Cross Sensory Inclusive Design for STEM Video Transcript

-: Hello. My name is Ainsley Latour. I'm a cofounder of IDEA-STEM. The purpose of my video is to introduce the content for our conference session around nonvisual representations of STEM concepts for students with vision loss.

This is a presentation that's going to be delivered by Dr. Peter Coppin.

Before we get started, I am just going to give some visual description for what is on the screen right now. That is, I am sitting in my home office. I'm a female in my 30s. My pronouns are she/her. I am sitting in front of a brown wall with a white door and a whiteboard which has no markings on it. I am wearing a black jacket with a black blouse that has some light-colored marking on it. I have light brown hair, which I am wearing down.

In this session, Dr. Peter Coppin discusses the theory and also the processes behind inclusive design and co-design of models that give nonvisual representations for concepts.

He begins by making a case for the need for tactile models for those with vision loss using a line graph as an example. So with that line graph, he's able to illustrate all of the information you'd be missing if you either aren't understanding that graph, if you can't read it, or if you can't see it. Or you can't see it well.

He then differentiates between iconic and symbolic representation of concepts, and he gives us examples of each of those types of representation.

He uses examples in this video of a soccer game, the painting at an art gallery, and also a globe. And he shows how each of these three concepts, or the concepts related to a soccer game and a globe and a painting, can actually be represented in tactile structures. And he gives a little bit of an outline of the thinking and considerations that went into developing each of those three tactile models, so a little bit more detailed than in Caroline Karbowski's session which has a bit of a different flavor to it.

He also illustrates why tactile representation of some of these examples is much more powerful than simply using descriptive language, so an auditory representation of the concept.

All students can benefit then from the use of tactile models or other types of representation.

Sonification is another type that's nonvisual. Using these examples, then, we know that not all of a concept's dimensions or characteristics or information can actually be understood using descriptive language or by relying on one particular model that's accessible to one particular sense.

And, of course, we know that the more students see something and the more different ways they see something, the greater their chances of retaining that information.

So as teachers and as educators and as parents and guardians, asking students then to create models, whether they're visual or tactile or using sound, whatever it might be, to represent different models in STEM is a way to support the learning of all students in STEM.

You could then have students analyze. You could have a tactile model and a visual model and have the students analyze it. What are the strengths and the weaknesses of these models, and which one do you think represents the concepts the most?

That could lead to some really rich discussion which then could have written descriptions and opinion pieces to them which could play into your literacy program as well. So there's a lot of possibilities in thinking about the value of tactile models to the classroom.

I would like to encourage everyone before they view Dr. Coppin's session to read the abstract and just think about how you might use a tactile model or a nonvisual model in your own classroom.

I also wanna mention that this session is quite rich in both theory and practice. I myself needed to watch it twice to fully appreciate all of the great information that Dr. Coppin has so graciously spent time preparing for us.

If you do have questions or comments on this session, they are very welcome. You're able to submit that through the general conference email, and we'll talk to you either one-on-one or we'll communicate with you through the Q&A session on the last day.

You're also more than welcome to contact Peter on your own, and he would be more than happy to work with you around any of the concepts in this session.

With that, I hope you enjoy the session, and we're looking very much forward to your feedback and interacting with you.

Thank you.

Peter: Hello, everyone. My name is Peter Coppin. Today, I'm gonna talk about cross-sensory, inclusive design for STEM. As you know, STEM stands for science, technology, engineering, and math. Sometimes, there's an extended acronym called STEAMD, which is science, technology, engineering, art, math, and design. This could probably also apply to that as well.

So, as part of this, the subtitle to this presentation is, "A Co-design of Non-visual Representations for Visually Impaired Students." I am an associate professor in the Faculty of Design and in the Inclusive Design graduate program at OCAD University.

I also direct the Perceptual Artifacts Lab. This presentation has elements from many of my students and research assistants, including Chris Schiafone, Runa Patel, Nikkie To, Rachel Han, Robert Ingino, and Marta Wnuczko. And then there might be some other people referred to.

There's a picture here which shows what I'm gonna be talking about, which is, it's a crazy-looking model but it's basically of... It's something that a blind student made. It's two eyeballs and the optic nerves going into the brain system, and it's sort of suspended in the air.

And this (indistinct)

(notification chimes) through a co-design session which I'll be talking a little bit about.

But co-design is when you design with your audience rather than for. So it's meant to be a collaborative process. This was done in our lab at OCAD University. And actually, during the pandemic, we've developed some techniques to do this over distance using household materials.

So I actually just talked to Mahadeo about maybe including a session on that at some point, if that can be worked out.

I'll try to talk a little bit about it in this presentation, even though I don't have a lot of slides on it.

Okay, so I'm gonna start by trying to illustrate... (notification chimes) (indistinct)

This'll be familiar to some, unfamiliar to some of you. And even for those who are familiar with this, I wanna present this example and give a really technical description of the problem, 'cause I'll be also introducing some theories that can be really helpful and help inform the design of these types of representations.

Recording: The graph on the IBM stock-

Peter: Okay, so in the next slide, you're gonna hear a recording. This is basically a text description of a chart which is on the screen. This is an example of the way many visual graphics are made accessible to blind or low-vision students, or visually-impaired students.

Recording: The graph of the IBM stock price and volume indicates that the stock price rose to a peak of $120 in early June, fell to a low of $105 in early July, rose to the maximum price of $133 in September, and fell to the minimum price of $87 in late October. The share volume was relatively constant with larger transient peaks near the minima in July and October.

Peter: Okay, so I'm gonna talk a little bit now about what is sort of lost in translation from visual graphics to text for accessibility. So you just heard this text description. For those of you who deal with digital media, you're probably familiar with the Web Content Accessibility Guidelines.

It mandates or recommends, (notification chimes) and many government agencies and institutions use these accessibility requirements, it advises on how to make a chart like this accessible.

Now, what's on the screen here is a rectangle with numbers going up on this vertical axis and then months going on the horizontal axis. This is a financial chart, and it's labeled, "6 Month Price and Volume as of 11/9/2000."

And you've got a rising/falling line in the background. And then you've got this blue contour, like a sort of a mountain range, which rising and falling elevations of a closed blue shape in the foreground.

Now, it's a big philosophical issue about what the difference is between graphics and text, but let's just talk about some intuition. The visual graphic, you can see this pattern. There's this notion that it's very simultaneous. It uses the parallel processing of vision.

Now, the text description, it's an interpretation. It's presenting basically a bunch of linguistic categories, like rising and falling, peak. So if this were an actual mountain range, let's say this is a picture of three peaks of varying heights, and it had a text description that said something like, "this is a picture of three peaks of varying heights," an infinite number of shapes could fall under that description. That's basically the problem here.

So what we're gonna be talking about is how text and spoken language is really good for abstract concepts, like infinity, love, spicy, whereas they're not so good for communicating concrete structures or visual spatial structures, like a shoreline or a mountain shape or the moon or something like that.

Okay, now, let's talk about what is inclusive design and what is co-design? Inclusive design has several different interpretations, but basically it aims to design for the fullest range of human diversity possible. Its history sort of comes out of accessibility and assistive technology. But over the last decade, it's broadened out to cover many, many facets of human diversity outside of disability: linguistic diversity, gender, you name it. Most of what I'll be talking about here is perceptual cognitive differences, and applying this in low vision in particular.

Now, I also wanna mention co-design, also called participatory design, and as I've mentioned before, this is designing with rather than for potential constituents of the thing you're designing. There's a picture here of an example of something that was co-designed. This is a picture from the Art Gallery of Ontario. In the background, there's a painting called "Jar of Apricots," which is a painting of a jar of apricots with other objects positioned around the jar of apricots.

It's a very famous painting, several hundred years old. And in the foreground is a cross-sensory translation or interpretation of this created by Nikkie To and Grace Mendez who were two inclusive science students at OCAD, now graduated. There are 3D-printed models in the foreground that correspond to the pictured objects in the painting.

For example, there's this Mason jar-like thing, just a jar of apricots, and there's a 3D-printed model in that shape. And then there's a wine glass in the painting, and there's a 3D-printed object shaped like a wine glass. And a tea cup in the picture and a 3D-printed tea cup. And then what they also did here is they had tactile paint on these objects, and so when you would touch the different objects, you'd actually hear auditory cues.

So this is an example where I could describe what's going on in that painting, and you would get a rough, abstract idea, but an infinite number of paintings could still fall under that. Whereas what this does is this cross-sensory translation, and by cross-sensory, we mean there are corresponding sounds... Actually, I'll talk about that a little bit in the next slide.

Like you get a better idea of what's actually is going on in this painting by providing a 3D model that people can access.

Alright. Okay. And to develop this, there were several co-design sessions in the class, including some members from the CNIB community.

Okay, now, I wanna talk a little bit about an idea that's very powerful in inclusive design. It's affordance-based approach. Affordances come out of ecological psychology in the '60s but then slowly made their way into design. This is very compatible with what we would know as the social model of disability.

It's this idea that disability is something that emerges through the way things are designed and the way society is constructed rather than it being something inherent in the individual. So the idea here is that affordances arise and also disability or access arise depending on the relationship between the environment, but the way the environment is configured relative to the capabilities of the individual.

So it's like the hammer, the shape of the handle, the weight of the hammer, and the shape of my hand and the way my hand functions, and the way that it interacts with the hammer is sort of how the affordances of the hammer arises and what the hammer affords.

But if my hand were injured or if I didn't have a hand or if my grip wasn't sufficient, that would also change the affordances of the hammer, right?

So what we've basically been doing is taking that idea and applying it to representations where it's not so much a physical object but a representation, like a picture or a sound is something that sort of emerges between the environment and the individual in perception. Alright?

This sort of comes out of my PhD... Well, what I'm getting ready to show comes out of my PhD research. And what I developed, just in a nutshell, is a way to distinguish pictures, diagrams, and text based on how objects and relations among objects were pictorially or symbolically represented. And just in a nutshell, pictorial properties, you could think of it as the light that reflects from a page or from a screen, whereas the symbolic properties are like the meaning or the categories you bring to it.

And actually, I sort of extended that idea for the work we're talking about right now into the cross-sensory domain, where... I'm gonna basically talk about everything that's going on in this slide that's in front of you, but you don't need to see it, obviously.

On the left here, we have what what we would call more iconic representations. These are representations that resemble the thing they represent. For example, like the "Jar of Apricots," like the 3D tactile model, there's some type of resemblance between that 3D model and what's visually represented in the painting.

Just for example, I could have like an outline drawing of a mountain shape. Or I could have a 3D model, or on the slide, I have like a bent object which was been into the shape of a mountain shape. There's like a iconicity or resemblance between the metal shape and the outline drawing. Or I could use sound to communicate this. So it's like there's just a spectral display up there I have in it. It's like middle C, like,

♪ Ooh wee ooh ♪

So that would be an example of sonification. That could be used, for example, as an alternative to that financial chart to actually show the shapes. Or another good example, if you're listening to the news or reading the news, it keeps talking about flattening the curve, and there's all of these COVID diagrams which are not very accessible.

So actually, a sound file where the rising and falling tone corresponds to the elevations of the graphic would be another way of making that cross-sensory. And then gesture is another example. There's just a little animated GIF of a person moving their hand in a mountain shape.

That's actually the American Sign Language gesture for mountain, I believe. So these are all types of iconic representations that resemble the thing they represent.

And then, of course, we have the written or linguistic or more symbolic side on the other end that's more about a category that the shape could fall under. Whereas, like the outline drawing is example of visual graphics. Obviously, printed words and a writing system are more symbolic versions of that, more on the symbolic side. And then in the auditory domain where you could use spatial sound or non-linguistic sonification, spoken language would be the more symbolic version on that side of the spectrum, in contrast to iconicity. And then in the tactile domain, we obviously have Braille or other tactile writing systems. And then within sign language, you have gestures with some iconicity, like this mountain shape example, but then there are also gestures that they are more referring to an abstract concept that doesn't necessarily have an iconicity to the thing it represents. And I'll be giving lots of examples of all this type of stuff.

Alright, so let me just start with an example. This is joint work with my advisee, Felipe Sarmiento, who graduated recently from Inclusive Design program, funded by NSERC and Scotiabank. Felipe sort of comes from the soccer or sports industry. Was a big soccer player in his former life and is a designer. And what we have here is just a standard type of description you would get from a soccer game. And although this is not a science representation, this is a great technique that could be used for lots of different scientific applications in the classroom.

So it said, "Player 12 for Red Team passed the ball diagonally to Player 14 but the ball was intercepted by Player 8 from the Blue Team." And on the right here, we have nine different diagrams that fit that description, right? I mean, the text description is helpful but it really has the same problem that the one for the financial chart did, which is that what's really relevant about watching a soccer game is the relationship between the players and the ball.

And it matters, the actual visual structure of what's happening on the field, or the spatial structure. So what I'm gonna talk about is a way Felipe actually discovered a new technique, an emerging sign language system, that actually communicated these concrete structures in the soccer field very effectively.

Okay, so I've got a picture here of just a video capture from a soccer game. Players on the field, blue ball somewhere in there. And then below that is the translator who's looking at the field, and they have their hands positioned over (notification chimes) a rectangular piece of wood shaped like a soccer field, and then the spectator has their hands on the translator's hands.

So the way this works is, as the game is progressing and the ball is moving across the field and as the attacking and defending player are moving, the translator's moving their fingers around on the board, and so the spectator, who in this case is a blind spectator, is able to follow along and get an idea of where the attacking and defending players are and the ball, which is, of course, between the attacking and defending players.

Now, I just wanna talk a little bit about some features he discovered that really get at this idea of the abstract concept you get with language versus the concrete structure on the soccer field that you get with these iconic gestures. He was able to watch, observe this language system evolve.

So the whistle blow, which would be when the ref blows the whistle, and there's all these different types of fouls and things like that, so all of these fouls are like abstract ideas. They're not really the concrete structure of where the players are on the field. They're like events, so they're more like a number system, or they're linguistic. They're a category. But it started out as a gesture in the shape of a whistle blow, but as he was able to observe the language system evolve, the gestures evolved into a series of puffs that represented these abstract categories that are fouls.

So it started out as something highly iconic which is resembling the whistle blow, and then it became a series of puffs. Because, obviously, it's better to leave your hands free so that they can be on the board. So this trajectory of starting out as highly iconic is the way a lot of languages evolve.

So when scientists have studied cohorts of deaf students... There's actually this famous example in Central America where the students weren't taught a sign language but one spontaneously emerged within like three cohorts.

And what they observed is it started out with gestures that resembled the things they represented, and then, as the language system became more advanced, it became more symbolic and it was able to refer to more abstract categories.

Now, the opposite trend occurred for the concrete structures. That's like the positions of the players relative to each other with the ball in between. So as they developed the technique and they got better at using this soccer field, the iconicity increased. There was more of a resemblance that more accurately conveyed the concrete structure of what's going on on the field.

And then Felipe created some instructions so that educators or translators could replicate this. You can download this for free from the OCAD Open Research Repository, which is where all the thesises of major research projects are.

Felipe made some instructions so that other people can deploy this technique. And this was a technique that Felipe discovered, and then his main contribution was the scientific description or his designerly description of this technique and then developing these instructions so that other people could replicate it.

And this is a sports example, but you can imagine using this for like a statistical chart or in geography or lots of different situations. You know, most graphics are on a rectangle and a soccer field is a rectangle, and so this could probably be used for lots of different techniques.

Okay, so now, let me give another example. This is an audio-tactile globe. This was joint work with Uttara Ghodke, collaborators, Steve Murgaski, Lena Yusim, Brandon Biggs, and Marta Wnuczko, also funded by the NSERC CREATE Data Analytics and Visualization Program and Scotiabank.

Let me just start off with an example. This is another situation where, to learn about the earth, we're talking about concrete spatial structures of the earth. This is well-illustrated through this situation that happened when we were developing this. Uttara had sculpted out of clay a 3D model of Italy, and the participants were interacting with it, and the participants were blind.

But one was participating through videoconferencing. They didn't have access to it but they were just brainstorming as the local participant who was blind was manipulating it. And then the person on the remote end was, "Oh, Italy is shaped like a boot, so look for a boot." And then someone else, I think it was me, said, "Yes, and it's like a Three Musketeers boot." And they just started laughing.

And now, I mean, it's an example of how it was obvious either... Like, how would you have access to what a Three Musketeers boot was shaped like? I think it was so funny because everyone had been imagining a different-shaped boot But also, it was also maybe funny because it's sort of ridiculous because if you're blind and have never seen a Three Musketeers boot, then you wouldn't have access to that information either.

The point is here is that these are all techniques to try and communicate, get more precise about the concrete shape. But language just has a really hard time with doing that because, in the same way all those other descriptions of the concrete structure create a situation where many possible concrete structures could fall under that description, an infinite number of boot shapes could fall under this description of a boot-shaped landform.

So what I'm gonna show here is an example where Steve Murgaski, who joined our program through one of our co-design sessions...

This is what we call a natural lab. What Felipe did, so that versus co-design where we actually co-design the entire thing with the audience, a natural lab is just a word we made up, but it refers to where a community developed it before we got there. So our goal is not necessarily to work with them to design it but to work to understand it and then work with them to maybe take the design to the next level.

And the benefit of this over co-design is it respects and reflects the worldviews of the constituents and often leads to something that designers, particularly sighted designers, wouldn't have thought of. They don't have that lived experience. So what Steve did here is he purchased a toy, an educational toy, called an Intelliglobe.

There's a picture of it there. Basically, it's a low-cost electronic globe that comes with a little stylus. So, for example, you can position that stylus, put it on different parts of the globe and it'll read off the country name. There's different settings, lots of different settings on it, but he mainly had it stuck on the country name setting 'cause that's what he really needed.

Okay, so that's good. That presents the symbolic information through this link, like speech, label, labeling system activated with the stylus. But he doesn't have any of the iconic information or information about the shape of the continents or the countries.

So then he separately purchased this plastic sheath from American Printing House for the Blind. And then, with his friend, he attached it to the globe and then registered it so that the raised-line continent outlines corresponded to the labels.

So this is an improvement. So now, he could press the pen through the sheath and get the symbolic information, so that's like the country name, and he had some information about the shape of the country, the landform, through the sheath. Now, the interesting thing is, is that, with just the sheath and no labels, the globe really doesn't have much meaning. A globe is like a combination of those things. For a sighted person, we get the outline shapes of the countries and the continents. That's important 'cause it shows the concrete structure.

But then we also need... These abstract categories have been created and cultured and assigned to these places like Germany, Brazil, Italy, Australia. Now, there were some problems with this globe that Steve was interested in working with us to improve upon, and that was that it was really hard to feel the shapes. They really weren't deep enough. It needed to be exaggerated.

So what we did is, Uttara Ghodke, working with Steve and the rest of the team, iteratively, we tried out lots of different ideas, and what we came up with was these 3D-printed continents that magnetically attached to the globe. And then, with a PENfriend 2 audio labeler, we then put audio labels to all the country names and city names, all the relative symbolic information in the globe.

I don't have an exploded view of it here, but I'll just describe it. Basically, you could remove like Africa or Australia or any of the landforms. It had a pulley system that would allow... It was magnetically attached. Those of you who've had a laptop such as a Mac with a little magnetic plug that attaches. It's sort of that concept so that you can snap off these continents and feel them individually.

The idea was, by making them removable, you'd get away from that cacophony that we, working with Steve and our other participants, sort of goes along with a lot of these raised-line maps with lots of countries put together, just a spaghetti of zigzagging lines. So you could feel each country individually, and then you can snap it back. And the pulley helps you not lose it if it were to fall on the ground or something like that. And then with the PENfriend 2, you can then position it over these bumps and read off the label.

So she developed that prototype over a period of like six or seven months, meeting each week with the team and our various lab members that included three blind participants, sometimes four, and then videotaping it, and then observing what worked and what didn't work, and then coming back with an iteration like the next week. Okay.

So those are some examples of some cross-sensory strategies. I mean, I think, just to summarize... I mean, I got a slide, but I won't go into too in depth. I guess the main idea is that there's spatial sound.

And I didn't show an example of that, but Brandon Biggs' technique that he developed actually use audio cues that, using binaural sounds, that's like surround sound or stereo, you can hear audio cues spatially. And you can think of it as an audio version of a diagram. Like in his playground interface, if you stay in the middle of the playground, in his audio map, and there's a swing set to the northwest, sounds like it's to the northwest, and if it's far away, it sounds far away, if it's close, it sounds like it's close. And then other objects can be around you in these spatial locations, and then when you bump into them, it would read off the audio label.

I basically just described a visual graphic that's on the slide, which goes from a rectangle to this surround-sound concept. And then, the technique we've talked about is this use of 3D models instead of raised lines. I've got a little picture of a street scene, so a car in front of a building in front of a mountain range.

So the car, which is in the extreme foreground, could be full 3D model, the building could be a 3D model, then, as you get further into the background, you might need something more like bas-relief, and then extreme background, something like a raised line, because the further it gets in perspective, the less you could make a full 3D model.

Another thing I don't have time to go into but I just wanna tell you about it is Rachel Han's major research project, which is the equivalent of a thesis in our program. She just developed a decision aid for translating scientific images and data to accessible format.

This is actually a decision tree that's intended to be used by educators. You can also access that through the Open Research Repository.

I could have Mahadeo's team post links to everything I've talked about.

So that's it. That's everything so far.

I just wanna say a few things about COVID-related stuff. Obviously, a lot of what I've just shown you requires an actual access to a physical object, but one of the things we've also been doing is developing co-design techniques that can be done over distance through videoconferencing.

And this is something that educators can do at home. We've worked with educators to develop to use everyday household materials to develop neuron models or brains or an ear.

We did an activity that focused on that. And then we've also been doing a lot of forward-looking work with haptic VR with our friend, the friend of our lab, Robert Ingino of SenseTech Solutions.

The future of that work would be, instead of having a physical globe, you can actually have a virtual, like virtual reality globe, a 3D model. And then, using this haptic glove, which is, imagine it's sort of like a marionette puppet for your hand but with servomotors to provide force feedback.

So it's like when you're grasping, say, a virtual ball, it would actually, you would get the force feedback through the servomotors on the haptic glove, to feel that. So then it's something where the potential is so that it doesn't have to be 3D-printed every time, it could be refreshable because just every...

Using the glove and then grasping a 3D model of a mountain or a human heart, so you would need a physical object. Now, that stuff's sort of far out.

And another thing we're... Well, that's sort of good enough for now.

I think I'll end there.

My contact info is pcoppin@faculty.ocadu.ca. That's P-C-O-P-P-I-N, @faculty, dot, O-C-A-D-U, dot, C-A. So feel free to get in touch.

And thank you very much.