaftesbury High School

In the Spring of 2012, a physics teacher from Shaftesbury High School, Mr. Robert Striemer, asked if the group could run a custom workshop to help his high school students interface a GPS to an Arduino for a high altitude weather balloon experiment. The teacher had already attended the Arduino workshop series, but wanted some assistance with new concepts like installing libraries, communicating with an asynchronous serial device, parsing data, and validating readings. Two UofM IEEE Student Branch members volunteered to run the activity and prepared some slides talking about GPS receivers, how they work, how the data is formatted, and serial interfaces. The initial tests were conducted in the classroom confirming the unit was reporting the correct coordinates. Afterwards, Robert presented a unique challenge to make the on-board LED blink whenever we entered the endzone of the school's football field. This required extracting the latitude and longitude coordinates from Google Maps and writing some simple logic to turn on the LED at the correct time. Testing the circuit was a memorable experience as shown in the picture. The rain did not deter students from walking with their Arduinos under an umbrella to see whether the lights would blink.

Culinary Arts and Embedded Systems at RRC

In March 2014, Red River College and IEEE Young Professionals organized a workshop to learn to interface with motors and sensors for a manufacturing environment. To make this more realistic, the instructors developed a test system that added motors to a cookie extruder purchased online and linked that to a conveyor belt that could carry

a baking sheet. During the workshop, the participants first interacted with individual components at their desks, developed the software, and after a quick peer review from the instructors, plugged in their programmed Arduinos to the full system. As cookies were being extruded, they were placed in a toaster oven, and served to the participants. Aside from the culinary challenges, the workshop successfully covered many topics related to interfacing, control systems, and testing that could be transferred into other applications in the future.

MANITOBA SPACE ADVENTURE CAMP

By ***Witold Kinsner***

While outer space was reserved for very few in the past, many more students today can find challenging opportunities in space-related jobs, education, and research. In order to provide a place to explore such opportunities, a unique affordable one-week summer space camp (SCM) has been developed at the University of Manitoba (UofM) for high-school students from Manitoba and elsewhere, as one element in our multi-faceted space-related education program. The purpose of the SCM is to encourage young men and women from high schools to engage in science, engineering and technology through experiential learning such as hands-on workshops, short tutorials, and related outdoor activities. Parents and friends are also invited to participate in some of the activities.

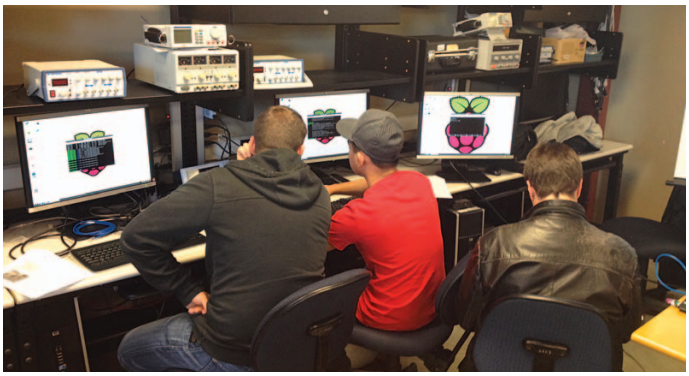
A cutaway model of a rocket motor showing the solid propellant and the nozzle is explained by Space Camp volunteer Diane Kotelko, Lead Systems Engineer at Magellan Aerospace.

Typical activities include: rocket building and launching; self-propelled robot building and testing; amateur radio operations and use for tracking of payloads; satellite ground station operation; fox hunting (transmitter locating); zero-G experiments; CubeSat design experience; Canadian Satellite Design Challenge (T-Sat) at the UofM; unmanned vehicles at UofM; simulation of orbital mechanics; demonstration of six high-technology labs at the Faculty of Engineering; space law; astronomy; industrial aerospace accomplishments (Magellan Aerospace); and small space business. The students have access to multi-million dollar space-related software for simulation and exploration.

The space camp is designed to satisfy several long-term objectives, including: (a) to understand the scientific method, (b) to understand the engineering design process, and how ideas can be implemented—not just with much money, but in a smart way; (c) to understand how the very-high level of science and engineering developed for space can be applied to our planet; (d) to learn how to work in teams; (e) to understand the relationship between our planet and space; and (f) how to be good stewards of this planet.

The SCM has been supported by over 20 organizations, including the strong Manitoba aerospace industry, the amateur radio community, and several schools.

To know more about the SCM, contact Witold Kinsner: w.kinsner@ieee.org



Introduction to Internet-of-Things Projects at RRC

Another workshop at Red River College focused on developing an Internet-of-Things application to turn on/off a device remotely. The workshop was broken down into three parts (i) learning to interface with devices on a Raspberry Pi, (ii) installing an Apache web server on the Raspbian operating system, and (iii) developing a web interface that would link a website to Python scripts to interact with peripherals. The objective from the workshop was to enable students to load the web interfaces on their phone and turn on/off devices remotely. In addition to embedded applications, this introduced many topics related to interacting between a server and low-level interfaces. More importantly, it engaged many discussions on network security and understanding the vulnerabilities of such systems.

Advanced Concepts with Arduino Shields at UofM

One of the challenge for most workshops is agreeing on a project to build and selecting parts that would provide the best educational experience. In 2013, the UofM IEEE Student Branch could not make up their mind, so they purchased ten pairs of different Arduino shields with different interfaces including MP3 audio, SD Memory Card storage, motor controllers, capacitive touch interfaces, displays, and different types of sensors. The workshop led by Dr. Ahmad Byagowi, presented the theory behind all the components, and then opened up the floor for students to take turns experimenting with different shields using examples provided by the manufacturer. The instructors walked around and helped people get the examples running, provided ideas on how they could be used in projects, and then encouraged people to try more devices. The free-for-all approach was challenging and stimulating for both students and instructors discussing the potential for the various devices.

Workshops for the Masses

In 2015, the Winnipeg Public Library started a series of Adult Programming classes following the Makerspace trends seen in other venues across North America and contacted IEEE to participate and develop the material. The staff at the Millennium Library managed the logistics, registration, and purchased the parts, while IEEE Young Professional members were responsible for preparing and delivering content to a wide audience that ranged from high school students to retired seniors. The demand for the sessions was very high and all the workshops were sold out with waiting lists of people trying to attend. Thus, in an effort to offer more options, the library staff took on the responsibility of delivering content for the introductory level workshops reusing existing material, while IEEE members continue to develop and run more advanced workshops on embedded systems, 3D printing, and other technologies.

Multiplying Factors through Teacher Workshops

In April 2015, Dr. Witold Kinsner and Ms. Andrea Misner organized a full-day workshop for 26 high school physics teachers through the IEEE Teacher In-Service Program (TISP). The event combined hands-on activities building a solar robotic car intertwined with examples of activities to run in the classroom, safety elements, and pedagogical discussions for teaching electronics to young audiences. The activities were run by university professors, graduate students, and industry professionals who were able to share their passion and experiences teaching and learning about embedded systems. The workshop was a great success and a second iteration was scheduled for March 13, 2017. We can estimate hundreds of students benefited.

The Impact of the Workshops

By the time this issue of the *IEEE Canadian Review* is printed, it will have been six years since the first workshop. In that time, there have been 60+ workshops, 1000+ participants and 40+ volunteer instructors. In order to understand the impact, one must look beyond the numbers and evaluate the benefits to different stakeholders. At a high level, these can be summarized as follows.

The workshops are an outreach tool that makes electrical and computer engineering more tangible through hands-on activities for pre-university students

The workshops are an outreach tool that makes electrical and computer engineering more tangible through hands-on activities for pre-university students. For most students, this is their first and possibly only exposure to the subject in high school. Thus, it is important for them to have a positive memory that involves some success completing the first examples, a high-level appreciation for the field, magnitude of applications in everyday life, and research potential. Some students become very engaged and are excited to learn about more advanced workshops that will challenge their understanding of the subject in a university environment. As an example, while in Grade 11, Erik Johnson attended the 2011 Manitoba Space Camp, was encouraged to participate in some of the university workshops, later enrolled in the Dept. of Electrical and Computer Engineering at the UofM, joined IEEE, delivered workshops himself, and will soon be transitioning to the Young Professionals member grade.

As mentioned in the examples of workshops, the activities through the IEEE Teacher In-Service Program (TISP) serve as professional development for teachers and help reach a wider audience. The

THE RESEARCH DISCOVERY SPRING CAMP

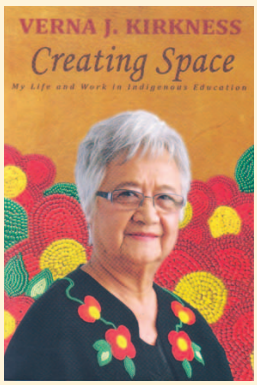
By ***Witold Kinsner***

A Verna Kirkness Discovery Week participant concentrates on soldering a circuit-board connection.

The University of Manitoba (UofM) has developed a very good Engineering Access Program (ENGAP) for Indigenous high-school students to facilitate their transition to the Faculty of Engineering. The program is also very helpful to the students already in Engineering. In order to motivate students even more, we have also developed an annual one-week Research Discovery Spring Camp (RDisc) for Indigenous high-school students. It is administered through the ENGAP in the Faculty of Engineering under the umbrella of the Verna J. Kirkness Science and Engineering Education Program (VKP) (http://www.vernajkirkness.org/). Grade 11 students from across Canada representing First Nations, Métis and Inuit are selected to come to our campus. We started the program with fewer than 20 in 2013, expanding to more than 80 students last year.

The program at the RDisc is very diverse, with emphasis on hands-on experience. Workshops include (i) exposure to research, (ii) building and testing of small smart robots (each student takes one home), (iii) Building of a small circuit and its analysis, (iv) computational workshop on Arduino, and (v) many demonstrations. Many seminars are interspersed among the workshops.

Another form to reach Indigenous students in Manitoba was the two-day Peguis First Nation Science, Technology and Engineering Symposium offered at the University of Manitoba in the past. We provided many presentations on research at the UofM, including major workshops on robotics.



Dr. Verna Kirkness graduated from the UofM in 1980 with a Master's in Education after she completed her BA and BEd at the U of M as well. She is a member of the Fisher River Cree Nation, and a member of the Order of Manitoba and Order of Canada. She is a national leader in education in Canada who has inspired countless students and educators in both Indigenous and non-Indigenous communities. In her book (left) Kirkness has written about the history of Aboriginal education in Canada and her valuable efforts in supporting Aboriginal education's development. Her book is published by the University of Manitoba Press: uofmpress.ca.

To know more about the RDisc, contact Witold Kinsner: w.kinsner@ieee.org

teachers and librarians can then incorporate elements of the workshops in their own classrooms, science fair projects, lunchtime clubs, and other activities that enhance the STEM curriculum. The best teachers plant the seed of embedded systems for students and use the network of IEEE volunteers to help address questions beyond their expertise in the subject. Such was the case when Mr. Striemer introduced Arduinos for his students after attending a few workshops at the UofM, and later contacted IEEE to address the specific need of interfacing a GPS to an Arduino.

As high school students become more engaged in electronics and want to attend workshops outside of school, it is not uncommon for their parents to drop them off, check out the place, meet the instructors, and ask questions. The most common questions have to do with purchasing components locally, recommendations for educational kits, and safety concerns. If parents are looking for mentorship opportunities, the tendency is to refer the students to a group of professors at the university who coordinate activities, meet with the students, and suggest projects. As they say, it truly takes a village to raise a child.

The workshops at the Winnipeg Public Library attract many hobbyists that can be often categorized as those wanting to learn something new about embedded systems versus those seeking advice on specific projects. The first group is eager to learn and maximize their time playing with hardware during the workshop. Their questions focus on hypotheticals for projects, capabilities of the system, and comparisons to other popular development boards like Arduinos and Raspberry Pis. In contrast, the second group of hobbyists comes prepared with questions that can dominate the workshop by asking about their specific project. These questions can involve anything from help to solve an interface issue to more advanced design decisions. In these cases, it is up to the instructors to defer those questions for after the workshop and use their judgment when answering questions without a full understanding of the system.

The events held at the university attract post-secondary students and practitioners. In general, the assumption is that the audience has some limited background in programming, electronics, and mathematics so instructors adjust by providing more theory and concepts rather than low level examples. The feedback from students is that the workshops complement the classroom education through hands-on activities, learning to use new tools, and information on how to set up development environments. The advanced sessions often attract practitioners with varying levels of experience. The junior engineers often use the activities as part of their Engineer-In-Training education requirements, while some of the more senior engineers are often interested in getting a quick tutorial of new tools that they read about in magazines. In any case, the advanced workshops are often eligible for credit with Engineers Geoscientists Manitoba (EGM) as long as the instructors send an outline of the activities covered to the association in advance of the workshop.

The volunteer instructors use the workshops to share their knowledge, prepare material, and practice their communication skills. In addition, those involved with organizing the event get lots of experience in management through planning, tracking budgets, funding proposals, advertising, and more. These activities help prepare instructors for many responsibilities they will face in industry, while also giving them an excuse to purchase new components, test development tools, and build prototypes for different machines. From the Section perspective, the workshops keep student members engaged as they transition to Young Professionals and allow the instructors to develop leadership skills for taking on new positions within IEEE.

Beyond the specific benefits for different stakeholders, there are many heartwarming personal stories from the workshops that include the bonding between a grandfather and his grandchildren over Arduinos, watching parents and children learning together, and witnessing many “eureka” moments.

Ultimately, one hopes that the activities will have an impact beyond the workshops. The appreciation and exposure to the field will play a role beyond the classroom,

Photo: David Lipnowski

help demystify what engineers and scientists do, and encourage a sense of experiential life-long learning. And, hopefully not too far into the future, the widespread understanding of computing will enables us to walk into our local coffee shop and think of someone writing an essay on their laptop as being ubiquitous with working on an embedded systems project. ■

Acknowledgements

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About the Authors

Dario Schor completed his B.Sc. and M.Sc. in Computer Engineering at the University of Manitoba in 2008 and 2013 respectively. Shortly thereafter, he attended the nine-week Space Studies Program from the International Space University in Strasbourg, France. Currently, he works as a Software Engineer for Magellan Aerospace on flight software, ground tools, and testing for the RADARSAT Constellation Mission and as a Seasonal Instructor for the UofM Computer Science Department. He has served many positions within IEEE Winnipeg since 2009 and is also an active contributor to other organizations. Dario has delivered many workshops on embedded systems, programming, amateur radio, and space systems to a wide range of audiences. He can be reached by email at schor@ieee.org.

Troy Denton is a Software Engineer (EIT) at JCA Electronics in Winnipeg, Manitoba, where he works on OEM Solutions for the Agriculture Industry. He obtained his B.Sc. in Electrical & Computer Engineering from the University of Manitoba in 2012. Troy has been an active volunteer with IEEE since his undergraduate days, serving various executive positions with the Young Professionals group. Troy regularly facilitates workshops on electronics, linux, and embedded systems with Winnipeg Public Libraries, multiple post-secondary institutions around Winnipeg, and at SkullSpace (Winnipeg's local hackerspace). Troy presently serves as a Director at SkullSpace (http://skull.space)—you can find him on IRC in #skullspace (irc.freenode.net)

Witold Kinsner is Professor in the Department of Electrical and Computer Engineering, University of Manitoba. He obtained his Ph.D. degree in Electrical and Computer Engineering from McMaster University in 1974, becoming Assistant Professor there and then at McGill University. He is a co-founder of the first Microelectronics Centre in Canada, and was its Director of Research from 1979 to 1987. Dr. Kinsner has authored or co-authored more than 700 publications in cognitive systems, computational intelligence, robust real-time computing engines, and computer memories. He is a Fellow of the Engineering Institute of Canada (FEIC), a Fellow of Engineers Canada (FEC), Life Senior Member of IEEE and a member of Engineers Geoscientists Manitoba. For more than 40 years he has been very active throughout IEEE—Region 7 (IEEE Canada), Council, Section, Chapter, and Student Branch. His roots in educational outreach date back to the establishment of the first IEEE McNaughton Learning Resource Centre at the University of Manitoba in 1979, in which he was instrumental. Dr. Kinsner is serving as IEEE Canada President and IEEE R7 Director 2016-2017; he can be reached by e-mail at w.kinsner@ieee.org.

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