Dr. Eric Jackman Institute of Child Study
Laboratory School

Lesson Study

Repeating Patterns:

Developing Children's Understanding of Computational Modelling

A Grade One Lesson

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Students: Half the Grade One Class
Location: The Grade One Classroom

1. The Lesson Rationale

"It's not what you know about the computer that's important, but your ability to do things with it. By studying French in an academic setting, you get to know a lot about it, but typically, you can't express yourself well or have an interesting conversation with it."

- Seymour Papert

Over the last couple of years, there has been a strong push for the inclusion of 'coding' into the school curriculum. Often, these 'coding' experiences appear in the forms of special 'coding' day activities or as after school programs where students learn to work with a specific programming language. More recently, there have been arguments against teaching 'coding' in its current way. Instead of teaching to use specific programming languages, the focus should be on computational thinking. As Karl Beecher (2017) states in his **re:publica** talk: *"Code is merely the means to implement an idea. Kids first need to learn how to properly form ideas computationally"(https://re-publica.com/en/session/teach-our-kids-code-no-teach-them-how-think).*

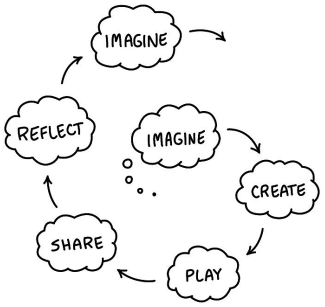
Programming languages rapidly change and evolve. It was only 40 years ago when programming was done with manual punch cards. However, the concepts, ideas, and theories behind the languages are consistent and much more resistant to change. As George Gadanidis (2017) states:

"At the heart of computational thinking – and mathematics – is abstraction. When children write code, they come to… 1. understand in a tangible way the abstractions that lie at the heart of mathematics, 2. dynamically model mathematics concepts and relationships, 3. gain confidence in their own ability and agency as mathematics learners"

Our goal as a group was to design a series of math lessons that could be easily integrated into an existing primary math program. Computer coding would act as a platform to explore mathematical concepts and while exposing students to the early ideas of computational thinking.

Fortunately, some of the core principles of coding complement the primary curriculum that we are working with. Specifically, concepts of patterning, sequencing, and geometry.

Our work is guided by mathematician and mathematics educator Dr. George Gadanidis who creates computational modelling experiences for children and teachers . For example, he created an app that allows children to discover “mathematical surprises” as they change values in blocks of code and immediately see how their code activates a repeating pattern. The idea is for students to learn how to work with the program, to learn some of the language of coding and become creators, rather than consumers of technology.



Additionally, Mitch Resnick (2017) has suggested that using a programming language as a platform for learning can be a great cultivator of creativity in children and adults alike. His work explores concept the *four P’s of creative learning:*

- Projects - whether they are small or large, projects allow for the *Creative Learning Spiral* (Resnick, 2017).
- Passion - when people work on projects they care about they are willing to work longer and harder.
- Peers - Creativity is a social process, we wanted students to collaborate and share ideas.
- Play - Providing the students with opportunities for playful experimentation opens pathways to creativity.

In our lesson design, we aimed to include all four areas. Ultimately, we are not just teaching students to learn code, we are using coding to learn.

As Jennifer Lewington (2017) points out, “Despite pockets of excellence, coding remains a hit-and-miss phenomenon in Ontario classrooms, often dependent on tech-savvy teachers and individual board practices” (p. 18).

Research highlights the key role of the teacher to draw on pedagogical perspectives that carefully scaffold and mediate the learning progression (Clements & Joswick, 2018).
We wanted to explore the following questions:

- *What can this tool do for students’ mathematical learning that can’t be done without it?*

- *How can coding become a door into computational thinking, providing students the opportunity work collaboratively, problem solve and embrace trial and error as a part of learning (Lewington, 2017)?*

Our Focus on Repeating Patterns
When children create, identify and extend patterns and when they make predictions based on observations and can name rules with words, symbols, numbers, and variables – they are demonstrating important mathematics learning. Rittle-Johnson et al (2016) point to children’s

awareness of mathematical patterns as a predictor of later mathematical achievement even over other areas of mathematics such as counting. Pattern awareness has been linked to early algebraic thinking (Kieran, Pang, Schifter & Ng, 2016). Children who have a sense of the structure of a pattern and can see the pattern core or "unit of repeat" have a good opportunity to develop multiplicative thinking and part-whole awareness (as children see the unit as well as the numbers that compose the unit).

2. Exploratory Lessons:

First Day: The students were given an opportunity to explore the coding program created by Dr. Gadanidis: http://researchideas.ca/patterns/ on the iPads. They interacted with the program, exploring what would happen by changing values within all of the variables. We felt that the children needed this experience to see what the program involved before they would be ready to approach subsequent lessons in a more intentional way.

Second day: We provided a more structured interaction with the program. The children gathered in front of the Smartboard to view a projection of the repeating patterns program. They listened to the sounds that the program made and tried to decide how many different sounds they could detect in the pattern. Nick showed them how they could slow it down so they could hear the different sounds more distinctly. Then Nick took the students through an exploration of most of the variables in the program, by changing one variable at at time, running the program, and then comparing the visual image with the original image. The children were invited to predict what they thought would happen when one value was changed to be larger or smaller. For example, Nick changed the size of the rotation, and invited the children to predict what would happen, asking, "What do you think would happen if we changed this number?" Then he did the same with the rate, the step size, the stamp size, etc. All the variables were explored except those of the x and y axis. He directed the children's attention to the displayed image and the colours that they saw. One child commented, "It's a pattern!" Zoe talked about noticing the pattern core.

Third day: Zoe gave the children time to play with iPads on their own again. This time, they were doing a lot more with the program now that they knew more about it and understood what was possible. They experimented with changing the values and for example, discovered they could increase the value of the number so that the shapes in the pattern would overlap. They also discovered how to use coding to change the colour of the shape. We realized that for the next lesson we would include constraints on number values.

3. The Lesson

Lesson Goals:

Is this lesson, we want the students to:

- comfortably use and understand the coding language embedded in the repeating patterns program (such as rate, step size, loop)
- see how numbers affect graphical representations
- connect the sequence of musical notes to the sequence of the pattern core
- experience direct feedback from the changes they make in the coding and persist in revising their inputs based on this feedback
- reinforce the idea of repeating patterns so that they are able to abstract the pattern core and predict how the pattern core is extended
- move into the role of creator, rather than user of technology
- Come to appreciate the aesthetic possibilities of patterns both visual and auditory

LESSON PLAN

Materials:
Wooden cubes in 5 colours in 5 containers
5 + strips of chart paper, 20 squares each (or possibly between 20-25 to elicit discussion about remainders)
5 colours of markers, one set per pair
Xylophones labeled with colours:

- Blue is A
- Green is G
- Yellow is E
- Orange is D
- Red is C

Colour mats – 5 sets
iPads/Laptops
connector – iPad to Smartboard

a.Introduction
Review with the children what we have been doing so far.

b. Demonstrate creating, dancing and playing patterns
What we are going to do today - Zoe
Zoe: We are going to show you what you will be doing today, then you will have a chance to do it too! You and a partner will get to make up your own pattern using 3 of these 5 colours – red,

blue, green, yellow and orange. First you are going to make your pattern with these wooden cubes. Together you can decide on what the core of your pattern will be and then you can make it repeat until you have used 20 cubes.
Zoe and Nick demonstrate, showing children how they are to work together, discuss, negotiate, compromise and take turns. The pattern the teachers show the children will be an ABBC pattern.

Once you are happy with your pattern you will show it to a teacher. Then we'll give you a strip of paper and some markers and you can record your pattern on it.
Zoe and Nick demonstrate.

Next you will get to dance your pattern on colourful mats and play your pattern on a xylophone.
Zoe and Nick demonstrate.

c. Work in pairs to create, dance and play patterns
Now it's your turn to create a new pattern. *Tell children their pairs and which colour they will start with.* Your pattern core will have 5 squares and use 3 or 4 colours. You're going to make a pattern using 20 blocks. Show a teacher when you are done.

Give each pair of students a strip of paper with 20 - 25 squares and invite students to record patterns on the paper.

Invite students to dance and play patterns.

d. Share patterns
Gather to share patterns. The teachers invite the children to dance and play their patterns, highlighting the pattern core. (*The purpose of this section is to give children a chance to internalize the pattern core both the visual and the auditory).*

e. iPad Demonstration/Modifying the program
Now, we are going to create our pattern on the computer. We're going to have to change the code so our pattern will appear when we run it.
Zoe and Nick demonstrate.
What sounds do you hear? Can you sing what you hear?
Zoe and Nick draw students' attention to the changes in the code that are being made in order for the ABBC pattern to appear.
Questions:

Now we are going to give you and a partner an iPad so that you can change the code to correspond with the pattern you created. When you put your pattern in you will leave the shapes as squares and just change the colours. We are going to take a screen shot of our pattern so we can remember what it looks like.
Zoe and Nick demonstrate with their pattern.

Now let's change some of the values. Any ideas? How would I do that? How could we make our code run faster? How could we make the squares bigger? What would happen if we changed the rotation to [x]?

Once you have put your pattern into the code you can change some of the other values. Before you do that please show a teacher so we can take a screen shot of your pattern. Before you run the code you and your partner can make a prediction about what you think it will look like. Please don't use any numbers higher than 400.

f. Work in pairs with iPads
Children work in pairs with a teacher assisting.
Teachers will ask students:
What are you planning to change and what do you think will happen if you make those changes? How do you know?

g. Share patterns on iPads
Gather and share. Show each group's original pattern and the one with the changed values. Ask the rest of the children to think about and comment on the new pattern and the changes from the original to the new.

h. Playing two patterns on one screen
As a final step, we will introduce the idea of running two codes on one screen (possibly the mirror image of a code?). We will ask students, "*What do you see? How did it work?"*

i. Extension: Extending patterns
If there is time in this lesson, this extension might be explored. If not, this could be the next steps or future directions for these lessons:
have a pattern core of 5. If I set the code to a repeat of 10, what colour will the last one be? What if I set it to a repeat of 12? 16? 21?

4. Ontario Ministry of Education Learning Expectations

Our lesson, *"Repeating Patterns: Developing Children's Understanding of Computational Modelling"* connects to and addresses the following notable curriculum expectations and areas:

Mathematics

Throughout this lesson, the Grade 1 children will have the opportunity to create and extend repeating patterns using a variety of manipulatives to develop their understanding as outlined in the **Ontario Mathematics Curriculum (2005)**.

- ***Grade 1: Patterning and Algebra***

– identify,describe,and extend, through investigation, geometric repeating patterns involving one attribute (e.g., colour, size, shape, thickness, orientation);
– identify and extend, through investigation, numeric repeating patterns (e.g., 1, 2, 3, 1, 2,3,1,2,3,...);
– identify a rule for a repeating pattern (e.g., “We’re lining up boy, girl, boy, girl, boy, girl.”);
– create a repeating pattern involving one attribute (e.g., colour, size, shape, sound) (*Sample problem:* Use beads to make a string that shows a repeating pattern involving one attribute.);
– represent a given repeating pattern in a variety of ways (e.g., pictures, actions, colours, sounds, numbers, letters) (*Sample problem:* Make an ABA, ABA, ABA pattern using actions like clapping or tapping.).

- ***Grade 1: Number Sense and Numeration***

– count forward by 1’s, 2’s, 5’s, and 10’s to 100, using a variety of tools and strategies
  - Skip count by twos, **fives,** and tens up to at least 50

Language

The modelled, shared, and guided experiences of this lesson provide children with the learning opportunities associated with listening and responding appropriately, while using a variety of strategies to communicate with peers. The following are notable curriculum expectations from the **Ontario Language Curriculum (2006)**.

- ***Grade 1: Oral Communication***

2.4 choose appropriate words to communicate their meaning accurately and engage the interest of their audience *(e.g., choose words relevant to the topic from the full range of their vocabulary, including new words used regularly in the classroom; use descriptive adjectives to clarify and add interest to a narrative; use inclusive language that conveys respect for all people)*
2.7 use one or more appropriate visual aids (e.g., pictures, photographs, props, puppets, masks) to support or enhance oral presentations (e.g., use a set of plastic animals during an oral recount about a visit to a zoo)

- ***Grade 1: Media Literac***y

1.1 identify the purpose and intended audience of some simple media texts *(e.g., this movie tells a story to entertain children; this sign gives information to travellers)*

Physical Education

This lesson provides Grade 1 children with the opportunity to, as stated in the **Ontario Health and Physical Education Curriculum (2015)**, apply movement strategies appropriately by demonstrating an understanding of the components of a variety of physical activities, in order to enhance their ability to participate successfully in those activities.

- ***Grade 1: Movement, Competence, Skills, Concepts, and Strategies***

B1.2 demonstrate the ability to move and stop safely and in control, with an awareness of people and equipment around them
B1.3 perform a variety of locomotor movements, travelling in different directions and using different body parts *(e.g., jump over lines; walk carefully backwards along a line while looking over their shoulder; move forward with different body parts touching the ground; move arms in different ways while walking, dancing, or skipping; take giant steps while moving sideways)* [PS]
B2.2 apply a variety of simple tactics to increase their chances of success while participating in and exploring physical activities *(e.g., extend arms to improve stability when balancing on one foot; change speed, direction, or level to avoid being tagged; move closer to a target to increase the likelihood of success when sending an object)*

The Arts

Through the dance, music, and visual arts activities of this lesson, children have the opportunity to use their prior knowledge and experiences to represent their higher-order thinking skills and capacity for reflection to demonstrate their understanding. The following are curriculum expectation connections from the **Ontario Arts Curriculum (2009):**

- ***Grade 1: Dance***

A1.1 use movements that are part of their daily experience in a variety of ways in dance phrases *(e.g., alter and exaggerate movements based on even rhythms such as walking, galloping, and swimming, and on uneven rhythms such as skipping and jumping; amplify and modify percussive movements such as the movement of a clock ticking or the sustained hold of a cat stretching)*
A1.3 create dance phrases using a variety of ways to connect movements (e.g., connect a melt and a spin using a non-locomotor movement; connect a walk and a skip [locomotor movements] with a circle [pathway])
A1.4 use varied and/or contrasting body shapes to communicate different types of messages (e.g., a high level and open, expansive shape to show dominance; a closed huddled shape to show that you are holding a treasured or secret object)

- ***Grade 1: Music***

C1.3 create compositions for a specific purpose and a familiar audience (e.g., use the notes "mi", "so", and"la"to create a melodic phrase that answers a sung question; use rhythm instruments, body percussion, or everyday objects to create an accompaniment to a story or song; use short rhythmic phrases in improvised answers to clapped questions)
C1.4 use the tools and techniques of musicianship in musical performances
C1.5 demonstrate understanding that sounds can be represented by symbols (e.g., show rhythm and beat with manipulatives such as math cubes or Popsicle sticks; use devised, or invented, forms of musical notation, or simple forms of standard musical notation)
C2.1 express initial reactions and personal responses to musical performances in a variety of ways
C2.2 describe ways in which the elements of music are used for different purposes in the music they perform, listen to, and create

- ***Grade 1: Visual Arts***

D1.3 use elements of design in art works to communicate ideas, messages, and personal understandings
D1.4 use a variety of materials, tools, and techniques to respond to design challenges
D2.1 express their feelings and ideas about art works and art experiences

5. Questions for Observers (please see Appendix A)

6. Resources & References

Repeating Patterns http://researchideas.ca/patterns/

"To Code or Model" George Gadanidis Blog http://imaginethis.ca/

Computational Thinking http://researchideas.ca/wmt/c6.html

Video: What is computational thinking? https://youtu.be/sxUJKn6TJOI

(13) Broadening the horizons of research on discovery-based learning. Available from: https://www.researchgate.net/publication/322936134_Broadening_the_horizons_of_research_on_discovery-based_learning [accessed Feb 16 2018].

Appendix A: Questions for Observers

The focus of this lesson is on facilitating the development of children's understanding of using code to create, identify, manipulate, and extend repeated patterns. As observers, please focus on how children are showing understanding and notice what they say that reveals their thinking. To avoid extra distractions for the children, we would ask that observers remain around the perimeter of the room, and silently observe the children when they come to the tables to work in pairs. Please focus on observing one pair, and members of our team will also sit with a pair.

Here are some questions to guide your observations.

When the students are working in pairs to create, dance and play patterns:

How do the children discuss, negotiate, compromise and take turns while working together? What does this talk reveal about their understanding of patterning?

Does the experience of playing and dancing the pattern affect their understanding? How?

Are the children aware of how the pattern core repeats?

When the students are working in pairs with the iPads:

When the children are working in pairs with the iPads, what are they saying to each other? What does this talk reveal about their understanding of how the program works, or how the different values will affect their pattern?

Do you notice children gesturing? How do children's gestures reveal their thinking?

Do the students show understanding of how the variables within the coding program work? Are they showing understanding of a sequence of steps? Do they understand that each piece of code does something different? Are they able to effectively manipulate the program in the way they want to, or do they get frustrated or stuck? How do the students persist through mistakes or surprises by trying another command or amount?

Team members will be asking: What are you going to change? What do you think will happen when you do that? (to give the observers something to watch, while we push their thinking further).

When the students are sharing the patterns they created:

When the children are asked to predict how the pattern will appear based on the values in the code, what do their answers reveal about their thinking? Do they show understanding about what has changed? Are there misconceptions or any confusion?

And generally throughout:

Are the students engaged throughout the lesson? When are they most/least engaged?

How did the students respond to the musical or visually artistic elements? Do you think this helped them with their understanding of the patterning? Did the students show appreciation for the artistic and musical aesthetics?

Do you see evidence of algorithmic thinking (a series of ordered steps) when problem solving?

How do students articulate their understanding/learning?