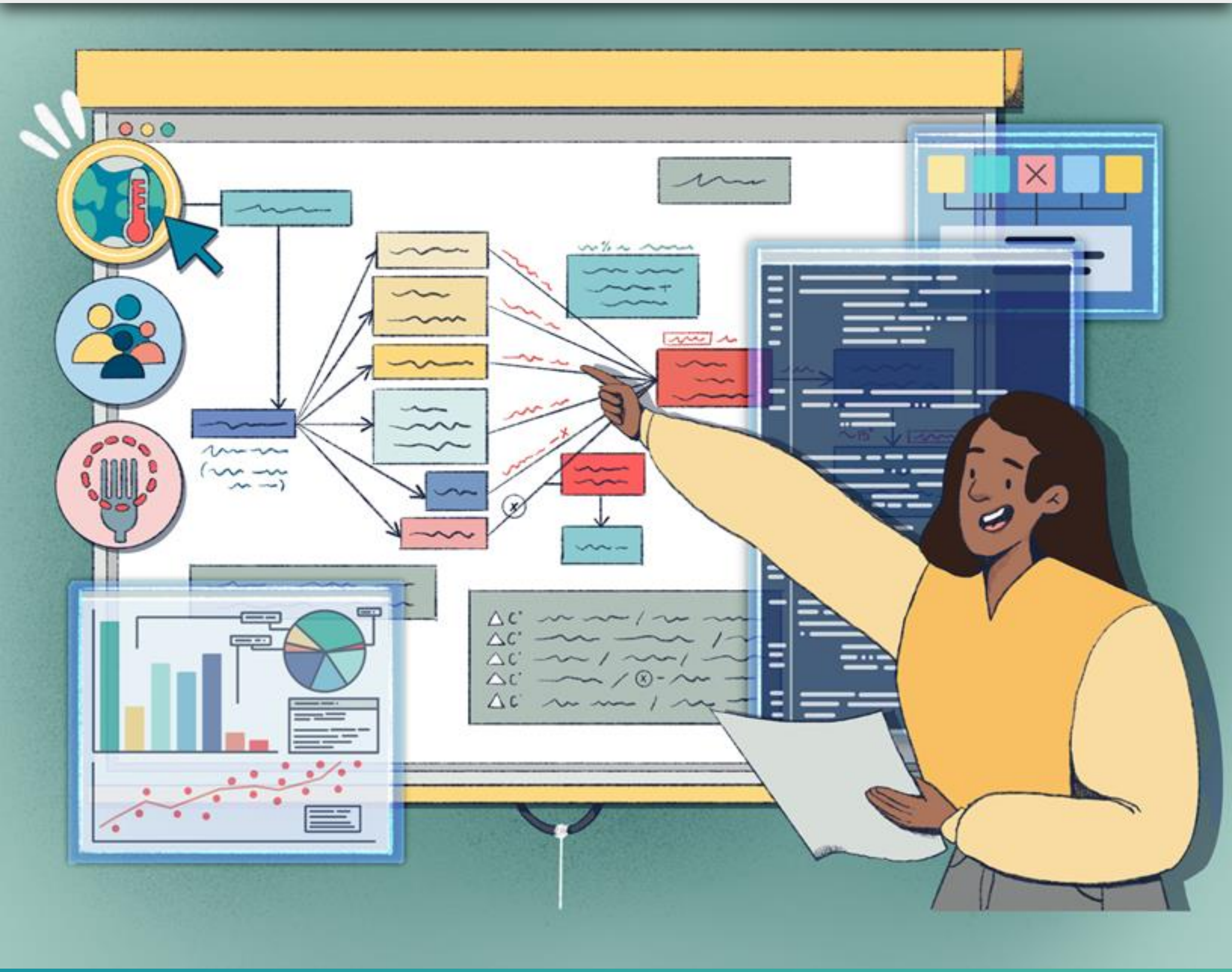
Inclusive and Experiential Pedagogies for Undergraduate Mathematics and Computer Science

Workbook



Developed through a partnership across two Ontario universities, this set of interactive modules offers self-paced professional development to help instructors of mathematics and computer science courses build capacity for enacting inclusive experiential computational modelling activities in their classrooms.

This project is made possible with funding by the Government of Ontario and through eCampusOntario's support of the Virtual Learning Strategy. To learn more about the Virtual Learning Strategy visit: https://vls.ecampusontario.ca

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Course Overview

As part of the Government of Ontario's Virtual Learning Strategy (VLS) and facilitated by eCampus Ontario, we are excited to present this interactive and multi-modal e-course **Inclusive and Experiential Pedagogies for Undergraduate Mathematics and Computer Science**. Designed to help Instructors, Tutors, & Teaching Assistants enhance and apply skills for leveraging inclusive, equitable, and experiential online teaching practices to support student learning and achievement.

Inclusive, equitable, and experiential online teaching practices offer educators new possibilities for how to engage, interact with, and support students from diverse backgrounds.

This course explores research-based strategies for leveraging high-quality inclusive teaching and experiential learning practices to enhance retention and reduce marginalization of women and underrepresented people in in post-secondary sciences and mathematics.

Inclusive teaching practices strive to cultivate equitable and accessible learning environments where students feel valued, supported, and a sense of belonging. In mathematics and computer sciences, inclusive teaching goes hand-in-hand with opportunities for students to experience real mathematics and computer programming in pursuit of solutions to real problems that are meaningful to them.

Course Objective:

The objective of this course is to support instructors as they develop and enhance inclusive teaching practices in undergraduate mathematics and computer sciences. This course examines how to develop and enhance inclusive teaching in mathematics and computer sciences through the incorporation of Experiential Learning (EL) practices. Specifically, the course examines the connections between engaging in computational modelling and EL practices, and lays a foundation for how to enhance pedagogy through activities that engage students in mathematically analyzing and modelling socially relevant issues that are important to them. By the end of the course, instructors will have new insights and resources through which to frame and extend their current teaching practice with EL opportunities and inclusive pedagogies.

Why bother?

When computational modelling is connected to experiential learning, computational modelling helps the learner to see and predict real-world phenomena. Learners gain insight, and the whole process helps the learner to grow and learn through these experiences. Implementing computational modelling and experiential learning together in the classroom can foster a sense of belonging for students. Having themselves represented in the work they are doing will help to build a sense of belonging and a STEM identity, or the feeling of being a STEM person. A sense of belonging supports students in feeling as though they are valued members of the STEM field they are in. Benefits include academic success, positive mental health, and higher retention rates, all of which connect to our STEM identity.

Through your participation in this course, you will:

- Enhance pedagogical strategies for designing and leading experiential learning activities in undergraduate mathematics and computer sciences.

- Build capacity for enacting inclusive pedagogies that apply mathematical and computational modelling to critically examine real-world societal issues.

- Enhance awareness and techniques for supporting student belonging, engagement, and achievement in undergraduate mathematics and computer sciences.

Self-paced Learning

We designed this course with flexibility in mind; learn in your own time and by your own schedule. Course material can be reviewed, rewound, revisited as many times as required.

Differentiated Experience

To complete this course, you will respond to the workbook questions included in this booklet. Questions focus on applying course ideas about inclusion and experiential learning to your personal teaching context, reflecting on those experiences, and developing new transferable competencies for undergraduate mathematics and computer science teaching.

The Research Behind this Course

This course is based on a recent Knowledge Synthesis Study by Robyn Ruttenberg-Rozen and Tapo Chimbganda (2021). For more information you can access the report from this study here: exploringideas.net/retention

This course consists of two modules:

Module 1:
Experiential Learning with Computational Modelling

Module 2:
Enhancing EL in the Classroom: Case Studies

The **workbook** serves as a companion guide for this e-course. The workbook is designed to help foster connections across modules for a holistic sense of how social justice focused computational modeling tasks can be purposefully integrated to enhance your practice. Through your engagement with the course you will develop awareness of inclusive practice, pedagogical skills, and transferable competencies that will equip you for teaching effectively using experiential and inclusive learning. You can record your written responses directly in this workbook. Click on the pins in the above image to jump to the workbook questions for each activity.

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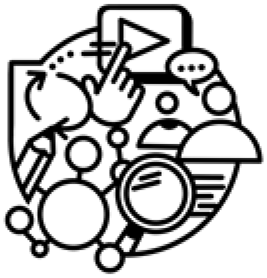
Module 1: Experiential Learning with Computational Modelling

In this module, we articulate the five phases of Experiential Learning and breakdown strategies for incorporating EL practices in undergraduate mathematics and computer sciences. Our activities unpack key aspects of designing and developing EL activities, while inviting instructors to consider how to (re)frame and enhance their teaching approaches.

List of Activities

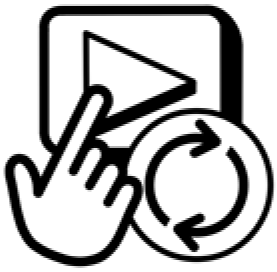


Activity 1:
What is Experiential Learning?

Activity 2:
Experiencing Computational Modelling

Activity 3:
Why is EL Important?

Activity 4:
Putting it All Together in Code



Activity 5:
Applying Ideas to Your Teaching Practice

Workbook Questions for Activity 1:
What is Experiential Learning?

Summarize in a couple of sentences what is meant by "experiential learning".

Can you provide an example of what you believe is experiential learning? In your example, what in particular is experiential?

How could you extend your teaching practices to include more (in quantity or variety) opportunities for students to engage in experiential learning?

Describe one of your current teaching activities in terms of the five phases of experiential learning. Reminder, the five phases are: experience, sharing, processing, generalizing, and application.

Choose a lesson from your teaching experience that you would like to modify into an experiential learning activity.

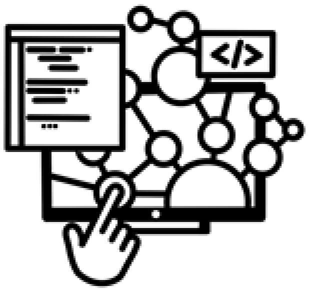
Sometimes, when modifying an activity, it is easier to start with one phase at a time rather than consider them all at once. Use your new learning to modify the activity into an experiential learning activity.

Which phase did you start with for the lesson you chose? Please explain.

Are you interested in learning more about experiential learning?

Here are some resources to get you started:

Institute for Experiential Learning webpage
Government of Ontario Considerations for Program Planning webpage
Experiential Learning Toolkit webpage



Workbook Questions for Activity 2: Experiencing Computational Modelling

Think of the most recent real-world issue that you have modelled. Each of the next questions relates to this issue.

In a few sentences, describe the problem, your rationale for selecting and studying the problem, and the initial questions you formulated (i.e., the questions you were interested in and hoped your model would be able to help you answer).

Now, provide an outline of the steps you took to model the issue. Include what you did to formulate and modify the questions, to source data and mitigate instances of inadequate data, to interpret results, refine the model, and so on.

Reflect on these steps in light of Activity One and describe your modelling approach in terms of the five phases of experiential learning.

What did the Experience Phase look like?

What did the Sharing Phase look like?

What did the Processing Phase look like?

What did the Generalizing Phase look like?

What did the Application Phase look like?

Think about communicating your model's output and the conclusions you reached (answers to your questions). How did you ensure that others were able to understand how you built your model and its output?

Describe how the model better helped you to see the issue/problem you identified. Which new insights did you gain?

Summarize in your own words the ways in which engaging in computational modelling is a form of experiential learning.

Why might it be helpful for your teaching to draw explicit links between computational modelling activities and the five phases of experiential learning?

When computational modelling is connected to experiential learning, computational modelling helps the learner to see and predict real-world phenomena. Learners gain insight and the whole process helps the learner to grow and learn through these experiences.

Are you interested in learning more about computational modelling?

Here are some resources to get you started:

NIH Computational Modelling webpage
IGI Global Computational Modelling webpage

Workbook Questions for Activity 3:
Why is EL Important?

As we learned in the video, implementing computational modelling and experiential learning together in the classroom can foster a sense of belonging for students.

How does a sense of belonging support student achievement?

Reflect on the course activities you tend to give. How do your course activities help foster a sense of belonging amongst students?

- Do the course activities consider your students' prior experiences, interests, and communities?
- How could you modify your course activities to better connect with your students' prior experiences, interests, and communities?

What preliminary questions or concerns do you have related to using computational modelling in your courses so that activities resonate with students' lived experiences, interests, and communities?

Are you interested in learning more about computational modelling?

This handbook details computational modelling and its benefits:

Computational Modelling: Technological Futures Handbook

Workbook Questions for Activity 4: Putting it All Together in Code

We worked extensively and collaboratively with students to gain insight into learner experiences and to co-construct materials and resources for this module. Here, we outline the steps we took:

How we did it:

1. We first met with the students to discuss topics and themes. This is important to help the students find their focus.

- Initially, students' suggestions for topics and themes were broad and vague (in terms of what question(s) they wanted to research)
- Some students' suggestions came with a bias, which, as researchers (and math modellers), they had to shed to keep neutrality (see also 4a below)
- The contexts of students' suggestions were wide, and reflected large societal issues that we've been facing (such as poverty, climate change, equity, racism)

2. We surfaced the student's questions related to their interests. Trying to pull out what they were interested in mathematically modelling.

It is important to let the students decide on the theme of their research of course, the theme they choose does not have to reflect their own personal experience; instead, it could be of global interest, such as climate change, economic disparities, global food supplies, etc.

3. As the students came up with questions, we **refined their questions** with them. This centered around what could be modelled and (later) what data is available.

- This refining process was initially challenging to students, as they had to learn/figure out what “can be modelled” actually means (e.g., understanding the limitations of coding, availability (or not) of data)
- This refining process resulted in initial fine-tuning of the questions
- At this stage, the model was revised to eliminate/add/modify “boxes” as dictated by the availability or absence of adequate data
- In some cases, in the absence of exact data, we decided to use approximations/ estimates (as is common in modelling)
- Students were asked to keep track of the limitations imposed, as well as list the assumptions that were made and approximations/ estimates

4. We negotiated the topics with the students. We tried to steer the students away from triggering questions and questions that were too personal/not data driven. This was a recurring process. These negotiations focused on the direction the students wanted as their directions tended to be personal and possibly related to the student’s own lived experiences. We directed students to topics that were more straightforward in order to model, and not connected to identity, or a person's experiences.

- The goal of this negotiation was to shift students from the idea of “my experiences” into modelling mathematically that requires a level of generality and relevance for a larger group.
    - This removes a layer of subjectivity and allows the students to be more objective because it is less personal.
    - It is based on data instead of the student’s own personal ideas.

- One reason why this is important is to make the models that we constructed less intimidating for math and comp sci instructors (who would likely shy away from "uncomfortable" themes such as identity, or discussing their students' personal experiences); as well, we have to be cognizant of the fact that the amount of time in a math/comp sci course that's dedicated to applications is limited.

- Our models could serve as a blueprint for instructors to create their own models.

5. Once the students had their questions **they did some research**.

- This research was needed to figure out exactly what elements (aka "boxes" or compartments) to include in the model, and what elements (although potentially relevant) will be dropped
- It became clear that students needed to learn more about their research topic (which is a benefit in itself; and also a humbling experience, as we realize that what we think we know is only the tip of an iceberg)
- This is a demanding phase as students had to spend time searching through numerous references, documents, etc., and judge what might be relevant for the model. This includes a challenging task of connecting various pieces together (is it really true that A causes B, or maybe it's just a correlation? This data shows that both X , Y and Z affect W, and not just X, etc.)

6. They collected raw data and secondary data to **create their fuzzy maps.**

- Once boxes/compartments were drawn, students needed to include the arrows, defining how one box effects the other(s), and how all these connections lead to the "final boxes" (ie, those which contain the quantities that help them answer their questions)
- Students soon realized that good, reliable, numeric data is hard to find, and that drawing these arrows is quite a challenge

- As is common in modelling, the absence of exact data had to be mitigated by using approximations and estimates, which was another challenge that the students faced, as this kind of approach is not routinely taught in level 1 math courses
- Because of the short time frame, collection of primary data (say, through surveys of students) was not feasible (although would have been very useful)

7. As the students collected data, **further negotiation was required** as the students continued researching and collecting data on their topics.

- Conversations related to the limitations of mathematical modelling and coding were pivotal to getting students to think about "what the math can do for us?"
- By this stage, students have understood why some questions they initially asked were not answerable using mathematics and coding (good learning experience)

8. The students' **fuzzy maps needed to be refined, this was a cyclical and iterative process.** The fuzzy maps needed to be refined based on what could be coded.

- On top of the limitations related to data collection, there are limitations that come from coding; for instance, one needs certain type of data (sometimes it is absolute numbers, but often rates of change were needed), and that data needs to be numeric (rather than categorical)
- A good way to imagine this process is to think of balls tied to each other with springs; when one ball is set into motion (say we hit it), it affects others as well (some more, and some less)
- It's a cyclic process which results in fine-tuning of the research questions, modifications of the fuzzy maps and the corresponding code. For instance, students had to realize that data comes with units, and that their map had to be adjusted based on dimensional analysis

9. We worked on **massaging the issue with them** all the while they were collaborating together.

- We revisited the data with the students and guided them toward which data would be most suitable for answering or modeling an issue.
- Several times, students were given a task to figure out the specific number that was needed to complete their fuzzy map

10. Once the issues were modelled **they were coded for the students.**

- Due to the lack of time, we did not ask students to code their models
- A group member wrote initial code in Python
- Another group member, in collaboration with students, modified the code to reflect the modifications in the fuzzy map
- As well, instructions to generate output (numeric and visual) were added to the code

11. **Adjustments were made to the data in the code** based on the data that went into it.

- In some cases, the outcome was judged to be disproportional, i.e., out of the expected range; that required that students revisit their data sources, check for accuracy and modify certain numeric values in the fuzzy map
- In a discussion with students we touched upon challenges in modelling that go beyond those imposed by the data or coding. For instance, a more complicated model is not necessarily a better model, and the art of modelling often revolves around including the right elements. This also means that not all data that students identified could be (or should be) used.

12. **The students interacted with the coded models, interpreted the results and altered the interventions** to see the outcomes of their models and the interventions.

- The students, together with a team member, went over interventions and decided on the range of values that the interventions could have (which either increased or decreased their role in the model outcomes). This gave the dynamic structure to the model (for instance seeing how the outcomes change based on incremental changes in interventions)
- Students were given a document with all code and output that is supposed to answer their questions
- Going over the code was optional
- Students were asked to look at the results, see that they make sense, and think about interpreting them in the context of the questions they asked.

In the 'Putting it All Together in Code' series of videos, Dr. Jeremy Bradbury discusses different strategies for using the code in your classroom (i.e., partially coded, skeleton codes, adjusting interventions, etc.).

Select one of the topics modelled in this section (Homelessness in LQBTQ Youth, Fast Fashion and Climate Change, and Diversity in Higher Education) and analyse the fuzzy model. What questions do you have about the model? What questions do you have about the issue being modelled?

Reflect on the steps taken to create and modify the fuzzy model (please see the ‘How we did it’ section). Did anything surprise you?

How might an individual’s lived experiences about social justice topics influence their comprehension of the fuzzy model?

Run the code for this model. What do you notice?

In what ways was the output as you expected it? In what ways did it differ from your expectations?

What questions does the output answer? What questions are not answered by the output?

How might you modify the model(s) in order to answer some of your other questions?

Workbook Questions for Activity 5:
Applying Ideas to Your Teaching Practice

1. Introduction

Reflect on the benefits of modelling real-world social justice issues with mathematics, listed in the video. Do you agree with them? Are there other potential benefits you think are important?

Some of the questions the professor asked in the video were, *"How do I start? Where do I look? Who do I ask? Has anything like this been done before?"* How do these questions relate to your own questions thus far?

2. Setting Up the Problem

What social justice issue would you be interested in modelling mathematically?

What social justice topics would you avoid using in your classes? What about these topics steers you away?

What resources do you have at your disposal to help navigate challenging social justice topics?

It is perfectly okay to limit topics to those you are comfortable discussing and mathematically modelling. You can control the topics that students interact with by prescribing a list of topics and allowing students to choose from your list. Over time, as you gain experience, you may become more comfortable adding different topics to your list or allowing students to select their own topics.

3. What Makes a Good Question?

In the video, we saw Dr. Ami Mamolo explain that “part of the entry into these topics is identifying what in these broad issues is a problem that we could understand better from exploring the data that exists or maybe questioning the data that exists, [and] trying to capture the trends in a model.”

Below is a list of topics of interest generated by students.

- Climate change
- Diversity
- Police brutality
- Food insecurity

Which of the above topics would make the best modelling problem? Why do you think the topic would make a good modelling problem?

Would you avoid any of the above topics in your class? Why?

Select one of the topics:

Write a question related to that topic that could be answered through computational modelling.

Consider what data you might need for your model and how you could access this data.

Identify what insight about the problem could be afforded through the modelling.

Anticipate challenges that could arise when tackling such a question in class.

When choosing a problem, Dr. Miroslav Lovric asks these questions:

1. Is there math in it, and is it related to the content of the course I'm teaching?
2. Are my students' backgrounds adequate for the approaches/techniques needed to solve the problem (in terms of math and coding)? If needed, is it possible to review/teach relevant background material, given the time constraints imposed by the course structure?
3. Is it easy to engage/ to start working on (the low floor)? Does it have a challenge (high ceiling)?
4. Is the problem theme relevant and does it reflect student interest (students are often aware of what's possible within the constraints of the course)
5. Do various approaches to solving a problem allow for extensions (i.e., can they be used to approach/solve other problems)?

Are you interested in learning more about mathematical modelling?

Here are some resources that you can explore:

Ten simple rules for tackling your first mathematical models: A guide for graduate students by graduate students webpage
Choosing the Best Model journal article

4. Dealing with Real Data

When dealing with real data, it is important to ensure that there is enough data to sufficiently model the problem and not too much data that the model will be too large and complicated. Having too much data is the better of the two scenarios because you can select what to include within the model.

How would you base your decisions on what data to include and to omit from your model?

Reflect on your experiences in modifying the formulation of a problem and the questions (output) due to a lack of relevant data. If the data your students needed was unavailable (or they could not find it), what approaches would you advise them to take in order to mitigate or resolve this situation?

What do students need to know about how the data available helps determine what mathematical formulas, ideas, or concepts to use?

The video mentions that some of what students think about a topic is not actually based on data. Have you ever encountered this in class? How have you responded?

What strategies can you use to mitigate students' biases and redirect them to focus on drawing conclusions from the data?

List some sample guiding questions that could help redirect students.

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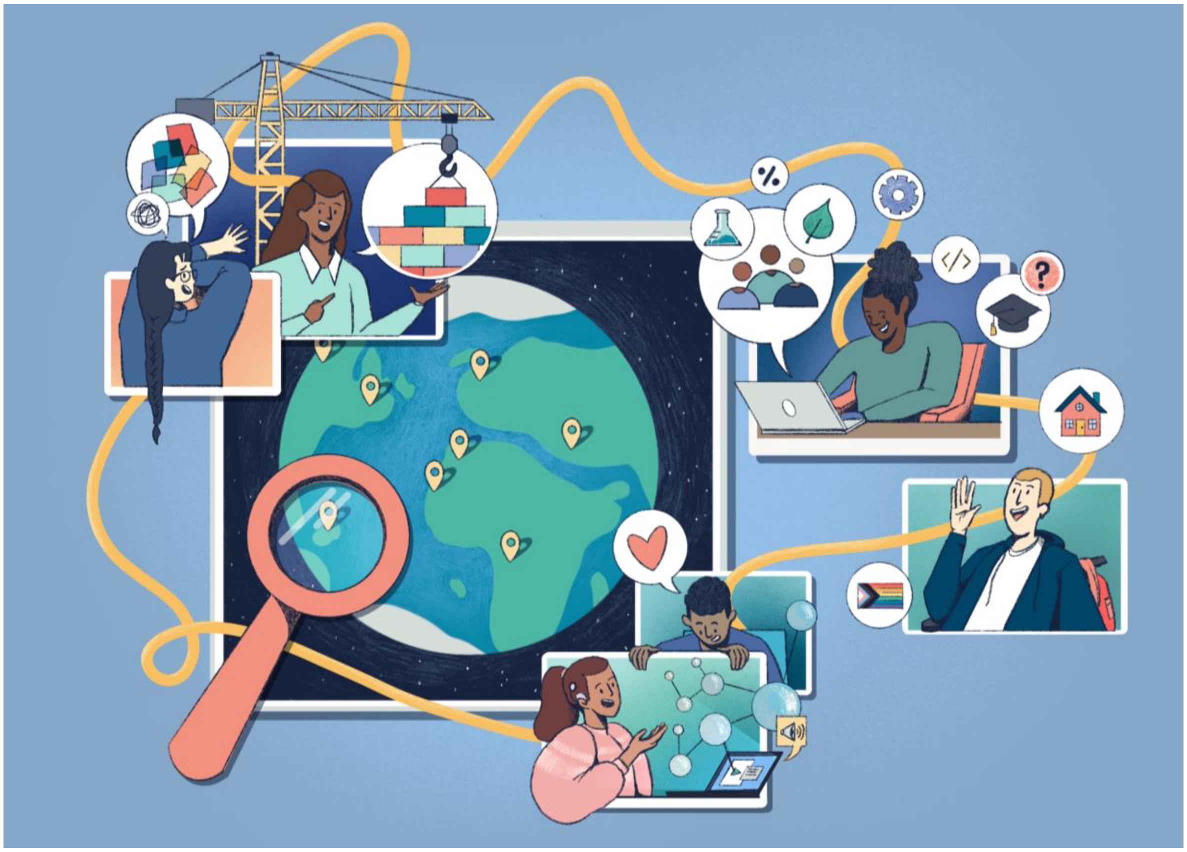
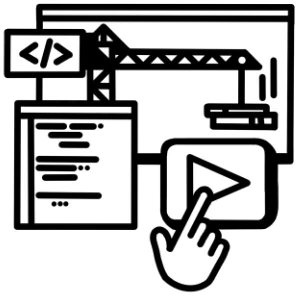
Module 2: Enacting EL in the Classroom: Case Studies

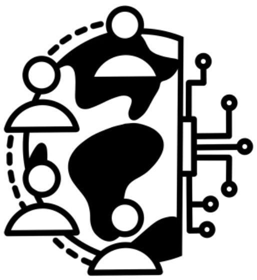


This module is designed to help you learn about inclusive practice when implementing experiential computational modelling tasks. Each Activity in this module is a case study about some aspect of inclusive practice. The four activities in this module address scaffolding and using supplemental resources to support students, inclusive practice, using Universal Design for Learning, creating an enriched learning environment, and how to answer difficult questions in the classroom.

List of Activities



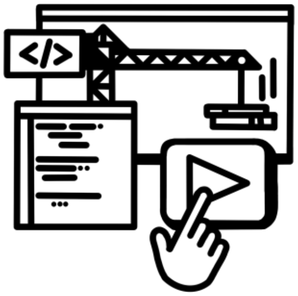
Case A:
Addressing Coding apprehension



Case B:
Embracing Diversity in STEM

Case C:
Supporting Student Engagement

Case D:
Handling Difficult Conversations



Workbook Questions for Case A: Addressing Coding Apprehension

In the video, Sarah was concerned about what her professor would think of her if she asked a “dumb” question about programming. What strategies (e.g., pedagogies, technologies, verbal / written assurances) could you use in the design and delivery of your course to help students like Sarah feel more comfortable asking questions and taking advantage of office hours?

In the video, Emma explained scaffolding as breaking down the content into more manageable pieces and providing tools or structure to better support learning. In relation to programming, scaffolding could involve learning the vocabulary (i.e., commands, pieces of code and syntax first before doing more complex problems. Part of scaffolding your students' learning involves helping them to draw connections between their goals, the social justice topic, and the mathematics. We saw Dr. Robyn Ruttenberg-Rozen do this in Module 1, Video 3.

How can you or how do you include scaffolding in your teaching practice?

Have you found that your students' varying levels of programming experience affect course participation and success?

What questions could you ask your students to help them draw connections across their learning?

Another important aspect of helping students - not just those with coding apprehension - is teaching them how to get ‘unstuck.’ For example, how to fix syntax errors, detect problems with the logical structure of their code, or look up concepts and ideas. How can you facilitate access to direct and self-directed support?

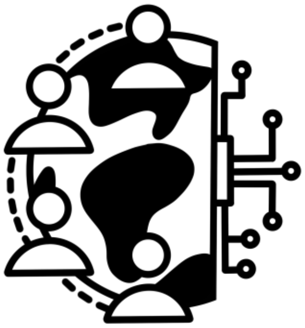
Do you offer your students supplemental resources to help scaffold their learning? Is this a practice you would consider adopting after watching this video?

How can you balance the 'amount' of scaffolding on the one hand and the development/promotion of your students' independence and self-regulation on the other?

Are you interested in learning more about scaffolding?

Here are some resources you may be interested in exploring:

18 Effective Ways To Scaffold Learning in the Classroom webpage
6 Scaffolding Strategies to Use With Your Students - Edutopia



Workbook Questions for Case B:
Embracing Diversity in STEM

For Evidence, seeing Black and female scientists contributing to her field is encouraging because “I can see how diversity in STEM leads to diverse thinking and problem-solving.” How can you include differing perspectives and voices within your classes in the examples you pick and the researchers you highlight? Can you give examples?

In what ways would this benefit your students?

Do you see any drawbacks?

In what ways have you tried to foster a sense of belonging in your classes?

Is this something you have thought explicitly about before? If not, what new insight or questions about student belonging do you have?

What are your takeaways from Evidence's story for your classes?

After listening to this recording and participating in this course, what ideas do you have for extending your approaches to foster belonging in your classes?

Workbook Questions for Case C: Supporting Student Engagement

Have you or someone you know ever felt unable to answer (or to adequately answer) your students' questions?

If so, please describe the situation.

How did you (or they) handle it?

Throughout these videos, scaffolding has been a constant theme to support students. How have your perspectives on scaffolding evolved throughout this course?

Are you interested in learning more about UDL?

Check out the link below:

https://udlguidelines.cast.org/

Workbook Questions for Case D: Handling Difficult Conversations

Have you (or someone you know) ever been in a situation where a student's comments have affected the classroom climate?

How did you (or they) address the question?

How did you (or they) restore the classroom climate? What challenges were experienced when trying to restore the classroom climate?

If you could go back and change the situation after watching this video, what would you want to happen differently?

What sort of training for handling difficult conversations or anti-oppressive and anti-bias practice do you think would be beneficial for your teaching practice?

What would you like to learn about anti-bias / anti-oppressive pedagogies for computational modelling and mathematics?

How will you implement the strategies outlined in this video into your own practice so that all voices are included in the conversation?

How might a student's lived experiences impact their perceptions and dispositions toward tackling social justice problems with mathematical and computational sciences approaches?