Computer programming and problem solving: A winning combination!

February 2020

Direction de la formation générale des jeunes
Ministère de l'Éducation et de l'Enseignement supérieur

Québec

Goals

- Develop a better understanding of computer programming as a learning tool and learning objective.
- Make connections between the creative process used in computer programming and the problem-solving process used in mathematics.

Presentation outline

1. Ministerial documents
2. Computer programming in schools
3. Programming and the Mathematics program
4. Examples of activities involving programming

Participants

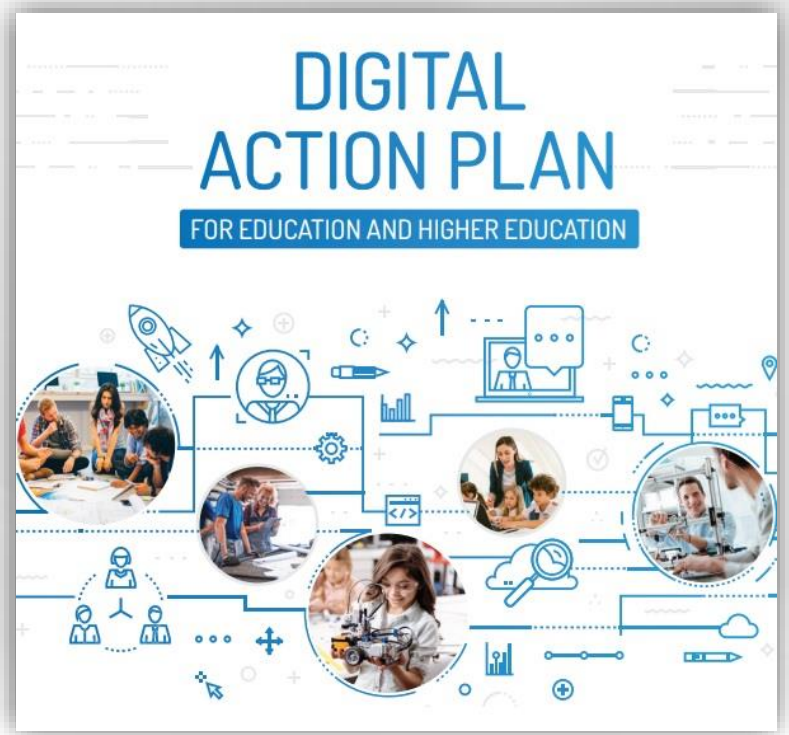
Elementary school teachers

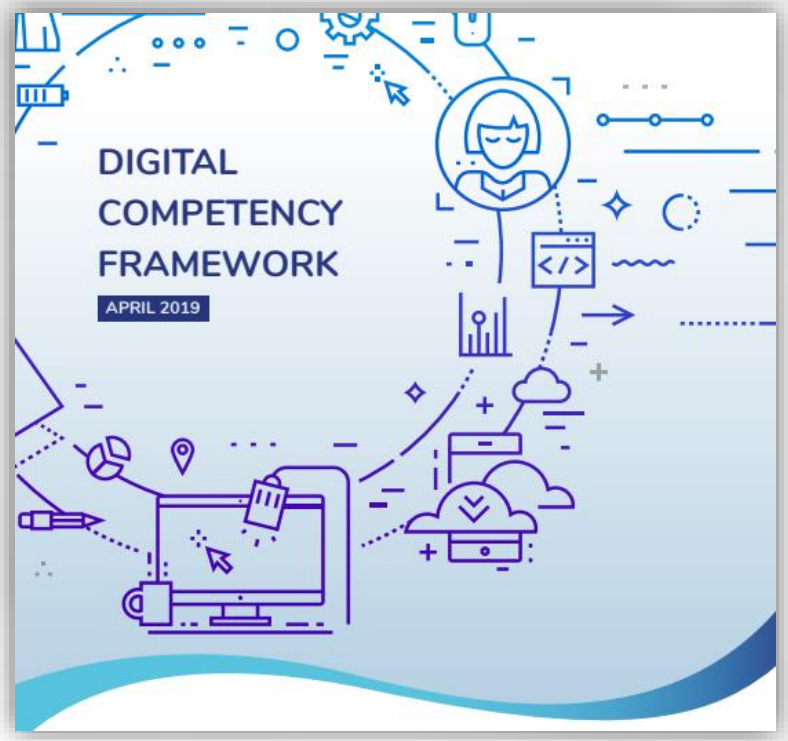
Education consultants in mathematics

Education consultants in ICT integration

Others

1 Ministerial documents





http://www.education.gouv.qc.ca/en/current-initiatives/digital-action-plan/digital-action-plan/

The *Digital Action Plan*

“The Ministère will encourage and support the use of coding for educational and didactic purposes in order to help students acquire the learning and competencies prescribed in the Québec Education Program (QEP).”

Source: *Digital Action Plan for Education and Higher Education*, p. 27.

The *Digital Competency Framework*

Source: *Digital Competency Framework*, p. 12.

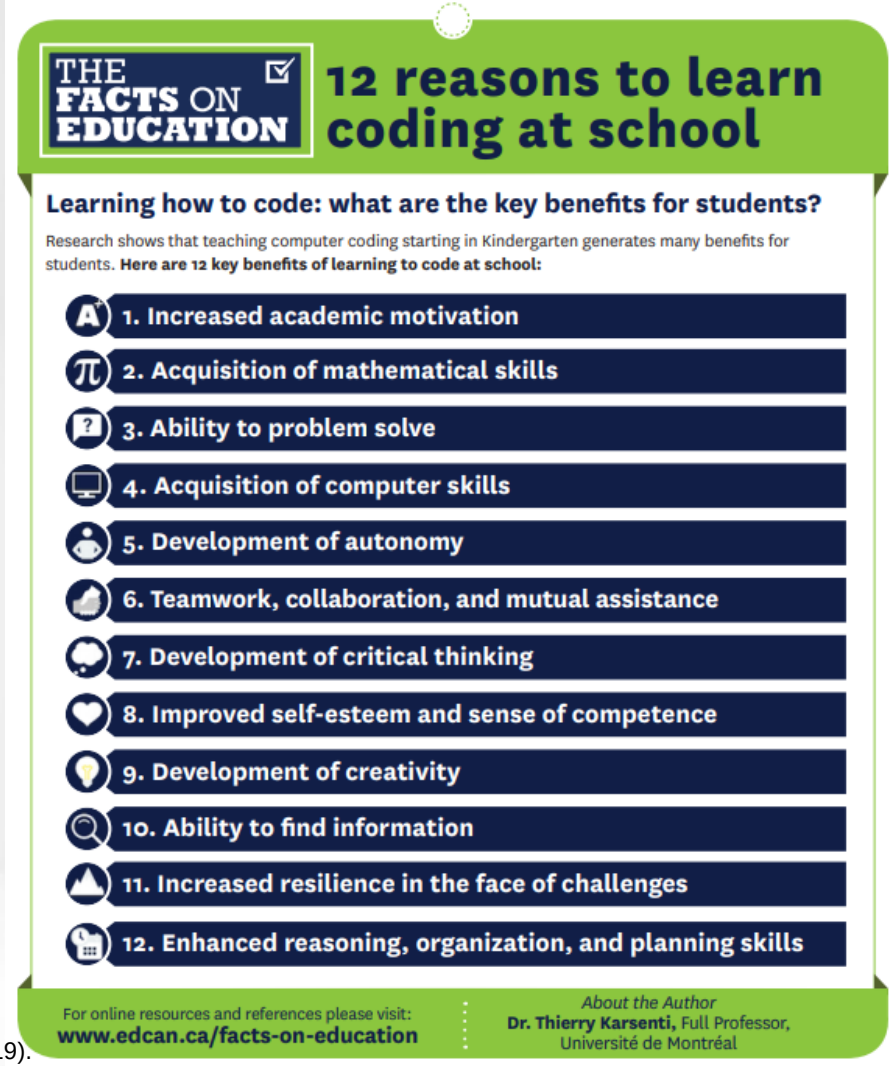
2 DEVELOPING AND MOBILIZING TECHNOLOGICAL SKILLS

ELEMENTS:

- Developing a general understanding of artificial intelligence and its impact on education, society, culture and politics
- Developing greater awareness of emerging issues concerning digital technology and its impact on education
- Learning to use new technologies to keep one's digital skills up to date
- Developing computational thinking, particularly through the improvement of one's programming skills and enhancement of one's understanding of computer programming
- Securing personal data with the appropriate resources, taking into account the risks associated with the use of digital technology
- Mobilizing the technological skills required to use different software, digital platforms and applications in educational activities and everyday life
- Exploring how everyday devices function on a mechanical, electronic and computer level
- Implementing an appropriate solution or seeking help to solve a technological problem

Source: *Digital Competency Framework*, p. 14.

2 Computer programming in schools



Source: Thierry Karsenti, *12 reasons to learn coding at school* (Toronto: EdCan Network, 2019).

Computer programming in a school setting

"Programming is more than just coding, for, it exposes students to computational thinking which involves problem-solving using computer science concepts like abstraction and decomposition. Even for non-computing majors, computational thinking is applicable and useful in their daily lives."

Source: Sze Yee Lye & Joyce Hwee Ling Koh, "Review on teaching and learning of computational thinking through programming: What is next for K-12?," *Computers in Human Behavior*, vol. 41 (2014), 51-61.

Learning how to program or learning through programming

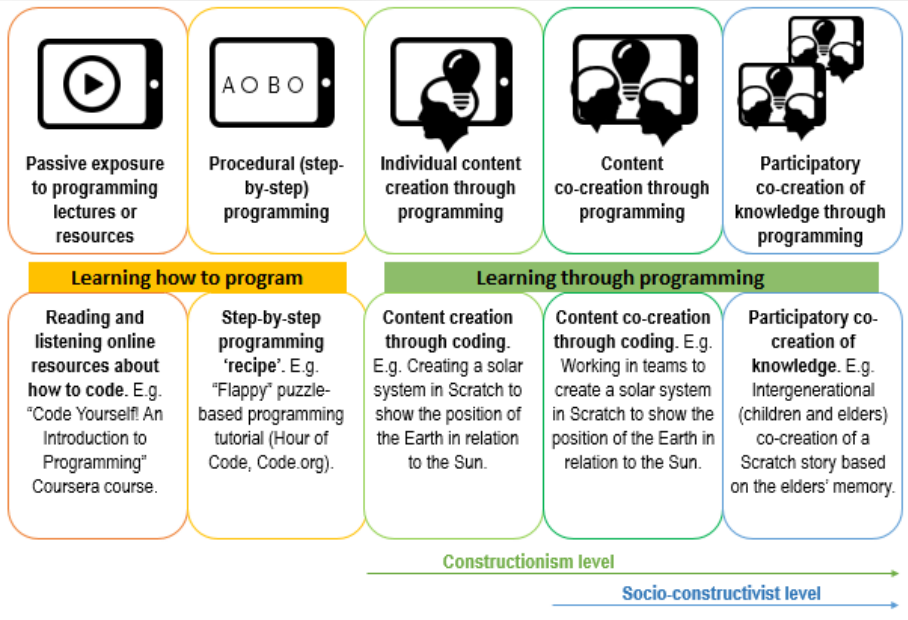


Image source:
https://www.researchgate.net/publication/305699926_Learning_to_code_from_procedural_puzzle-based_games_to_creative_programming

Margarida Romero "De l'apprentissage procédural de la programmation à l'intégration interdisciplinaire de la programmation créative," *Formation et profession*, vol. 24, no. 1 (2016), 87-89, http://dx.doi.org/10.18162/fp.2016.a92.

Computer programming: Learning tool or learning objective?

Learning tool

- May be used in **all subject areas**
- **Simple** to use, with a **short training phase**

Learning objective

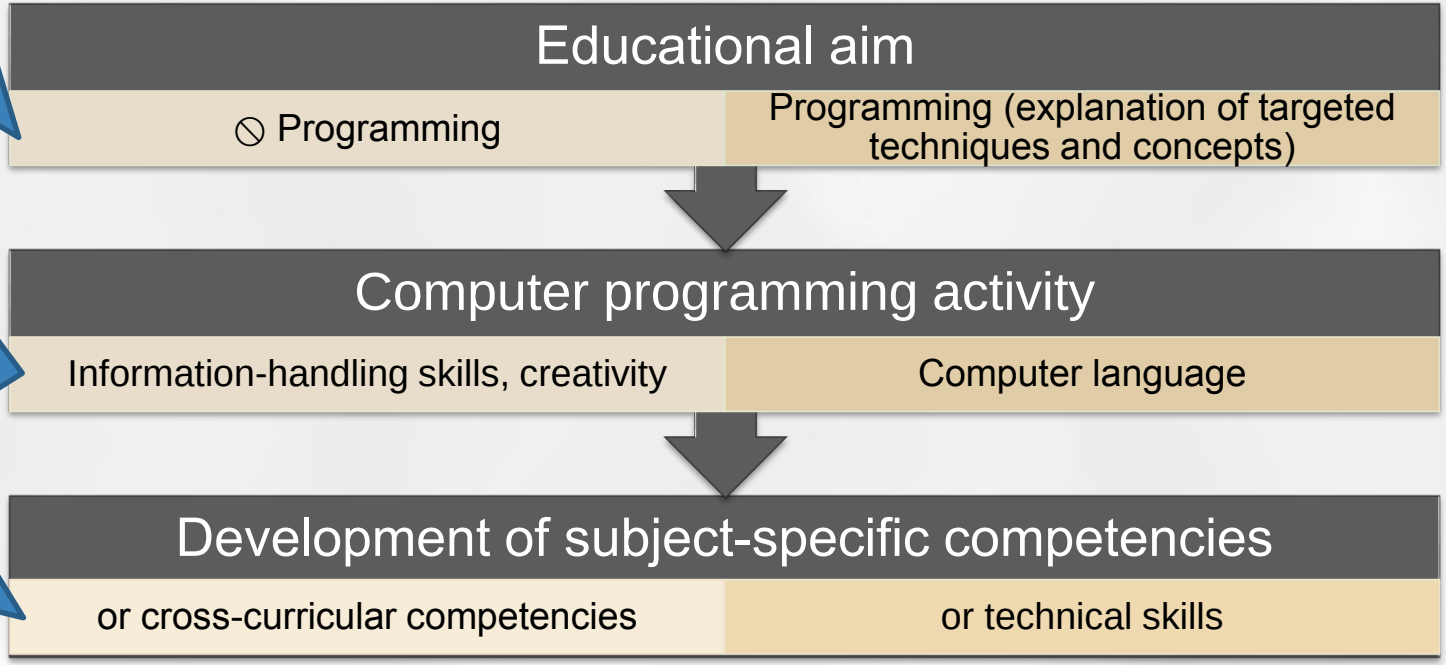
- More commonly used in **Mathematics, Science and Technology** and **Computer Science** (as well as Arts Education)
- More **complex** to use, with a **long training phase** (e.g. conditional constructs, types of variables, repetition structures, object-oriented programming)

Computer programming: Learning tool or learning objective? (cont.)

The educational aim may be learning a mathematical concept or process.

How students learn the mathematical concept or process.

Students develop mathematical competencies.



Initial strategies

Start with activities that require little material and equipment

Encourage participation in non-digital activities

Observe a programming activity in a colleague's class

Participate in training sessions on the topic

Establish a group of student experts

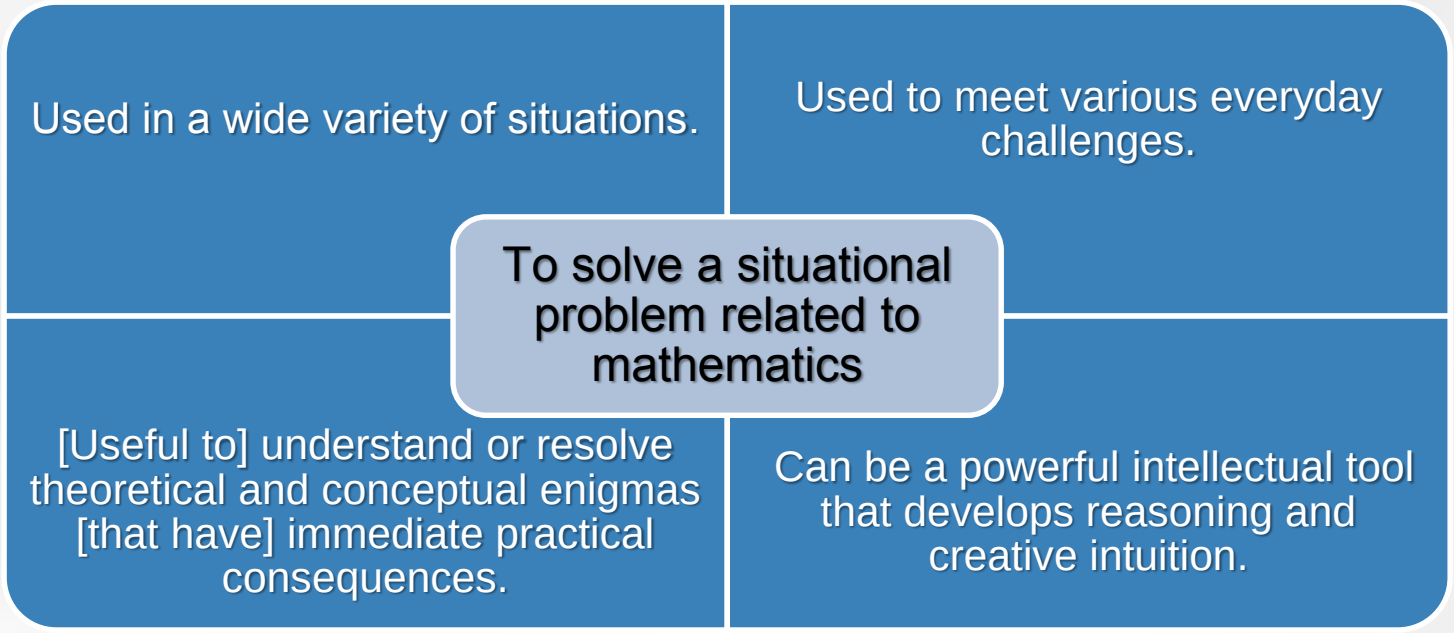
Source: Thierry Karsenti, *12 reasons to learn coding at school* (Toronto: EdCan Network, 2019).

3 Computer programming and the Mathematics program

“High technology, engineering and computer programming are among the many fields requiring the use of mathematics, but it is also used in manufacturing common everyday objects, in measuring time or in organizing space.”

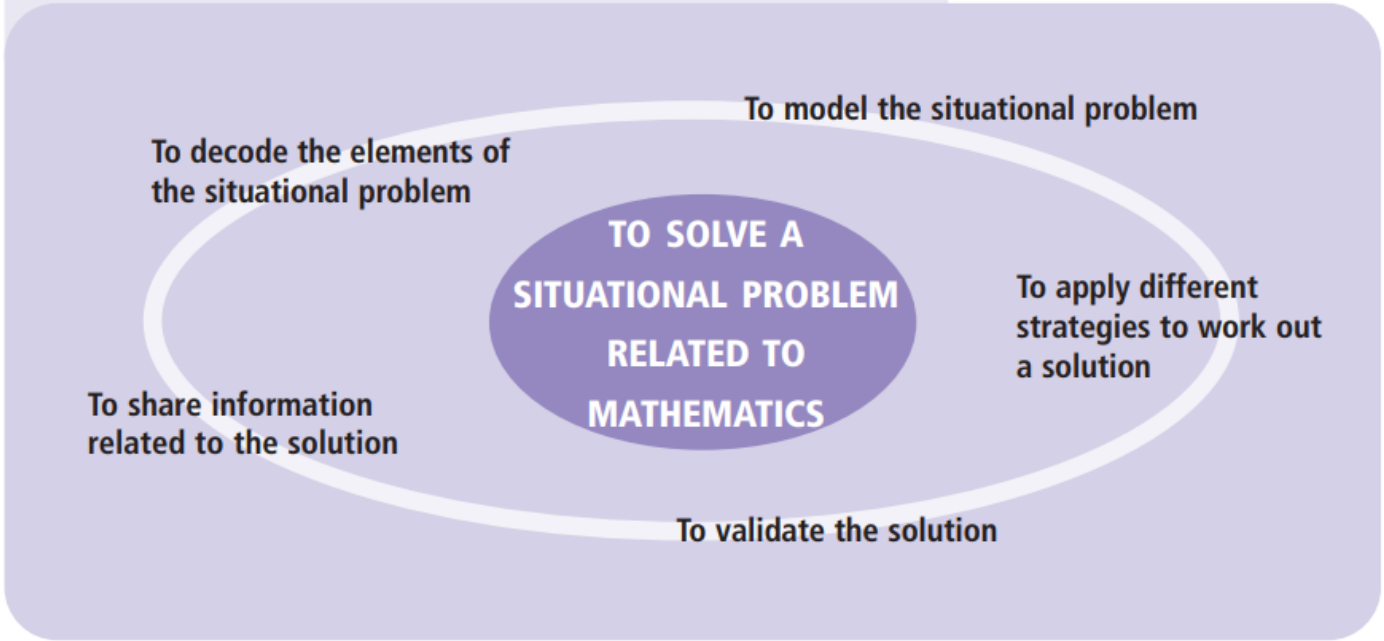
QEP, Elementary, p. 140.

Connections with problem solving in mathematics



QEP, Elementary, p. 142.

Key Features of the Competency

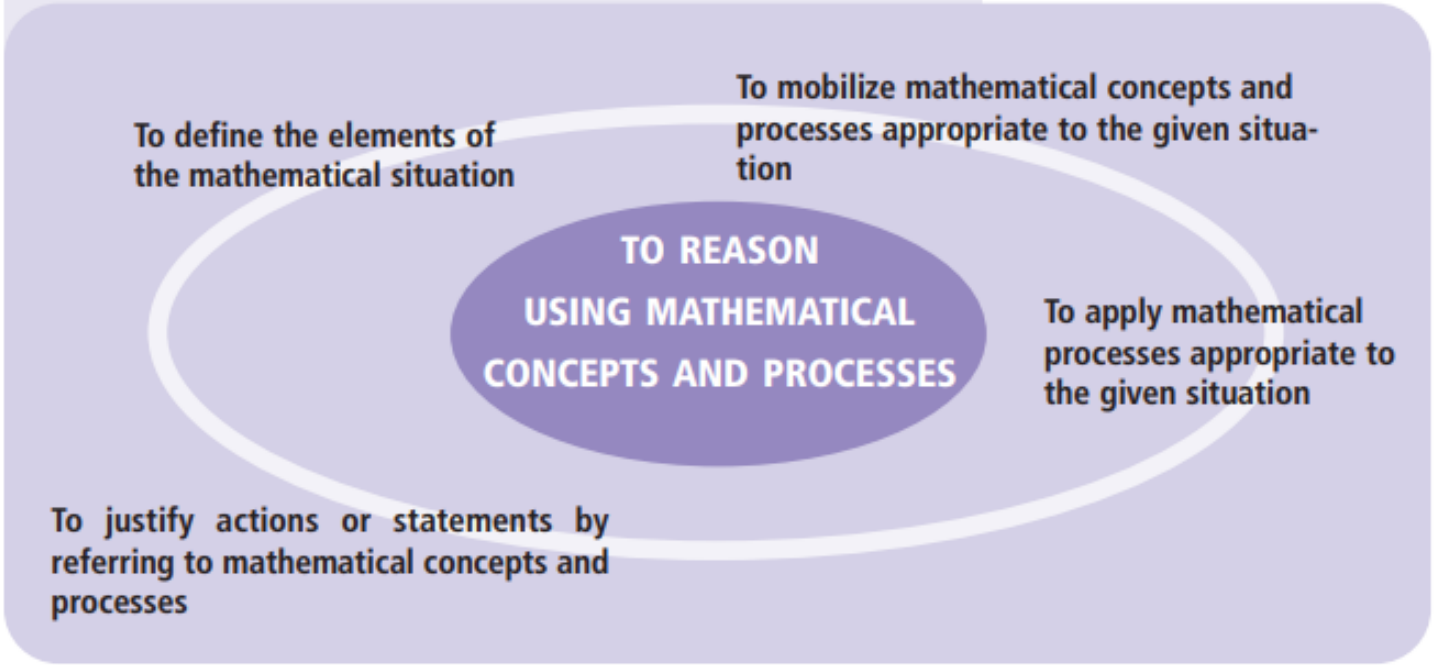


QEP, Elementary, p. 143.

Computer programming and the problem-solving process

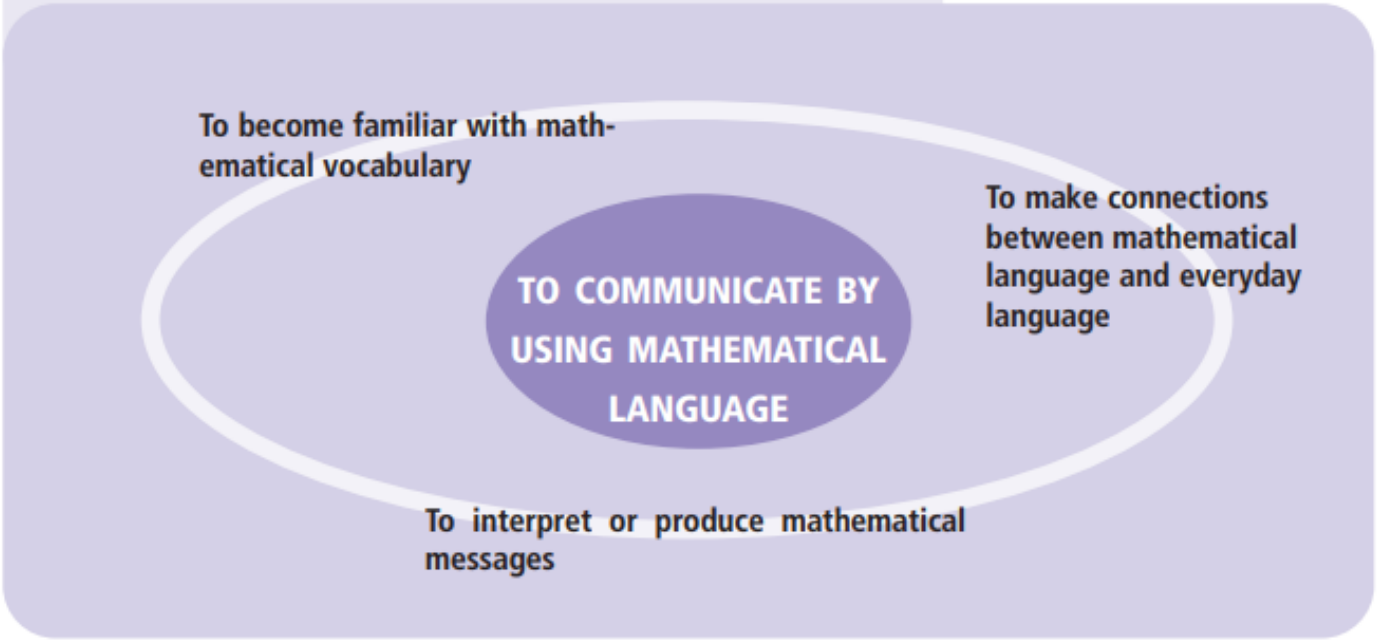
Image source: http://slidemodel.com

Key Features of the Competency



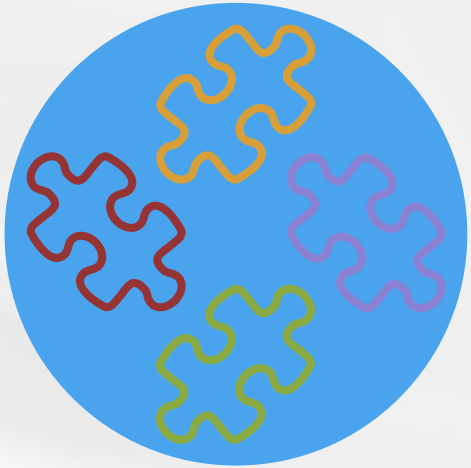
QEP, Elementary, p. 146.

Key Features of the Competency

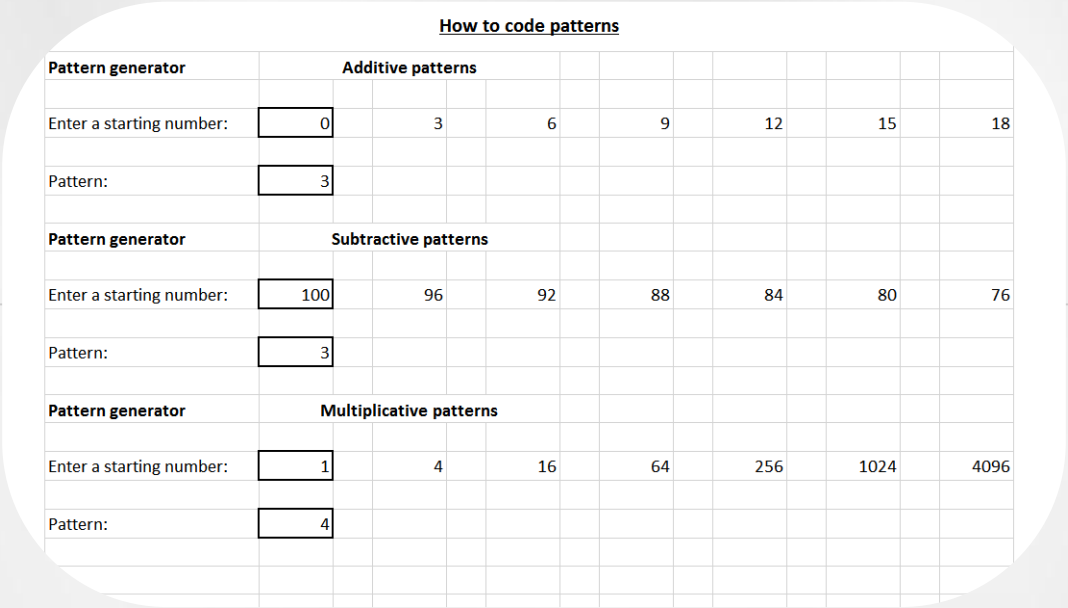


QEP, Elementary, p. 149.

4 Examples of activities involving programming



- using a spreadsheet
- using dynamic geometry software
- using presentation software
- using a coding application



How to code patterns

Pattern generator	**Additive patterns**						
Enter a starting number:	0	3	6	9	12	15	18
Pattern:	3						
Pattern generator	**Subtractive patterns**						
Enter a starting number:	100	96	92	88	84	80	76
Pattern:	3						
Pattern generator	**Multiplicative patterns**						
Enter a starting number:	1	4	16	64	256	1024	4096
Pattern:	4						

Generating arithmetic sequences using a spreadsheet

How do I program my spreadsheet to generate an arithmetic sequence that follows a specific pattern?

Examples of formulas that generate arithmetic sequences

D15 | =B15*B17

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	**Pattern generator**	**Additive patterns**																
2																		
3	Enter a starting number:	0		=B3+B5		6		9		12		15		18		21		24
4																		
5	Pattern:	3																
6																		
7	**Pattern generator**	**Subtractive patterns**																
8																		
9	Enter a starting number:	100		=B9-B1		92		88		84		80		76		72		68
10																		
11	Pattern:	3																
12																		
13	**Pattern generator**	**Multiplicative patterns**																
14																		
15	Enter a starting number:	1		=B15*B17		16		64		256		1024		4096		16384		65536
16																		
17	Pattern:	4																
18																		

Mathematical concepts and processes involved in this task

Arithmetic

- Using [their] own words and mathematical language . . . describes numerical patterns
- Using [their] own words and mathematical language . . . describes series of numbers and family of operations
- Adds new terms to a series

Progression of Learning in Elementary School; Mathematics, p. 12.

Name	Result #1	Result #2	Result #3	Mean
Annie	8	10	6	8.0
Julie	6	7	7	6.7
Geneviève	9	7	6	7.3
Martin	9	7	6	7.3
Raymond	7	8	8	7.7
Sophie	8	7	10	8.3
Mean	7.8	7.7	7.2	

=AVERAGE(C3:E3)

=RANDBETWEEN(6;10)

Calculating the arithmetic mean

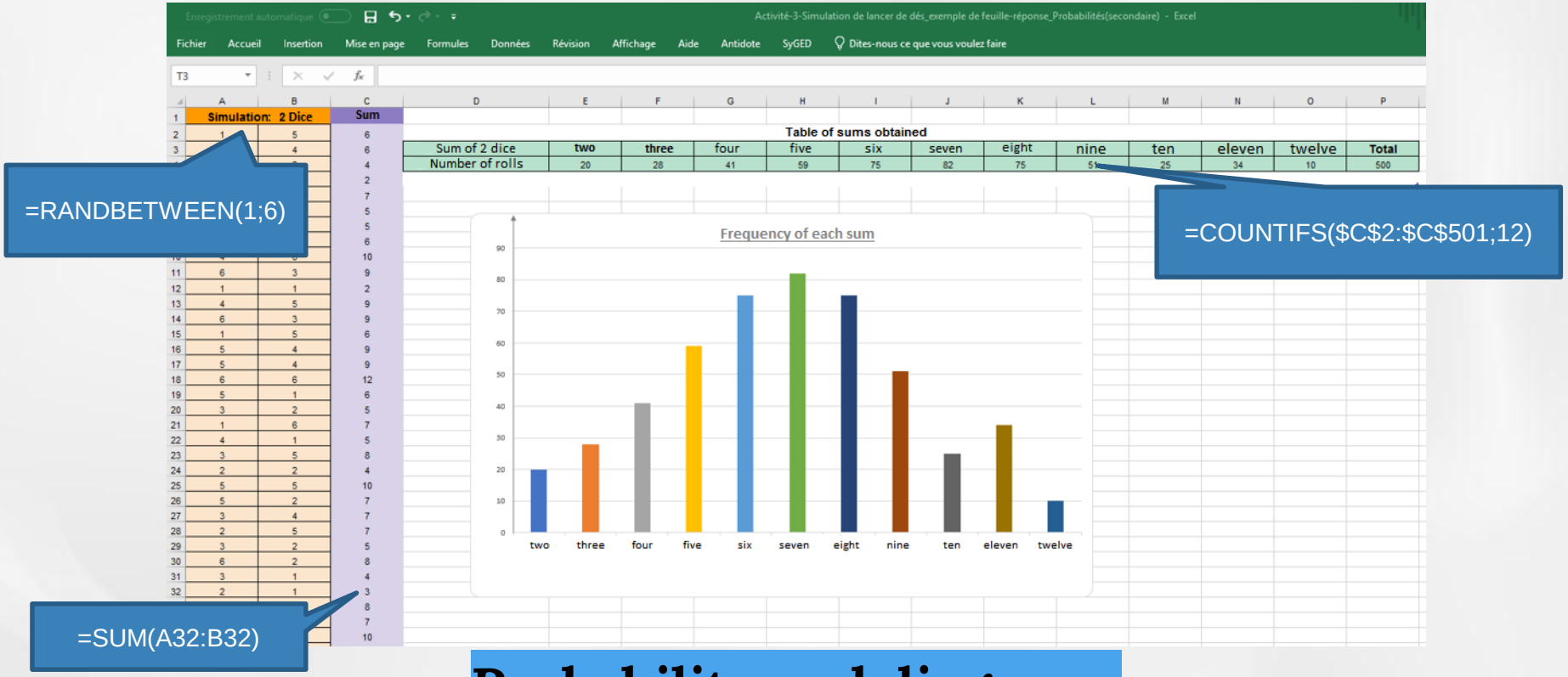
How do I program my spreadsheet to randomly generate results and calculate the mean for each student?

Mathematical concepts and processes involved in this task

Statistics

- Collects, describes and organizes data (classifies or categorizes) using tables
- Displays data using a table, a bar graph
- Understands and calculates the arithmetic mean

Progression of Learning in Elementary School; Mathematics, p. 20.



Probability and diagrams

How do I program my spreadsheet to randomly generate dice rolls, calculate the sum of two dice and display the frequency of each sum?

Mathematical concepts and processes involved in this task

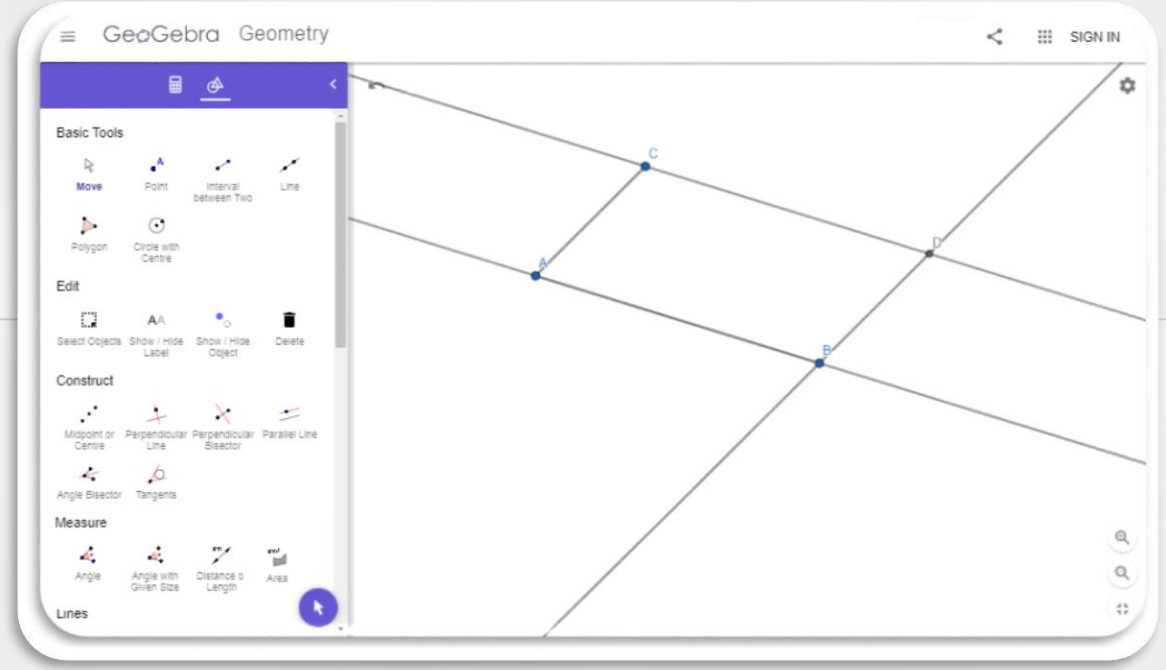
Probability

- Experiments with activities involving chance, using various objects
- Uses tables or diagrams to collect and display the outcomes of an experiment
- Compares the outcomes of a random experiment with known theoretical probabilities

Statistics

- Collects, describes and organizes data (classifies or categorizes) using tables
- Displays data using a table, a bar graph

Progression of Learning in Elementary School; Mathematics, pp. 20-21.



Drawing plane figures using GeoGebra's Geometry application

How do I draw a figure using GeoGebra's Geometry application?

Mathematical concepts and processes involved in this task

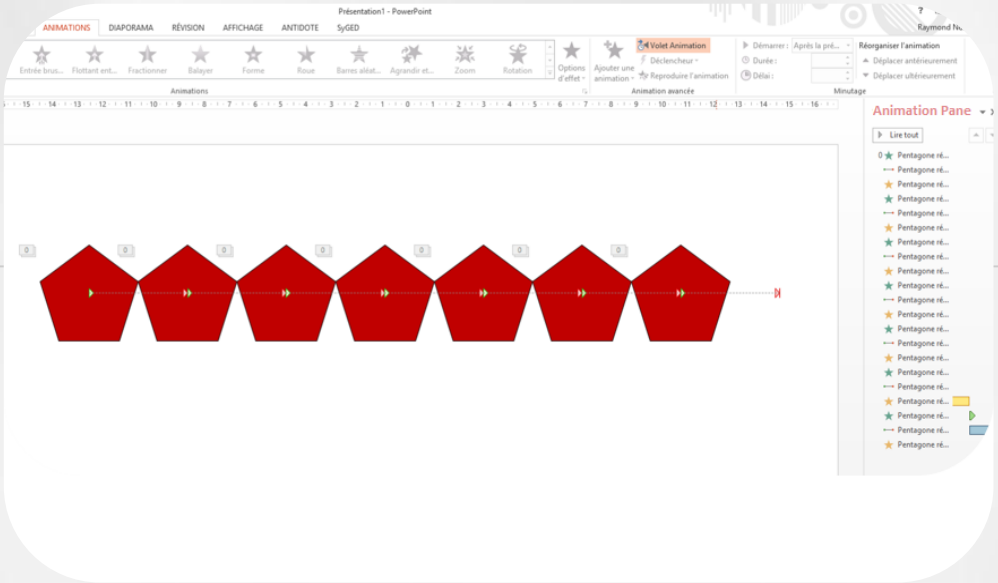
Geometry

- **Plane figures**
  - Constructs figures made with closed curved lines or closed straight lines
  - Constructs parallel lines and perpendicular lines
  - Describes quadrilaterals

Measurement

- **Lengths**
  - Estimates and measures using unconventional units
- **Angles**
  - Estimates and determines the degree measurement of angles

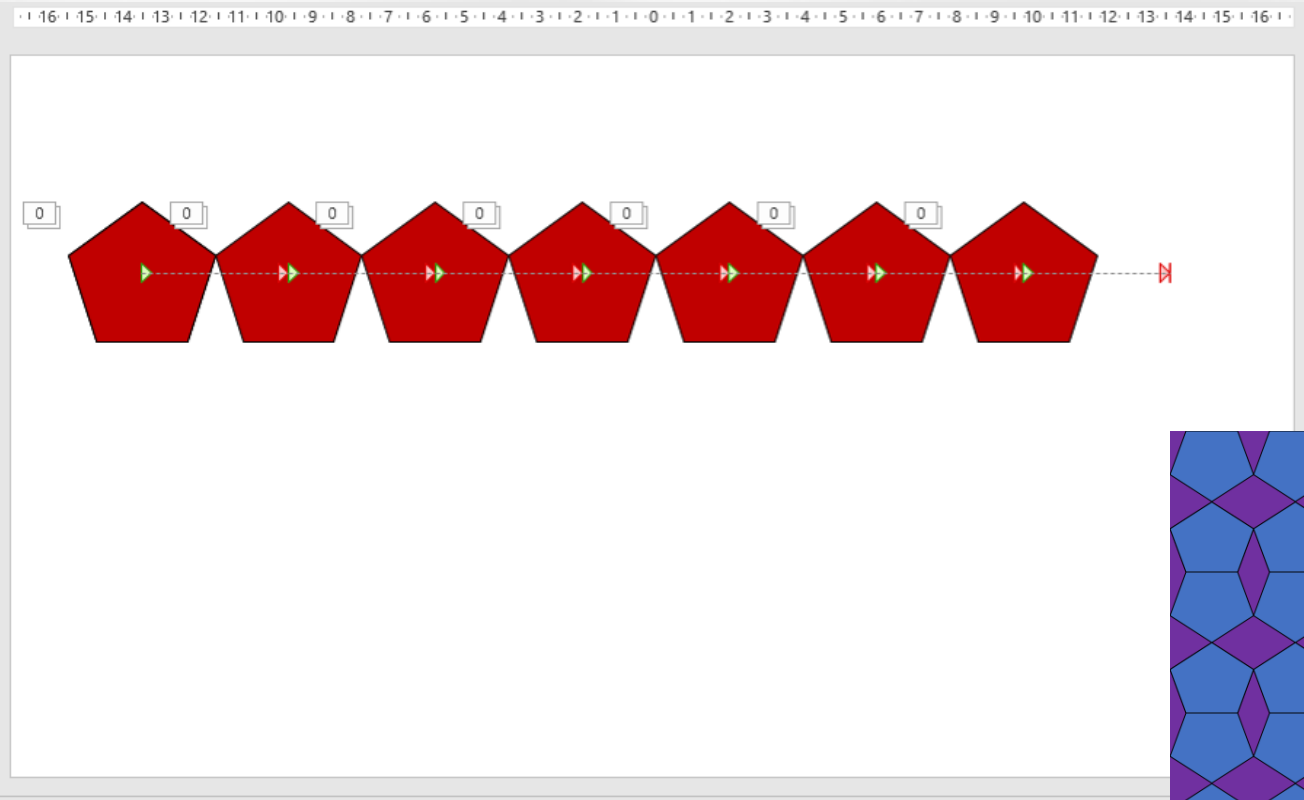
Progression of Learning in Elementary School; Mathematics, pp. 15-18.

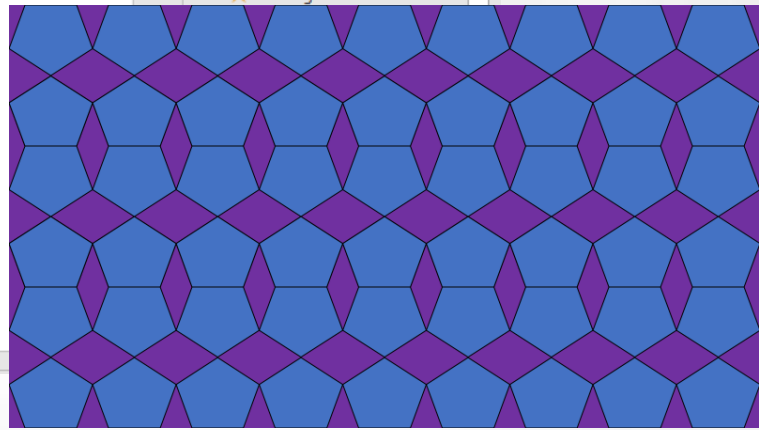


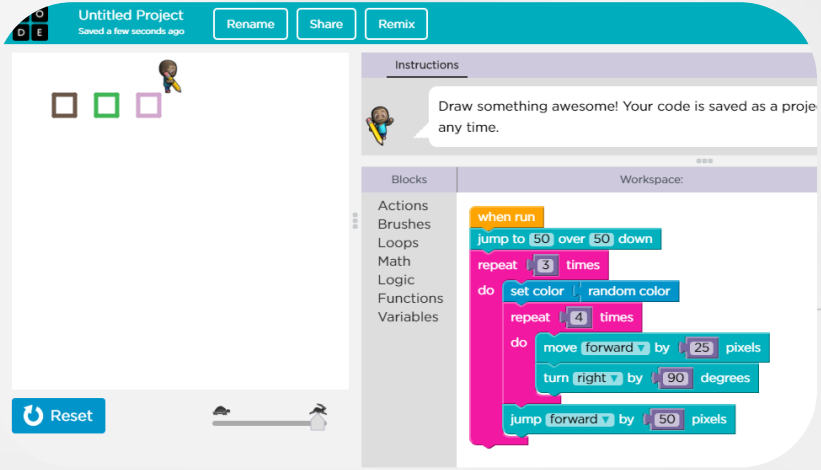
Creating frieze patterns and tessellations using presentation software

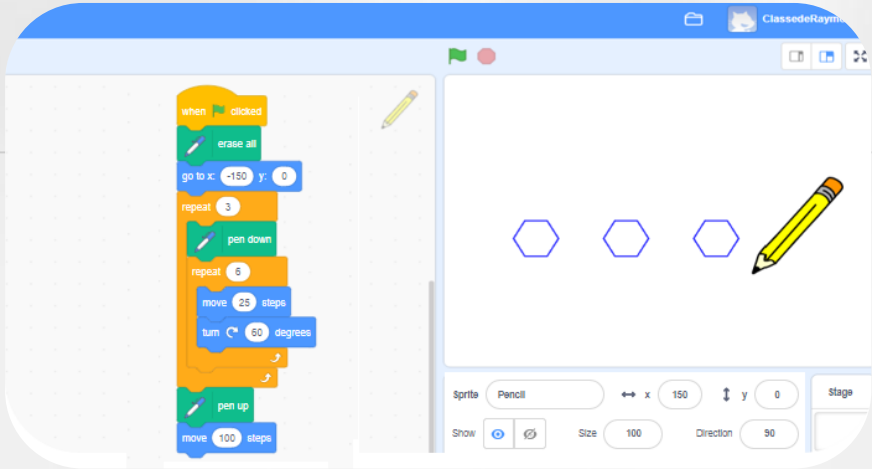
How do I program my presentation software, using animations, to create a frieze pattern or a tessellation using translations and reflections?

Examples of student processes









Creating frieze patterns and tessellations using a coding application

How do I program a coding application to draw a frieze pattern using translations and reflections?

Mathematical concepts and processes involved in this task

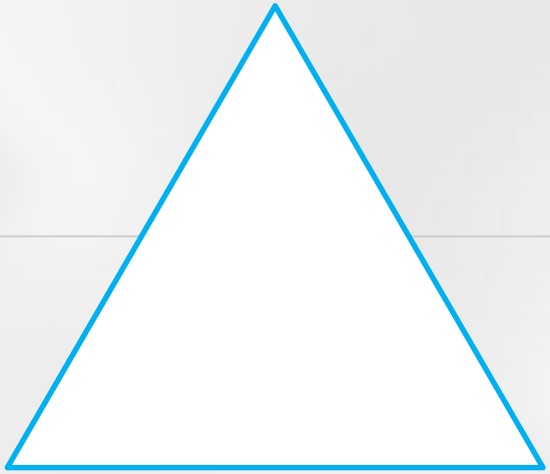
Geometry

- Observes and produces patterns using geometric figures
- Observes and produces frieze patterns and tessellations
  - using reflections
  - using translations

Measurement

- Estimates and measures time using conventional units

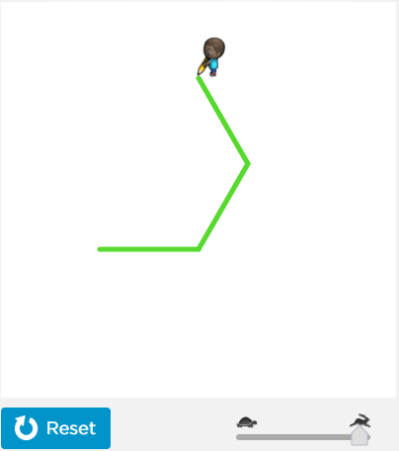
Progression of Learning in Elementary School; Mathematics, pp. 15-19.

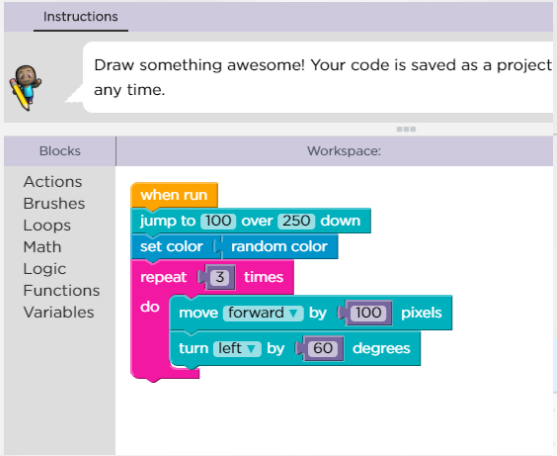


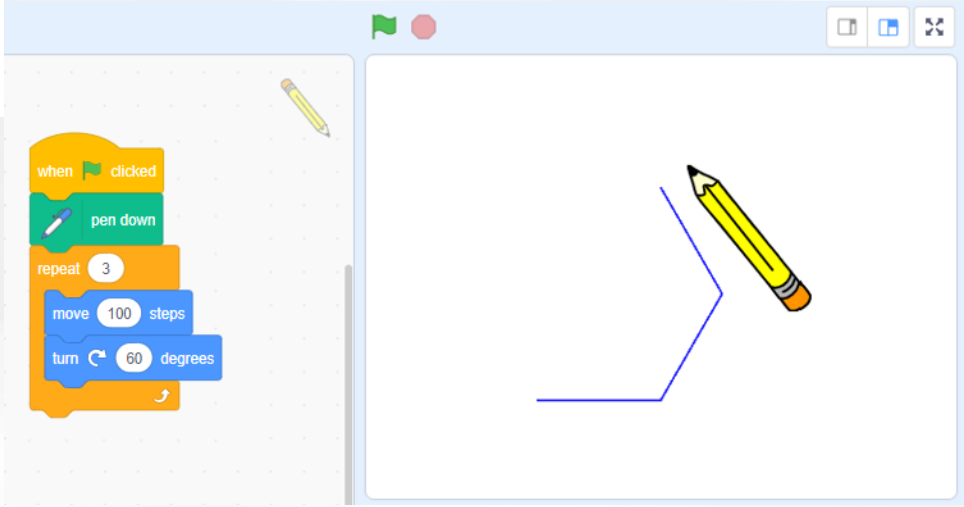
Drawing plane figures using a coding application

How do I program a coding application to draw an equilateral triangle?

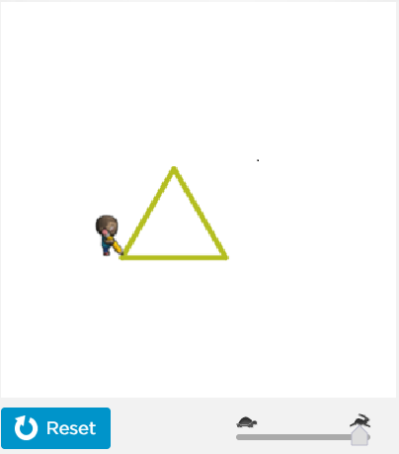
Examples of student processes

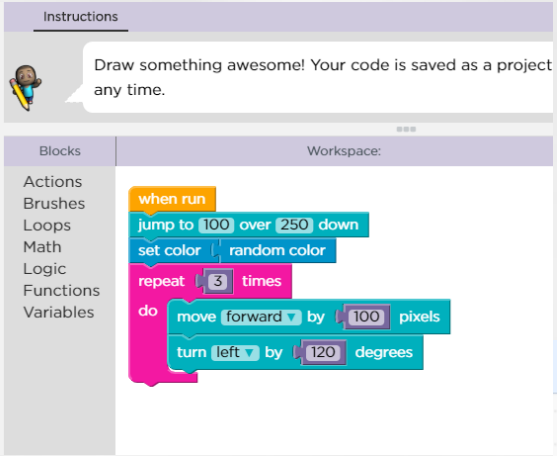


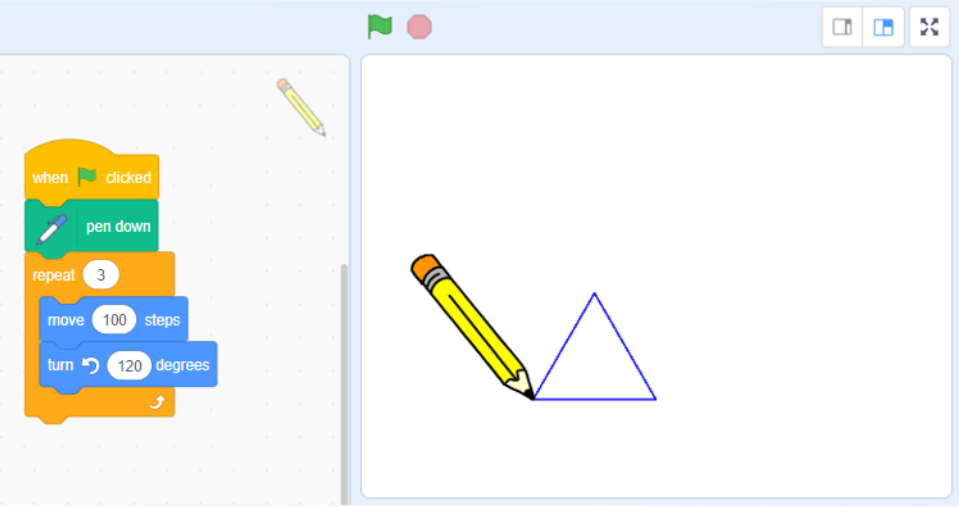




Examples of student processes







Mathematical concepts and processes involved in this task

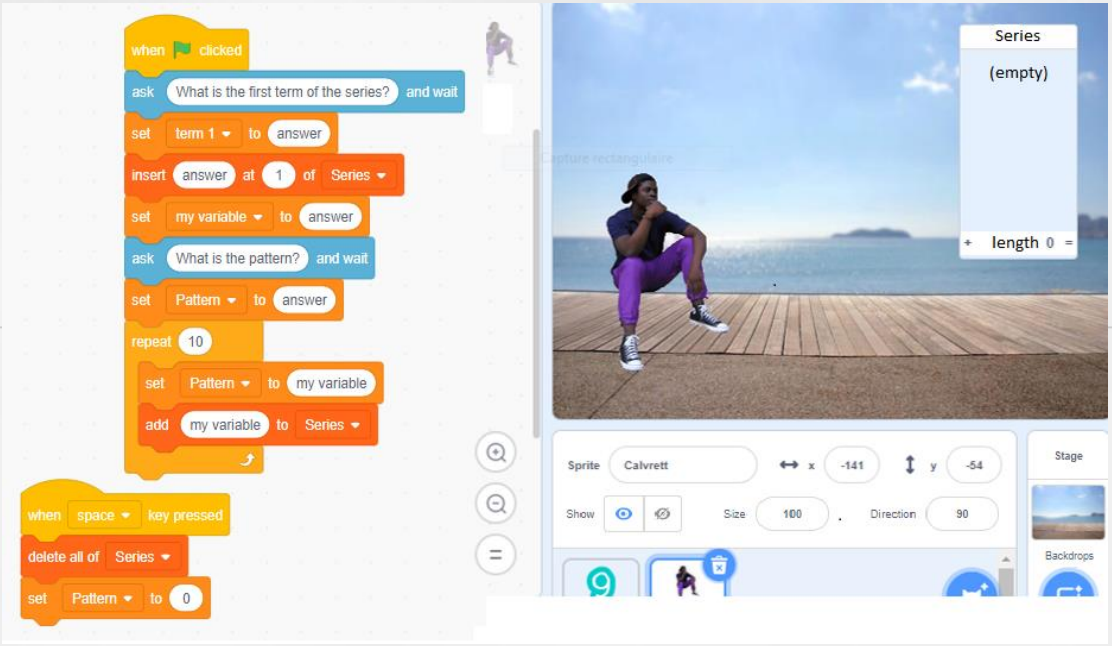
Geometry

- **Plane figures**
  - Constructs figures made with closed curved lines or closed straight lines
  - Describes triangles: scalene triangles, right triangles, isosceles triangles, equilateral triangles

Measurement

- **Lengths**
  - Estimates and measures using unconventional units
- **Angles**
  - Estimates and determines the degree measurement of angles

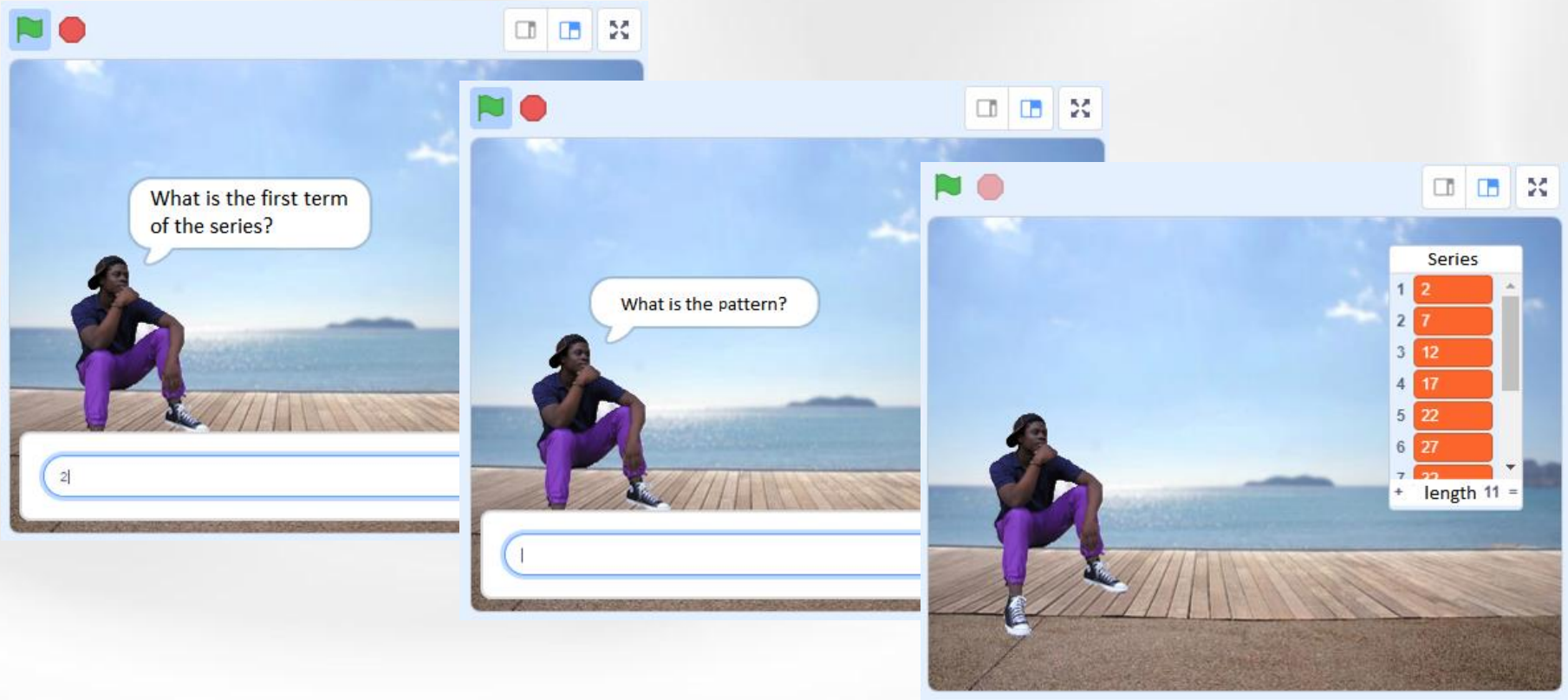
Progression of Learning in Elementary School; Mathematics, pp. 15-18.



Determine a series of numbers using a coding application

How do I program a coding application to determine a series of numbers?

Examples of student processes



Mathematical concepts and processes involved in this task

Arithmetic

- Using [their] own words and mathematical language, describes numerical patterns
- Using [their] own words and mathematical language, describes series of numbers and family of operations
- Adds new terms to a series

Progression of Learning in Elementary School; Mathematics, p. 12.

Other ideas?

Food for thought

My knowledge

How can computer programming help students to develop problem-solving skills in mathematics?

Can computer programming help motivate students to solve mathematical problems?

My experience

Which role should computer programming activities play in mathematics courses?

Am I comfortable enough to tackle computer programming with students?

Some references*

- *Le Site du Domaine de la mathématique*: domaine.recitmst.qc.ca
  - Networking session of January 16, 2018
- *Récit MST* website: recitmst.qc.ca
  - Presentation – *Initiation à Scratch en mathématique (Introduction to Scratch in mathematics)*
  - *Spreadsheet – Planification globale : Leçons de programmation mathématique (Overall planning: Mathematical Programming Lessons)*
- National Récit website: recit.qc.ca
  - Campus récit, Premiers pas avec scratch en mathématique
- Personal website of Professor Jean-François Maheux: jfmaheux.net
  - Some notes on three programming environments

*Available in French only

Thank You!

If you have any questions, please contact us!

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