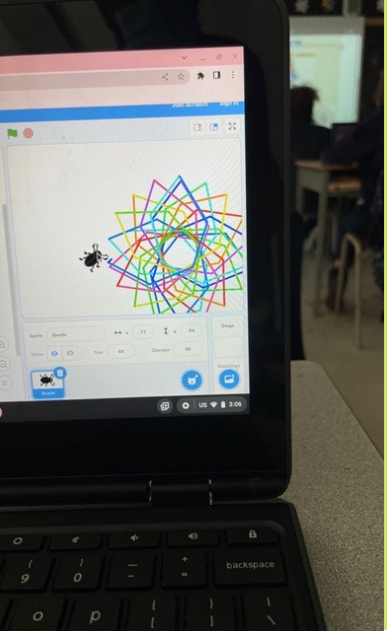

Implementing coding in Gr. 1-9 math classrooms

A Collaborative Approach

involving pre- and in-service teachers, numeracy consultants, and university faculty

Laura Cronshaw and Jeffrey Martin
(Niagara Catholic District School Board)
Dr. **Chantal Buteau and Dr. Laura Broley**
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Document prepared by:
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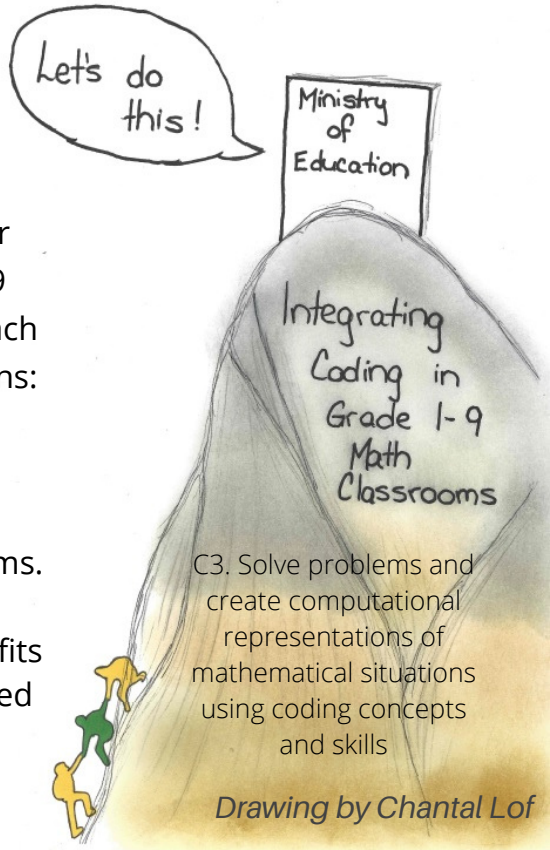
A MOUNTAINOUS CHALLENGE...

With the 2020-2021 curricular revisions in Ontario, teachers are now expected to implement coding in Gr. 1-9 mathematics. Adapting to new curricular expectations can be challenging for teachers: We predict that it could be even more challenging in relation to the topic of coding. Coding is a creative process, depending on concepts, practices, and perspectives that cannot be learned overnight. Moreover, teachers are not only expected to teach coding, but how it can be used as a productive tool for mathematics learning and problem solving. For some teachers, being asked to implement coding in math class may be like facing a big mountain to climb.

...A COLLABORATIVE CLIMB?

This past winter, 25 Niagara Catholic District School Board in-service teachers and 36 Brock University pre-service teachers worked together to prepare and implement coding and mathematics activities in Gr. 5-9 classrooms. In this presentation, we describe this collaborative approach as one way of supporting the enactment of the new coding expectations: that is, as one possible way to start climbing the mountain.

We provide a window into how the collaboration worked, including concrete examples from specific pre-service and in-service teacher teams. Key insights they gained about implementation, grounded in their experiences, will be discussed. To end the presentation, potential benefits of the collaboration, as well as difficulties, for all involved, will be outlined and used in presenting concrete recommendations to other numeracy consultants who may want to try a similar approach in their context.



Drawing by Chantal Lof

OUR COLLABORATIVE APPROACH

2018

First Instance of the Collaboration

4 in-service teachers + 5 pre-service teachers (4 teams)

2020-21

Gr. 1-9 Math Curricula Revised

2022

Second Instance of the Collaboration

25 in-service teachers + 6 pre-service teachers (18 teams)

- Gr. 5-9 teachers from Niagara Catholic District School Board
- Many with beginning fluency with coding

- 3rd/4th-year concurrent I/S math students at Brock
- Enrolled in their 3rd *Mathematics Integrated with Computers and Applications* (MICA) course, in which students learn to use coding for math investigation projects (Buteau, Muller, & Ralph, 2015)
- Most of them learned coding in MICA I (1st year)

February 16

Planning Meeting I (online, 120 minutes): The collaborative project was introduced. Then pre- and in-service teacher teams met in break-out rooms to introduce themselves and start planning their implementations. This included deciding whether to use a suggested resource or create a new activity.

March 9

Planning Meeting II (online, 60-90 minutes): Each pre- and in-service teacher team met to further discuss and refine their chosen activity, and to plan its implementation in the classroom (including logistics and individual roles). Once their activity was complete, one of the project facilitators (Cronshaw, Martin, Buteau, Broley) met with them for feedback.

Extra Planning: *Many teams touched base and engaged in additional preparation before the classroom implementations. For in-service teachers, this included preparing their students (sometimes using activities prepared by their associate pre-service teachers).*

Week of March 28

Classroom Implementations (in-person or online, 1 or 2 lessons): Each pre- and in-service teacher team implemented their planned activity (on the same or different days), and when possible, one of the project facilitators was also present for observation and support.

April 6

Collective Reflection Meeting (online, 90 minutes): Following a questionnaire prompting pre- and in-service teachers to reflect on their implementations, teams were grouped in 6 break-out rooms, each with a facilitator, and discussed benefits, challenges, and recommendations that emerged from their experiences.

SUB-PROCEDURES AND DILATIONS IN SCRATCH

implemented in Gr. 7 and 8 Mathematics Classrooms

by Abbey and Jessica (pre-service)

John and Stephanie (in-service)

Planning Meetings I & II

- *chose an activity found in a resource selected from our list, namely from MathUP (Rubicon Publishing Inc.), that involves both mathematics (similar shapes) and coding (sub-procedure) learning objectives*
- *decided on conducting the activity over 2 lessons in 2 consecutive days*
- *agreed on everyone's role in the classroom: Abbey & Jessica will tag team facilitating the activity, and John & Stephanie will actively help*

Extra Planning

- *John and Stephanie prepared their classes one week prior, to "get everyone on an even playing field ... Especially them getting to work with Scratch ... we had them do some sequencing, repeating codes, ... some nested and conditional statements..." to bring them up to about a Gr. 6 level.*

Classroom Implementation

- *According to the teachers, students were particularly engaged in the activity, "taking risk", and were "proud showing off to their peers". By the second day, students asked for less help: they "seemed to be working together and collaborating more."*
- *Based on lesson 1, Abbey and Jessica slightly modified the planned lesson 2: e.g. they purposely paused mid-way into the lesson "to do a check in regarding the scale factor variables."*

Collective Reflection

- *"I was surprised with just how much agency there was within the activity and how large of a role and impact it made" Jessica.*
- *"I found [the discussions at the planning meetings] gave me a different (pedagogical) perspective... It was very valuable working with [Abbey and Jessica]" Stephanie*

For more details, see the related Experience Report at the link below.

RESOURCES: mkn-rcm.ca/brock-u-ncdsb-ct-math-tasks/

Documents Supporting the Collaboration

- guidelines for the meetings between pre- and in-service teachers
- additional material for pre-service teachers (course readings, project guidelines, etc.)

4 Experience Reports

including activity descriptions and videos on insights gained from pre- and in-service teachers

Sub-Procedures and Dilations in Scratch

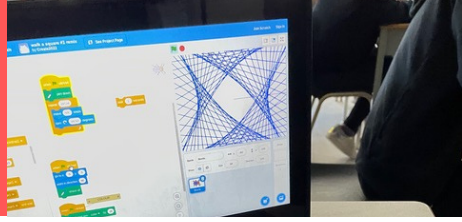
Surface Area Exploration in Scratch

Angles and Polygons in Scratch

Solving Algebra Word Problems in Python

LESSONS LEARNED

about implementing coding in math class



The following benefits are not surprising.

Many of them were already proposed in the 70s and 80s with the pioneering work by Seymour Papert, who envisioned coding as a powerful tool for inviting all children to do mathematics as mathematicians do (1980). These benefits have also been reported in research literature since that time: see the references, which include, e.g., Gadanidis' affordances of coding for mathematics, described at https://imaginethis.ca/educating-young-mathematicians-3-five-as-for-coding-math/.

What is exciting is that the collaborative approach we took enabled pre- and in-service teachers to experience these benefits together.

BENEFITS

Supporting multiple levels of learning

Coding activities allow for multiple entry points , different trajectories, room for extensions and further learning.

“The coding was applicable to all levels of learning (Beginner-Advanced).” *

Inviting students to be involved in their own learning

Students can experiment, take ownership of their work, be creative, and share their work with others.

“Being able to experiment with code. Increased agency to create their own thing. Unique in its own sense.” *

Providing students with a new tool for exploring and learning mathematics concepts

Students can use coding to deepen their exploration of specific math concepts they've already learned and as a learning tool for new concepts.

“Better understanding of the math process, able to see it, see the math behind the problem...” *

Allowing students to learn mathematics in a new way

Students can interact, explore, see different methods or routes to solve a problem, and use their understanding to create.

“Idea generation and seeing how to solve problems in different ways, try different routes, expand." *

Providing students with a new tool for engaging in mathematical practices

Students can learn how to use coding for mathematics, e.g. for the purposes of graphing or solving a word problem.

“Students might have learned how to use coding for...word problems in a way that a computer can understand.” *

Enabling students to gain familiarity with coding

Students can gain a familiarity with coding itself: coding techniques, related SEL skills, the benefits of coding, the uses of coding, how multiple approaches can be taken when coding, etc.

“The students ... became more comfortable with coding in Scratch ... [and] testing and debugging as a necessary coding practice.” *

“Students saw how code can be used to solve problems that would take too long by hand.” *

Encouraging (new) student leaders

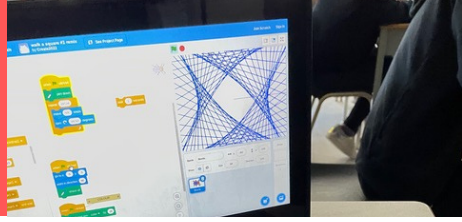
"It also allows students to succeed that sometimes struggle in other subject areas." ~

"I was able to see the students that grasped coding and witness them become leaders in the classroom and helping their classmates." ~

Quote from: '*' - Pre-/In-service teacher team; '~' - In-service teacher

LESSONS LEARNED

about implementing coding in math class



CHALLENGES

Timing the lesson

Getting through everything planned, knowing when to move on.

“[We] maybe overestimated their coding skills, over-created activities for the amount of time it actually takes in the classroom.” *

Ensuring students stay on task

Reducing distractions such as having "too much fun," exploring non-relevant features of a programming language (e.g. Scratch).

"Some students got distracted by the coding environment (cats meowing everywhere).” *

Addressing students' differences

Different levels of knowledge and confidence, different experiences and interests, may or may not require IEPS, etc. In relation to both mathematics and coding. Lead to different student responses.

"Trying to get students to get on the same page with their peers as some were way ahead of the program while others were having difficulty with other parts of the code” *

Responding to students' needs

Helping many students at once, getting students to ask for help (and helping those who did not), using productive strategies to provide help (e.g. helping without giving the answer). Also being flexible in the sense of re-evaluating and adapting the lesson.

“...students who were stuck often would not ask for help.” *

“Unexpected development: Based on how day 1 went, day 2 had to be modified.” *

Connecting mathematics and coding

Ensuring students understand both math and code, can combine new math concepts and coding (also new). Understanding the goal- coding to learn math or math to learn coding?

“Getting students to understand and see the math inside coding...” *

"...are we teaching code using math or are we teaching math concepts using code... we agreed it was the second point...” ~

Supporting students who lack experience in coding

“Trying to explain the code to students that are not very familiar with Scratch.” *

"...the main hurdle was how do we teach a math concept using a method that students do not understand...” ~

Helping students overcome the fear of making mistakes

“Sometimes students who 'know more'/'are very confident' expect everything to be perfect and experience some stress - less willing to take risks.” ~

Handling technological issues

Working with classroom constraints

E.g. lack of technology or classroom set-up.

“Orientation of the classroom was not optimal for computers because we couldn't see what is occurring on every computer screen, whereas if it was a circle the educators could keep better track." *

Quote from: '*' - Pre-/In-service teacher team
'~' - In-service teacher

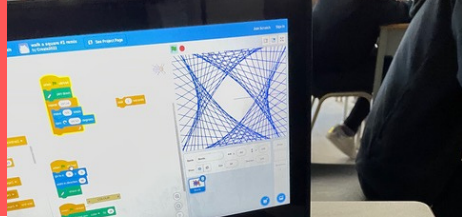
The above challenges experienced by pre- and in-service teachers in our collaboration, among many others, are also being reported by other teachers facing new curricular demands involving coding (see, e.g., Sentance & Csizmadia, 2017; Vinnervik, 2022).

How can teachers overcome such challenges?

One useful resource presenting pedagogical strategies and additional readings for teachers is a recent handbook on teaching coding in K-12 (Grover, 2020). It includes chapters related to: *assessment (Chap. 6), cross-curricular integration (Chap. 9), knowledge and SELs (Chap. 11), learner-centered and universal design pedagogies (Chap. 12 and 21), scaffolding approaches (Chap. 23).*

LESSONS LEARNED

about implementing coding in math class



RECOMMENDATIONS

Allow students to collaborate

Prompt group discussions and invite students to work together, think about how to pair students appropriately, teach students how to give their peers feedback.

"Have students collaborate with others with building their codes, whether they work on it together or they ask questions to peers." *

Ensure students have sufficient knowledge and/or scaffolding

For the coding, mathematics, and activity itself. Use "pre-lessons" to desired activities if necessary. Consider certain lesson structures, e.g. taking a "three-step process" (learn coding, learn math, then integrate together), following the "use-modify-create" model, or giving students part of the code.

"Just an intro to Scratch and what each [piece] of the code does and how to use the program...a review of the lesson material prior to the lesson would help." *

"...prompting questions... Giving them codes to see if they could visualize the result of running the code." ~

Foster an environment that is accepting of errors and mistakes

"When bugs/errors occur, have students develop mindset to debug - not saying 'what did I do wrong' [but] 'what is happening here?'" *

Check-in on students

"Polling to check the progress. About how students are feeling (not only what they are learning). Students can see how other students are feeling too." *

Just go with it, and be adaptable

"There is more than one way to learn coding. If a lesson goes in a different direction, you may not want to shut it down ... IF learning is occurring, let them have freedom." *

Create lessons that meet varying levels of needs

"Prepare for low-floor, high ceiling BECAUSE of the possible range [of students' knowledge] in classrooms." *

"Be aware of where your students are so that the activity challenges them without being overwhelming." *

Give sufficient time for student learning

"Give students more time to explore (trial and error), and collaborate with their peers. The students work well together and learn from each other, and this allows them to be successful." ~

Make coding a consistent part of the classroom

"My next step towards implementing coding is to continue to give the students the opportunity to develop their coding skills: Building coding into their daily schedule." ~

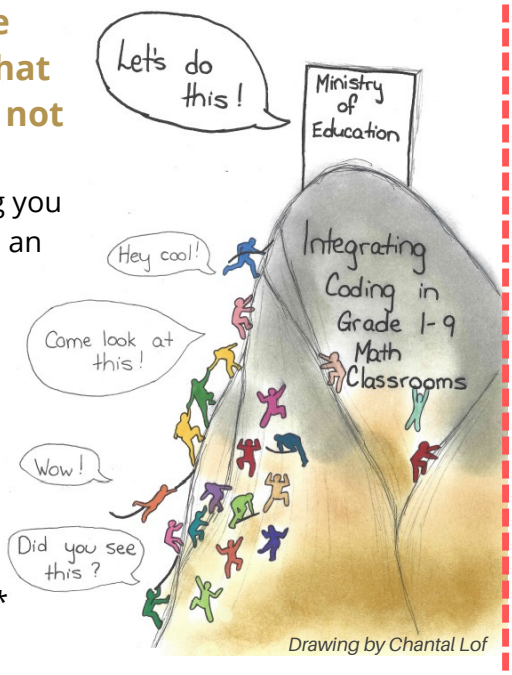
Do not limit coding tools to the computer

"Using white board, paper, pencil, and other tools available in the class. Not just computer." *

Highlight the conventions of coding

Acknowledge and accept that teachers are not experts

"To teach coding you don't have to be an expert. 'Do you know what is going to happen...?.' Being able to say, 'Let's try this together...' - co-discovery." *



Drawing by Chantal Lof

REVISED TITLE:

A Collaborative Approach

*involving pre- and in-service teachers, **school students,** numeracy consultants, and university faculty*

Quote from: '*' - Pre-/In-service teacher team
'~' - In-service teacher

LESSONS LEARNED

about the collaborative approach

BENEFITS

Combining different expertise to lead to enriched, mutually beneficial experiences

"Watching the [pre-service teachers] interact with the kids, it was ... of a different dynamic for sure ... and [we were] learning from them as much as they were learning from the kids and they were learning from us." ~

Bringing new ideas and approaches to the classroom

"Doing things that teachers and [their] students didn't think of." *

Having someone with more experience in coding to lead the lesson

"My own coding experience is quite limited. ... It was great to have someone leading the lesson who had a deeper understanding of coding and specifically about Scratch." ~

Having new people and energy in the classroom

"Having two new people or two new faces in the room. ... They were very engaged with the kids ... the kids themselves were right into it." ~

Providing additional role models in the classroom

"One of our girls ... said 'Oh my gosh, it's so cool that we have girl mathematicians." ~

For pre-service teachers:

Gaining experience in a classroom

"We got to learn how unpredictable a lesson can be and how we must always be ready to adapt on the fly" =

Seeing "theory in action"

For in-service teachers:

Being free to walk around the room

"...we got to walk around ... usually we are drawn to specific kids that need our help and that need us to be in the vicinity of them ... they got a new face and we got to go and see the other kids and their thought processes." ~

Gaining familiarity with and confidence in coding

"I gained more information on using blocks and how they can run concurrently." ~

"I feel much more comfortable with debugging and breaking the steps down into the small steps needed for coding." ~

Seeing how coding can connect to mathematics

"I really enjoyed seeing the direct connection between the math concepts I had taught the students and how they connected to the coding commands." ~

Seeing how to implement coding in mathematics classrooms

"... I have also gained some much-needed insight into how to run a coding lesson in my classroom." ~

Learning new pedagogical approaches

"It gave me a different perspective ... traditionally we would put up something and then take it up ... then she says 'well, don't take it up: have them do this, and then build on this skill, and then articulate the whole process' ... I had never thought of it that way." ~

These benefits, highlighted by in-service teachers in our collaboration, suggest that **they may be further equipped for their climb** (integrating coding in their math classrooms).

"Introducing new content does not merely mean that teachers have to equip themselves with new subject knowledge... Teachers also need to learn appropriate pedagogies for delivering a new subject"
(Sentance & Csizmadia, 2017, p. 470).

Quote from: '*' - Pre-/In-service teacher team
'~' - In-service teacher
'=' - Pre-service teacher

LESSONS LEARNED

about the collaborative approach

CHALLENGES

The main challenge recognized by pre- and in-service teachers:

Making time to prepare the lesson and the class

"In intermediate [classes] we needed to cover the majority of skills that should have been presented in grades K-6, as the exposure of coding prior to the availability of resources varied." ~

"Time (1 Meeting, 1 Planning Session, and we are LIVE) ... No meet and greet with students and pre-service students" *

"My biggest problem with this project was the misunderstanding that students have experience with coding..." ~

The main challenge recognized by the project facilitators:

Providing in-depth support for all teams

"The large number of teacher teams made it difficult to provide support to all of them during the planning and implementation. It was difficult to ensure the meaningfulness of activities selected or created by each team. With only 3 support people (2 numeracy consultants and 1 university faculty) and most implementations occurring at the same time, it was also difficult to ensure someone was present at each implementation." +

Quote from:
'*' - Pre-/In-service teacher team
'~' - In-service teacher
'+' - Project facilitators

RECOMMENDATIONS

Provide more time for planning and suggestions for further preparation.

"...if we were to do again, I'd have the Brock students run through the actual Scratch portion of their lesson so I could understand it before they actually taught it" ~

Conduct the planning sessions in person.

"Due to the pandemic, planning sessions were online, which constrained the initial interactions between the pre- and in-service teachers." +

Include preliminary visits to the classroom.

"Having pre-service teachers visit the class before, at least to say 'hi,' could help them become more comfortable in the classroom. It could also assist with spreading the word about the collaboration and increase future participation!" +

Allow for multiple teaching sessions or lessons.

"because I had made it a two-part lesson, the next day when [the pre-service teachers] came back, we were able to troubleshoot some of the things that were preventing [students] from going through the problems. ... having at least two hours – two lessons a day apart– I think that was very valuable, as opposed to just making it an event." ~

Invite elementary-secondary collaboration.

"The collaboration involved few secondary in-service teachers. It could be useful to have teams involving in-service teachers from both elementary and secondary levels. Pre-service teachers could then co-teach across grades and see how related activities build on one another." +

Spread out implementations and/or request additional support at the time of implementation.

"Have pre- and in-service teachers implement their planned lessons at different times, on different days, over a longer period, or ensure that there are more people (other university faculty or numeracy consultants) willing to visit the classes and provide additional support." +

QUESTIONS FOR REFLECTION

How can this collaboration be productively adapted and used in other contexts?

How can these kinds of collaborations be initiated?

How can more time and support be provided for the planning and implementation stages of the collaboration?

If you would like to reflect together, please reach out:

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Dr. Chantal Buteau
cbuteau[at]brocku.ca

SOME REFERENCES (with links)

Benefits of Implementing Coding in Math

Brodie, I., & Deneau, A. (2021). *Coding in the Ontario mathematics curriculum intermediate grades* [Webinar]. OAME - AFEMO.

diSessa, A.A. (2018). Computational literacy and "the big picture" concerning computers in mathematics education. *Mathematical Thinking and Learning, 20*(1), 3–31.

Gadanidis, G. (2017, November 21). Educating young mathematicians (#3): Five As for coding + math. *Imagine This!*

Gadanidis, G., & Cummings, J. (2018). *Integrated mathematics + computer studies – Gr. 10* [MKN White Paper].

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas.* Basic Books.

Challenges Facing Teachers

Gr. K-13 teachers in the UK, who have been expected to teach computing since 2014:

Sentance, S., & Csizmadia, A. (2017). Computing in the curriculum: Challenges and strategies from a teacher's perspective. *Education and Information Technologies, 22*, 469-495.

Gr. 1-9 teachers in Sweden, who have been expected to implement coding in math since 2017:

Vinnervik, P. (2022). Implementing programming in school mathematics and technology: Teachers' intrinsic and extrinsic challenges. *International Journal of Technology and Design Education, 32*, 213-242.

Strategies for Implementing Coding in Math

Grover, S. (Ed.). (2020). *Computer science in K-12: An A to Z handbook on teaching programming.* Edfinity.

For example:

- assessment (Chapter 6)
- cross-curricular integration (Chapter 9)
- knowledge and SELs (Chapter 11)
- learner-centered and universal design pedagogies (Chapters 12 and 21)
- scaffolding approaches (Chapter 23)

The MICA Program at Brock University

Buteau, C., Muller, E., & Ralph, B. (2015). Integration of programming in the undergraduate math program at Brock University. In *Proceedings of Math+Coding Symposium*.

THANKS TO

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