

## The Problem with Problem-Solving

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### Introduction:

- Welcome to this presentation on the Problem with Problem-Solving.
- **Introduction of me:** I am mathematics educator with a focus on problem-solving and work here at George Brown College. I have Doctorate in Education from Columbia University.
- Today, you are going to learn all about problem-solving. Specifically, we will discuss the impact of problem-solving on transforming curricula and classroom practices.

### Preview:

- The session will be in 3 parts
  - Philosophy behind problem-solving
  - The changing history of problem-solving
  - Evidence on problem-solving
- Throughout this presentation, we will discuss the role of problem-solving in education and its importance in the classroom to develop creative and critical thinking students.

### Goal of presentation:

- At the end of this presentation, I hope you will see the value of bringing problem-solving into your classrooms.

### Richard Feynman Story

- In many classrooms students **memorize information rather than create connections**, make hypothesis and have an understanding.
- A story that illustrates this beautifully comes from the book “**Surely you’re joking Mr. Feynman**”, which is a collection of essays written by Dr. Richard Feynman.
- Dr. Richard Feynman is a **famous physicist** who is a Nobel prize laureate for physics, and is known for his work in investigating the Challenger space shuttle disaster and quantum physics.
- In this essay, Dr. Feynman was invited to **Brazil as a guest researcher** and instructor to help improve Science and Technology learning at Brazil universities.
- Dr. Feynman sat in a final examination for a top graduating student in physics. The student was asked questions about the definition of **polarization of light** and follow-up calculations and did perfectly, but **Dr. Feynman was suspicious**.
- After the examination, Dr. Feynman pulled the student aside and asked him some follow-up questions like “**can you give me an example of polarization of light**”, but the student was unable to give an example. Even with a hint, “look at the water”, since water polarized light the student kept **repeating the definition**.

- Dr. Feynman realized the student had **just memorized the material**, and had no actual understanding.
- This story illustrates that many students memorize formulas and algorithms rather than creating an understanding. To add to this, **even high achieving students may just be memorizing the information.**
- **This is why I am going to talk about the importance of problem-solving in the classroom.**

### What is Problem-Solving?

- Problem-solving is when a solver does not know a direct path to achieve the given goal.
  - Problem-solving is when you do not know a formula or algorithm to solve the question.
- Problem-solving allows for **original thought and not just repetition of an algorithm.**

### Examples:

- Q1:  $12 \times 10$ : is NOT a problem because we know an algorithm to get the answer
- Q2: A cooking class at GBC with 20 needs cutting boards. If each student requires 2 cutting boards. How many cutting boards are needed? is NOT a problem.
- Q3: You're GBC cooking class is interested in getting new cutting boards. How many cutting boards are needed? is A PROBLEM. NEED TO MAKE HYPOTHESES AND CONJECTURES. **More open.**
- Learning should be more than a body of facts. Students need to develop connections, explore patterns and make conjectures

**Activity:** Spend 2-3 minutes coming up with your problem-solving question in groups of 2-3

### Changing History of Problem-Solving

- In 1945, George Polya published his classic book *How to Solve It*, which became the building blocks for further research into mathematical problem-solving.
- Much of the subsequent work in problem-solving has offered adaptations of Polya's fundamental ideas (Lopez-Real, 2006).
- Polya (1945) believed the purpose of his ideas **was to help one think, rather than replace thinking.** His problem-solving framework is a four-step process: understand the problem, devise a plan, carry out the plan, and look back.
  - (1) *Understand the problem*: refers to defining the problem, identifying the unknowns, and piecing together information.
  - (2) *Devise a plan*: refers to understanding how problem variables are interrelated. Creating connections and identifying solution methods.
  - (3) *Carry out the plan*: refers to carrying out the chosen strategy.

(4) *Look back*: refers to reflection on the process and results.

- Problems have been a way to link school with everyday life.
- In the 1930's there began a shift toward bringing real-life connections to mathematics (Hiebert & Wearne, 1996).
  - Debate as to whether the goal of **learning was for learning's sake or to learn directly applicable skills.**
- In the 1970's the focus turned to skill acquisition
- In the 1980's and onwards it was commonly held that students should work on problems with broad applications and explore many areas of learning.

### **Why is Problem-Solving Important?**

#### **Problem-solving and the Curricula**

- Problem solving initiatives appear in most curricula, are considered important among employers, and, most importantly, are a fundamental component of success in learning.
- Everyday people encounter problems-some simple and others more complex and people need to be able to be comfortable working through them.
  - It does not matter if you are a student, business person, or the prime minister, you face problems that need to be solved.
- Yet, **problem solving is often incorporated in a peripheral manner** in the classroom, whereas it deserves to be at the center of the curriculum. It is important to learn how to incorporate problem-solving meaningfully into the curriculum.

### **Reasons why problem-solving is not at the forefront of the classroom**

- Challenging to **assess and grade** student success in problem-solving activities.
  - Multiple solutions or solution methods which are difficult to assess
  - Problem solving tasks can take a far greater amount of time.
  - Students are inexperienced problem-solvers

Given the prominence of problem-solving in the modern educational and business environments, it is **important that problem-solving be at the forefront of our classroom experiences.**

### **Evidence/Research on Problem-Solving**

#### **My Research Russia/Argentina**

I will discuss the impact of problem-solving on transforming curricula and classroom practices from my experience as an invited researcher and educator in Russia and Argentina.

#### **Russia Story**

- November 2013-- travelled to Russia as part of a research team through Columbia University to see first-hand how mathematics is taught in Russia.
- Attended lectures at some of the top schools with advanced teaching of mathematics in Russia including **School Number 30** and **School Number 75**.
  - *Impact problem-solving has on transforming curriculum and creative teaching methods in Russian mathematics education.*

### *Background on Russian Education System*

- In Russia, education is run by the state and regulated by the Ministry of Education and Science.
- 11 grades and school is free
- Since the 1950's the Russian government has set-up special schools, known as schools with **advanced teaching of mathematics**, whose focus is on enriched mathematics learning.
  - The mathematics learning at these schools is challenging and demanding.
  - Students may spend as much as 10-12 hours a week studying mathematics

### *Lessons from Russia*

#### *Mathematics Learning Should Not be Limited to the Classroom*

- Mathematics learning is not limited to the mathematics classroom (Karp & Zvavich, 2011).
- Many schools with an advanced teaching of mathematics offer extracurricular clubs such as mathematics clubs where students study unsolved problems, or very advanced mathematics such as Galois Theory or Hyperbolic Geometry (Karp & Zvavich, 2011).
- **Special presentation by prominent scientists and mathematicians** at schools with advanced teaching of mathematics (Karp & Zvavich, 2011).

#### *Professional Mathematicians Working With Students*

- School Number 57, has another special class for its students. The students spend two hours a week with **professional mathematicians** in small groups working on difficult mathematical analysis problems.

#### *Notable Classroom Practices*

##### *Grappling Problems Alone Without Instruction*

- It is often the case in the schools with advanced teaching of mathematics that students are given handouts with problems to grapple with (Karp, 2011).
- Students are expected to work on these problems **individually without aid from the teacher, their classmates, or the outside resources** (Karp, 2011).

- Students may be given a brief instruction on the topic, but are not given a detailed explanation like in North America (Karp & Zvavich, 2011).
  - In Canada, it is the norm to teach mathematics in a hierarchal fashion, introducing topics step-by-step and then explaining to the students the bigger picture.
  - In Russia, students are expected to understand all of this on their own (Karp & Zvavich, 2011). Students are expected to create the holistic picture for themselves.
  - Russian schools try to instill a **spirit of research and independent study** in their students (Karp, 2011).
- Overall, from my research in Russia it is my hope that some of these practices could be used to **better our teaching practices at home**.

## Argentina

- In March 2014, I had the privilege of being an invited education researcher in Buenos Aires, Argentina with Columbia University.
- The goal was to learn and experience the challenges and ingenuity found both at elite private schools and parochial schools in Argentina.
- We spent time at private and parochial elementary and secondary schools, as well as private and public universities.

### *Background on Argentine Education System*

- Education in Argentina is quite different than Canada.
- Compulsory education in Argentina is a relatively new concept as it was only in 2006 that the Argentine government passed a law making 12 years of education compulsory.
- Education is a national policy, with both private and public schools at all levels.
- Similar to the United States, private schools in Argentina tend to have newer buildings, more programs, and fewer students, and public schools tend to struggle with funding, job security, and working with students from low socioeconomic backgrounds.
- University education in Argentina is where educational differences from Canada are more pronounced.
  - **Public universities are free** for all students and there are **no admission requirements**.
  - If students wish to study a certain field such as medicine or law, students can do so.

- Another difference is **that liberal arts programs do not exist in public universities.**
- Students start in first-year studying their field of study and most programs take about six years of full-time study.
- Students with low socioeconomic status may not study in university even though university is free.
- It could be because they would not be able to study full-time because they need to work to support themselves or the costs of books or transportation are too prohibitive.
- The **goal from the research was to see how different educational systems continue to stimulate student thinking.**

### *Story from Argentina*

- At one of the private grade-school schools we visited we took part in the school's math club.
- Students meet for **two hours once per week** to prepare for the Olympiad competitions.
- At this school students volunteer to be part of the club. Over **sixty students took part** on the day we visited.
- Students were given about **one hour to work a single problem in a small group.** **The focus was not one getting a correct answer, but working through problem-solving strategies as a group.**
- At the end of the session students presented their work to the group.
  - I was impressed that students were so interested in mathematics.
    - It is important to let **students work through problems on their own without time pressures and free from adult involvement.**
    - It is important for students to have this **experience both inside the mathematics classroom and outside.**
    - To add to this, having students practice their presentation skills is something that we do not do enough in mathematics classes.
    - If your school does not already have one, creating a mathematics club where students meet for one lunch hour every week to **work on open-ended or ill-defined problems** may be something worthwhile. Another take home lesson would be to have students spend more time explaining their work to the class.

### **What does this mean for us as educators?**

There are many ways to bring problem-solving into the classroom to improve students' ability to develop connections, explore patterns, and formulate conjectures.

So, as educators what should we be doing?

### *Make the Classroom a Place of Investigation*

- **One of the best ways is for the educator to make the classroom a place of investigation.**
  - Piggott (2007), a former mathematics education professor at Cambridge University, argues in an article on teaching creativity in the classroom that fostering **creativity requires a commitment from the teacher**. She suggests encouraging **students to get “stuck” with problems** and to use manipulatives, heuristics, or strategies to attempt to solve the problem.
  - Allowing students to explore and work at their own levels is valuable, and will help foster creativity. Further, according to Piggott (2007), problem-solving abilities will **improve if students are given the opportunity to ask questions**
  - **This was also exemplified in the math club in Argentina**

### *Classroom Learning Should Not Just be A Subject of Right and Wrong Answers*

- Another way to foster creativity, critical thinking, and innovation is to make **classroom learning not just a subject of right and wrong answers**.
- Edgar, et al. (2008) examines literature and discusses the definitions of creativity, processes, and methods of creative thinking, as well as strategies to promote and develop creativity.
  - (1) establish rules that encourage openness
  - (2) use real-life examples
  - (3) resist the urge to use a dictated path
  - (4) commend mistakes
  - (5) model the expected student behaviour
  - (6) encourage teamwork
  - (7) brainstorm.
- **If students think learning is black and white, creativity and critical thinking will be discouraged.**
  - Hoffman and Brahier (2008) maintain a similar viewpoint in their article discussing major findings from the Third International Mathematics and Science Study (TIMSS):
  - **Classroom needs to offer more than formulas and algorithms**, and suggest having **students work on open-ended problems then compare their solution methods as a way to gain different perspectives**.
  - Classroom scheduling should also allow time for students to grapple with problems on their own (Burns, 1992).

**Too often instruction focuses on finding a quick and simple answer using a type of algorithm**, which makes it seem as though the only thing that matters is getting the correct answer.

- As Harvard psychologist Jerome Bruner and his colleagues so aptly write in *A Study of Thinking*, most of the learning in **school textbooks is polished, but mathematical thinking is not what is in textbooks.**
- Teaching practices should **focus on giving students the opportunity to problem-solve**, by making the classroom a **place of investigation** with creative and problem-solving tasks, asking **open-ended questions**, and making learning more than just a thing of right or wrong answers.

Lessons:

- Making the classroom a place of investigation
- Learning is not polished
- Not a subject of right and wrong answers

How to bring Problem-Solving into the classroom

- Groups or individually
- Problem posing
- Think Pair Share
- Open-ended problems/questions
- Problems that lead to a creative result
- Allow students to get stuck with problems (like in Russia)
- Probe students about their questions and assumptions (problem-posing)
- Problem-solving should not be limited to the classroom

Where can I get ideas:

- Taking curriculum questions and removing the numbers (making the problem more general)
- What if XKCD
- Case Studies with multiple responses

**Activity:** Reflect on your own teaching practices, and make one goal on how you might bring problem-solving into your class. (**Sticky note activity-** everyone write the goal on a sticky note, to bring home with you and put on your computer screen as a remainder)

*Question Time:*

We have time for a few questions. Anyone have any questions?

*Wrap-up*

- **Thank you for being a fantastic group**
- Feel free to reach out

- Today you learned about: (1) problem-solving and (2) how to bring into the classroom
- **THANK YOU!**