This keynote will examine problem solving in the mathematics classrooms from the perspective of teaching via/through problem solving using the Constructivist Learning Design (CLD). The talk will illustrate through the use a CLD package that has been employed in Singapore Mathematics classrooms how CLD could help to promote the development of students as not only effective consumers but also effective creators of mathematics. Through the lens of students’ work, a discussion would also be made on how such a learning design motivate students to be curious about mathematics, delighted by mathematical possibilities, and excited to contribute mathematically. At the same time, the rigor of the mathematics learnt will be examined and viewed in particular from the perspective of Big Ideas.
Overview

• Joy in Learning
• Orientation towards Learning
• The Constructive Learning Design (CLD)
• Sample CLD Task
• Conclusion
Episodic Learning
Vs
Schematic Learning
What triggers learning?
What exactly happens when learning occurs?

1. Cognitive conflict or disequilibrium
2. Accommodation and assimilation
3. Change of schema

Jean Piaget
Born: Jean William Fritz Piaget
9 August 1896
Neuchâtel, Switzerland
Died: 16 September 1980 (aged 84)
Geneva, Switzerland
“For our students to get better at **transfer**, we must help them both pay attention to the deeper structures of their learning and organize knowledge into these structures the way experts do. This means helping students build these arrangements int their brains.”

” **A shift (from subject) to disciplinary literacy** is a powerful way to figure out what is most important and how to help students see how the world is organized.”


**Disciplinary literacy** refers to the specialized ways of knowing and doing that characterize a particular field of study.

Addressing Disciplinary Connections?
What is the BIG IDEA that binds these connected concepts?

<table>
<thead>
<tr>
<th>Big idea of measure of boundary</th>
<th>Big idea of measure of space within</th>
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<tbody>
<tr>
<td>Perimeter</td>
<td>Area</td>
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<tr>
<td>Surface Area</td>
<td>Volume</td>
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</table>
How to Engage + Sustain Learning?

Entertaining vs Teaching?
Fun Vs Joy In Learning

Intensity      Motivation

Key Idea – Instilling Curiosity in Learning
An Orientation Towards Learning

Metacognitive Mindset

Growth Mindset

Strategic Mindset
Procedural vs Strategic Learning

Novelty

Transfer

Key Idea – Learning through problem solving
Elements in our class that foster Growth Mindset…?

- Multiple pathways for success – e.g. open-ended tasks
- Value for individual differences – e.g. differentiated instruction
- Emphasis on learning through experience – e.g. reflective practice
• Learning is about problem solving – learning through problem-solving tasks
• Emphasis on connections – learning is making linkages and extension of current knowledge
• Value for individual capacity to solve problem – Everyone has something to offer to the solution
Constructivist learning designs engender active, meaningful, and deep learning.
- activate students’ prior knowledge structures.
- instruction build upon these structures, through processes and metacognition to extend big ideas, to teach canonical concepts
- allow for students to see the affordances and constraints of their methods and the critical conceptual features of targeted concepts
The Constructivist Learning Design (CLD)

**Problem Solving**

- Collaborative solving of a complex, open-ended problem
- Problem that deliberately designed to target a concept that is not formally taught and to activate students’ prior knowledge.

**Instruction**

- Building on students’ solutions, examining their affordances and constraints to teach the targeted concept.
- Inclusion of practice problems and homework targeting higher-order thinking

**DESIGN NOTES**

- Students typically cannot discover the canonical concept, but are able to generate multiple solutions
- Collaboration allows for negotiation of meaning
- Teachers’ role – get students to persevere, point of constraints and limitations of students’ strategies

- Reflection and resolution of the conceptual conflict and gaps that were induced during the problem solving phase
- Affordances and constraints of each solution type is compared and contrasted with the critical features of the targeted concept
Elements in CLD that foster Growth Mindset…?

• Multiple pathways for success – e.g. open-ended tasks: CLD Tasks are open-ended tasks

• Value for individual differences – e.g. differentiated instruction: CLD Tasks are accessible to all students

• Emphasis on learning through experience – e.g. reflective practice: CLD Tasks encourages intra- and inter- comparison and contrast of solutions
Elements in CLD that foster Strategic Mindset…?

- Learning is about problem solving – learning through problem-solving tasks: In CLD, learning is situated in a problem-solving task
- Emphasis on connections – learning is making linkages and extension of current knowledge: In CLD, emphasis is on activating students’ relevant prior knowledge
- Value for individual capacity to solve problem – Everyone has something to offer to the solution: In CLD, we value the affordances and limitations of students’ solution to arrive at the canonical concept.
Sample CLD Task
On
Gradient of A Linear Graph
David enjoys hiking on a small mountain with a peak of 1200m. Figure 1 shows a sketch of David’s trail, which has 7 sections. He starts at point A, hikes through points B to G, and ends at point H. The vertical heights, the horizontal distances, and slope lengths (rounded to the nearest 10m) of each section are also indicated in the figure.

David notices that some sections are steeper compared to others. He seeks your group’s help to describe both the steepness and direction of the mountain’s slopes mathematically. Here is what you must do:

(i) Assuming that all other things are equal, please use the information provided in Figure 1 and come up with as many ways as possible to rank the various sections of the trail both in terms of their steepness and the direction.

(ii) For each way of ranking in (1), justify your ranking mathematically to describe both the steepness and direction of different sections.
What is the BIG IDEA in teaching gradient?

To measure or quantify both steepness and direction of a slope.
What is the BIG IDEA that binds these connected concepts?

<table>
<thead>
<tr>
<th>Big idea of measure of</th>
<th>2-Dimension</th>
<th>3-Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>boundary</td>
<td>Perimeter</td>
<td>Surface Area</td>
</tr>
<tr>
<td>space within</td>
<td>Area</td>
<td>Volume</td>
</tr>
<tr>
<td>slope</td>
<td>Gradient of a straight line</td>
<td>Others?</td>
</tr>
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Conclusion
“I am enough of an artist to draw freely upon my imagination. Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world.”

— Albert Einstein

“Logic will get you from A to Z; imagination will get you everywhere.”

— Albert Einstein

“Imagination does not become great until human beings, given the courage and the strength, use it to create.”

— Maria Montessori
Equip our students with the relevant orientation & Skills

So that they can derive joy from learning... giving them wings to their imagination.
Some considerations ...

• Teacher Capacity – supplementing our practices, not displacing our good practices, with those we may not employ as often or as comfortable → skills and knowledge. NLC?
  (Mathematics Master Teachers are leading the CLD NLC.)

• Resources – examples and not a buffet table; our students are unique and special → adaptation and not mere adoption. Validated Examples?
  (You may download a copy of the CLD e-book containing some sample tasks at https://ebook.ntu.edu.sg/constructivist-learning-design/full-view.html:
Establish our classrooms as a place where students can derive joy in mathematics learning by helping them to *develop a metacognitive mindset* – *Growth and Strategic Mindsets*. This will help to *nurture* them into not just knowledgeable but also *knowledge-able citizens of the 21st centuries* whose *disposition towards problems is “I can and there is a way”* as they become *both effective and efficient consumers and creators of mathematics*. 
thank you