Classroom Implementation Report (Grade 7): Algebra + Python: The Crazy Hat Shop and The Water Problem

Introduction:
This is a report on the implementation of a newly created math + coding activity with Python in a Grade 7 classroom by two pre-service teachers in collaboration with an in-service teacher. This report includes information about the activity, its implementation, and some reflections. In addition, it includes the student handouts and the necessary Python files.

Learning objectives:
The activity covers a variety of learning objectives pertaining to both math and coding, with a primary focus on problem solving and real-life application. The math learning objectives for this activity cover the Grade 7 curriculum strands of SEL skills and algebra. This activity meets the grade 7 curriculum goals that students should be able to:

- A1. apply, to the best of their ability, a variety of social-emotional learning skills to support their use of the mathematical processes and their learning
- C2. demonstrate an understanding of variables, expressions, equalities, and inequalities, and apply this understanding in various contexts
- C2.3 solve equations that involve multiple terms, whole numbers, ... and verify solutions
- C2.4 verify and graph the solutions
- C4. apply the process of mathematical modelling to represent, analyze, make predictions, and provide insight into real-life situations

The activity requires students to persevere and aims to remind them that 'failure' is simply a part of the learning process. The activity also aims to deepen students' understanding of algebraic concepts and their connection to real-life situations.

The coding learning objectives for this activity meets the grade 7 curriculum goals that students should be able to:

- C3. solve problems and create computational representations of mathematical situations using coding concepts and skills
- C3.1. solve problems and create computational representations of mathematical situations by writing and executing efficient code, including code that involves events influenced by a defined count and/or sub-program and other control features
- C3.2. read and alter existing code, including code that involves events influenced by a defined count and/or sub-program and other control structures, and describe how changes to the code affect the outcomes and the efficiency of the code

The activity also covers learning objectives from other grades, due to the relatively new implementation of coding in the curriculum. These include coding concepts and skills such as

repeating events, conditional statements, and the analysis of data in order to inform and communicate decisions.

Activity instructions:

The activity is divided into two lessons involving two types of word-problems and two separate files for code for the students.

- Lesson 1: The Crazy Hat Shop:
  - Remind students of the strategies they know for solving algebraic expressions, and have students independently solve for 'x' in an expression such as
    - 3x+3=x+7
  - Introduce students to the "Crazy Hat Shop" problem, explain how you would formulate an expression, and have them solve the example:
    - "A new hat shop has opened in town, and it has become extremely popular. So popular that customers are buying multiple hats, and the owners have started to charge an entry fee! Let's say that each hat costs $10, and the entry fee is $8. Sabrina spent $78 at the shop. How many hats did she buy?"
  - Direct student attention to The Crazy Hat Shop code. Have them run the code and solve the randomly generated questions
  - After students have solved 3 to 4 expressions, ask them to analyze and explore the code. Discuss with a partner what they think it's doing.
  - Conduct a class discussion about what the code is doing and explain any parts that are not discussed
  - Ask students to modify their program to ask and solve for the variable of 'cost' instead of the number of hats.
  - Wrap-up: Show students the correct solution of the code and answer any questions
- Lesson 2: The Water Problem:
  - Remind students of the "Crazy Hat Shop" problem and code, and introduce them to the "Water Problem":
    - "Both container A and container B have leaks. Container A has 1390 mL of water and is leaking 8 mL per minute. Container B has 1890 mL and is leaking 9 mL per minute. How many minutes, t, will it take for the two containers to have the same amount of water?"
  - Show how an expression can be formulated for the problem and solve as a class after they have tried to solve it individually.
  - Direct student attention to The Water Problem code. Have them complete the unfinished base code as directed in the instructions using the strategy of "use, modify, create"[1] reflecting on the lesson 1 code. Once finished, have them solve a few problems.
  - When students have completed this, go over the solution code as a class and explain the meaning behind the code. Answer any questions.

[1] Waite, J., & Grover, S. (2020). Worked examples & other scaffolding strategies. In S. Grover (Eds.),ComputerScience in K-12: An A-to-Z handbook on teaching programming(240-249). California, CA: Edfinity.

Discussion points:
When implementing the activity, it is extremely important to guide students by asking questions during every step.

- *Before introducing the activity:*
  - How do we solve algebraic expressions?
- *After introducing the problem:*
  - How can we represent this problem algebraically and solve it?
- *After students solve expressions for The Crazy Hat Shop Problem:*
  - What do you think the code is doing?
  - What are the variables?
  - How do you create text?
  - How does the code solve the problem?
  - How did you learn this?
  - What aspects of the code are similar to what you have seen in Scratch? e.g. if statements, for statements, repeats
- *After students finish The Water Problem:*
  - How did you complete the code?
  - How did you know what to do?
- *After the completion of both activities:*
  - What was hard about completing the code?
  - How did you overcome this?
  - Did you enjoy coding?

Classroom implementation:

To integrate this activity into the classroom it would be recommended to implement the lesson over at least two class periods of 1 hour each. For new programmers, the two problems and their respective tasks can take a long time to complete, so we implemented the first problem on the first day, and the second problem on the next. During the implementation of the activity, students will also need time to explore and ask questions, so time must also be allotted for the discovery aspect of the activity. If students finish early, ask them to invent their own problem and alter the code again or simply explore Python.

Things to note:

- Teachers do not need to have immense coding knowledge to implement the activity, but must be familiar with the code for both problems before implementation to solve any problems that may arise
- This activity might be slightly frustrating for students as it involves a lot of testing and debugging. Teachers should consistently remind students that it's okay if their code is not working, and that failure is a shared experience by all programmers regardless of skill level
- Give students the opportunity to interact with the code

- Our activity was implemented in a Grade 7 classroom where the students had some knowledge of programming in Scratch. However, this activity could also be suited for Grade 8 students with little programming knowledge.

Brief Reflection on Classroom Implementation:
The implementation of our activity went well overall. Some students were very receptive and excited to use Python and were exploring the code a lot by altering it. One student changed the problem in their code to be about a hockey jersey shop, and another made the price of each hat $1,000,000. Other students were less engaged and fearful of trying to alter the code. An aspect we were surprised by when we arrived was that the students were solving algebraic equations using something called the box method. I think this made it more difficult for the students to understand the code as this method did not translate well to the word problem or coding. As a result, this also meant they had difficulty understanding how to create an equation for a word problem and substitute the correct values. We had the students answer their questions that were randomly generated in the program on a piece of paper, but this took the students longer than expected so we had less time for them to explore the code and explain it. Since our time spent on the code was less than expected for the first lesson, we altered Lesson 2 so that the students had more instructions on how to alter the code to solve the word problem and we provided more comments in the base code. Even though we altered the lesson many of the students were unsure of what to do and froze. We guided some students by showing them how they needed to modify the code from Lesson 1 and think about what each part of the code was doing in that lesson. Thus, applying the strategy of "use, modify, create"[2].

Two Major Takeaways:

1. **We would provide a JupyterLab worksheet** that applies the "use, modify, create"[2] method so that students can learn different coding techniques in JupyterLab and get familiar with this coding platform. We would do this because we think many of the students got overwhelmed since Python was completely new and many were not comfortable solving word problems involving algebraic expressions. This meant that the students did not learn Python as in depth as they could since they did not understand the math they were coding. Next time we would have one lesson focusing just on Python, a second lesson focusing on algebraic expressions, and then a third lesson similar to the one we had prepared where mathematics and coding are integrated together.

2. **Students need to be okay with failure and know that it is common to all programmers**. Many of the students were so used to being told what to do while learning that they were afraid to try to code first by themselves. Another issue was that if any of them had a bug they wouldn't try to problem-solve and immediately wanted help. This meant that we were often with the students offering guiding questions and explaining difficult parts of the code and the math.

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Resources:

- Student guidelines/handouts (see next pages)
- Presentation Slides (see next pages as well as separate pptx files)
    - Lesson 1 Hat Problem
    - Lesson 2 Water Problem
- Python Files
    - Lesson 1 Hat Problem
    - Lesson 2 Water Problem
- Complete Solutions
    - Lesson 1 Hat Problem
    - Lesson 2 Water Problem

Coding in Python and Exploring Simple Equations: Day 1 Handout

Warmup:

Solve for x in the following expression:

$$3x+3=x+7$$

"The Crazy Hat Shop"

A new hat shop has opened in town, and it has become extremely popular. So popular that customers are buying multiple hats, and the owners have started to charge an entry fee! Let's say that 1 hat costs $10, and the entry fee is $8. Sabrina spent $78 at the shop. How many hats did she buy?

We can represent this problem algebraically by letting x be the number of hats Sabrina bought:

$$\text{price} \times \text{hats} + \text{entryfee} = \text{Cost}$$

$$10x+8=7810x+8=78$$

Now solve it using the strategies from the problem above.

Using Python:
Now together as a class we will upload the file into JupyterLab that you were given by your teacher. The file is titled *Lesson1_HatProblem.ipynb*

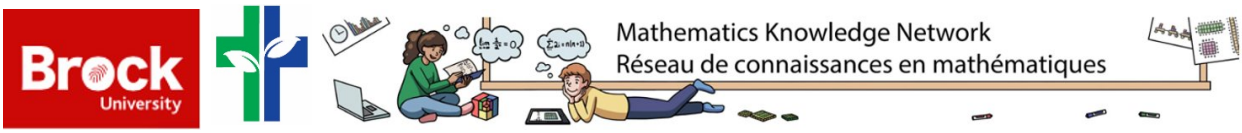
1. Download the provided files
2. Open "JupyterLab" from the link, or type https://try.jupyter.org and click "JupyterLab"
3. Click the upload button and select "Lesson1_HatProblem.ipynb"
4. Click to open

Once you have uploaded the file you may run the program and solve randomly generated problems. Write your solutions to the questions on a separate sheet and share with a partner what you think the graph is doing. Solve three to four questions.

Instructions:

1. Explore the code and discuss with a partner or in a group of three what you think different parts of the code do. We will then have a class discussion where you will share what you think each aspect of the code does.
2. After the class discussion you are to modify the code to solve the variable *cost*
3. When you are done you can add comments to your code to tell the user what each part is doing.
4. Conclusion and wrap-up with the class

Activity created by Ashley Reinarts and Rachel Ansems for MATH3P41 at Brock University in collaboration with a teacher from the Niagara Catholic DSB under the Math Knowledge Network. Coordinated by Laura Cronshaw and Jefferey Martin (Niagara Catholic DSB) and Dr. Chantal Buteau and Dr. Laura Broley (Brock University). Adapted by Chantal Lof. June 2022.



Coding in Python and Exploring Simple Equations: Day 2 Handout

Problem:

Both container A and container B have leaks. Container A has 1390 mL of water and is leaking 8 mL per minute. Container B has 1890 mL and is leaking 9 mL per minute. How many minutes, t, will it take for the two containers to have the same amount of water?

How can we represent this problem algebraically and solve it?

Initial amount in A – rate × time = Initial amount in B – rate × time

Coding:

1. Open “Water Problem.ipynb” in JupyterLab.
2. Use the comments to complete the code. Use the Python Tips at the end of this document and the program from yesterday for reference.
3. Collaborate with each other! Ask for help when you need it!
4. If you finish the code, you can investigate the graph at the bottom of the code or create a new program based on what we have done yesterday and today

Python Tips

Don't forget failure is a shared experience by ALL programmers regardless of skill level. Perseverance, questioning, exploring, and solving problems is what makes a "good" computer programmer good!

[13]:
```
# this is a comment!
# they are not a part of the code at all,
# unless they are on a line with code
# and are used by programmers to understand their work.
# use # to make a comment

# tip: remember to press the play button before moving
# on to the next section, they depend on each other!

# these are our imports. they are essentially different
# calculators, and do not need to be changed for our program
import numpy as np
import matplotlib.pyplot as plt
import random as ra

# our variable 'x' will be assigned to a random number from 1-10
x = ra.randrange(1,11)

# the print command lets us say things! use quotation marks around
# your text and close them to refer to a variable like this:
print("My favourite number is",x,". It is a really cool number!")
```

```
My favourite number is 6 . It is a really cool number!
```

Uploading Files:

1. Download the file *Lesson 2_WaterProblem.ipynb*
2. Open "JupyterLab" from the link, or type https://try.jupyter.org and click "JupyterLab"
3. Click the upload button and select "name of file"
4. Click to open

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MATH & CODING:

"The Crazy Hat Shop"

THINKING BACK…

- A few weeks ago, you worked on solving for 'x' in equations like this:

$$3x + 3 = x + 7$$

- How do we solve this?

HOW TO SOLVE EQUATIONS

$$3x + 3 = x + 7$$
$$3x - x = 7 - 3$$
$$2x = 4$$
$$x = 2$$

WELCOME TO THE CRAZY HAT SHOP!

- A new hat shop has opened in town, and it has become extremely popular. So popular that customers are buying multiple hats, and the owners have started to charge an entry fee! Let's say that 1 hat costs $10, and the entry fee is $8. Sabrina spent $78 at the shop. How many hats did she buy?
- How can we represent this problem algebraically and solve it?

THE CRAZY HAT SHOP

- We can represent this problem algebraically by letting x be the number of hats Sabrina bought:

$$\text{price} \times \text{hats} + \text{entryfee} = \text{Cost}$$

$$10x + 8 = 78$$

- Now solve it using the strategies from before.

THE CRAZY HAT SHOP SOLUTION

$$10x + 8 = 78$$

$$10x = 78 - 8$$

$$10x = 70$$

$$x = 70/10$$

$$x = 7$$

Therefore, Sabrina bought 7 hats.

USING PYTHON

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- Once you have uploaded the file you may run the program and solve randomly generated problems. Write your solutions to the questions on a separate sheet and share with a partner what you think the graph is doing. Solve three to four questions.

INSTRUCTIONS

1. Solve 3-4 randomly generated problems on a sheet of paper
2. Explore the code and discuss with a partner or in a group of three what you think different parts of the code do. We will be getting you to share with the class later!
3. Modify the code to solve the variable *cost* instead of the # of hats
4. Conclusion and wrap-up with the class

MATH & CODING:

"The Water Problem"

Brock University

Mathematics Knowledge Network
Réseau de connaissances en mathématiques

THINKING BACK…

- A few weeks ago, you worked on solving for 'x' in equations like this:

$$3x + 3 = x + 7$$

- How do we solve this?
- We used the box method, then collected like terms, and finally we divided by the coefficient
- We then created new problems using Python in the form:
  - price × hats + entry-fee = Cost
  - Ex: 10x+8=78

TODAY

- We are going to be working on a similar problem to those you have done in class
- Ex. $3x + 3 = x + 7$
- What do word problems of this form look like?

WATER PROBLEM

- Both container A and container B have leaks. Container A has 1390 mL of water and is leaking 8 mL per minute. Container B has 1890 mL and is leaking 9 mL per minute. How many minutes, t, will it take for the two containers to have the same amount of water?
- How can we represent this problem algebraically and solve it?

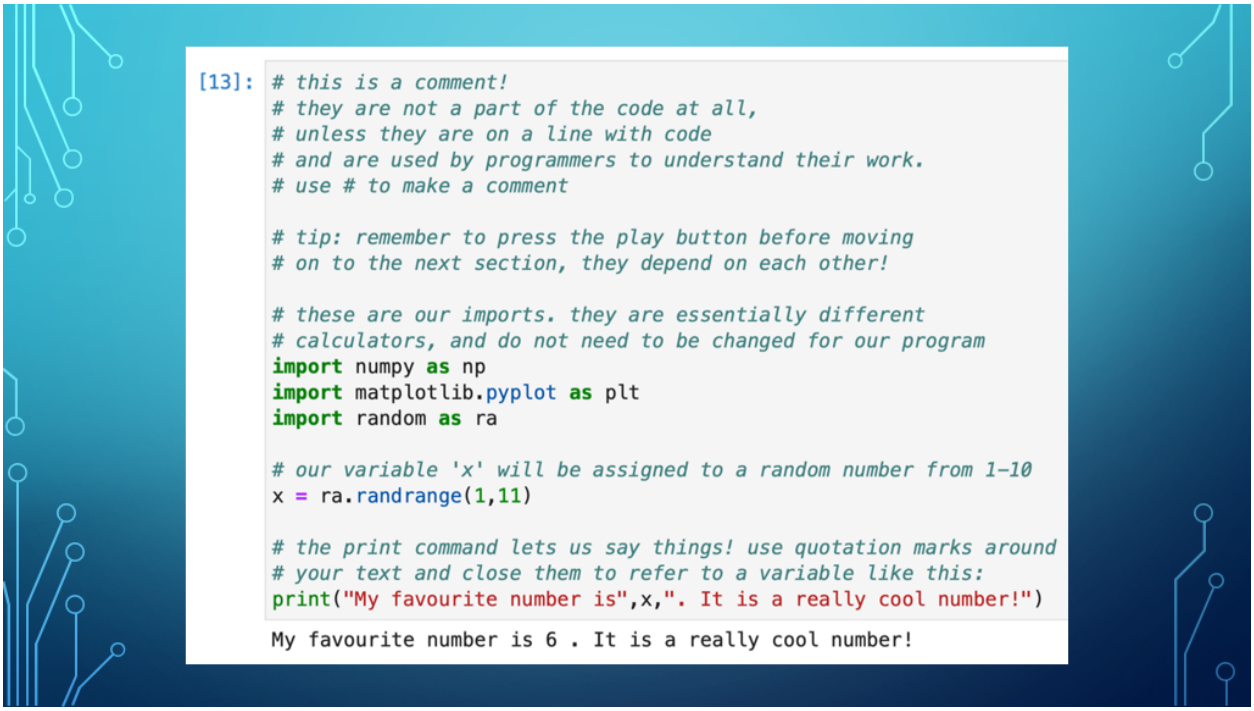
Both container A and container B have leaks. Container A has 1390 mL of water and is leaking 8 mL per minute. Container B has 1890 mL and is leaking 9 mL per minute. How many minutes, t, will it take for the two containers to have the same amount of water?

$$1390 - 8t = 1890 - 9t$$
$$-8t + 9t = 1890 - 1390$$
$$t = 500\ minutes$$

- In general:
  - $Initial\ amount\ in\ A - amount\ x\ time = Initial\ amount\ in\ B - amount\ x\ time$
- For coding today:
  - $iAmL - at = iBmL - bt$

CODING

- Open "Water Problem.ipynb"
- Follow the comments on the code, they will guide you
- Ask for help when you need it!
- If you finish the code, you can investigate the graph or create a new program based on what we have done yesterday and today



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