Computational Thinking in Mathematics and Science Education  
(Intermediate/Senior) 5467  
Section 001, Tuesdays 10:30-12:30, Room 2054  
Thursdays 2:30-4:30, Room 2036

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The best way to contact me is through my Western email account (lpennaru@uwo.ca). I am happy to set-up appointments by request.

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**Calendar Course Description:**

A critical introduction to the role of computer coding and digital making as ways of teaching mathematics and science concepts and relationships. The history, current trends, future possibilities of computational thinking in mathematics and science education are situated within the broader context of mathematics, science, and technology education.

**Learning Outcomes:**

By the end of this course, students will be able to:

- Explore, share, and reflect on the mathematical and scientific learning through computational thinking tasks (both coding and unplugged)
- Describe how computational thinking may be used to develop mathematics and science concepts
- Describe the affordances and challenges of teaching mathematics and science with computational thinking including the areas of planning, implementation, and assessment
- Explore, share, and reflect on coding environments for computational thinking in mathematics and science education
- Build connections between curriculum expectations, both within a specific grade/course as well as across grades/courses to create a more connected and relevant mathematics and/or science program for themselves, their students, and their colleagues
• Review, discuss reflect on, and critically evaluate theory and research on computational thinking in mathematics and science education

• Identify opportunities to use computational thinking to develop deeper, more connected understandings within mathematics and/or science programs

• Identify opportunities to connect research to practice to support teacher professional practice decisions

• Discuss and reflect on theoretical research concerning the use of computational thinking in mathematics and science education

• Communicate with education stakeholders, with specificity and clarity, the affordances and issues of implementing computational thinking in mathematics and science education

• Recognize how changing perspectives (e.g., environmental; stewardship), current research from fields outside of mathematics (e.g., cognitive science), and technology may generate a need for change in areas of mathematics education

• Demonstrate initiative, responsibility, accountability, thoughtful decision-making, reflective practice, ethical behaviour, academic integrity, and responsible conduct of research that is in compliance with policy and procedural guidelines.

Course Content:

Week 1 (in-class) Weekly of September 6th

Tuesday

**Algorithms and Computational Thinking**
–actions and simple math will be used to promote understanding of Computational Thinking
- introduction into how/why computational thinking can be used to enhance math understanding (not an “add-on”)

**Coding in Geometry**
- coding shapes using online programming software
- use of extensions in math tasks
- introduction to variable use

Thursday

**Coding in Geometry (continued)**
- coding shapes using programmable robots (tangibles)
- consider possible extensions of this task in math and science

**Preparation for Online Learning**
- explore concept mapping software

**Characteristics of Electricity (Part 1): Using Digital Tangibles**
-investigate basic principles of electricity and flow of negatively charged particles (e.g., electrical source, load, connecting wires, switch, resistor) in preparation for investigations using Arduino and electronics

**Week 2 (online)**  

**Readings/Viewings –**


http://researchideas.ca/mc/article-1-title-recent-issue/interview-september/


5) Explore: Online simulation software for Arduino (tutorial)

doi: 10.1109/EduCon.2013.6530096

- Respond to prompts/questions based on this week’s readings/viewings and classroom activities
- Complete all online activities

**Week 3 (in-class)**  

**Week of September 19th**

**Tuesday**

*Characteristics of Electricity (Part 2): – Using Digital Tangibles*

- explore methods to promote understanding of current, voltage and resistance using a breadboard
- introduction to the Arduino Integrated Development Environment (IDE)
- design and construct projects involving series and parallel circuits
- write introductory programs in Arduino to control circuits, reading input and triggering output
- investigate the use of sensors in the Arduino programming environment
-explore various sensors that can be used to support and enhance math and science understanding

Thursday


-continue to explore the use of sensors in a science and/or math classroom
-discuss and critically analyse the decision to integrate sensors into the math/science classroom
-examine computational thinking and pedagogical approaches for introducing students to digital tangibles, such as Arduino
-explore ways to connect digital tangibles, such as Arduino to the I/S math and science curriculum

*Introduction to Critical Analysis Tool Assignment*

**Week 4 (online)**

**Week of September 26th**

*Readings/Viewings –*

1) *Examine the following figures related to Problem Solving, Computational Thinking and Investigative Learning (for your convenience, a document with all figures will be posted in Owl by instructor):*

   a) Figure 1, p. 54: Sneider, C., Stephenson, C., Schafer, B., & Flick, L. (2014). Computational Thinking in High School Science Classrooms. *Science Teacher, 81*(5), 53-59.


   http://researchideas.ca/mc/article-1-title-recent-issue/a-coding-story/

   http://l3d.cs.colorado.edu/~ctg/pubs/artmath05.pdf

5) Try these: Repeating and Growing Pattern Simulations:
   http://www.researchideas.ca/wmt/c6.html

6) Continue to work on critical analysis tool in groups of 3-5, which will be used in-class on October 6th in class. Prepare a presentation (in groups of 3-5) on a digital device/application that will be presented in-class on October 6th in class. *See Assignment #1 in Appendix A


   • Respond to prompts/questions based on this week’s readings/viewings and classroom activities
   • Complete all online activities

*Week 5 (in-class) Week of October 3rd*

*Tuesday*

*Mathematical Patterns – Exploring Patterns through Coding and Digital Tangibles*
   - code patterns in online programming environments
   - explore tangibles to enhance understanding of mathematical concepts in patterning

*Prepare materials for Critical Analysis Tool Assignment and Presentation*

*Thursday*

*Examining Current Trends in Education - The Makerspace in the Intermediate/Senior Math and/or Science Classroom*
-Copies of Critical Analysis Tool required for this class *See Assignment 1, Appendix A
-Group presentations of Digital Device/Application use in a math/science classroom

**Using Digital Tangibles (electronic stickers) as a Math Performance and to Facilitate Learning of Electricity Concepts**
-Use electronic stickers to display knowledge of math ideas and to explore circuits

**Week 6 (online) Week of October 17th**

Readings/Viewings –

   [https://www.cs.cmu.edu/~15110-s13/Wing06-ct.pdf](https://www.cs.cmu.edu/~15110-s13/Wing06-ct.pdf)


- Respond to prompts/questions based on this week’s readings/viewings and classroom activities

**Week 7 (in-class) Week of October 24th**

**Tuesday**

**Abstraction and Computational Thinking in Math and Science**
- use of variables in Computational Thinking, Math and Science – connecting conceptual and procedural understanding

**Mathematics Pedagogy and the Math Processes, Fermi Questions**
- computational thinking approach to problem solving in mathematics

**Measurement and Number Sense**
-explore big ideas through a computational thinking lens and through computational thinking math tasks

**Thursday**

**Probability**
- Binomial Theorem: Coin Toss Activity
- Explore connection of probability to algebra
- Using unplugged and technology to support big ideas in Data and Probability, Algebra

**Coordinate Grids and Coding**
- Cartesian Plane in programming environments
- Code movement, rotations, translations, symmetry
- Plot points, random pairs by programming
- Move shapes and characters along x,y plane in a programming environment

**Week 8 (online) **

**Week of October 31st**

**Readings/Viewings –**


2) *Read/View: Probability and Statistics Interview with Western Statistician*  
   [http://www.researchideas.ca/wmt/c6b2.html](http://www.researchideas.ca/wmt/c6b2.html)


5) *Optional Viewings:*


• Respond to prompts/questions based on this week’s readings/viewings and classroom activities
• Complete all online activities
• Read through your classmates’ posted Computational Thinking Task assignments *(see Assignment 3, Appendix A)* and comment on at least one task

**Week 9 (in-class)  Week of November 7th**

**Tuesday**

**Motion, Properties of Linear Relations – Using Digital Tangibles**
- investigate and conduct an investigation involving speed, distance, time and programmable robots
- apply problem solving method by programming applications
- reflect on best pedagogical practices for teaching math and science investigations through computational thinking

**STEM Challenge**
- Exploring math and science problem solving activities

**Thursday**

**Computational Thinking Olympics – Consolidation of our Learning**
- Complete challenges, revisit concepts and complete tasks that involve the use of Computational Thinking skills to solve science and math problems

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**Course Materials:**

**Resources:**
- suggested resources will be recommended throughout the course

**Assignments and Other Course Requirements:**

**It is possible to adapt assignments 1, 2 to suit specific interests that relate to the course. Please propose such alternate assignments to your instructor for feedback and approval.**

**Appendix A – ASSESSMENT**

1 – Critical Analysis Tool for a Digital Device/Application (30 %) – Key Dates: October 6th, October 15th
Part A - In groups of 3-5, you will develop a tool that can be used to assess the usefulness of a digital device/application (e.g., sensor, programmable robot, raspberry pi, app) in the instruction of math and/or science concepts. The group members will decide upon the format of the tool (e.g., checklist, rubric, form, questions, etc.). The tool should be designed in a way that could allow it to be used by a teacher to evaluate the effectiveness (from a pedagogical perspective) of any digital device/application. Later in the course (see Part B), you will use this tool to evaluate the effectiveness, as well as advantages and disadvantages, of a specific digital device/application.

Part B – In groups of 3-5, you will present on a digital device/application (e.g., sensor, programmable robot, raspberry pi, app) for teaching math and/or science concepts on October 6th. During the presentations, you will use your tool to assess the effectiveness of each digital device/application. Please come to class with copies of your Tool from Part A (electronic copies are acceptable). *This presentation will not be assessed by your instructor.

What you submit for assessment for Assignment 2 (Due: October 15th)

Samples of completed Critical Analysis Tools (based on the information from the presentations on February 3rd) and a reflection that includes:

✓ The best device for teaching math/science concepts based on your tool (depending on your end-goal), along with an explanation

✓ A reflection that explains what you would change/add to your Critical Analysis Tool to ensure that it will be an effective tool for teachers in making pedagogical decisions on what types of devices/applications they will implement in their classrooms

✓ Your paper should be submitted as a Word document, not as a pdf. It should be written using Times New Roman 12-font, have 1.5 line spacing, have “portrait” orientation, and be sized as 8.5 x 11. You are to use APA formatting for any references used. It is to be a maximum of 500 words excluding the sample tools and an (optional) bibliography.

2 – COMPUTATIONAL THINKING TASK for teaching Math/Science (40 %) – Draft to be posted in Week 8 online (Week of October 31st), Final Draft due end of Week 9 (November 11th)

NOTE:

• A draft of this assignment will be shared with class during the last week of the online discussion forum
• The task may become part of an online resource (e.g., www.mathncode.com, with your permission)
**OPTION 1 - Design a computational thinking + math/science task for a teaching resource e-book**

**Requirements:**

The task should be based on the readings and in-class activities presented in this course and will be shared, with your permission, in an e-book format with all course participants at the end of the course.

*Please...*

- Indicate a math/science strand and/or big idea that will be addressed and the grade levels the task could be extended to
- Provide a brief Summary/Description of Task
- Provide a rationale for the task choice
- Provide an outline of how the task could be presented, performed by students
- List any prior-learning students might require for completing the task
- Describe how the task can be assessed (but no formal assessment scale/rubric is required)
- Provide an exemplar of what students might create through the task (e.g., options for this could be a short video clip, screen prints, photos, etc.)
- The product can be presented in a form of your choice: Word Document, PowerPoint, Prezi, blog, etc.

**Provide a list of all resources used in the creation of this task – APA formatting**

- The task should be the equivalent of two pages (1.5 line spacing, 1 inch margins), including images, excluding the resource list

**OPTION 2 - Teach and reflect on a computational thinking + math/science task**

Select/design/teach a math/science task (plugged or unplugged) through Computational Thinking based on the readings and in-class activities presented in this course.

**Requirements:**

- Indicate a math/science strand and/or big idea that will be addressed and the grade levels (two to three grade levels) the task could be extended to
- Teach the math/science task to an intermediate or senior math/science class*
- The task should not take-up more than 75 minutes of class time (there is no minimum
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- Provide a brief summary/description of the task selected/designated (250 words)
- Write a reflection on how it went – include an explanation of how the learning of math was enhanced through the use of Computational Thinking (500 words)
- Provide a list of all resources used in the creation of this task (use APA formatting)

*Your instructor can provide you with a list of teachers/schools who are willing to have you present the task to their students, but you are free to find a willing teacher/school on your own.

OPTION 3 – Analyze a Computational Thinking + Math Lesson Plan/Task

Find a CT + math lesson plan (not discussed in the course), analyze it using criteria/themes from our course, suggest revisions for improvement and possible extensions.

Provide a list of all resources used in the creation of this task (use APA formatting)

3 – ONLINE CONTRIBUTION (30 %) See Expectations in OWL.

ONLINE REQUIREMENTS – CRITERIA

Please log on regularly and actively participate throughout the week. As this course contains alternating online and in-class components, your attendance will be monitored online (see Attendance Policy).

Ensure you contribute productively to discussions, by providing constructive feedback to your classmates, suggested extensions and next steps, and using effective critical thinking skills.

IN-CLASS REQUIREMENTS – CRITERIA

Please attend every class, be an active listener, participant in discussions/tasks.

Policy Statements:

Accessibility: The University of Western Ontario is committed to recognizing the dignity and independence of all students and seeks to ensure that persons with disabilities have genuine, open and unhindered access to academic services. Please contact the course instructor if you require course materials in an alternative format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 x 82147 for

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information about requesting academic accommodation, or go to the following website: http://www.edu.uwo.ca/programs/preservice-education/documents/policies/Accessibility_Western.pdf

Attendance: The B.Ed. program is an intense and demanding programs of professional preparation. You are expected to demonstrate high levels of both academic and professional integrity. Such integrity is demonstrated in part by your commitment to and attendance at all classes, workshops, tutorials, and practicum activities. Read more about the Faculty’s attendance policy on-line: http://www.edu.uwo.ca/programs/preservice-education/Attendance%20Policy%202016.pdf

EXCUSED ABSENCES: If you are ill, require compassionate leave, or must miss classes for religious observance, your absence is excused; you will not be penalized but you are responsible for work missed.

UNEXCUSED ABSENCES: Any absence that is not a result of illness, bereavement, or religious observance is an unexcused absence. Three unexcused absences will result in you being referred to the Associate Dean and placed on academic probation. Any further unexcused absence will result in failure of the course and withdrawal from the program.

Language Proficiency: In accordance with regulations established by the Senate of the University, all teacher candidates must demonstrate the ability to write clearly and correctly. Work which shows a lack of proficiency in the language of instruction is unacceptable for academic credit, and will either be failed or, at the discretion of the instructor, returned to the teacher candidate for revision to a literate level.

Late Penalties: Normally, the only acceptable reasons for late or missed assignments are illness (for which a doctor’s statement may be required) or extreme compassionate circumstances. Unexcused late assignments will not be accepted after the due date unless prior arrangements have been made with the instructor.

Academic Offences: Scholastic offences are taken particularly seriously in this professional Faculty. Teacher Candidates should read about what constitutes a Scholastic Offence at the following Web site: http://www.edu.uwo.ca/programs/preservice-education/documents/policies/WEB_ScholasticDiscipline.pdf

Plagiarism: Plagiarism means presenting someone else’s words or ideas as one’s own. The concept applies to all assignments, including lesson and unit plans, laboratory reports, diagrams, and computer projects. For further information, teacher candidates may consult their instructors, the Associate Dean’s Office, and current style manuals. Advice about plagiarism and how to avoid it can also be found on the Teacher Education website: http://www.edu.uwo.ca/programs/preservice-education/documents/policies/WEB_PlagiarismPolicy.pdf

Plagiarism-Checking:

a. All required papers may be subject to submission for textual similarity review to the commercial plagiarism detection software under license to the University for the detection of plagiarism. All papers submitted for such checking will be included as source documents in the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between The University of Western Ontario and Turnitin.com (http://www.turnitin.com)

b. Computer-marked multiple-choice tests and/or exams may be subject to submission for similarity review by software that will check for unusual coincidences in answer patterns that may indicate cheating.
Use of Laptops & Notebooks in Class: Mobile devices including smart phones, tablets, ipads are encouraged! Please use them to enhance your learning in this course. Laptops and other electronic devices may be used in a professional manner to facilitate your activities in the course, but out of courtesy to colleagues and the instructor, please engage in personal networking and non-course communication only outside class time – before or after class, or at the break.

SUPPORT SERVICES

A variety of support services are available at Western.
If you need advice or assistance, do not hesitate to get in touch with any of these services.

FINANCIAL ASSISTANCE: Registrarial Services (http://www.registrar.uwo.ca)

WRITING SUPPORT: Student Development Centre (http://www.sdc.uwo.ca/)

LEARNING SKILLS SUPPORT: Student Development Centre (http://www.sdc.uwo.ca/)

INTERNATIONAL STUDENTS: Student Development Centre (http://www.sdc.uwo.ca/)

ABORIGINAL STUDENTS: Student Development Centre (http://www.sdc.uwo.ca/)

STUDENTS with DISABILITIES: Student Development Centre (http://www.sdc.uwo.ca/)

SOCIAL & CULTURAL ISSUES: University Students’ Council (http://westernusc.ca/service/the-peer-support-network/).

EMOTIONAL or MENTAL DISTRESS: Students who are in emotional or mental distress should refer to Mental Health @ Western http://www.uwo.ca/uwocom/mentalhealth/ for a complete list of options about how to obtain help.

B.Ed. PROGRAM ISSUES: zuber@uwo.ca, Teacher Education Office, room 1166

NEED HELP but not sure what to do: zuber@uwo.ca, Teacher Education Office, room 1166