# Integrating Computational Thinking in the Primary Grades


Steve Floyd

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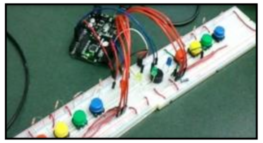
**Steve Floyd - London, Ontario - @stevenpfloyd**

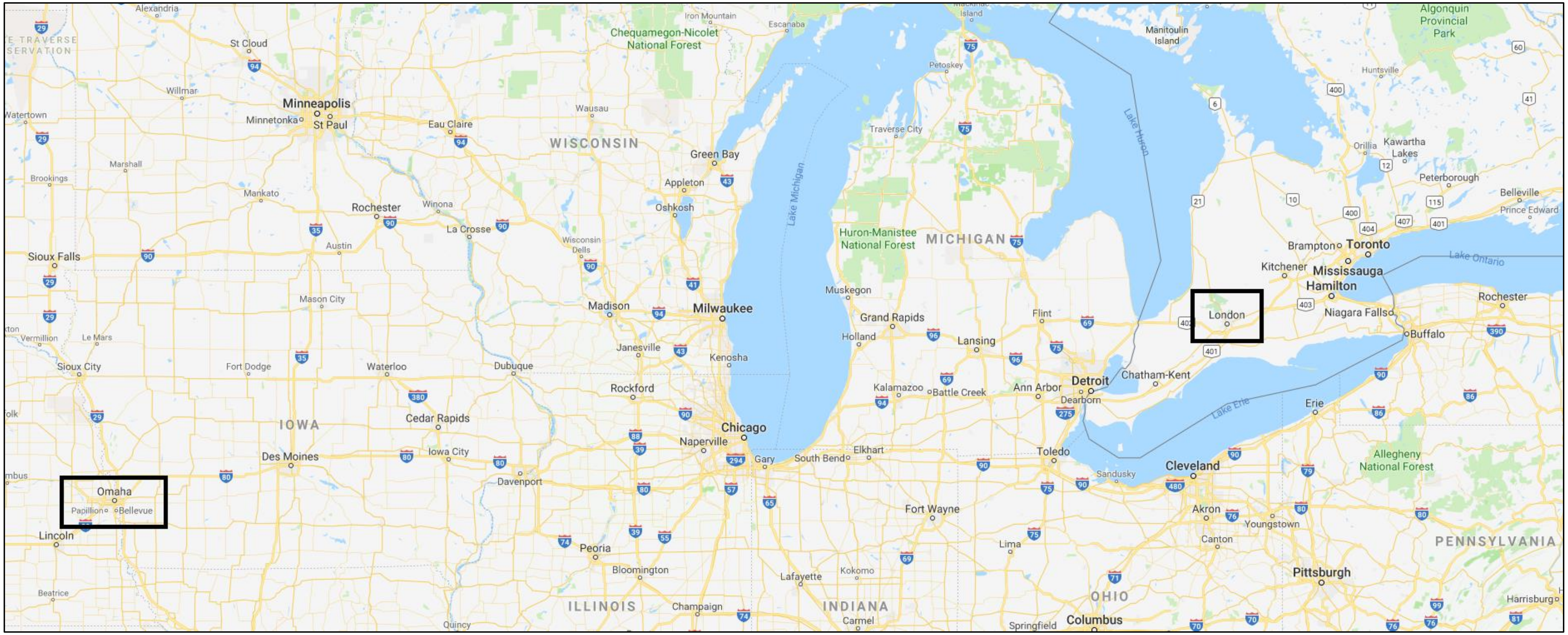


- 14 years - High School Computer Science/Computer Engineering Teacher
- 2017 CSTA Award for Teaching Excellence in Computer Science
- M.Ed. Educational Policy
- Lead elementary school projects in Coding and Robotics
- Beginning my PhD in Curriculum Studies (with a focus on CS Education in K-12)
- Cohost TVO TeachOntario - Coding and Computational Thinking in the Classroom

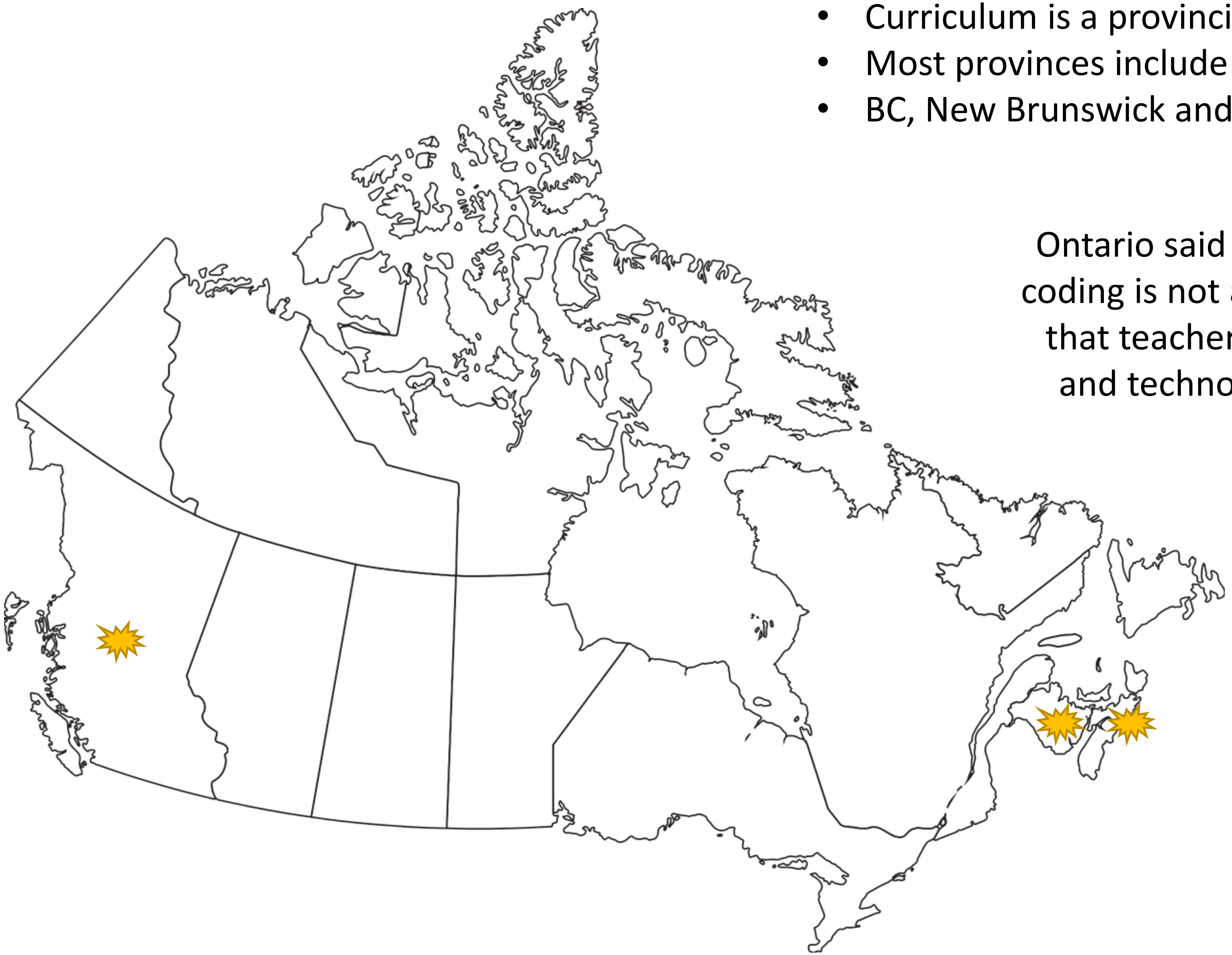


```
package premiershipdemo;

import java.io.*;

public class PremiershipDemo {

     public static void main(String[] args) {

     String valueReadS;
     int valueReadI;
     int total;
     int firsthalf;


     firsthalf = 0;
     secondhalf=0;
     total = 0;

        try

        {FileReader file = new FileReader ("goalsTrial.in");
        BufferedReader buffer = new BufferedReader(file);

        while ((valueReadS = buffer.readLine())!=null)

        {
            valueReadI = Integer.parseInt(valueReadS);
            total=total+1;
            if (valueReadI <= 45)
            {firsthalf= firsthalf + 1;}
            else
            {secondhalf=secondhalf + 1;}

        }
        }
        catch(IOException e)
        {System.out.println ("Sorry, file not found");}

        //OUTPUT YOUR DATA TO THE SCREEN

    }
}
```

# Where I'm coming from - geographically



# Where I’m coming from - pedagogically



- Curriculum is a provincial matter
- Most provinces include CS courses in grade 10, 11 and 12
- BC, New Brunswick and Nova Scotia elementary curriculum

Ontario said in a statement that as of August 2017, coding is not a mandatory part of the curriculum but that teachers are encouraged to “use information and technology tools in their teaching practice”.
Global News

# Where I'm coming from - pedagogically

## Coding as a Trojan Horse for Mathematics Education Reform

Gadanidis, George

Journal of Computers in Mathematics and Science Teaching, v34 n2 p155-173 Apr 2015

The history of mathematics educational reform is replete with innovations taken up enthusiastically by early adopters without significant transfer to other classrooms. This paper explores the coupling of coding and mathematics education to create the possibility that coding may serve as a Trojan Horse for mathematics education reform. That is, once we accept that young children are able to learn complex and abstract coding concepts, such as algorithms, loops, variables and conditional statements, then we are more likely to also accept that they can also learn more complex and abstract ideas of mathematics. In addition, coding is a natural fit to mathematics, as it can be used to model and investigate mathematical relationships and as coding and mathematics have a shared logical structure.


## Math Connections…

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**TeachOntario Talks**

### Driving Student Engagement in Mathematics with Coding and Programming

Posted by teachontarioteam in TeachOntario Talks on Aug 30, 2016 8:50:13 AM

Learning programming and coding can be a helpful tool when learning about mathematics.

***In this installment of TeachOntario Talks, we are profiling and celebrating a group of teachers from the London District Catholic School Board (LDCSB) who embarked on an Ontario English Catholic Teachers Association (OECTA) Collaborative Learning Community (CLC) Project to explore the role of computer programming and coding in mathematics instruction.***

Across Ontario, school districts are very aware of the ever-quickening pace of programming and coding education worldwide. Students are excited and ready to go when it comes to learning how to code and program, and teachers are stepping up to ensure students are getting a jumpstart at an early age.

**The Project**

LDCSB educators Richard Annesley, Steve Floyd, Tim Miller, Mark Palma and Catherine Veteri, believe students learning how to code is of the utmost importance.

This group, ranging from grade 4 to high school, developed a Collaborative Learning Communities (CLC) project to research the benefits of student coding and programming. This unique project not only focused on an innovative topic, but also included students from elementary and secondary schools.

# Where I'm coming from - pedagogically



The mathematical processes cannot be separated from the knowledge and skills that students acquire throughout the year. Students must problem solve, communicate, reason, reflect, and so on, as they develop the knowledge, the understanding of concepts, and the skills required in all the strands in every grade.

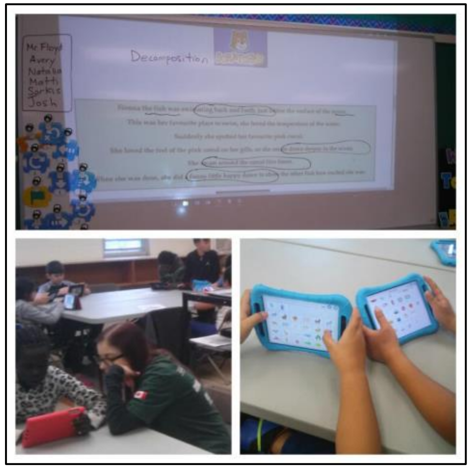
**Problem Solving**

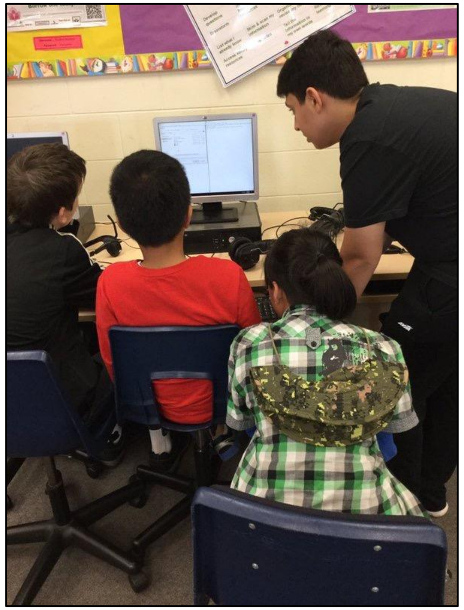
Problem solving is central to learning mathematics. By learning to solve problems and by learning *through* problem solving, students are given numerous opportunities to connect mathematical ideas and to develop conceptual understanding. Problem solving forms the basis of effective mathematics programs and should be the mainstay of mathematical instruction.

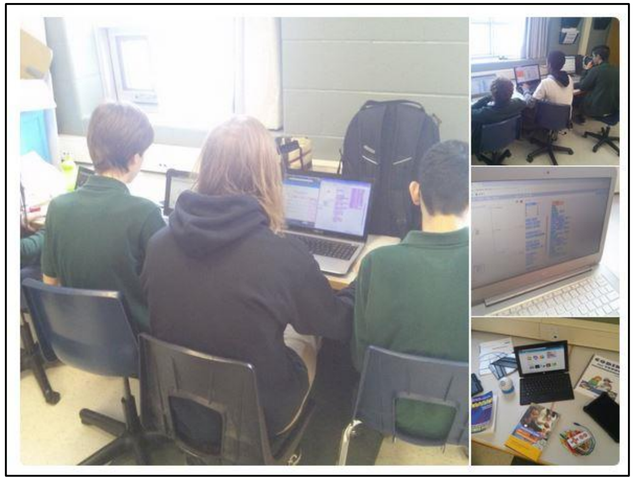
The computer and the calculator should be seen as important problem-solving tools to be used for many purposes. Computers and calculators are tools of mathematicians, and students should be given opportunities to select and use the particular applications that may be helpful to them as they search for their own solutions to problems.

***Computational Strategies.*** Problem solving often requires students to select an appropriate computational strategy. They may need to apply the written procedures (or algorithms) for addition, subtraction, multiplication, or division or use technology for computation. They may also need to select strategies related to mental computation and estimation. Developing the ability to perform mental computations and to estimate is consequently an important aspect of student learning in mathematics.

# Where I'm coming from - pedagogically

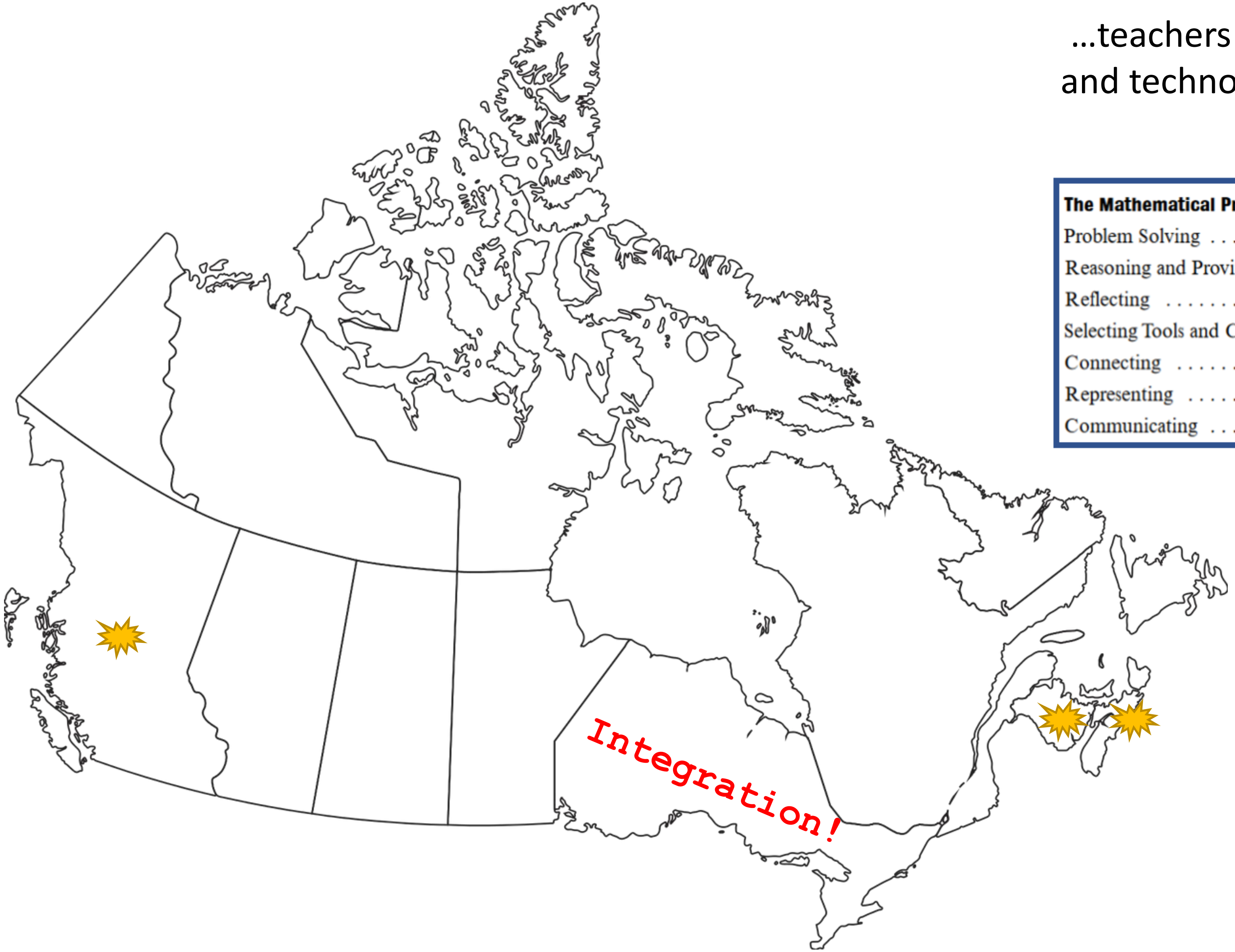






"Feeder School" Connections…

# Where I'm coming from - pedagogically




…teachers are encouraged to "use information and technology tools in their teaching practice".
[Global News]

# Where I'm coming from – Computational Thinking

## Key concept: CT concepts and practices

CT concepts include:

1. Logic and logical thinking
2. Algorithms and algorithmic thinking
3. Patterns and pattern recognition
4. Abstraction and generalization
5. Evaluation
6. Automation

CT practices include:

1. Problem decomposition
2. Creating computational artefacts
3. Testing and debugging
4. Iterative refinement (incremental development)
5. Collaboration & Creativity (part of broader twenty-first century skills)

Grover, Shuchi & Pea, Roy. (2017).
Computational Thinking: A Competency Whose Time Has Come.

**Box 1.**

**Computer Science Teachers Association's Concepts of Computational Thinking:**[4]

Formulating problems for computational solution

Logically organizing and analyzing data

Abstractions including models and simulations

Algorithmic thinking

Evaluation for efficiency and correctness

Generalizing and transferring to other domains

Supported by: dispositions of confidence in dealing with complexity, persistence with difficult problems, tolerance for ambiguity, open-ended problems, communication and collaboration

**Box 2.**

**Computing at School's Concepts of Computational Thinking:**[3]

Logical reasoning

Algorithmic thinking

Decomposition

Generalization

Patterns

Abstraction

Representation

Evaluation

Supported by: techniques of reflecting, coding, designing, analyzing, and applying

**Box 3.**

**ISTE's Standards for Students in Computational Thinking:**[15]

Leverage the power of technological methods to develop and test solutions

Collect data

Analyze data

Represent data

Decomposition

Abstraction

Algorithms

Automation

Testing

Parallelization

Simulation

Supported by: empowered learner, digital citizen, knowledge constructor, designer, communicator, collaborator

Denning, Peter J. (2017).
Remaining trouble spots with computational thinking.

# Specific Examples - Kindergarten

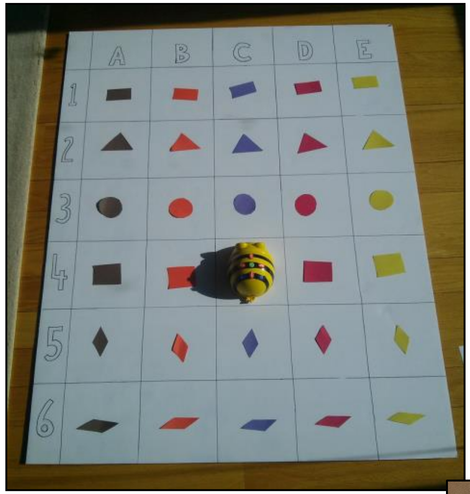


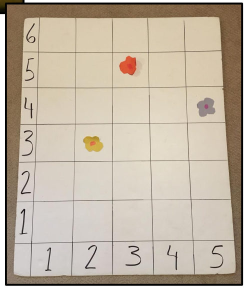
**Figure 2.** The four frames of Kindergarten (outer circle) grow out of the four foundations for learning and development set out in the early learning curriculum framework (inner circle). The foundations are essential to children's learning in Kindergarten *and beyond*. The frames encompass areas of learning for which four- and five-year-olds are developmentally ready.

## PEDAGOGICAL APPROACHES

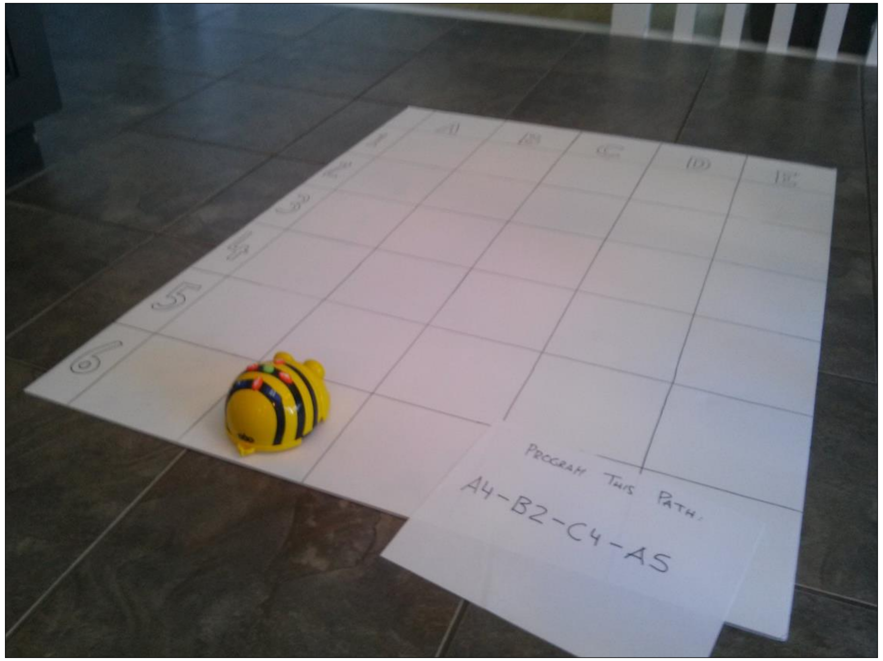
- **Learning through exploration, play, and inquiry** – As children learn through play and inquiry, they develop – and have the opportunity to practise every day – many of the skills and competencies that they will need in order to thrive in the future, including the ability to engage in innovative and complex problem-solving and critical and creative thinking; to work collaboratively with others; and to take what is learned and apply it in new situations in a constantly changing world. (See the "Fundamental Principles of Play-Based Learning" in the following section, and Chapter 1.2, "Play-Based Learning in a Culture of Inquiry".)
- **Educators as co-learners** – Educators today are moving from the role of "lead knower" to that of "lead learner" (Katz & Dack, 2012, p. 46). In this role, educators are able to learn more *about* the children as they learn *with* them and *from* them.
- **Environment as third teacher** – The learning environment comprises not only the physical space and materials but also the social environment, the way in which time, space, and materials are used, and the ways in which elements such as sound and lighting influence the senses. (See Chapter 1.3, "The Learning Environment".)


Digital tangibles promote deeper engagement and prolonged focus when exploring concepts and have been shown to be more appealing to children than solely coding
Horn, Crouser & Bers (2012)

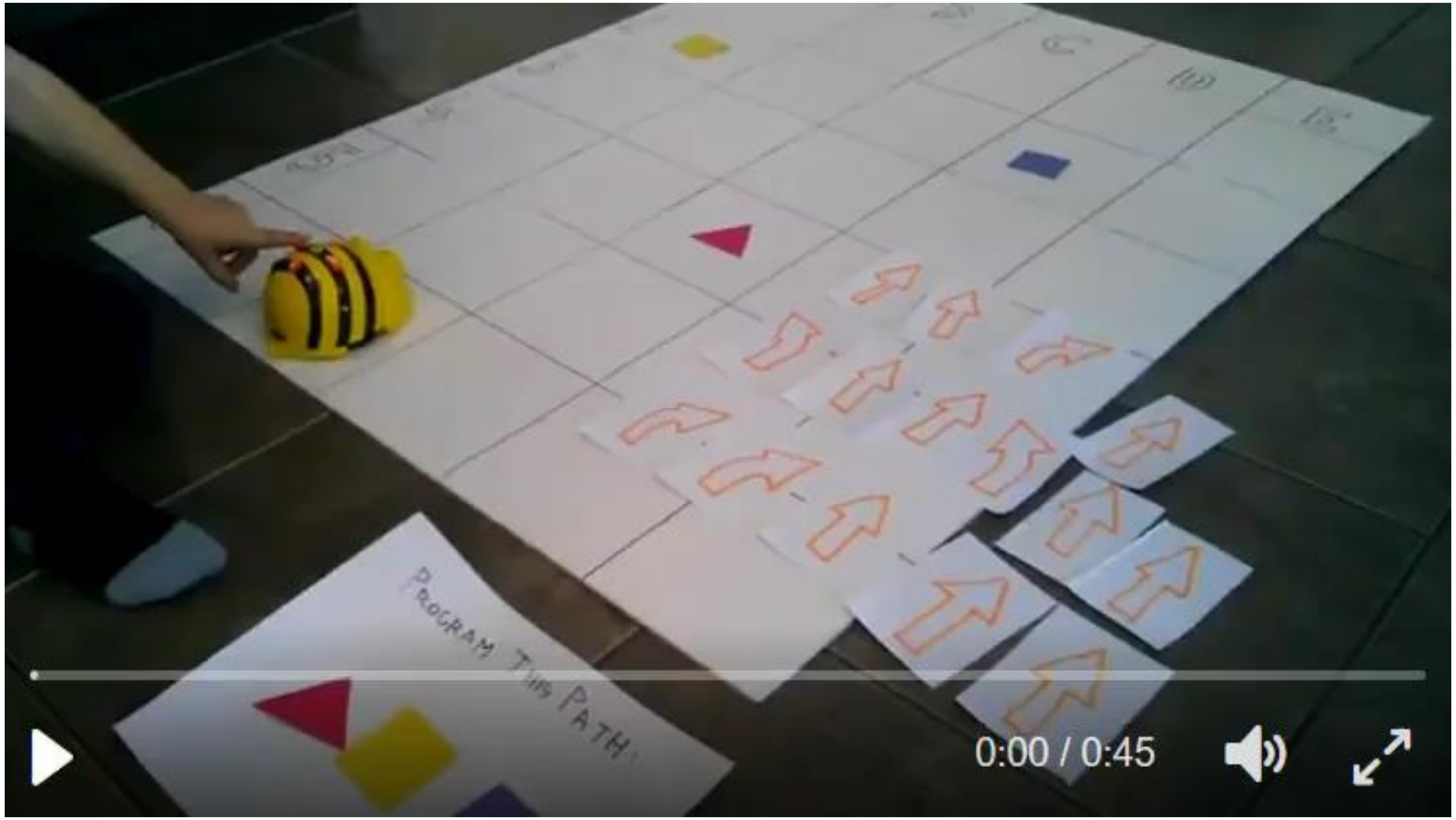






# Specific Examples - Kindergarten



# Specific Examples - Kindergarten

"Objects-to-think-with"
Seymour Papert

**PEDAGOGICAL APPROACHES**

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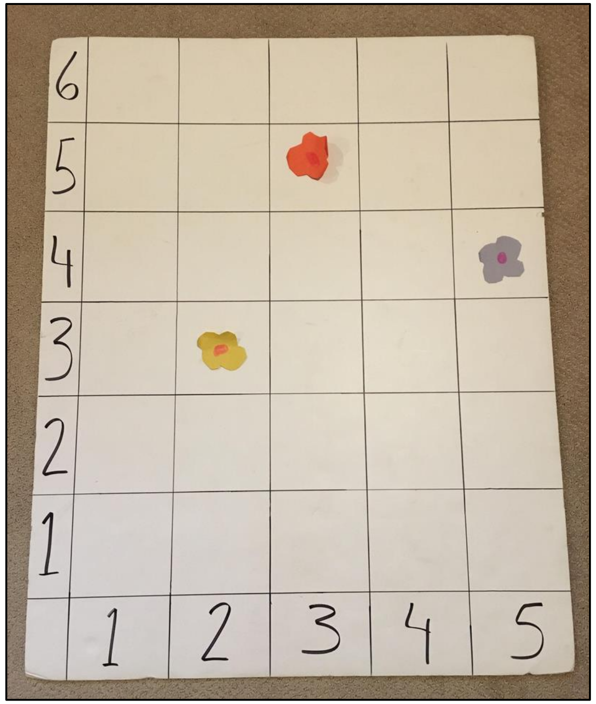
Discussions and Discovery

Donna Forster - @dforster123
Carolyn Mussio - @cmussio14
Blessed Sacrament - London Canada -@BSCS6

# Specific Examples - Kindergarten



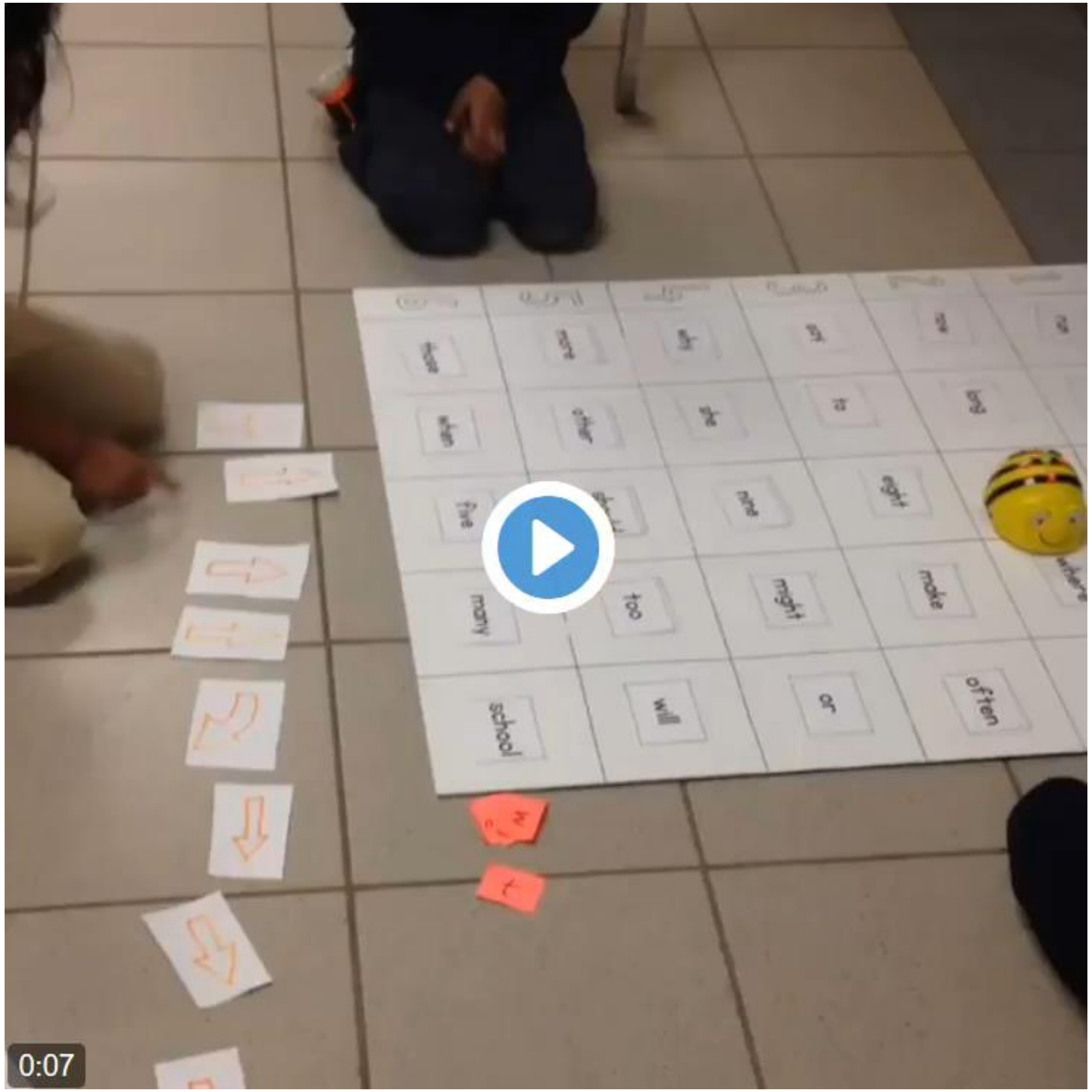

**Try Reiterate Collaborate**

**Can you program Beebot to execute each of the following programs?**

1. **Travel from the orange flower to the blue flower**
2. **Travel from the blue flower, to the yellow flower, to the orange flower**
3. **Travel from cell 2,1 to cell 5,4**
4. **Travel from cell 1,1 to 2,5 to 4,3**
5. **Travel from the orange flower to the blue flower in an inefficient way**
6. **Travel from the orange flower to the blue flower in the most efficient way**

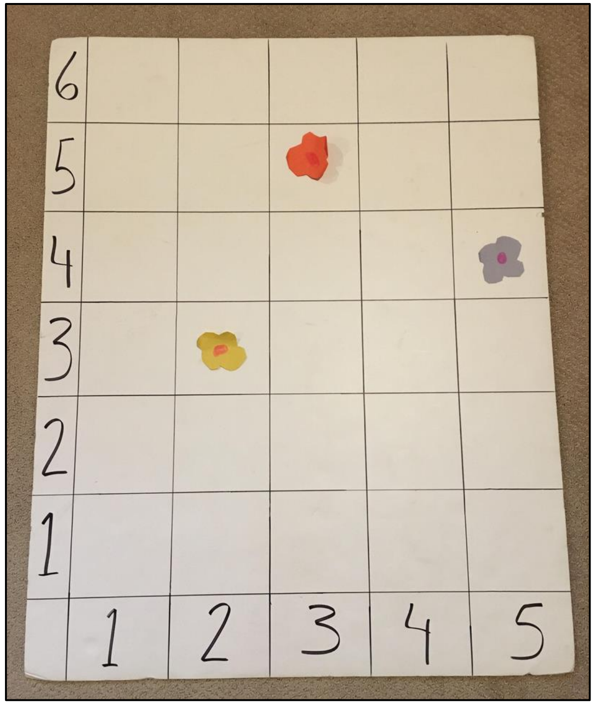
**(What characteristics make your code inefficient in program 5?)**

# Specific Examples - Kindergarten

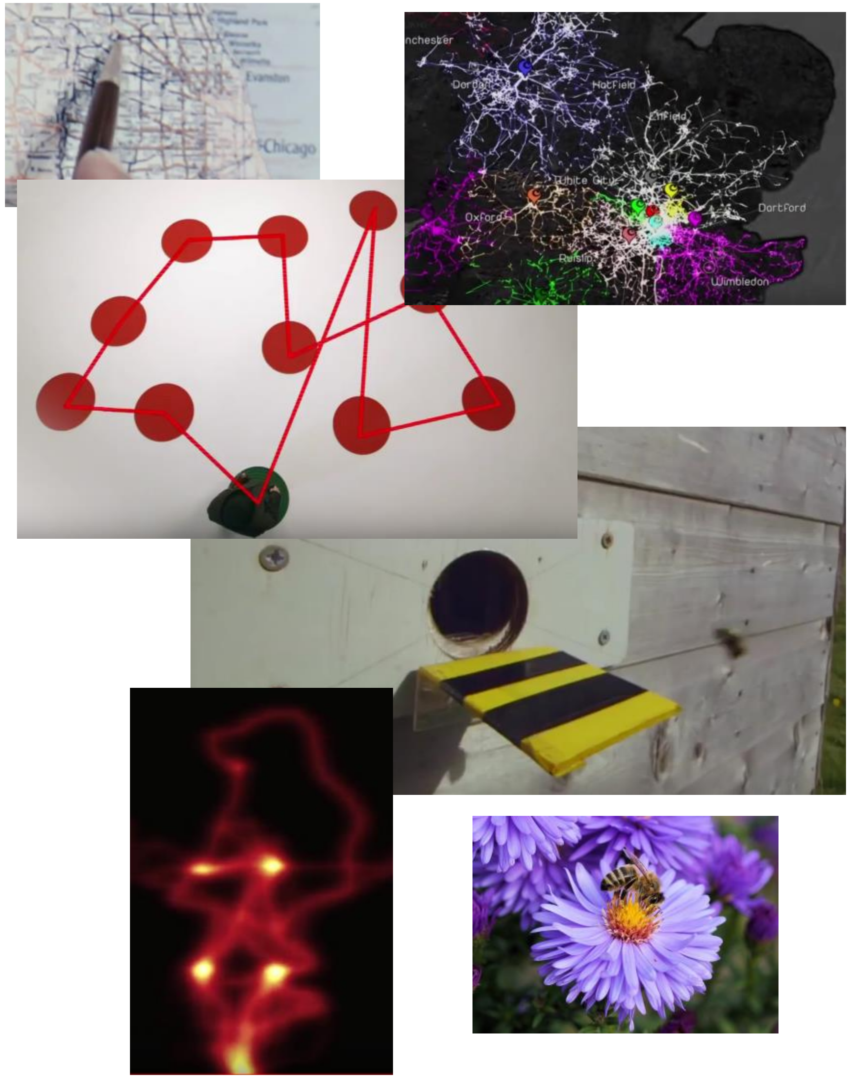
## Specific Examples - Kindergarten

# Travelling Salesman Problem



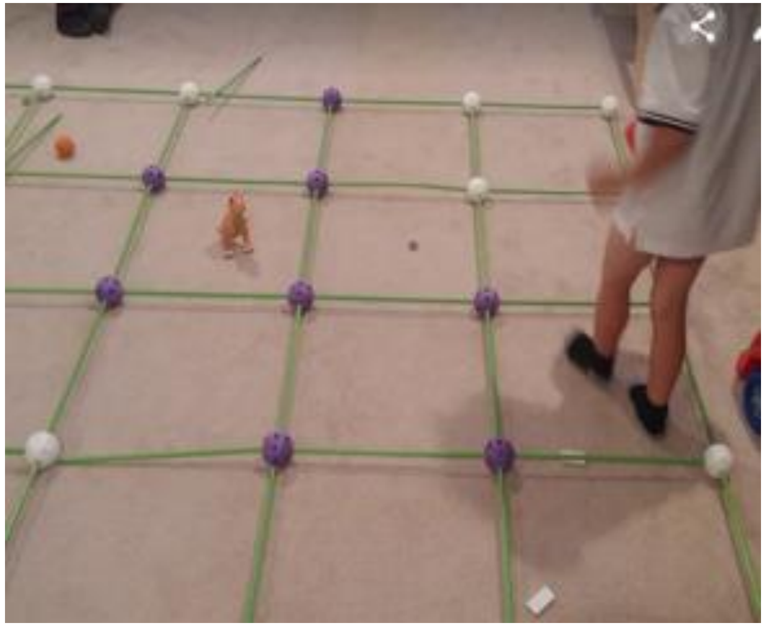


**Travelling Salesman Problem (TSP):**
**Given a set of cities and distance between every pair of cities, the problem is to find the shortest possible route that visits every city exactly once and returns to the starting point.**
(GeeksForGeeks.com)

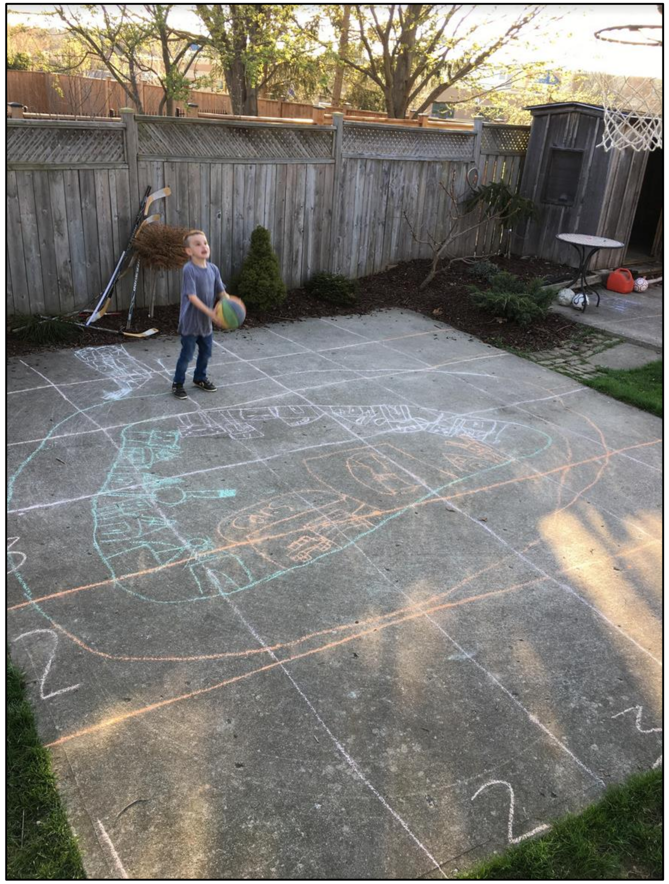


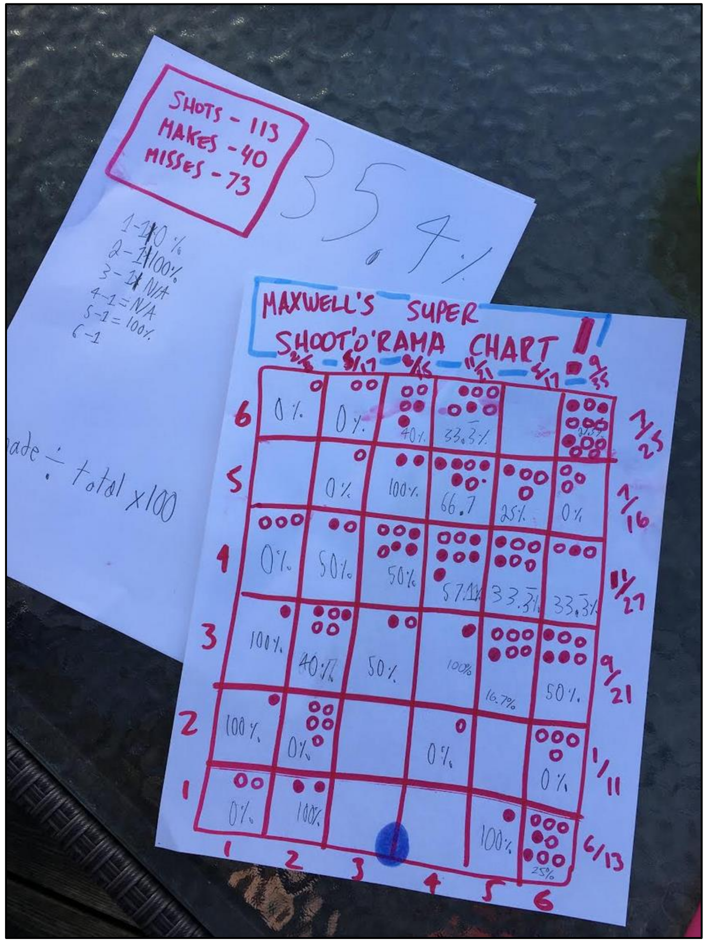

**The Secret Rules of Modern Living: Algorithms**

**Specific Examples - Grids**

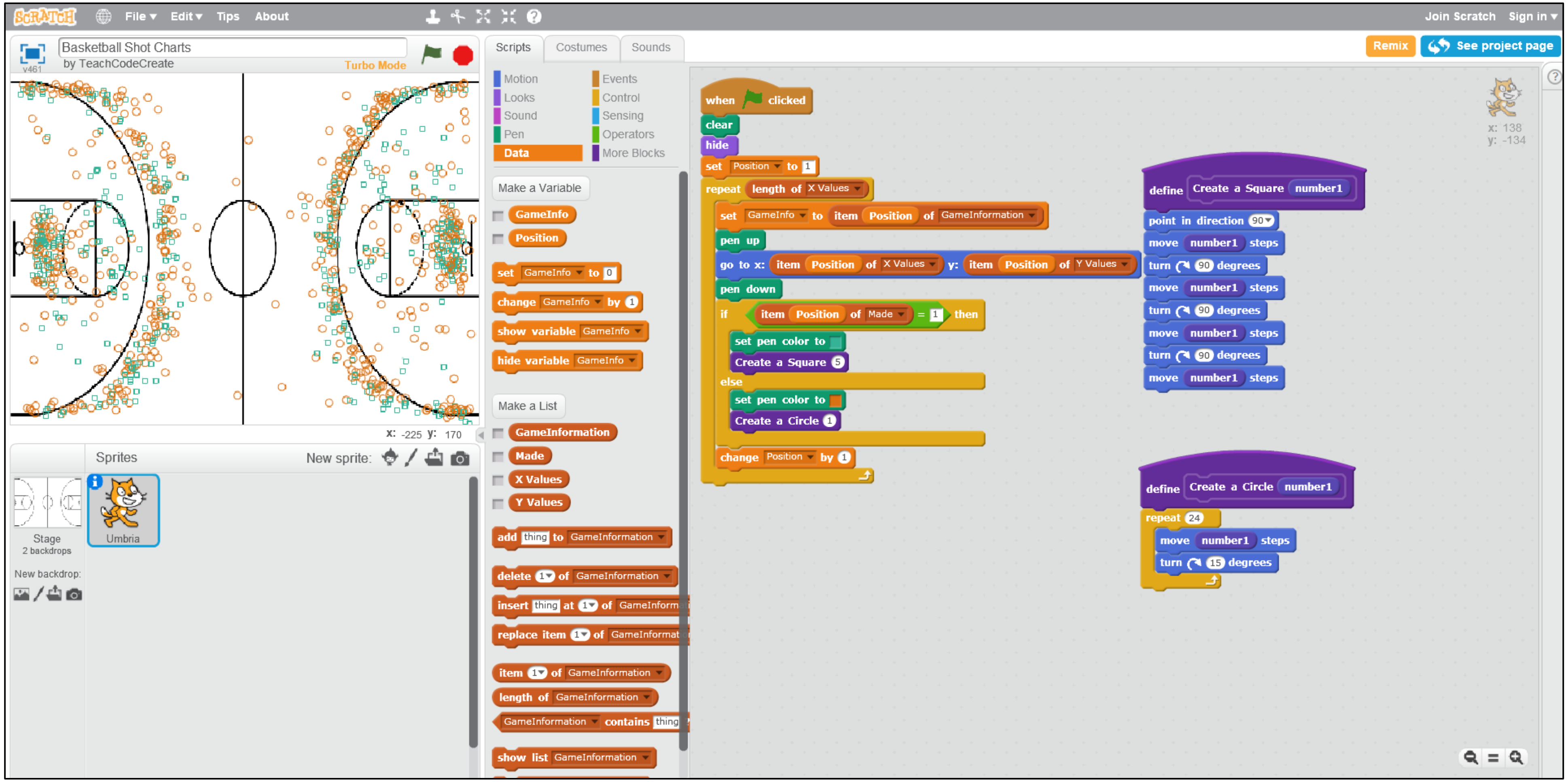


# Specific Examples - Grids





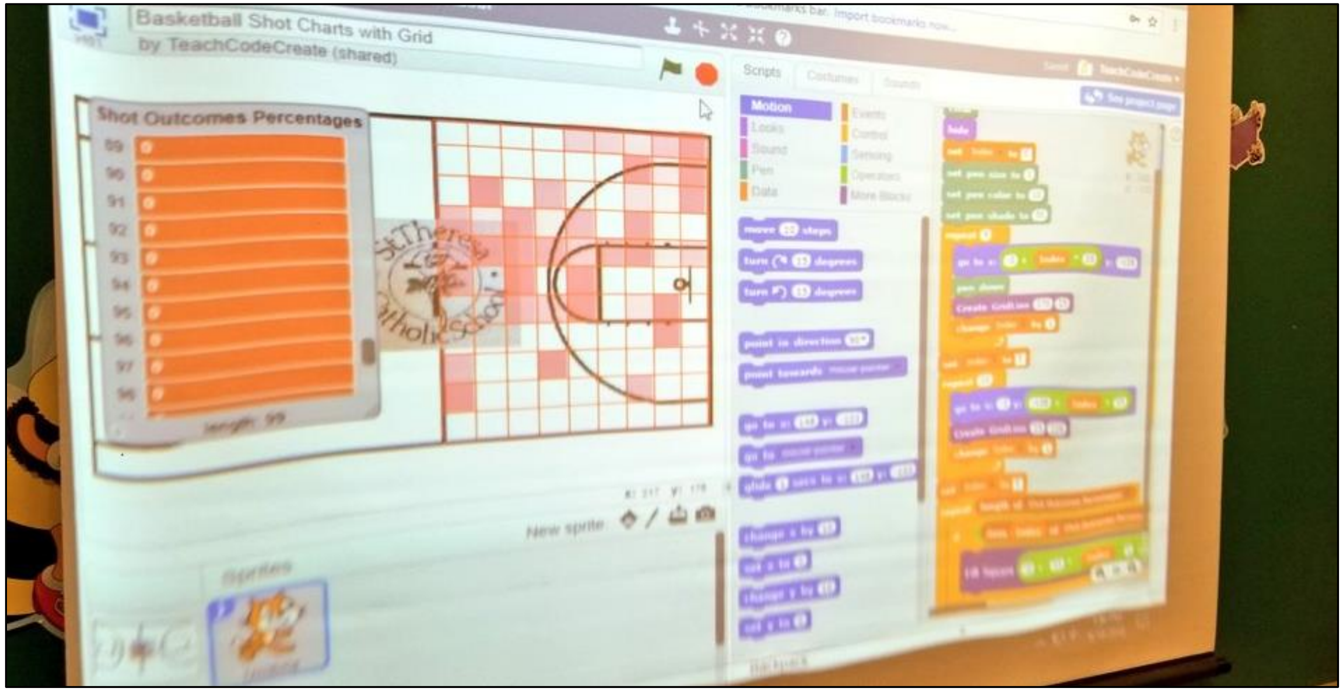
# Specific Examples - Grids




[Shooting Chart Scratch Program]

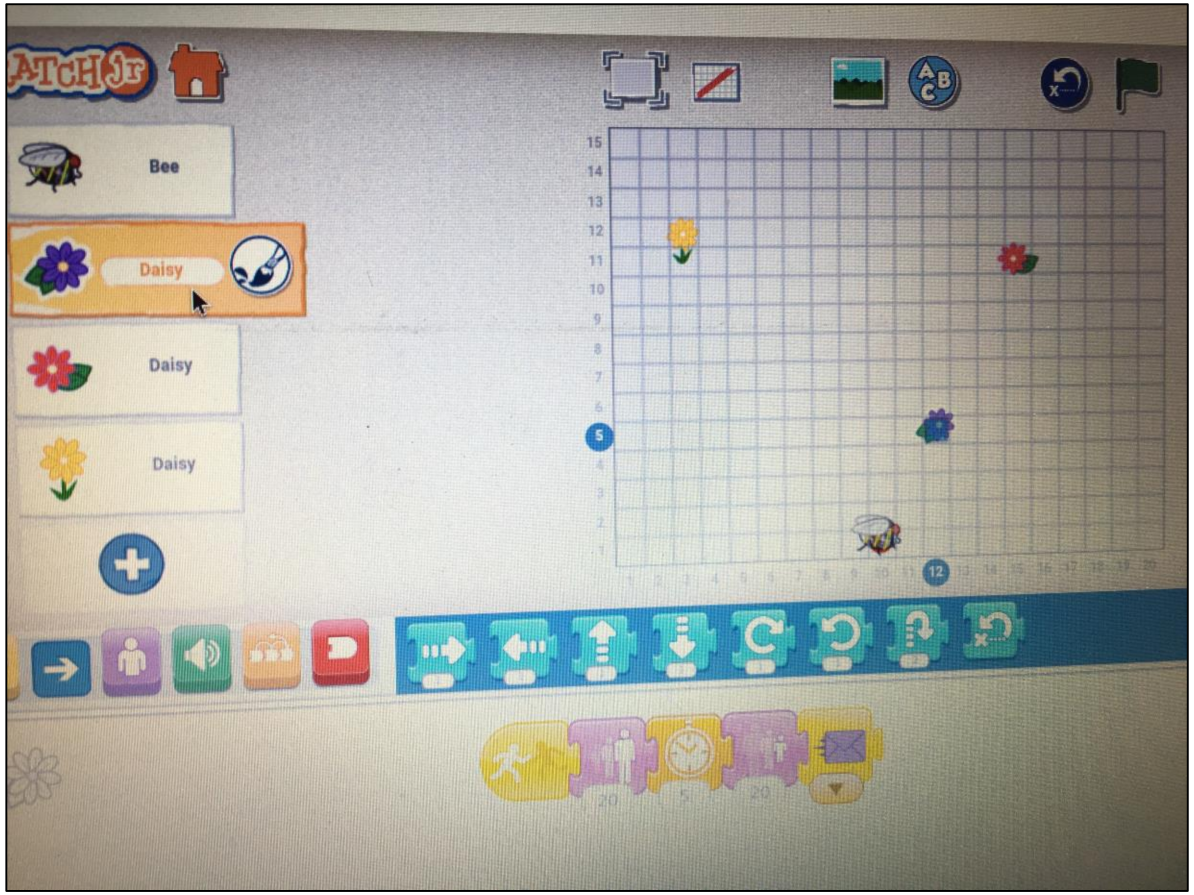
**@teachcodecreate**

# Specific Examples - Grids


**Luigi Sorbara - @teachcodecreate**
**Rich Annesley - @richannesley**
**St.Theresa, London Canada @StTheresaShark**

# Travelling Salesman Problem



# Specific Examples – Grades 1-3

Movement

Grids

GRADE 3

Grade 3: Geometry and Spatial Sense

**Overall Expectations**

By the end of Grade 3, students will:

- identify and describe the locations and movements of shapes and objects.

***Location and Movement***

By the end of Grade 3, students will:

– describe movement from one location to another using a grid map (e.g., to get from the swings to the sandbox, move three squares to the right and two squares down);

In Scratch Jr it is possible to have a grid appear on the screen.

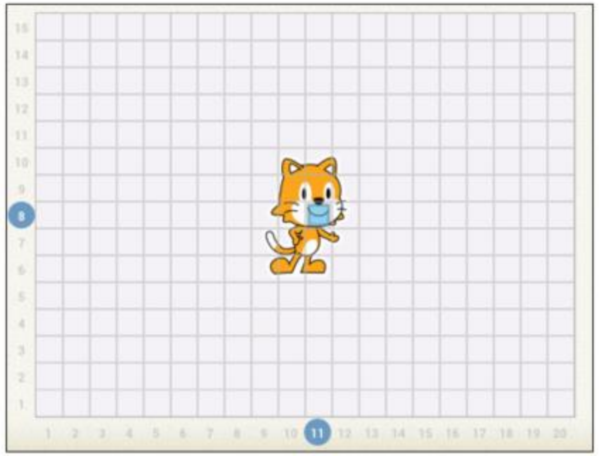
A grid is a whole bunch of lines that cross each other creating squares or rectangles.

A grid lets us describe how something is moving and lets us talk about where something is located.

You can turn the grid on in Scratch Jr by clicking the Grid button:

With the grid turned on, it is now easy to explain locations on the screen.

Can you see why we would say that ScratchJr is located at spot 11, 8?




This grid gives us something called the x-axis and the y-axis.

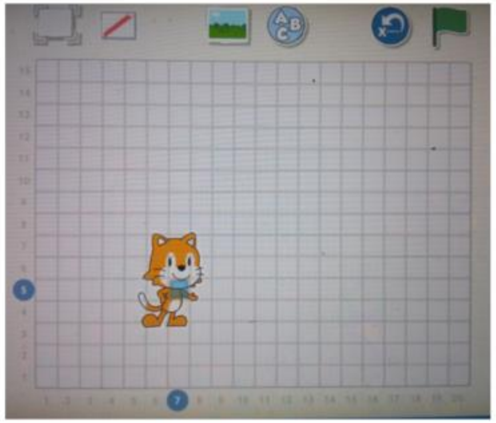
The x-axis includes the numbers along the bottom.
The y-axis includes the numbers that go upwards, on the left.

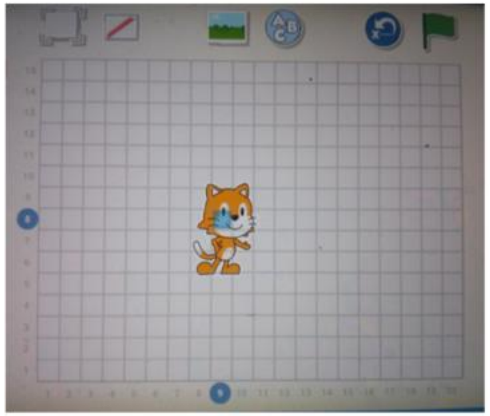
We would say that Scratch Jr is at spot 11 on the x-axis and at spot 8 on the y-axis.

# Specific Examples - Grades 1-3

With the grid turned on, it also makes it easier to describe movement that is taking place.

Take a look at these two images:





Can you tell us Scratch Jr's exact location in each one?

Can you tell us how many places Scratch Jr moved, from one image to the next, along the x-axis?

Can you tell us how many places Scratch Jr moved, from one image to the next, along the y-axis?

Can you create the following programs, then have a partner check them to make sure they are correct?

- Have Scratch Jr start at point 5, 9.
  Make him move to point 13, 4.

- Have Scratch Jr start at point 4, 2.
  Make him move to point 13, 6.
  Then make him move back to point 4,2.

- Have Scratch Jr start at point 6, 4.
  Make him move 5 positions along the x-axis.
  Then Make him move 3 positions along the y-axis.
  What location is he now at?

Try to figure this out without using Scratch Jr:

Scratch Jr starts at point 4, 4.
He then moves 3 positions to the right, along the x-axis.
He then moves 2 positions down, along the y-axis.
What is Scratch Jr's new location?

Try to figure this out without using Scratch Jr:

Scratch Jr starts at point 9, 13.
He then moves to position 7, 9.
How many positions did Scratch Jr move along the x-axis and in what direction?
How many positions did Scratch Jr move along the y-axis and in what direction?

# Specific Examples – Grades 1-3

Movement

Transformations:

Translations, Rotations, Refelction and Resizing

GRADE 3

**Grade 3: Geometry and Spatial Sense**

**Overall Expectations**

By the end of Grade 3, students will:

- identify and describe the locations and movements of shapes and objects.

***Location and Movement***

By the end of Grade 3, students will:

– describe movement from one location to another using a grid map (e.g., to get from the swings to the sandbox, move three squares to the right and two squares down);

– identify flips, slides, and turns, through investigation using concrete materials and physical motion, and name flips, slides, and turns as reflections, translations, and rotations (e.g., a slide to the right is a translation; a turn is a rotation);

A transformation is when an object, like Scratch the Cat, is moved.

**A Translation (Scratch Slides):**
When Scratch the Cat moves places, from one point to another.

**A Rotation (Scratch Spins):**
When Scratch the Cat spins.

**Reflection (Scratch Flips and points in other direction):**
When Scratch the Cat flips, and faces the other direction.

**Resizing (Scratch Shrinks or Grows):**
When Scratch the Cat gets bigger, or smaller.

| | |
|---|---|
| **A Translation (Scratch Slides):** When ScratchJr moves places, from one point to another. | |
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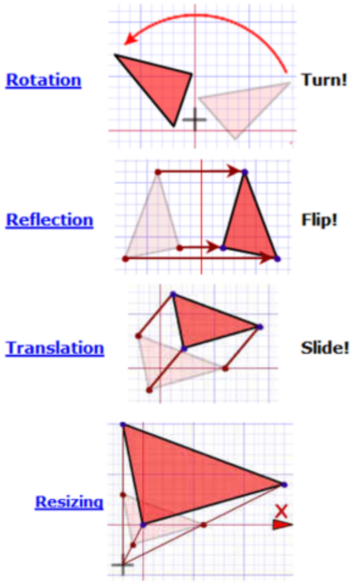
| **Reflection (Scratch Flips and points in other direction):** When ScratchJr flips, and faces the other direction. | |
| **Resizing (Scratch Shrinks):** When ScratchJr gets bigger, or smaller. | |



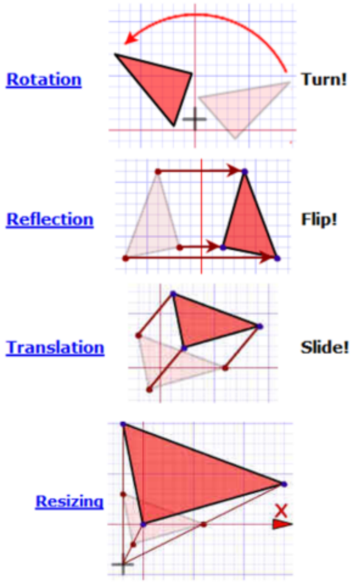

Can you make Scratch do a dance where he goes through all four transformations?

Scratch should do:

- a translation (a slide)
- a rotation (a spin)
- a reflection (should flip and point in the other direction).
- a resizing (should grow or shrink)

Add a Wait block after each transformation.
See if you can loop this program forever.
See if you can add the sound of your voice, naming each transformation as it occurs.

# Specific Examples – Grades 1-3

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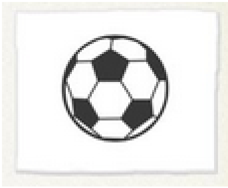
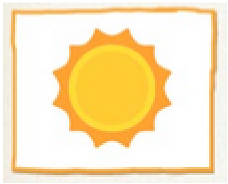




# Specific Examples - Grades 1-3

Fionna the fish was swimming back and forth, just below the surface of the ocean.

This was her favourite place to swim, she loved the temperature of the water.

Suddenly she spotted her favourite pink corral.

She loved the feel of the pink corral on her gills, so she swam down deeper in the ocean.

She swam around the corral five times.

When she was done, she did a funny little happy dance to show the other fish how excited she was.

**Organizing Ideas**

1.5 identify and order main ideas and supporting details into units that could be used to develop a short, simple paragraph, using graphic organizers *(e.g., a story grammar, a T-chart, a paragraph frame)* and organizational patterns *(e.g., comparison, chronological order)*

**Extending Understanding**

1.6 extend understanding of texts by connecting the ideas in them to their own knowledge and experience, to other familiar texts, and to the world around them

**Clarity and Coherence**

2.3 communicate orally in a clear, coherent manner, presenting ideas, opinions, and information in a logical sequence *(e.g., use an organizational pattern such as comparison or chronological order in presenting a short oral report)*

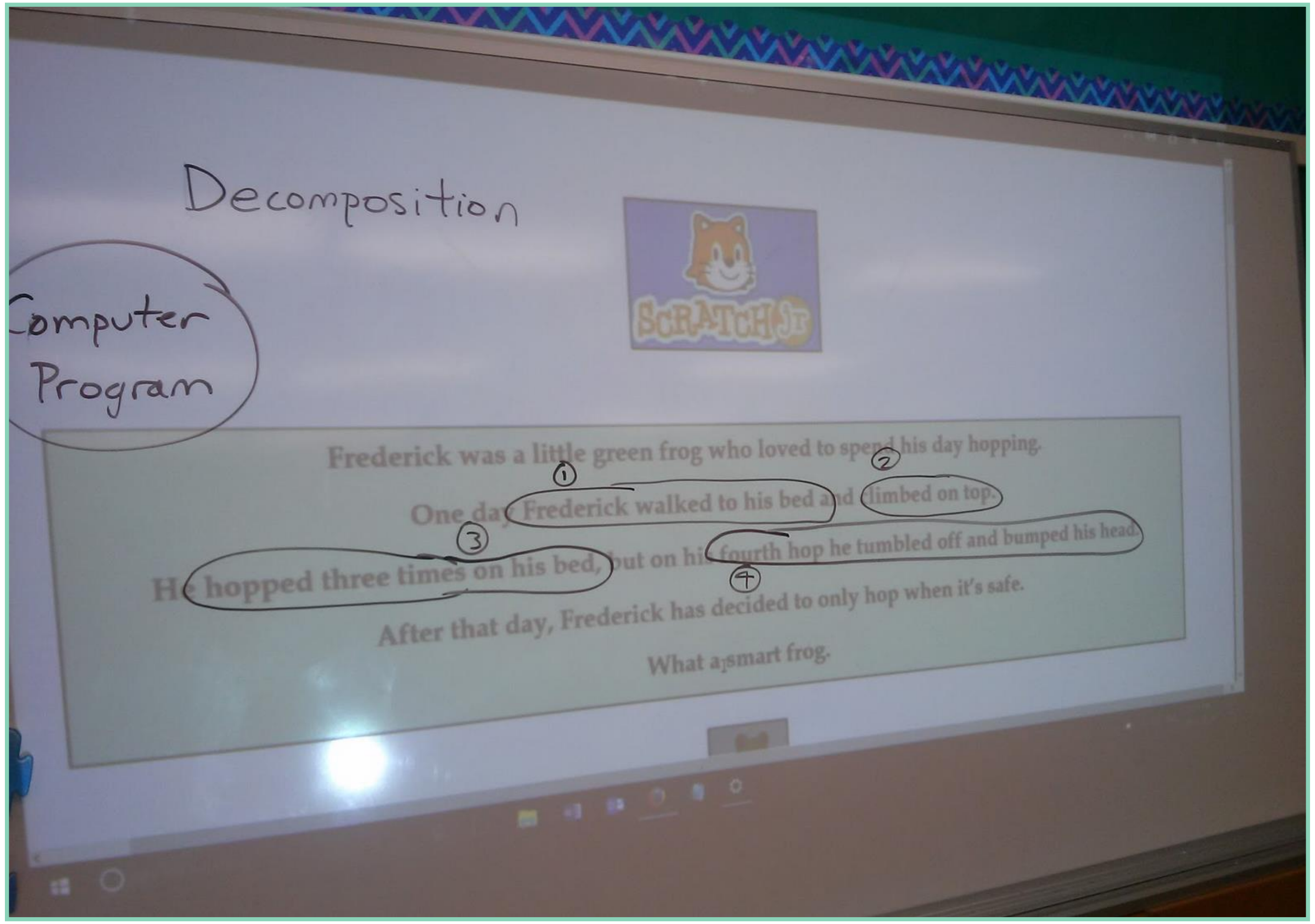
**Developing Ideas**

1.2 generate ideas about a potential topic, using a variety of strategies and resources *(e.g., formulate and ask questions to identify personal experiences, prior knowledge, and information needs and to guide searches for information; brainstorm and record ideas on the topic)*

**Producing Media Texts**

3.4 produce media texts for specific purposes and audiences, using a few simple media forms and appropriate conventions and techniques *(e.g.,*

# Specific Examples – Grades 1-3




Program this story in ScratchJr using an appropriate background and sprite.

You may want to decompose this story into separate parts first.
This might make it easier to program.

Frederick was a little green frog who loved to spend his day hopping.

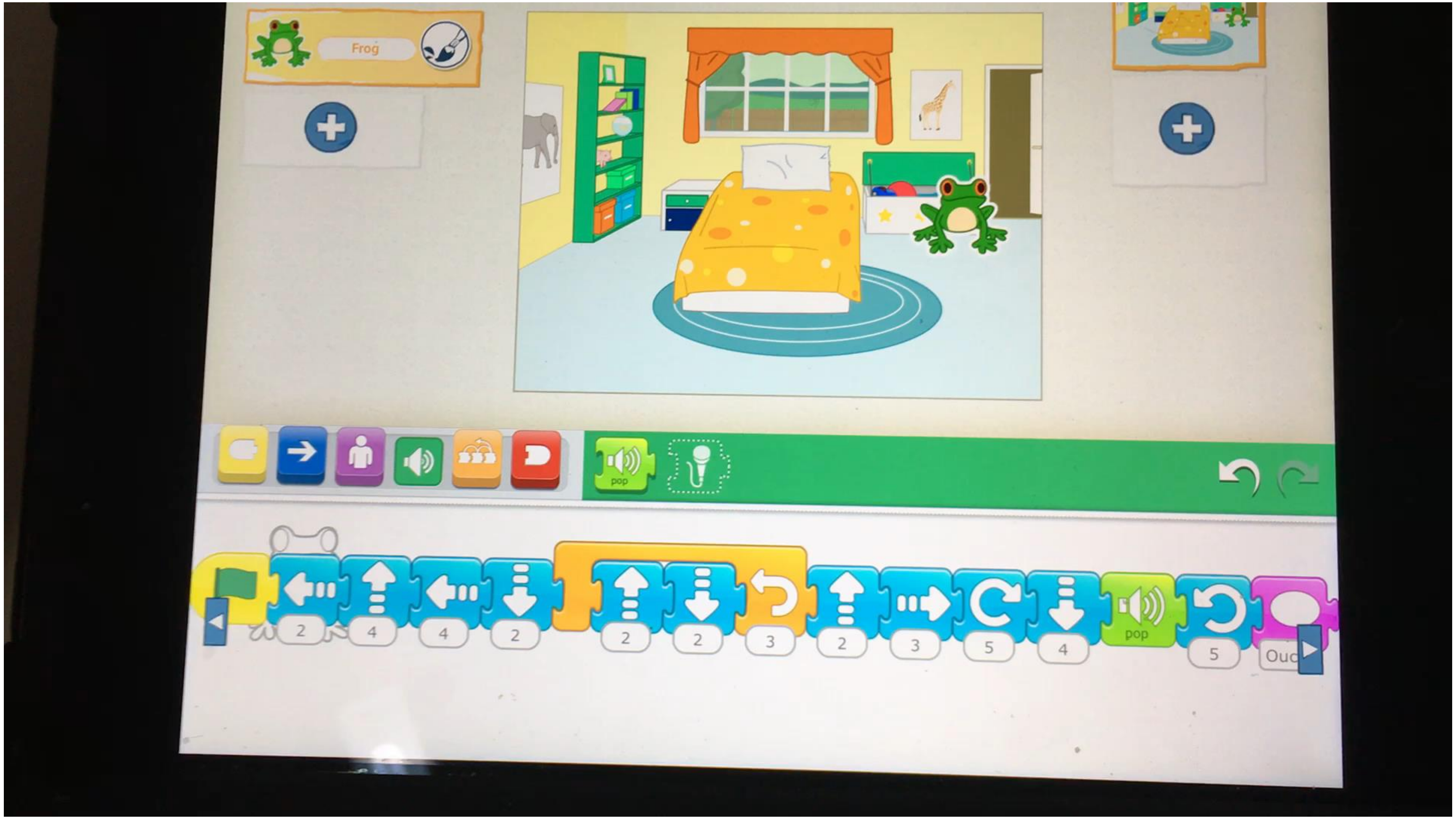
One day Frederick walked to his bed and climbed on top.

He hopped three times on his bed, but on his fourth hop he tumbled off and bumped his head.

After that day, Frederick has decided to only hop when it's safe.

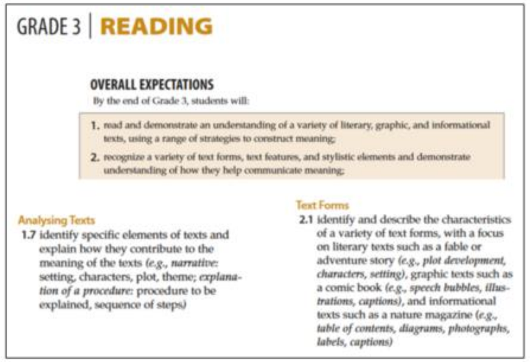
What a smart frog.

# Specific Examples - Grades 1-3



# Specific Examples – Grades 1-3

**CREATING YOUR OWN STORIES**



GRADE 3 | **READING**

**OVERALL EXPECTATIONS**

By the end of Grade 3, students will:

1. read and demonstrate an understanding of a variety of literary, graphic, and informational texts, using a range of strategies to construct meaning;
2. recognize a variety of text forms, text features, and stylistic elements and demonstrate understanding of how they help communicate meaning;

Analysing Texts

1.7 identify specific elements of texts and explain how they contribute to the meaning of the texts *(e.g., narrative:* setting, characters, plot, theme; *explanation of a procedure:* procedure to be explained, sequence of steps)

Text Forms

2.1 identify and describe the characteristics of a variety of text forms, with a focus on literary texts such as a fable or adventure story *(e.g., plot development, characters, setting)*, graphic texts such as a comic book *(e.g., speech bubbles, illustrations, captions)*, and informational texts such as a nature magazine *(e.g., table of contents, diagrams, photographs, labels, captions)*

Today you are going to get a chance to write your own story using Scratch Jr.

But instead of writing your story right away, you are going to plan out your story first.

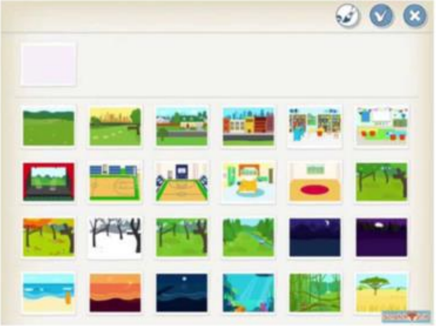
Before you begin, you will decide on these three things:

The Setting, the Character and the Plot.

When you are done writing your own story, find a partner who is also finished.

See if you can figure out the setting, the character and the plot for each other's stories.

**The Setting:** The setting is where the story takes place.
In Scratch Jr, you have a few different settings to chose from.
Does your story take place on a farm?
On a basketball court?
At night on a lake?



**Character:** The character is the person or the animal that is in the story.
It is possible to have more than one character in your story.

**Plot:** The plot includes the main events that happen in your story.

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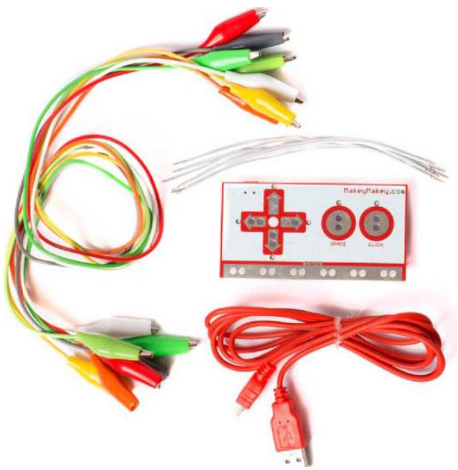


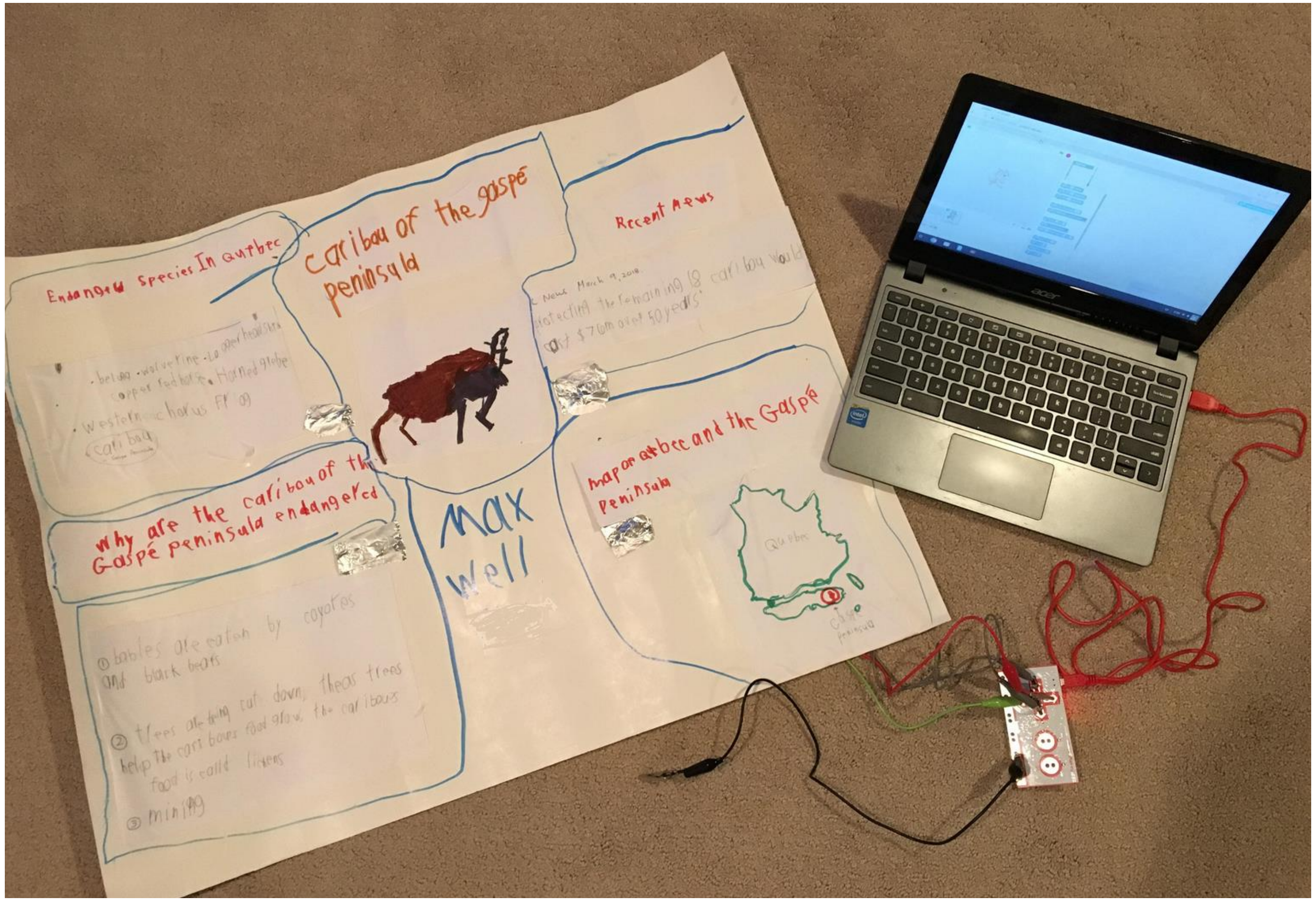

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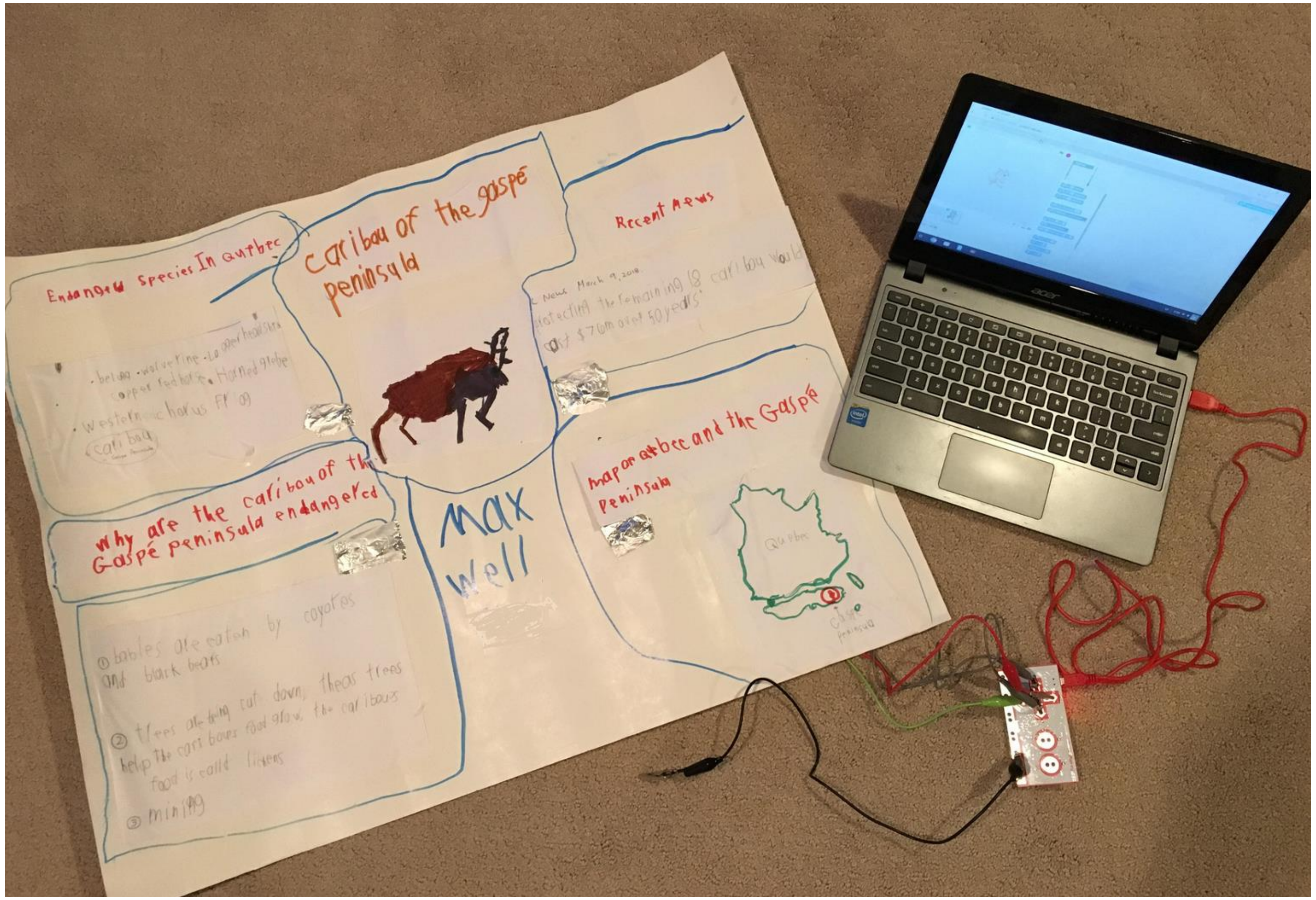


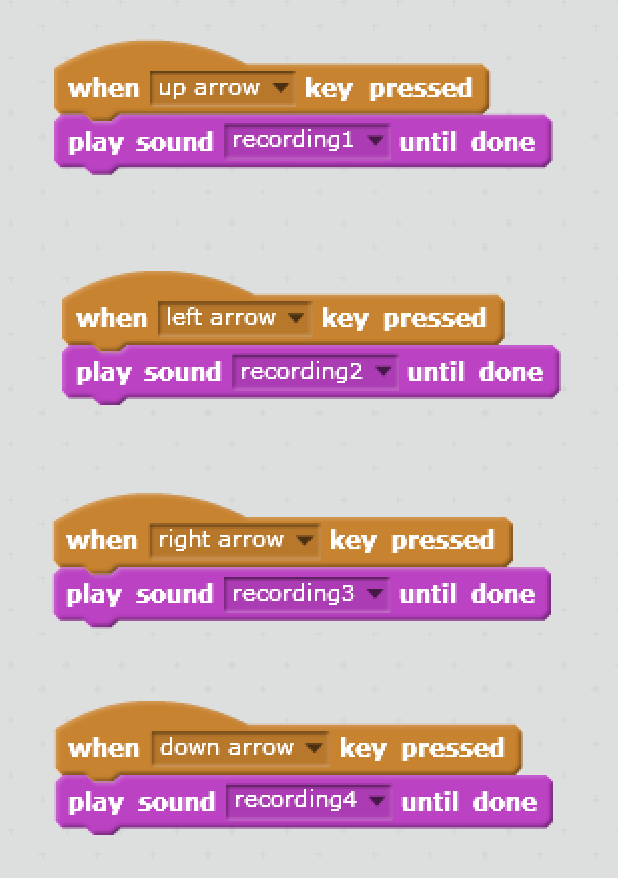

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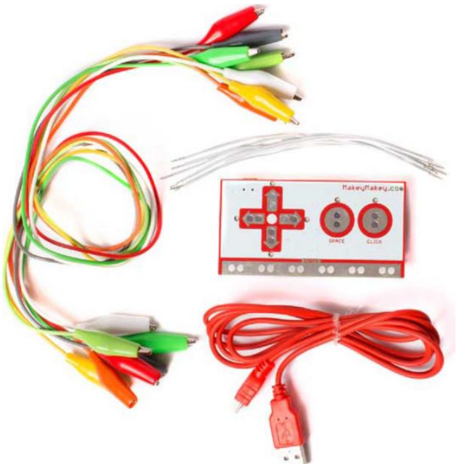
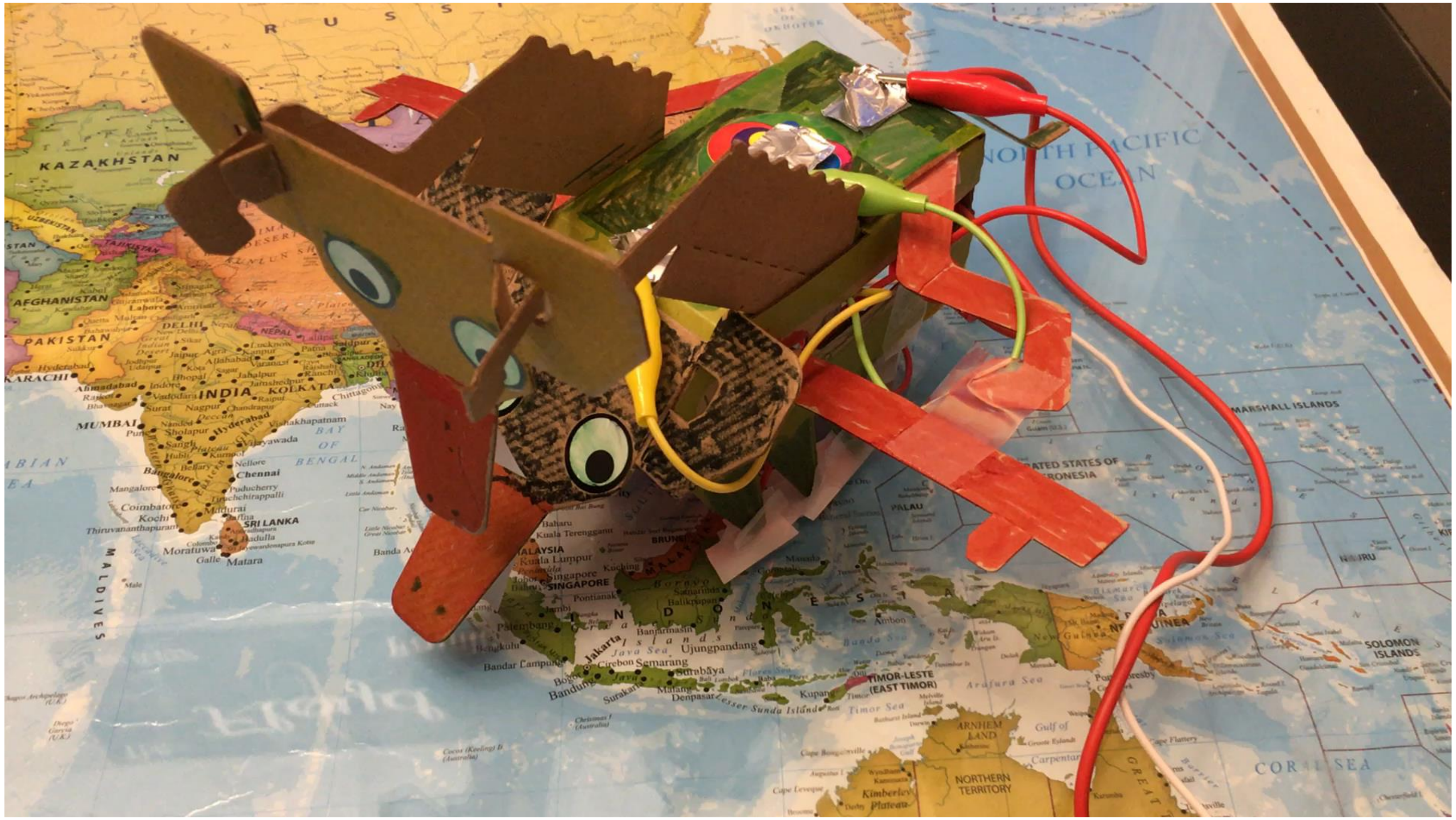
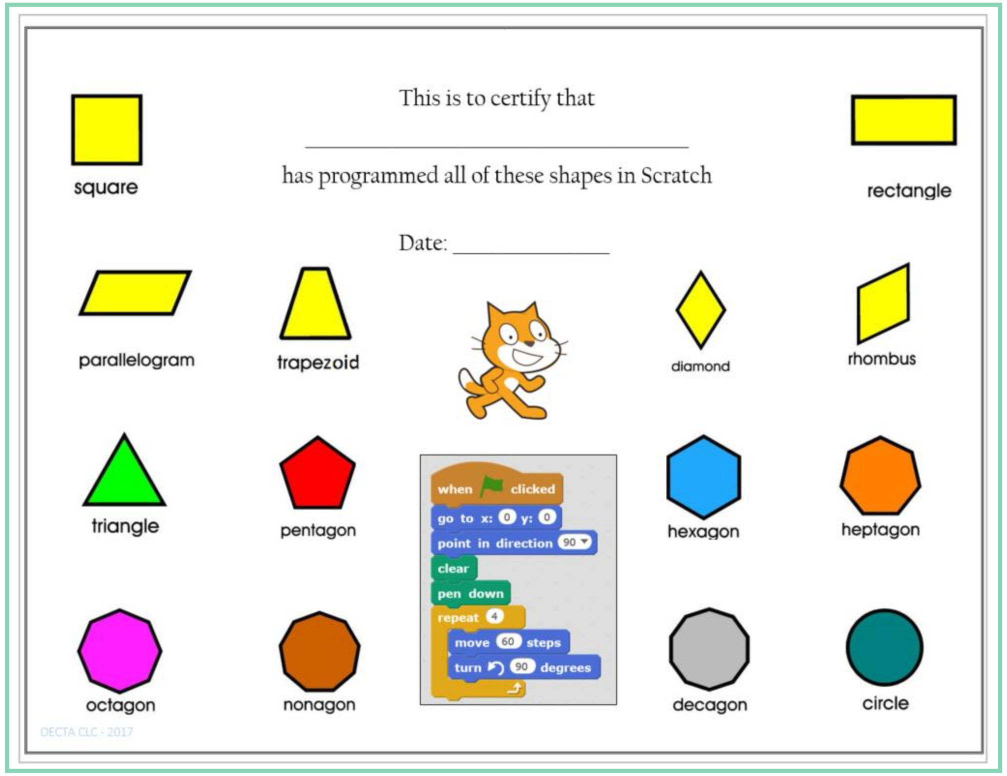
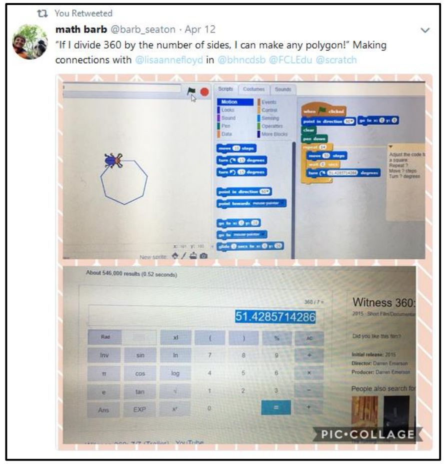
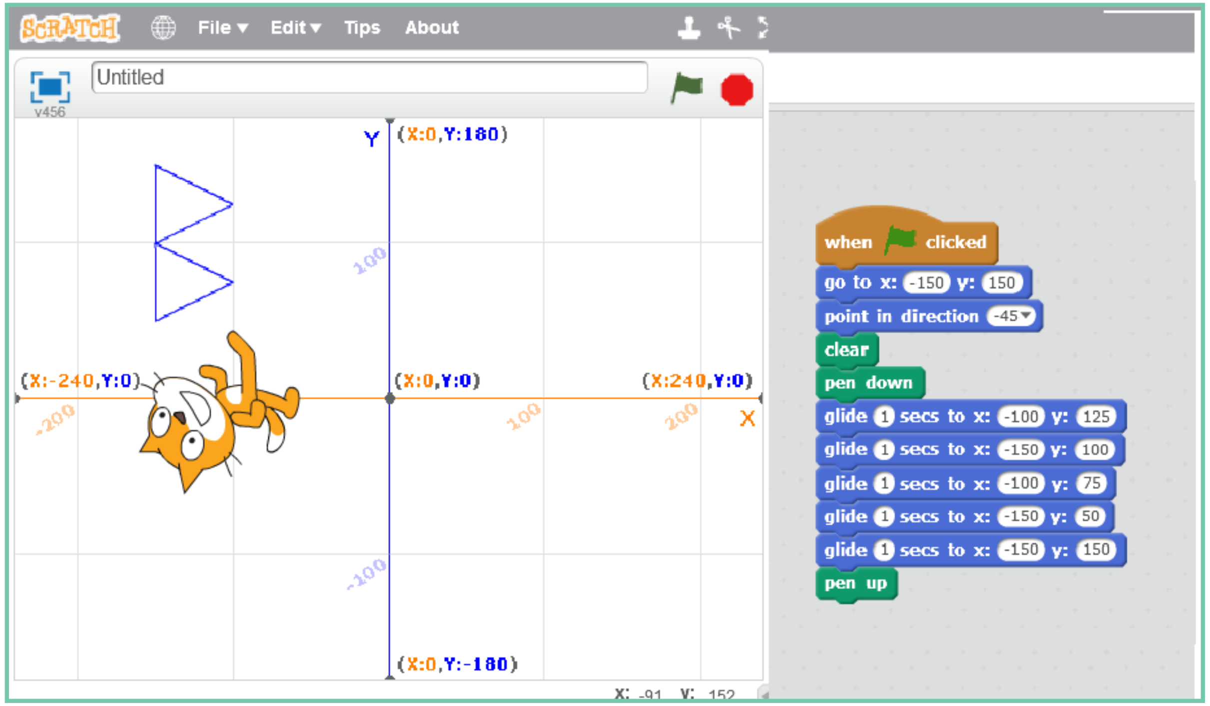




# Specific Examples – Perhaps Beyond Grades 1-3




**Can you program any other letters in another quadrant?**

**... I tried to find the answers to the following questions:**

1) **which teaching opportunities for mathematics learning occur in a classroom within some play activity of 4-7 year olds?**

2) **how can teachers take advantage of such teaching opportunities within play activity?**

Bert van Oers (1996)
Are you sure? Stimulating mathematical thinking during young children's play
European Early Childhood Education Research Journal, 4: 1, 71 – 87

## Integration – Identifying and Capitalizing on Existing CT Experiences

**... I tried to find the answers to the following questions:**

1) **which teaching opportunities for mathematics learning occur in a classroom within some play activity of 4-7 year olds?**

2) **how can teachers take advantage of such teaching opportunities within play activity?**

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# Specific Examples – Unplugged

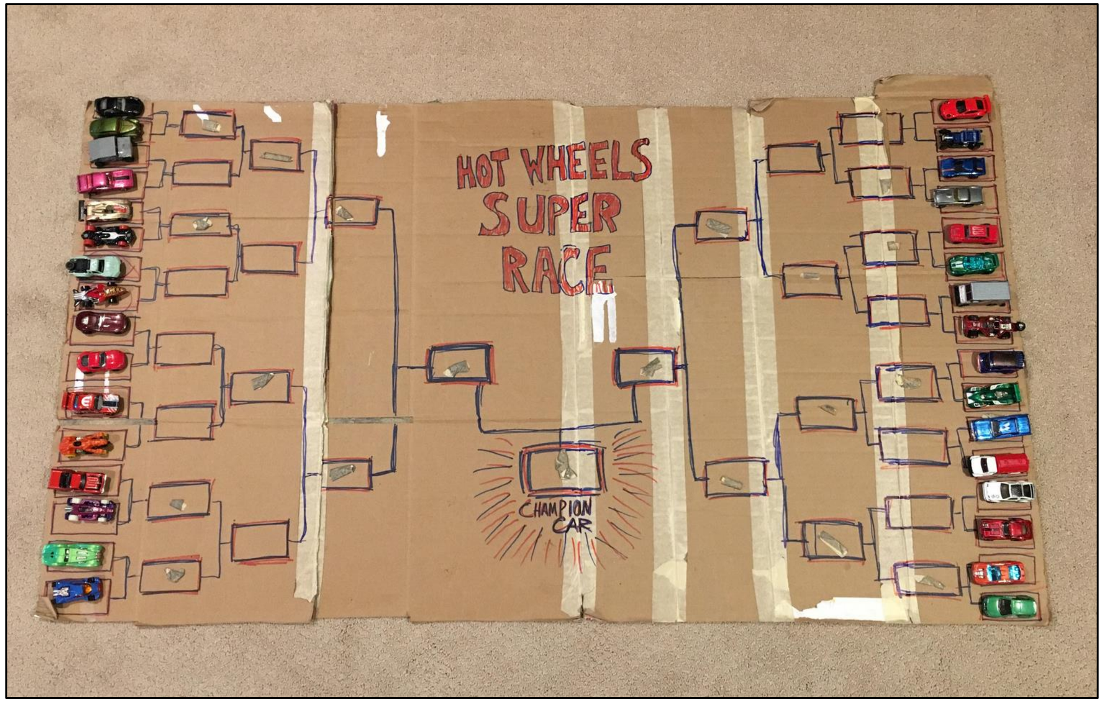
***Collection and Organization of Data***
By the end of Grade 1, students will:

– demonstrate an ability to organize objects into categories by sorting and classifying objects using one attribute (e.g., colour, size), and by describing informal sorting experiences (e.g., helping to put away groceries) (***Sample problem:*** Sort a collection of attribute blocks by colour. Re-sort the same collection by shape.);

***Collection and Organization of Data***
By the end of Grade 3, students will:

– demonstrate an ability to organize objects into categories, by sorting and classifying objects using two or more attributes simultaneously (***Sample problem:*** Sort a collection of buttons by size, colour, and number of holes.);


# Specific Examples – Unplugged



**Using CT concepts, practices and language in our classes…**

Wait (5 seconds)

*If* Toronto is the capital of Canada *Then*

  *Flap your arms* 3 times

*ElseIf* Ottawa is the capital of Canada *Then*

  *Tap your foot* 3 times

*Else*

  Snap 3 times

*End If*

# Global Competencies

## Assessing Global Competencies / Transferable Skills

The province's renewed vision for education will help ensure that all students develop the knowledge, skills and characteristics to become personally successful, economically productive and actively engaged citizens.

| Critical Thinking and Problem Solving | Innovation, Creativity, and Entrepreneurship | Self-Directed Learning |
|---|---|---|
| **Definition**<br>Critical thinking and problem solving involve addressing complex issues and problems by acquiring, processing, analysing and interpreting information to make informed judgments, decisions and actions. The capacity to engage in cognitive processes to understand and resolve problems includes the willingness to achieve one's potential as a constructive and reflective citizen. Learning is deepened when situated in meaningful, real-world, authentic experiences. | **Definition**<br>Innovation, creativity, and entrepreneurship involve the ability to turn ideas into action to meet the needs of a community. The capacity to enhance concepts, ideas, or products to contribute new-to-the-world solutions to complex economic, social, and environmental problems involves leadership, taking risks, independent/unconventional thinking and experimenting with new strategies, techniques, or perspectives, through inquiry research.<br>Entrepreneurial mindsets and skills involve a focus on building and scaling an idea sustainably. | **Definition**<br>Self-directed learning means: becoming aware and demonstrating agency in one's process of learning, including the development of dispositions that support motivation, perseverance, resilience, and self-regulation. Belief in one's ability to learn (growth mindset), combined with strategies for planning, monitoring and reflecting on one's past, present, and future goals, potential actions and strategies, and results. Self-reflection and thinking about thinking (metacognition) promote lifelong learning, adaptive capacity, well-being, and transfer of learning in an ever-changing world. |

| Collaboration | Communication | Citizenship |
|---|---|---|
| **Definition**<br>Collaboration involves the interplay of the cognitive (including thinking and reasoning), interpersonal, and intrapersonal competencies necessary to participate effectively and ethically in teams. Ever-increasing versatility and depth of skill are applied across diverse situations, roles, groups, and perspectives in order to co-construct knowledge, meaning, and content, and learn from, and with, others in physical and virtual environments. | **Definition**<br>Communication involves receiving and expressing meaning (e.g., reading and writing, viewing and creating, listening and speaking) in different contexts and with different audiences and purposes. Effective communication increasingly involves understanding both local and global perspectives, societal and cultural contexts, and adapting and changing using a variety of media appropriately, responsibly, safely, and with regard to one's digital footprint. | **Definition**<br>Citizenship involves understanding diverse worldviews and perspectives in order to address political, ecological, social, and economic issues that are crucial to living in a contemporary, connected, interdependent, and sustainable world. It also includes the acquisition of knowledge, motivation, dispositions, and skills required for an ethos of engaged citizenship, with an appreciation for the diversity of people, perspectives, and the ability to envision and work toward a better and more sustainable future for all. |

Framework of Global Competencies

**Computer Science/Computational Thinking for All Students…**

languages

weather

art

science

sales

sports

video games

literature

business

agriculture

politics

drama

marketing

fashion

geography

**If we're telling students that CS/CT will impact all areas of our lives, then we should be facilitating its instruction in all areas!**

# Integrating Computational Thinking in the Primary Grades

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