Robotics as Accessibility Solutions in STEM (with Described Video) Video Transcript

-: Title a tri-campus partnership between U of T accessibility offices and admissions and student recruitment.

-: Hello, my name is Ainsley Latour, I am one of the co-founders of IDEA-STEM, and the purpose of my video this afternoon is to introduce the session about robotics. It's accessibility solutions and STEM by Dr. Ronald Soong.

Before we get started, I am just gonna introduce myself in a little bit more detail. So I'm a female in my thirties. My pronouns are she, her, I'm sitting in my home office where there's a brown wall behind me and a whiteboard. The whiteboard has no markings on it, of any sort. And the door behind me is white as well.

I'm wearing a black jacket with a black blouse, with some light colored markings on it. So in this session on robotics, as accessibility solutions for students with disabilities in STEM, Dr. Ronald Soong is gonna demonstrate how robotics can be used to assist students with different types of disabilities, and how they can use those robotics to perform labs or other activities in the STEM classroom.

These examples are gonna be relevant to the high school classroom in particular chemistry and general science measurement tools. And you guys are also going to be able to learn about the source of those robots.

So Dr. Soong gives us very specific information about the cost of these parts, and the parts we need to assemble your own robot and where you can find them.

So if you are interested in using robotics in your classroom, and maybe you're a little bit uncomfortable, or you don't have much of a backronym robotics, please, don't worry. Don't let that be a barrier for yourself or your students. Dr. Ronald Soong is very, very happy to speak to anyone one-on-one who is interested in learning more about how to build robots in the classroom, either for accessibility purposes or for learning purposes, because other students without disabilities will obviously benefit quite a lot from these activities as well.

Please feel free to reach out to him. You are also welcome to submit any questions or comments you have to the general conference email and we'll address them in the Q & A session on Thursday or we'll get back to you one-on-one.

Thank you and enjoy the session.

Narrator: A smartphone. Button pressed and experiments started. The pH value equals 6.2.

Narrator: University of Toronto Scarborough, Dr. Ronald Soong, senior research associate.

-: As a lab coordinator, I see areas where I can use technology to help improve some of the accessibility issue that I've seen around the lab.

Narrator: Dr. Soong examined the mechanical device in a lab. Caption, Soong has created an assistive lab device for students with disabilities. It can inject a precise amount of liquid, read and record data, and even has text to speech capabilities, sound waves eminate from an illustrated face on a screen.

Narrator: The pH value equals 6.2.

Narrator: Dr. Soong watches a motorized bread, drip liquid into a beaker.

Similar devices can cost $2,000 but this one could be made for around $150. He hopes by lowering the cost it can help make science more accessible.

-: I became involved in this project because I want to reduce the barrier to learning for student with a disability or student with accessibility needs. The major goal of this project is to empower students. I want to empower students so that they feel they're included in the lab.

I want them to be involved, and I want to promote a culture of inclusiveness. I don't want to be the case where they worry about how to conduct the experiment than just doing the experiment.

Narrator: Dr. Soong speaks over a slideshow.

A maker's approach to overcoming accessibility barriers in a general science lab.

-: For today's talk, I will be presenting some of the work that I have been doing at the University of Toronto, Scarborough campus, where my aim is to reduce the barrier to learning through open source technology in the undergraduate chemistry lab. Understanding that science is one of the bedrock in our society, a knowledgeable public is always good for the society.

Before we start today's talk, I would like to thank the organizer for this invitation. And it is an honor to be able to present my work in this conference. Lastly, I would like to thank the following people who have contributed, and has supported my work over the years. And I would like to thank Professor Andre Simpson, and also his student Amy Jenne, Rajshree Biswas, as well as Daniel Lysok for their contribution and support. Lastly, I would like to thank the UTSC Library Makerspace, who allows me to use their 3D printer for printing some of these devices. In addition, I would like to thank my department, department of physical and environmental sciences, Traces lab manager, Tony Adamo, as well as ITIF for their continuing support in my goal.

So here is an outline of today's talk. I'm gonna briefly go over what is open-source technology, and then I'm gonna switch gear and talk about some of the common barriers that I see in undergraduate lab. And now I'm gonna talk about how this one designed their own laboratory assisted devices that will achieve some of the learning objective. And I'm gonna talk about some of the examples that people can use.Some of the example of laboratory assistive devices that are built using open source technology. And lastly, where we can go from here.

Narrator: Open source technology, an overview.

-: So what is open source technology? Open source technology is based on the concept of collaboration, such that source code and hardware can be distributed, and are distributed openly, meaning that there is very little copyright or patent infringement.

What this does is that it create a very collaborative platform for many individuals who share the same goals. So this allow a bunch of individuals to work together to a common problem and allow knowledge to freely flow from one individual to another, such that it create a very excellent ecosystem for collaboration and support.

Arduino is one such open source technology that are very popular currently in the world. And Arduino is as essential as a microcontroller, and this is a century, it's the brain that controls all the hardware peripherals that are connected to this hardware unit.

Another popular open source hardware that people use is Raspberry Pi. But unlike Arduino, Raspberry Pi is a fully functional computer. And it has a very high computing power as well as memory capability that allows you to essentially operate more advanced sensor and hardware peripheral like Tamra, and also have the memory capability to do some of the image rendering if you, so you please.

So depending on the applications and the learning objective that you want to achieve, you have a choice between the two. But for today's talk, I'm gonna mostly talk about the use of Arduino in this case.

Narrator: The slide show returns to the title page. Dr. Soong appears in a small video window in the top right corner of the screen.

-: Good morning, everyone, and welcome to my presentation. For today's talk, I will be presenting some of the work that I have been doing at the University of Toronto, Scarborough campus, where my aim is to reduce the barrier to learning via open source technology in an undergraduate chemistry lab.

Understanding that science is one of the bedrock in our society, a knowledgeable public is always good for the society. Here we have a slide, on the top right-hand corner is a logo of the University of Toronto Scarborough campus. And we have the title of the slide. The first slide, title of the slide is a maker's approach to overcoming accessibility barrier in a general science lab. And on the right-hand side, we have a banner showing the word maker, because it is a maker's approach to how do we solve these accessibility barrier in a general chemistry lab.

Narrator: A slide titled acknowledgments.

-: Before I start today's talk, I would like to thank the following organization. I would like to thank the UTSC Library MakerSpace, who allows me to use their 3D printer, I would also like to thank the department of physical environmental sciences for their continuing support, as well as Tony Adamo from Traces, and the ITIF fund for supporting my initiative. On this slide, on the top left hand corner is the word acknowledgment.

And right beside the key point of all the people that I want to thank is a boat of three person rowing indicating it's a collaborative work amongst all of these organizations who have helped me out.

Narrator: A slide titled outline.

-: Here is an outline for today's talk. We're gonna briefly talk about the open source technology, what it is about. We're gonna also talk about some of the common barrier that I have seen in the undergraduate lab. And then I'm gonna go ahead and talk about how can one design their own laboratory assisted technology based on their learning objective that they want to achieve. And I'm gonna go over some of the example of the laboratory assistive technology that one can build using open source technologyand where we go from here.

And on this slide, on the top left-hand corner is the word outline written, and right beside the key point where I have outlined all the other presentation objective, are again the same picture of three person rowing indicating all these people are working collaborative together on a common goal.

Now let's talk about what they mean by open source technology. On this slide, there is a title saying open source technology and descent overview. Basically it's a very brief overview of what open source technology is all about.

So what is open source technology? Open source technology is based on concept of collaborations, such as source code and hardware distributed openly, meaning you can assume basically no copyright or patent infringement. Therefore people who use these technology can freely collaborate without the need to worry about any legal issue pertaining to ownership agreement.

This is important for creativity and collaborations as individual can work together freely and openly without worrying about who takes ownership or any kind of legal issue involved. So therefore it allowed open collaboration and essentially innovation to occur without the worry of all of these legal issues.

On this slide, on the left-hand column is the description of what open source technology is all about.

And on the right-hand side, it shows a motherboard of a Arduino.

Arduino is a micro-controller. And essentially it is the brain that control all the hardware peripherals that are connected to this system.

Narrator: The Arduino is a small motherboard with two rows of pins and a USB port.

-: Another popular open source technology that are popular in the world are Raspberry Pi. Raspberry Pi essentially is a fully functional computer. It has much higher memory capacity and computing power compared to an Arduino. And it allows you to operate a more complex hardware peripherals, such as Tamra or LCD screen, or so you please.

On this slide, on the top left-hand corner is a motherboard of the Raspberry Pi. It has various pins that you can connect your hardware peripheral to, and right beside it is an Arduino motherboard showing the differences between the two hardware architecture, and depending on what you want to do, you will choose between the two.

But for today's talk, we're gonna focus more on the open source technology that are pertaining to the Arduino microcontroller architecture. Here is a slide showing all the different peripheral that one can actually buy in the open source market.

We have on the left-hand corner, it's a robotic hand that people can actually buy and program to do whatever thing that they want.

And then we have a servo, which is a molder control unit that allows you to turn at a particular angle that you set, and right beside it we have a line sensor where we can sense any kind of black line that you draw on the surface so that it allows any kind of robot or anything to follow a particular line, and right underneath it, well we call it, jumper cables.

They're essential to build your own hardware because it's forms the connection between your hardware peripheral to the Arduino, and right underneath a whole host of sensor that you can buy from places like Amazon or any kind of electronic store like digitally online.

Here you have a range of sensor ranging from the ultrasonic sensor, Alcor sensor, as well as other LED light that you can buy to connect to your system, depending on what application you want to do. And on the very bottom corner, this is called a time of flight sensor, where you can measure the distance towards an object as it approaches you.

And on the very top right hand corner is a open source educational toy tank, where you can buy on the market. What this I want to show, is that because of the popularity of the open source platform, you have a whole host of these component that is available to individual that they can buy, or they can assemble together to whatever they so desire, because it's all depending on what you want to do when you build your device and what tasks you want to accomplish.

And also because you have a huge ecosystem of support, it also allows you to choose from a whole host of sensor, and also all the technical support that you need to put these sensors together to good use.

So I'm gonna switch gear and talk about the common barrier in the undergraduate chemistry lab. On this slide, the title slide that read common barriers in undergraduate chemistry lab and an overview.

On this slide, on the top right-hand corner, is a schematic of what an undergraduate chemistry lab looks like.

It has a person, instructor walking down an aisle, and you have fume hood lining up against the wall as well as a lab pantry in the middle. So for most chemistry lab at the university setting, they're all designed under the universal design approach, so that they are all accessible to all student.

At the bottom right hand corner is a slide showing some of the simple laboratory equipment. One of them is a pH meter. The other one is a thermometer. One of the issue we found is that some of the simple lab equipment that students use are inaccessible, because they are designed for able bodied student. And to finish off with this slide, the very right hand is a banner showing the logo, maker indicating that we have to use a maker's approach to solve some of these accessibility barriers currently or current in the chemistry lab.

So what we want to do right now is, is it possible for us to build something using open source technology that bridge this accessibility gap laboratory by looking at some of the laboratory equipment? You can buy some of these assisted laboratory equipment, they're commercially available.

On the left hand side here showing a equipment called the Talking LabQuest. It is a device with a LCD screen. and what this device does is that it can essentially read out the output from the sensor all audibly, so that the user can listen to it.

Therefore student with some form of visual impairment can participate in an experimentby just listening to the output from the sensor. What this device also do is that it's a data locker so that it will lock down the data for the student for later use.

So on this slide on the left-hand side is a picture of a lock of a Talking LabQuest.

It is a device with an LCD screen, and it's made by Verna Technology so that it is designed for students with accessibility needs. On the left hand side here is, now we ask ourselves can we reverse engineering it?

Meaning that can we assemble enough open source component and design a device that allows one to essentially build something similar to a Talking LabQuest but with open-source component?

Here we have Arduino microcontroller which is a computer board as shown here. We have a pH electrical connected to a BNC connector that way it can be easily connected to the Arduino pin, so that you can control it using the Arduino. And lastly, we have shown a text to speech module which is a small computer board, so that you can convert the reading from the sensor to a speech so that the student can listen to the reader from the sensor so that he can record the data accordingly or this whole system can be configured to be a data logger.

So in this case, yes, it is possible to create a device that is similar to the Talking LabQuest by using various open source component. And we have demonstrated that in our first publication here by showing something like this.

So here we have created a open source talking datalogger.

On this slide, there is a title that says open source talking datalogger, and on the top right-hand corner, top, sorry, my top left hand corner is showing the different component that can be connected to the assembled talking datalogger device where we have put the data logger, sorry, the Arduino, the shield that allows us to connect the text to speak module to the Arduino.

And depending on what sensor you want to use, you can connect them to the pin of the Arduino. And lastly, there is a text to speech science showing that this datalogger is capable of doing text to speech conversion.

And on the right hand corner, is showing a picture of a datalogging setup, silo of a temperature experiment where we're looking at the cooling curve of a hot water inside a 3D printed insulated cup.

And underneath the picture, we have short graph where we have a temperature as a function of time where we see the change in temperature as a function of time, where we see how the hot water cool inside the 3D printed cup.

Here, we can see that it characterize a cooling curve very correctly, and it also shows that that allow it at enough density for it to characterize the curve accordingly.

Lastly at the bottom left-hand corner is showing a titration curve where we have created when we titrate. So hydrogen chloride, hydrochloric acid with sodium hydroxide, and with titrating it using a micropipette.

And we are listening to the pH reader, as we titrate to control this pH titration curve. And on this curve, we see that we have various pH value, as a function of volume of (NaOH) sodium hydroxide added.

And we can see a typical titration curve that one would expect. And what this demonstrate is that based on our approach, it is possible to essentially accomplish some of the learning objective in this basic undergraduate experiment, by using this open source talking datalogger.

Narrator: A slide titled part cost.

-: One of the advantages of this open source approach is that it cuts down the cost significantly. By looking at all the cost of all the module, you can essentially build this for less than $200 in total cost.

On the left-hand side of the slide is showing a table showing the various components that are needed to build this device. On one column, that reads Arduino, text to speech module, EMICS, prototype shield, water proof thermal couple, pH sensor, and then the column next to it, it indicates the vendor.

Here we bought the Arduino from Amazon, a text to speech module from RobotShop, the prototype shield from RobotShop, water proof thermal couple at RobotShop, and the pH sensor again, we bought it at Amazon. And on the very last column show the various costs.

So the Arduino is $25, the text to speech module we bought at RobotShop for $90, the prototype shield at $10, water proof thermal couple at $20, and the pH sensor through Arduino at $45.

So what this shows is that we can essentially build something using open source technology that have the capability similar to that other commercially available laboratory assisted devices for less than $200 in total cost which is significant cost saving, if you were to build more of this for your student when you need it.

So with the success of this particular approach now we are thinking about, can we look back at some of the basic titration cellar?

So in my titration I have basic experimental cellar that inaccessible to student, now we wanna make it accessible for all students. And on this slide, we have a title that says, rethinking a titration experiment. The reason why we have chosen to look at titration, because titration is a very important experiment that people have that type in classroom all over the world in both high school and undergraduate level.

Here on this slide, we have the title called traditional titration set up. And on the left-hand side, we have a picture showing the traditional titration setup which consists of a burette, a turnable knob, and a flask containing a pink color liquid. And in order for a student to perform a titration experiment, it will need to be able to read the marking.

You have to be able to turn the knob, and you have to be able to see the color change. If you are unable to do any of these tasks, these represent a barrier for students with accessibility needs. Because in order for you to successfully perform a titration experiment, you have to be able to perform these three tasks.

So my question to myself is, can I make this more accessible to all students by using the universal design approach? So that it help eliminate some of these unnecessary physical barrier that have very little learning objective.

And on this slide on the right-hand side, there's a picture that's showing accessibility with a magnifying glass showing a serval connected to the turning knob of the burette, and the various component for assemble pH meter, a servo and a three-in-one microcontroller board and a cell phone, together in this picture showing how we connect all of these components together to form a universal design titrator.

So here is a slide showing a comparison of what we currently on the market, and what we can make using open source component.

On the top left-hand corner is the word that says comparison, and underneath is assisted laboratory equipment. On the left column, is an Autotitrator, that is currently on the market that you can buy from Thermo Fisher. And it is priced at around $4,000 American dollar. And on the right-hand side here, a column showing all the open source component that one can buy to build a similar Autotitrator.

In this column, we have Arduino microcontroller board, a pH sensor, a pH electoral with a BNC connection so that you can easily connect it to the Arduino, a cell phone moulder, a cell phone, and I would say not my cell phone, but a smartphone or a tablet and a Bluetooth connection sign.

What this picture is trying to show is that it is possible to gather enough open source part to essentially build your own Autotitrator. One of the issue we have in building an Autotitrator is that if you look at the commercial design, it involves too many components that are not necessary because all we need to do is to overcome some of these barrier that I have discussed in a previous slide.

So what we can do is that we can essentially strap on a cell phone molder, that allows the knob to be turned automatically by using the Arduino to control this or the servo to turn the knob.

We can also monitor the titration process using the pH sensor so that we know the pH value, so that we know when to stop the titration when it is appropriate. And we can also, if we can using the Bluetooth technology that connect our Arduino to our smartphone to take advantage of the assistive features currently in a cell phone in particular text to speech capability so that it can read out the pH value from the sensor from the Arduino, so that the user can listen to the changes to the pH value as the titration progresses.

This is a clutter slide, but I will do my best to describe what's going on. On the top left-hand corner is essentially as a connection diagram of how we connect all the parts together. We have a picture showing essentially a universally design talking all the titrate here, we have a servo that strap onto the knob of the burette. We have a pH electrical currently inside a beaker, inside a solution of acid, and the beaker is on top of our stir place so that you can stir the solution and homogenize it as you titrate.

And all of these components are connected to the Arduino, such that the Arduino serve as a controller to control all the different components, so that not only you can record the value but also turn the knob.

On the very bottom here, we have a picture showing how can you strap on the servo on to the knob of the burette so that we can control the turning of knob and dispense a precise amount of titrate every time during a titration?

And on the very top right-hand corner is showing the connection of all the hardware together where we have the Bluetooth module that are connected to the Arduino that is served as a connection between our cell phone, and the Arduino.

Narrator: A slide titled auto titration setup.

-: So I'm gonna move on to the next slide. The next slide is showing how this, the auto-titration is being set up. What this essentially does is that we have open source Bluetooth module that can connect to Arduino.

What this module does is that it form a bridge between your cell phone and Arduino, and by downloading their open source app, you can now access the accessibility feature on your cell phone so that you can not only datalog where the data are transferred via Bluetooth to your cell phone from the Arduino, it also read out that particular value from the pH reading as the titration progresses so that a student can listen to the changes in the pH as the amount of titrate added so that they can listen to when the equivalent point has occurred.

By using this approach, we were able to design what we call a universally design talking, although titrated with data logging capability.

So what this does is now we solve essentially all the barrier that we have described earlier in preventing a student to perform a titration if the student have accessibility needs that have difficulty in performing some of these tasks.

To demonstrate that our system work here, we have show a titration curve of a phosphoric acid in Pepsi-cola with NaOH. So here is a titration curve where on the Y axis is a pH value, and on the X axis is volume of sodium Hydroxide added.

Here we see a typical titration curve with two inflection point showing indeed this is a polyprotein acid. And this curve is consistent is what reported in the literature with the Pepsi-cola titration.

What this shows is that our approach worked and invalidate our universal design auto-titrator approach, in creating a titration curve. I was saying a titration curve in performing a more complex titration experiment.

Narrator: Title, removing economic barriers in science education.

-: Lastly I'm gonna switch gear, and talk about another barrier that currently in science education. With the current COVID 19 pandemic, we can see that there is a huge disparity in economic barrier in science education depending on where you live.

If you're living in a low income neighborhood, you will be affected more, because for example, in remote learning, some of these low-income neighborhoods have difficulty accessing fast internet access, as well as computer resource and necessary in remote learning.

And so therefore economic barrier is a form of barrier in science education, where it prevent people or students from accessing the resources necessary to enhance their experience or accomplish the learning objective in science education.

One example I wanna point out is that sometimes a picture is worth 1000 words. Here we have shown a thermal image of different object, the top right-hand corner. So the top left-hand corner is an image of a cat where the red color showing where the most heat is being released, while the blue color is showing the coldest spot on the system.

Here we see that depending on the temperature of the object, it has different color. For example, for very hot liquid, such as the one that is showing on the right-hand side, it's a very hot liquid in a beaker that is 136 degrees Celsius, is up here red in the color.

On the other hand, for very cold liquid, for example, 18 degrees Celsius it appeared as purple. And by using these color scheme, it's a good way to explain heat loss and he gained for many of the students because sometimes a picture is worth 1000 words and picture is at times intuitive in terms of describing how heat loss and heat gain occur by just looking at changes in color.

But in order for us to create these thermal image, we need a thermal camera. So here is a thermal imaging camera that you can buy on Amazon that will require you to connect to a cell phone.

Here on this slide on the top left-hand corner, it wrote comparison, and on underneath the slide, it said low cost laboratory equipment. And we have two columns here. On the left hand column, is the commercially available thermal imaging camera where the thermal imaging camera module of our LIR is connected onto an iPhone at the bottom of the jerk.

On the smartphone there's a picture of a plug showing where the heat are glowing from a socket where the red indicate a very high temperature, and the blue background indicate very little heat is being output it.

So the whole cause of this cellar is around $400, but the smartphone is not included. On the other hand, so we ask ourselves, is it possible for us to create a thermal imaging camera for a low cost?

And by storing the internet, we have a look at various open source component that is currently showing on the right hand side of the column, where we have shown Arduino microcontroller, a thermal camera breakout unit, and an LCD screen where we can combine all of these component together, perhaps we can make a low cost thermal imaging camera.

In this slide, the title is called low cost thermal imaging system. And it's the title of the slide, it is at the top. On the right hand side is showing a connection diagram showing how the Arduino microcontroller board is connected to the various components such as the thermal camera sensor, as well as a bread board, and how the breadboard connected to the smart LCD screen that are currently connected to the breadboard via a different colored jumper cable.

We can now further lower the cost of this unit. We have now put all of these together inside a small cardboard box. On the right-hand side, we have shown our low cost thermal imaging camera, where we put all the component inside a small cardboard box, where the battery strap on to the box by two elastic band.

And it shows how the components are put together inside these cardboard box. And we have recently published this particular thermal imaging module in the journal or chemical education as outlined at the bottom with the citation.

So, we can make it, but now can it deliver the same learning objective? So here with two video, on the right-hand side is showing what we're calling a hot ice reaction. This reaction is a rapid recrystallization of sodium acetate. It is an exothermic reaction. And on the camera screen, from our low cost thermal imaging system, is showing a concentric circle where the middle is bright reaction where the seat of the crystallization happened and where the most heat is occur. And what we can see is that the heat is released from the surrounded by looking at the differences in the color change, from red, blue, blue, to red, green, to blue.

Now we're gonna talk about another reaction. It is an endothermic reaction. This is a cold reaction. In this case, we're just looking at the neutralization of a worn solution of acidic acid using sodium bicarbonate. This is an endothermic reaction.

In the beginning, what it shows is a very warm solution with a red dot in the center, a concentric circle of different color, where red is the hardest, and the blue and the green at the slightly colored temperature.

Once we add a spatula tip of sodium bicarbonate, the color changes from red to green to blue, indicating that the temperature decreasing as the reaction occur.

What this images and these video shows is that it is possible to use these low budget thermal imaging system to describe or to visualize a chemical reaction without literally breaking the bank. And it get the job done. While the resolution is not as great compared to the commercially available one, but it's undeniable.

It has educational merit because it actually demonstrate how the heat loss and heat gain happen depending on the chemical reaction.

And here's the conclusion. This is the conclusion slide, at the top left-hand corner it wrote conclusion. And on the screen, we have a couple of key points I want to talk about.

The first point is the open-source technology can provide an alternative to overcome a barrier to learning, and through the process of making, students will learn about design thinking as well because it actually let them think about what does it mean to be accessible?

And what it mean to be inaccessible, a student under new circumstances. And because you're making your own devices, you have the freedom to design devices that serve a particular need without incurring significant financial cost which is great.

And lastly, what we found is that when there's a will, and there is a way. And on the right-hand side, I ended with a picture of a rowing boat where three people are rowing in the same direction showing a collaborative motion through the course of the water, as a mean to show that we have to work together towards a common goal.

In this case, it's reducing the barrier to learning in the sciences. This is our last slide, and it is a thank you slide, and thank you for your time.

And I hope that this presentation will enlight some of you into taking up open-source technology, as a way to overcome some of the barrier that you see in your chemistry lab, or in your science education.

Thank you.

Narrator: A tri-campus partnership between U of T AccessAbility offices and Admissions and Student Recruitment. University of Toronto. IDEA- STEM.

uoft.me/STEMandDisability.