Western Education

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EDUC 5467

Computational Modelling in Mathematics & Science Education

Instructor:

Steve Floyd
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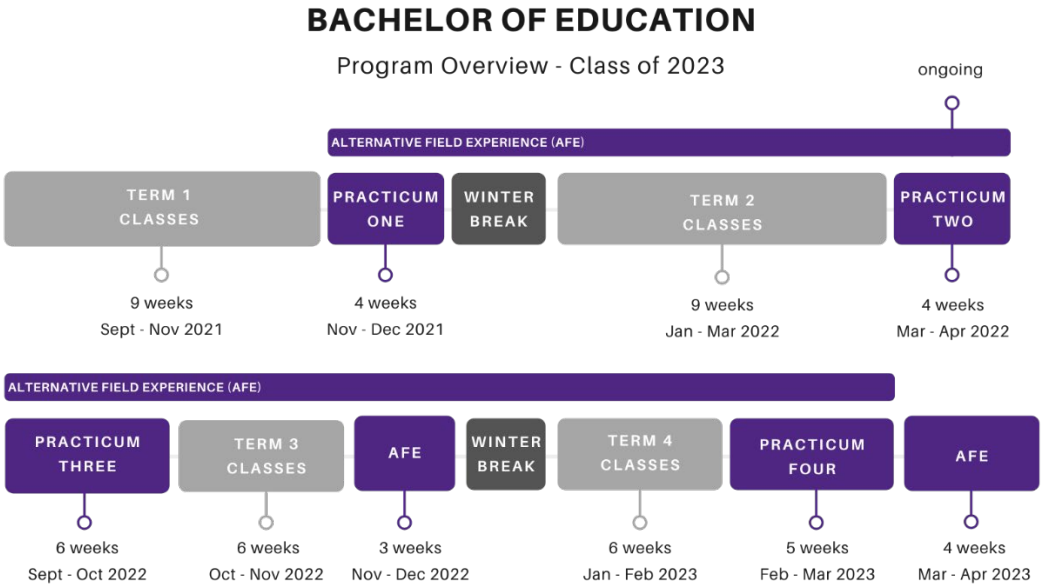
Office Hours: by appointment
Course Coordinator: Dr. George Gadanidis

Schedule:

Section 001: Thurs 2:30PM-4:30PM,
Room: 2036

Program Context:

This is a **Elective Course** taken by Teacher Candidates during **Year 1, Full Year** of the Bachelor of Education.



Computational Modelling in Mathematics & Science Education (EDUC 5467)

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, and future possibilities of computational modelling in mathematics and science education are situated with the broader context of mathematics, science and technology education. 2 hours per week, two terms, .5 credit.

All required readings will be provided in OWL. Several freely available online coding platforms will be used throughout the course.

This course is offered as a blended learning course, with weeks alternating between on-site (face-to-face) and on-line.

Term 1: Weeks 1, 3, 5, 7 and 9 will be on-site in room 2036.
Term 1: Weeks 2, 4, 6 and 8 will be on-line and asynchronous.
Term 2: Weeks 10, 12, 14, 16 and 18 will be on-site in room 2036.
Term 2: Weeks 11, 13, 15 and 17 will be on-line and asynchronous.

Number of Credits : 0.5

Number of Weeks: 18

Week 1: On-site - Introduction to Our Course and Exploring Geometry and Spatial Reasoning Concepts Through Coding

- Overview of course schedule, structure and content
- Introduction to concepts and approaches surrounding computational modelling, computational thinking and coding in Mathematics and Science
- Exploring geometry concepts with Scratch the programming environment

Learning Activities

Type	Name	Description
Practice	Experiential, hands-on computational modelling and coding	Let's get started with geometry Using https://scratch.mit.edu/ to learn geometry concepts
Presentation	The course	Course schedule, structure and content
Discussion	Where we are starting from	Experiences and opportunities with computational modelling and coding

Week 2: On-line – Connecting Research to Practice I

- Become familiar with introductory research surrounding computational modelling, computational thinking and coding
- Connect research to practical experiences and curriculum in our schools

Learning Activities

Type	Name	Description
Practice	Experiential, hands-on computational modelling and coding	Programming in Scratch https://scratch.mit.edu/
Reading	Introductory readings related to computational modelling, computational thinking and coding	Gadanidis, G., Brodie, I., Minniti, L., & Silver, B. (2017). Computer coding in the K-8 mathematics curriculum? What works: Research into practice. Retrieved from https://oere.oise.utoronto.ca/wp-content/uploads/2018/02/Computer_Coding_K8_en.pdf Wing, J. M. 2006 Computational thinking. Communications of the ACM 49, 33–35. Retrieved from https://www.cs.cmu.edu/~15110-s13/Wing06-ct.pdf
Discussion	Owl Discussion Forum	Consider the readings, respond to assigned questions and discuss the implications of research for classroom practice, with peers in the course.

Week 3: On-site – Exploring Spatial Reasoning and Coordinate Grids Through Coding

- Reviewing and expanding upon concepts and approaches surrounding computational modelling, computational thinking and coding in Mathematics and Science

- Exploring spatial reasoning and coordinate grids with the Scratch programming environment

Learning Activities		
Type	**Name**	**Description**
Presentation	Computational Modelling, Computational Thinking and Coding	Review of readings and connections to our current practical work
Practice	Experiential, hands-on computational modelling and coding	Let's take a look at spatial reasoning and coordinate grids Using https://scratch.mit.edu/

Week 4: On-line - Connecting Research to Practice II

- Exploring the connections between mathematics and computer modelling and relevance to the K-12 classroom
- Introducing the large, longer term, bigger picture view of Computational Literacy

Learning Activities		
Type	**Name**	**Description**
Practice	Experiential, hands-on computational modelling and coding	Programming in Scratch Using https://scratch.mit.edu/
Reading	Introductory readings related to computational modelling and the mathematics classroom, and to Computational Literacy	Gadanidis, G., Cummings, J. (2018). Integrated Mathematics + Computer Studies. Reforming Secondary School Mathematics Education. KNAER Mathematics Knowledge Network. http://mkn-rcm.ca/wp-content/uploads/2018/04/MKN-white-paper-April-2018.pd Gadanidis, G., Floyd, S., Hughes, J.M., Namukasa, I.K., & Scucuglia, R. (2021). Coding in the Ontario Mathematics Curriculum, 1-8: Might it be transformational? Math Knowledge Network. Retrieved from http://mkn-rcm.ca/coding-in-the-ontario-mathematics-curriculum-1-8-might-it-be-transformational/ Optional: Andrea A. diSessa (2018) Computational Literacy and "The Big Picture" Concerning Computers in Mathematics Education, Mathematical Thinking and Learning, 20:1, 3-31. https://escholarship.org/content/qt4bv8b9d2/qt4bv8b9d2.pdf

Learning Activities		
Type	**Name**	**Description**
Discussion	Owl Discussion Forum	Consider the readings, respond to assigned questions and discuss the implications of research for classroom practice, with peers in the course.

Week 5: On-site – Exploring Physics, Geometry and Spatial Reasoning Through Programmable Robots

- Reviewing and expanding upon concepts and approaches surrounding the integration of computer modelling with code in Mathematics, and Computational Literacy
- Exploring physics, geometry, and spatial reasoning with Sphero programmable robots

Learning Activities		
Type	**Name**	**Description**
Practice	Experiential, hands-on computational modelling and coding	Let's take a look at physics, spatial reasoning and geometry Using https://sphero.com/products/sphero-bolt
Presentation	Integrating computer modelling and mathematics, Computational Literacy and Ontario's Curriculum	Review of readings and connections to our current practical work

Week 6: On-line – Connecting Research to Practice III

- Exploring Papert's ideas of Turtle Geometry and their applications today, with programmable robots
- Exploring the affordances of computational thinking and the power of coding in the classroom

Learning Activities		
Type	**Name**	**Description**
Practice	Experiential, hands-on computational modelling and coding	Programming and the sphero Using https://sphero.com/products/sphero-bolt

Learning Activities

Type	Name	Description
Reading	Mathematics made for learning and the affordances of computational thinking in mathematics education	Papert, S. (1980) Turtle geometry: A mathematics made for learning. Chapter 3 in Mindstorms. http://worrydream.com/refs/Papert%20-%20Mindstorms%201st%20ed.pdf Gadanidis, G. (2017). Five Affordances of Computational Thinking to support Elementary Mathematics Education, 36, 143–151. https://www.learntechlib.org/p/174346/
Discussion	Owl Discussion Forum	Consider the readings, respond to assigned questions and discuss the implications of research for classroom practice, with peers in the course.

Week 7: On-site – Exploring Electricity Through Tangible, Programmable Devices

- Introducing and expanding upon Papert's ideas of "objects to think with"
- Exploring science concepts related to electricity, and bringing them to life with "objects to think with"

Learning Activities

Type	Name	Description
Practice	Experiential, hands-on computational modelling and coding	Makey Makeys and electricity Using the makey makey device to for hands-on, experiential modelling of science of concepts
Presentation	Objects to think with and circuits, voltage, electron flow and tangible devices	Explore Papert's research surrounding objects to think with, and consider how experiential, hands-on learning can bring electricity to life

Week 8: On-line – Connecting Research to Practice IV

- Considering makerspaces and Meaningful Making for the science classroom
- Exploring the approaches, considerations and guidelines for making in the classroom

Learning Activities

Type	Name	Description
Practice	Experiential, hands-on computational modelling and coding	Making with Arduino and prototyping with tinkercad Using https://www.arduino.cc/ and https://www.tinkercad.com/
Reading	Makerspaces and the approaches students and teachers should have when “making”	Hughes, J.M. (2017). Meaningful making: Establishing a makerspace in your school or classroom. What works: Research into practice. Retrieved from https://oere.ca/wp-content/uploads/2018/02/meaningful_making_en.pdf Kurti, R., Kurti, D., & Fleming, L. (2014). The philosophy of educational makerspaces. Teacher Librarian, 41(5), 8–11. Retrieved from http://teacherlibrarian.com/2014/06/18/ educational-makerspaces/
Discussion	Owl Discussion Forum	Consider the readings, respond to assigned questions and discuss the implications of research for classroom practice, with peers in the course.

Week 9: On-site – Modelling Applications and Systems with Tangible Devices I

- Connecting electricity concepts and our environment through sensors and programmable controllers (arduino)
- Exploring systems (traffic lights, bat’s echolocation) and modelling with tangible, computational devices

Learning Activities

Type	Name	Description
Practice	Experiential, hands-on computational modelling and coding	Prototyping and making with tinkercad and arduino Using https://www.arduino.cc/ and https://www.tinkercad.com/
Presentation	Modelling systems and making with tangible devices	Review the approaches, considerations and guidelines for making and exploring microcontrollers (arduino)

Week 10: On-site - Modelling Applications and Systems with Tangible Devices II

- Expanding on the connections between electricity concepts and our environment through sensors and programmable controllers (arduino)
- Exploring further systems and modelling with tangible, computational devices

Learning Activities

Type	Name	Description
Presentation	Adding complexity and expanding upon modelling systems and making with tangible devices	Review the approaches, considerations and guidelines for making and exploring more complex microcontroller concepts (arduino)
Practice	Experiential, hands-on computational modelling and coding	Prototyping and making with tinkercad and arduino Using https://www.arduino.cc/ and https://www.tinkercad.com/

Week 11: On-line – Connecting Research to Practice V

- Exploring important topics surrounding culturally responsive making, equity, diversity and inclusion in computational modelling, computational thinking and coding
- Exploring the broadening of participation in subjects related to computational modelling, computational thinking and coding
- Considering classroom practices that are inclusive, diverse, and authentic and that honour the life experiences of students

Learning Activities

Type	Name	Description
Reading	Culturally responsive making and the broadening of coding related education opportunities	Searle, K. A., & Kafai, Y. B. (2015, April). Culturally responsive making with American Indian girls: Bridging the identity gap in crafting and computing with electronic textiles. In Proceedings of the third conference on genderIT (pp. 9-16). Margolis, J., Ryoo, J. J., Sandoval, C. D., Lee, C., Goode, J., & Chapman, G. (2012). Beyond access: Broadening participation in high school computer science. ACM Inroads, 3(4), 72-78.
Discussion	Owl Discussion Forum	Consider the readings, respond to assigned questions and discuss the implications of research for classroom practice, with peers in the course.

Week 12: On-site – Exploring Probability and Other Cross-Curricular Activities with Tangible, Programmable Devices

- Exploring cross-curricular and cross-disciplinary activities related to computational modelling and coding with tangible devices
- Considering alternative, extension activities that incorporate computational modelling and STEM learning

Learning Activities

Type	Name	Description
Practice	Experiential, hands-on computational modelling and coding	Modeling and coding with MakeCode and micro:bit Using https://microbit.org/ with https://www.microsoft.com/en-us/makecode
Presentation	Probability and tangible devices	Explore math and science concepts with the micro:bit

Week 13: On-line – Connecting Research to Practice VI

- Exploring Computational Participation and Computational Action, and expanding the focus and goals of computers in classrooms

Learning Activities

Type	Name	Description
Practice	Experiential, hands-on computational modelling and coding	Modeling and coding with MakeCode and micro:bit Using https://microbit.org/ with https://www.microsoft.com/en-us/makecode
Reading	From CT to CP and CA, perspectives for broadening computational modelling and computers in classrooms	Burke, Q., & Kafai, Y. (2016). Computational Participation. Journal of adolescent & adult literacy 59(4): 371-375. Tissenbaum, M., Sheldon, J., & Abelson, H. (2019). From computational thinking to computational action. Communications of the ACM, 62(3), 34-36.
Discussion	Owl Discussion Forum	Consider the readings, respond to assigned questions and discuss the implications of research for classroom practice, with peers in the course.

Week 14: On-site – Exploring Growing Patterns, Block-based and Text-based Programming Languages

- Discussing growing patterns and relationships to computational modelling opportunities
- Exploring both block-based and text-based programming languages for computational modelling

Learning Activities

Type	Name	Description
Practice	Experiential, hands-on computational modelling and coding	Modelling and coding with Scratch and Python Using https://scratch.mit.edu/ and https://www.python.org/
Presentation	Growing patterns and computational modelling opportunities	Connect growing patterns with tools available in programming languages and environments

Week 15: On-line – Connecting Research to Practice VII

- Exploring the importance of patterns in mathematics and connections to computational modelling
- Exploring work in the field and the future for students in mathematics

Learning Activities

Type	Name	Description
Practice	Experiential, hands-on computational modelling and coding	Modelling and coding with Scratch and Python Using https://scratch.mit.edu/ and https://www.python.org/
Reading	Growing patterns and computational modelling	Beaty, R. (2014). Exploring the power of growing patterns. What works: Research into practice. Exploring online resources at https://researchideas.ca/mathncode/sims-growpatt.html
Discussion	Owl Discussion Forum	Consider the readings, respond to assigned questions and discuss the implications of research for classroom practice, with peers in the course.

Week 16: On-site – Exploring the Use of Electronic Components in Cross-Curricular ways

- Exploring alternative and creative tools for mathematics and science education
- Considering the potential cross-curricular connections of various tools for STEM learning

Learning Activities		
Type	**Name**	**Description**
Presentation	Cross-curricular tools and connections in STEM learning	Cross-curricular connections and alternative, creative tools for mathematics and science education
Practice	Experiential, hands-on computational modelling and coding	Chibitronics and cross-curricular connections Using https://chibitronics.com/

Week 17: On-line – Connecting Research to Practice VIII

- Exploring the future directions for computational modelling, computational thinking and coding in STEM education
- Finalizing and submitting course assignment

Learning Activities		
Type	**Name**	**Description**
Assignment	Computational Modelling Task for Teaching Mathematics and/or Science	See Assessment Activities section below for details.
Reading	CT, computational modelling and STEM education	Li, Y., Schoenfeld, A. H., Graesser, A. C., Benson, L. C., English, L. D., & Duschl, R. A. (2020). On computational thinking and STEM education. Retrieved from https://link.springer.com/content/pdf/10.1007/s41979-020-00044-w.pdf
Discussion	Owl Discussion Forum	Consider the readings, respond to assigned questions and discuss the implications of research for classroom practice, with peers in the course.

Week 18: On-site – Unplugged Activities and Next Steps

- Course evaluation and wrap-up
- Exploring unplugged activities related to computational modelling and computational thinking

- Final thoughts and discussion on computational modelling and mathematics and science education

Learning Activities

Type	Name	Description
Practice	Experiential, hands-on computational modelling and coding	Unplugged activities and computational modelling in mathematics and science Unplugged activities in small groups and individually
Presentation	The course wrap-up	Course evaluations, final thoughts and takeaways, the future of computational modelling in mathematics and science education
Discussion	Where we started from, where we are now	Experiences and opportunities with computational modelling and coding, and final thoughts on course concepts

Assessment Activities

Type	Name	Description
Assignment	Due Mar 13/21: Computational Thinking Task for Teaching Mathematics and/or Science (once at end of course)	OPTION 1 - Teach and reflect on a computational thinking + math/science task Select/Design and then teach a math/science/STEM task (plugged or unplugged) through Computational Thinking based on the readings and in-class activities presented in this course. OPTION 2 – Analyze a Computational Thinking + Math/Science Lesson Plan/Task Find a CT + math or science lesson plan (not discussed in the course), analyze it using criteria/themes from our course, suggest revisions for improvement and possible extensions. OPTION 3 – Create a Critical Analysis Checklist designed to determine which devices are best for teaching STEM concepts. Using the Critical Analysis Checklist, assess a minimum of four digital devices/applications that educators might consider implementing in their classrooms. Reflect on how effective the Critical Analysis is to support educators who are deciding on which devices/applications are best to use within their classroom. OPTION 4 - Please connect with your instructor for an alternate assignment Please submit via Assignments on or before March 13th.

Assessment Activities

Type	Name	Description
Assignment	Due Wk 07 & 16: Personal Reflection or MindMap (due twice during course)	Select one of own posts from on-line discussion and/or one of a classmates' post – expand, reflect. OR Create a mindmap (your choice of software – Mindomo recommended) on a selection of one or more readings/activities so far and/or summarize forum discussion for selected topic. OR Select a mode of your choice to complete a reflection - please consult with teacher if you select this option. This will occur twice in the course • by end of Week 7 – on or before October 31st; • by end of Week 16 – on or before February 20th. The length is the equivalent of about 250-400 words (not including references or selected post) Please submit via Assignments AND also post in your group's forum for week 7 and week 16.
Assignment	Ongoing: On-line discussions (throughout the course)	In addition to participation in synchronous lessons, students will participate in a variety of on-line tutorials/activities and will engage in open discussions within small groups on-line.

This course meets the following Course Outcomes:

Explore, share, and reflect on the mathematical and scientific learning through computational modelling tasks

Describe how computational modelling may be used to develop mathematics and science concepts while fostering innovation, creativity and criticality

Describe the affordances and challenges of teaching mathematics and science with computational modelling including the areas of planning, implementation, and assessment

Explore, share, and reflect on coding environments for computational modelling 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 modelling and associated concepts in mathematics and science education

Identify opportunities to use computational modelling 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 modelling and associated concepts in math and science education

Communicate with education stakeholders, with specificity and clarity, the affordances and issues of implementing computational modelling 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 and science education

Respect and address culturally responsive and culturally instructive pedagogies (i.e., culturally responsive making) when planning and implementing computational modelling activities for mathematics and science education

Assume and plan for diversity in student prior knowledge, experiences abilities in relation to course content (i.e., consider ways to address gender gap in many of the STEM areas)

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.

How to Protect Your Professional Integrity:

The Bachelor of Education is an intense and demanding program of professional preparation. Teacher Candidates are expected to demonstrate high levels of academic commitment and professional integrity that align with both Western University's Academic Rights and Responsibilities and the Professional Standards and Ethical Standards set by the Ontario College of Teachers. These expectations govern your time in class, in your Practicum, in your Alternative Field Experiences, and include the appropriate use of technology and social media.

The Teacher Education Office will only recommend teacher candidates for Ontario College of Teachers certification when candidates have demonstrated the knowledge of, and adherence to, the faculty polices throughout the two-year program.

To review the policies and practices that govern the Teacher Education program, including attendance, plagiarism, progression requirements, safe campus and more, visit: edu.uwo.ca/CSW/my-program/BEd/policies.html

Faculty of Education Pass/Fail Policy:

All courses and assignments in the Bachelor of Education are assessed as Pass/Fail.

Instructors will make the Success Criteria of the assignments clear, and refinements of the criteria may take place in class as a means of co-constructing details of the assignments in the first two weeks of a course. This will allow for differentiation of process, product and timeline depending upon student needs.

Success Criteria will

- Articulate what needs to occur to demonstrate learning outcomes for a course/assignment;
- Inform the instructional process so that teaching can be adapted to ensure students continue to remain on track to meet the criteria as needed and appropriate.
- Align with the assignments created to provide opportunities for students to demonstrate the knowledge, skills and abilities they are working toward;
- Establish clear descriptive language that allows Teacher Candidates to identify, clarify and apply the criteria to their work and to their engagement in peer feedback;
- Focus the feedback on progress toward meeting the overall and specific tasks/assignment goals for the course.

Participation:

Participation is essential to success in the Teacher Education program. As a professional school, you need to treat coming to class as showing up for work in the profession. If you are not in class, you cannot participate. Actively participating in discussions, peer reviews/feedback, group work and activities is integral to the development of your own learning and to the learning within your classroom community.

Given the varied experiences of Teacher Candidates in the program, you may engage with ideas/concepts or skills that are familiar or unfamiliar to you.

A Professional Teacher Candidate is one who:

- Arrives in class (virtual or online) on time, and prepared. This includes completing any readings, viewing assignments or tasks in advance of class as requested.
- Listens to others and contributes thoughtfully to discussions;
- Models respectful dialogue and openness to learn, monitors, self-assesses and reformulates one's prior beliefs and understandings in light of new information;
- Monitors and addresses their wellness, practices self-care, and seeks appropriate support when necessary.

Support Services & Resources:

Health and Wellness
uwo.ca/health

Peer Support
westernusc.ca

Learning Skills
uwo.ca/sdc/learning

Indigenous Services
Indigenous.uwo.ca

Student Accessibility Services
sdc/uwo.ca/ssd

Writing Support
writing.uwo.ca

Financial Assistance
registrar.uwo.ca

Not sure who to ask?
Contact the Teacher Education Office at eduwo@uwo.ca