'Learning by Doing' in P5 Shape and Space

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Activities in Math Lessons

How to make the activities interesting?

How to engage students in the activities?

How to ensure that students learn Mathematics?

Learning by Doing

- The idea of ‘Learning by Doing’ was introduced by a learner-centered educator Dewey (1938).

- active doing is a necessity of learning;
- doing alone is not sufficient;
- reflection upon experience is required in order to solidify knowledge.

- Bruce and Bloch (2012) suggest the f**eatures** of ‘learning by doing’

- learn by doing; draw meaning; understand from these experiences;
- allow students to engage in their learning;
- through direct experience with objects and phenomena, students can build functional understanding and develop inquire ability.

Dewey, J. (1938). *Logic: A theory of inquiry*. New York: Henry Holt.

Bruce B.C., Bloch N. (2012) Learning by Doing. In: Seel N.M. (eds) *Encyclopedia of the Sciences of Learning* (pp.1821-1824). Springer, Boston, MA

Learning by Doing in Classrooms

- In a classroom context, learning-by-doing can be seen as solving problems through hands-on or inductive approaches.
- Pedagogically, teachers try to engage learners in more hands-on, creative modes of learning.
- Students can further use those experiences in which they actively engage to make things and explore the world.

First example – P5 Area of Triangles

Task 1

Observing the relationship between area of triangles and area of parallelograms.

A. Using the same base but different height, find the area of parallelogram and triangle in the following table.

Base (cm)	Height (cm)	Area of parallelogram	Area of triangle
10	2		
10	3		
10	4		
10	5		
10	6		

From observation, the area of triangle is ___________ of the area of parallelogram that with the same base and height.

First example – P5 Area of Triangles

Task 2

Verifying the conjecture with the GeoGebra applet.

B. Estimate the area of triangle in the following table.

Base (cm)	Height (cm)	Estimate Area of triangle	Area of triangle
8	2		
8	3		
8	4		
8	5		

First example – P5 Area of Triangles

Task 3

Using paper manipulatives to verify the conjecture and to explain why the formula holds.

C. Hypothesis "the area of triangle is ______________________________.

Triangle A is (equal to / not equal to) Triangle B.

Triangle C is (equal to / not equal to) Triangle D.

A parallelogram can be cut into ________ identical triangles.

The area of triangle is ________ of the area of parallelogram with the same base and height.

The area of parallelogram is **Base × Height. (Mathematical expression)**

So, the area of the triangle is ___________________________________. (Mathematical expression)

Lesson episodes

A. Using the same base but different height, find the area of parallelogram and triangle in the following table.

Base (cm)	Height (cm)	Area of parallelogram	Area of triangle
10	2	20	10
10	3	30	15
10	4	40	20
10	5	50	25
10	6	60	30

From observation, the area of triangle is ~~30~~ half of the area of parallelogram that with the same base and height.

B. Estimate the area of triangle in the following table.

Base (cm)	Height (cm)	Estimate Area of triangle	Area of triangle
8	2	8	8 ✓
8	3	24	12 ✗
8	4	2~~4~~ (16 ✓	16 ✓
8	5	32 ✗ (30 ✓	30 ✓

Lesson Episodes

Video 1

Students exploring (15s)

Lesson Episodes

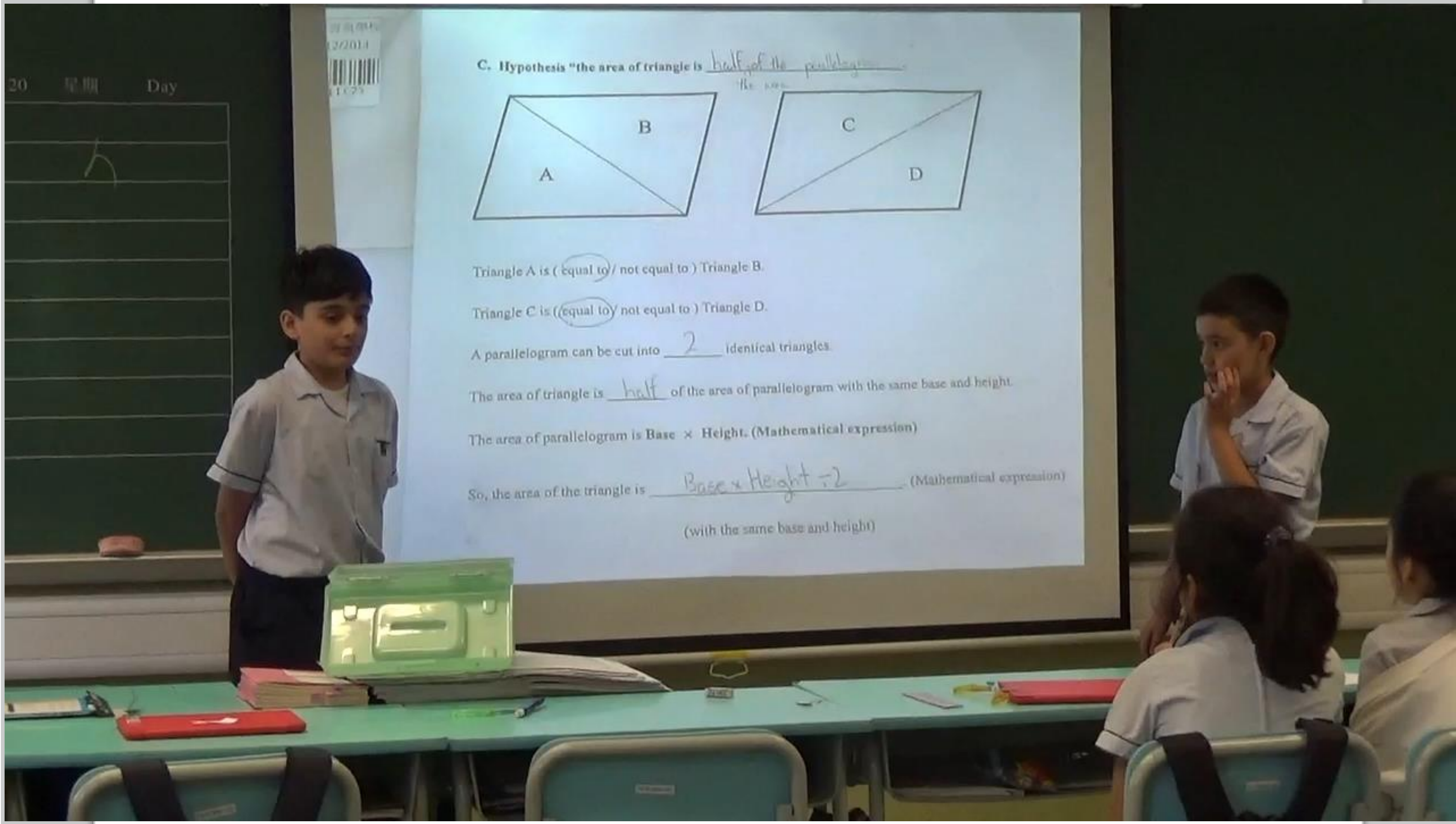
Video 2

Students collaborating (21s)

Lesson Episodes

Video 3

Students presenting in front of the class (50s)



Design of the tasks

Learning objective: Understand the formula of the area of a triangle

- **Task 1**

- From prior knowledge to new knowledge
- Very easy task
- Room to discover the pattern

- **Task 2**

- Guess the answer from what they learnt in task 1
- Use GeoGebra applet to check the conjecture and confirm the results in task 1

Design of the tasks

- **Task 3**

- Use physical tools to explain why the result in task 2 is correct.

- Conclusion: Students derived the formula of the area of a triangle in an inductive way from different perspectives.

Classroom Arrangement

- Pair-work
- Each student had an iPad
- A pair of students worked on the same set of worksheet.
- Students reported the results before moving on to the next task. Teacher served as a facilitator to lead the teacher-student discussion.
- Time was reserved for student presentation of their results.

Good practice in the lesson

Tool – GeoGebra Applet - A tool for exploration and a tool for self-assessment

Talk – student collaboration, teacher-student discussion, student presentation

Task – inductive tasks from easy to difficult; room for exploration and conjecturing, tools (GeoGebra applet and paper manipulatives) to verify the conjecture and explain the reason behind

'Learning by Doing'- Students learnt from exploring and verifying by themselves.

Second Example – Different Nets of a Cube

- Learning objective: recognize that the 1-4-1 pattern of a hexomino (六連形) can be folded into a cube; recognize that the 'Break-and-Turn' rule can give a 1-4-1 pattern to another net of a cube
- Background: There are 11 different nets of a cube. From teachers' experience, students could not recall all the 11 different nets of a cube as they usually memorized these nets. Teachers from HKTAWTS introduced the term 'Break-and-Turn' rule.

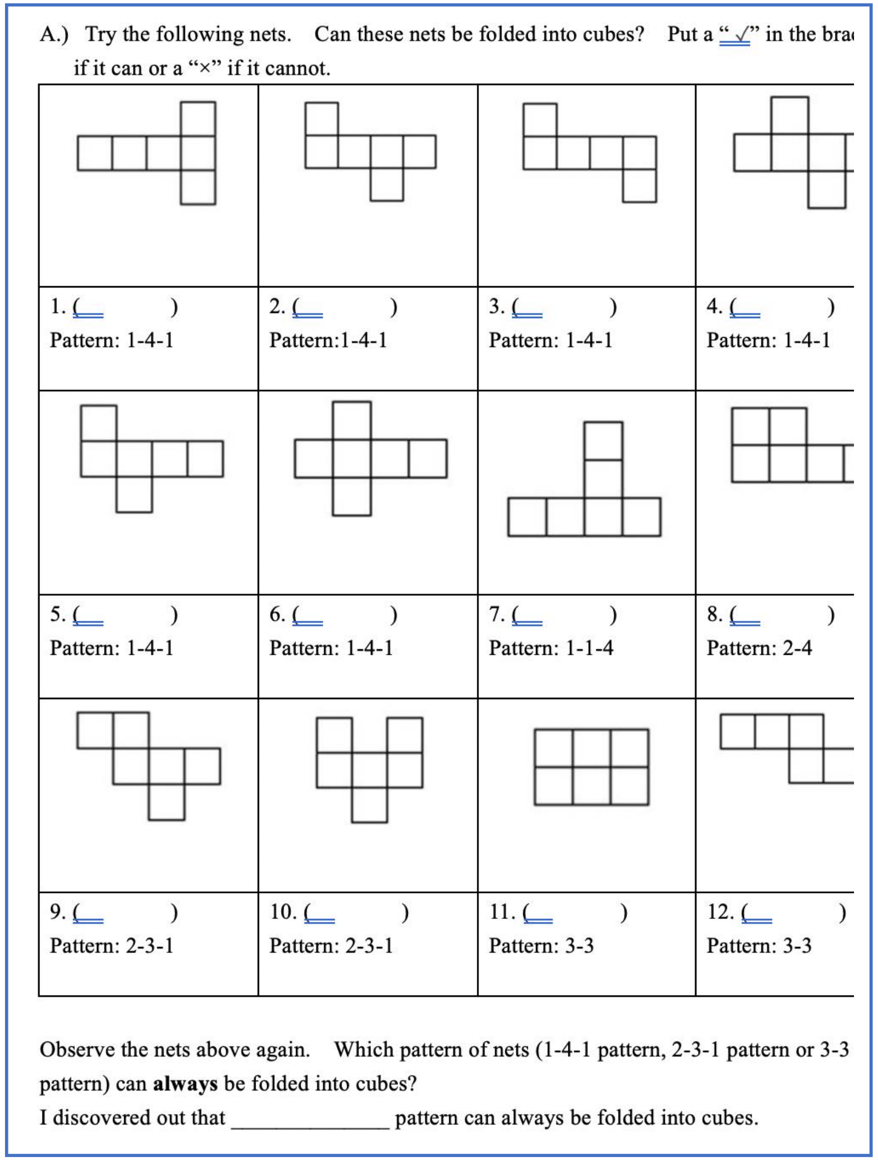
‘Break-and-Turn’ rule

Second Example – Different Nets of a Cube

- **Task 1**

Check whether a hexomino can be folded into a cube

Discover that a net in 1-4-1 pattern can be folded into a cube.



A.) Try the following nets. Can these nets be folded into cubes? Put a "√" in the bra
if it can or a "×" if it cannot.

1. ( ) Pattern: 1-4-1	2. ( ) Pattern:1-4-1	3. ( ) Pattern: 1-4-1	4. ( ) Pattern: 1-4-1
5. ( ) Pattern: 1-4-1	6. ( ) Pattern: 1-4-1	7. ( ) Pattern: 1-1-4	8. ( ) Pattern: 2-4
9. ( ) Pattern: 2-3-1	10. ( ) Pattern: 2-3-1	11. ( ) Pattern: 3-3	12. ( ) Pattern: 3-3

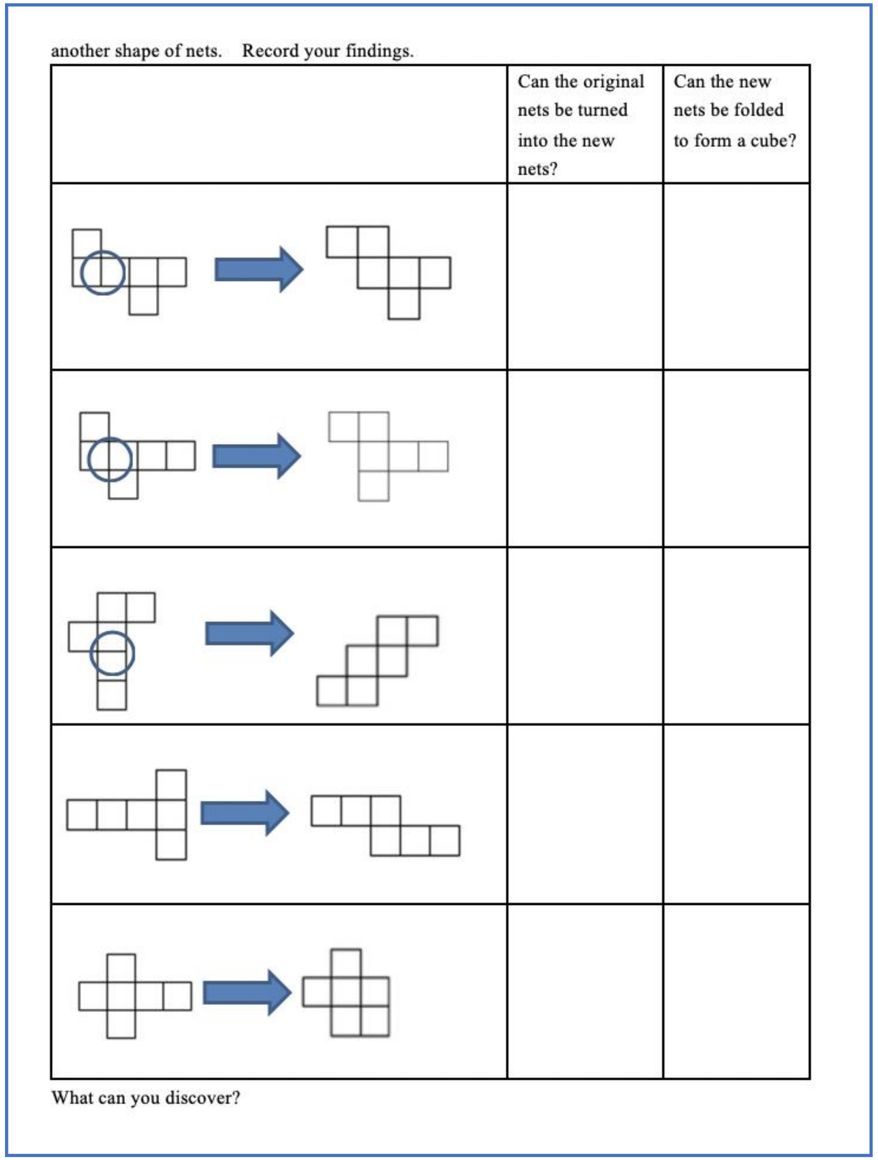
Observe the nets above again. Which pattern of nets (1-4-1 pattern, 2-3-1 pattern or 3-3 pattern) can **always** be folded into cubes?

I discovered out that _____________ pattern can always be folded into cubes.

Second Example – Different Nets of a Cube

- **Task 2**

Starting with a net in 1-4-1 pattern, form another net with the ‘Break-and-Turn’ rule.


another shape of nets. Record your findings.

	Can the original nets be turned into the new nets?	Can the new nets be folded to form a cube?

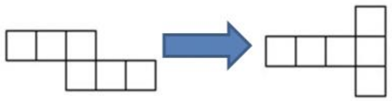
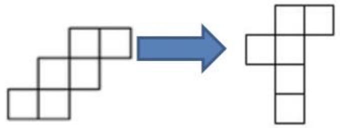
What can you discover?

Second Example – Different Nets of a Cube

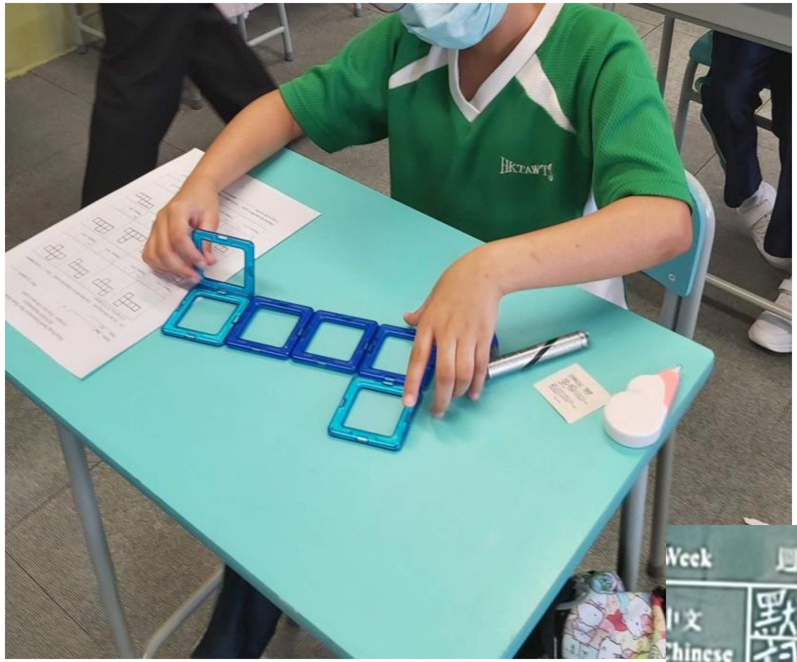
- **Task 3**

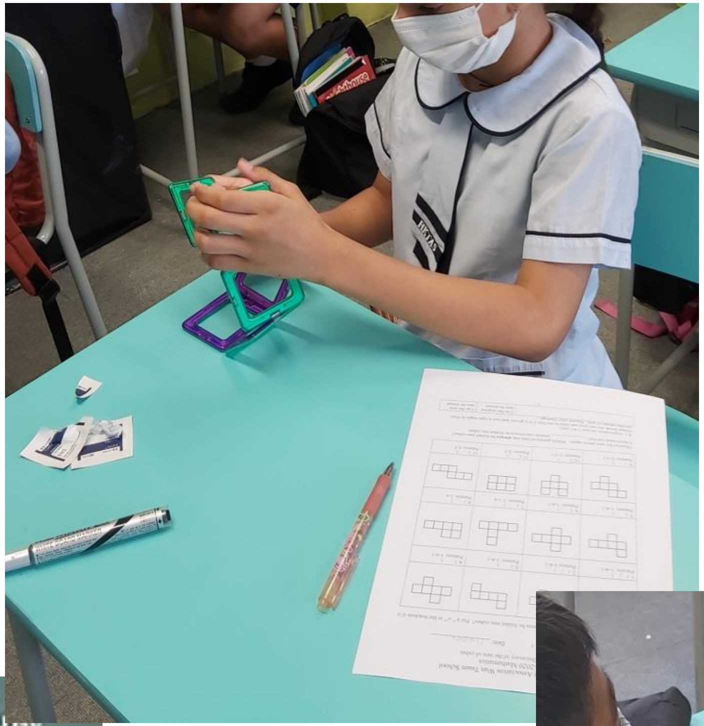
Check if nets in non-1-4-1 pattern can be turned to form nets in 1-4-1 pattern.

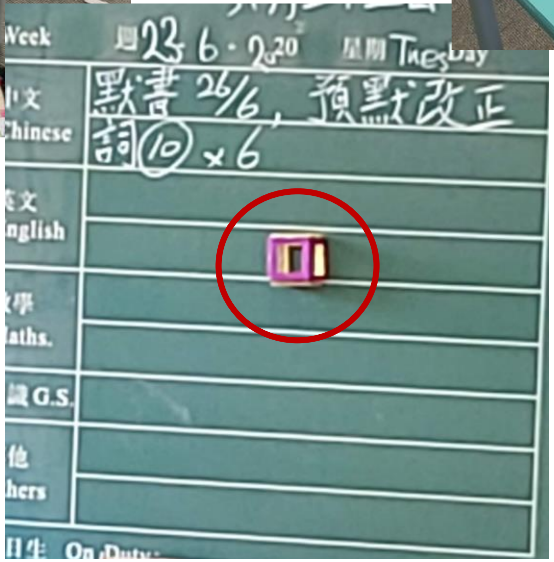
Please break the net (you can refer to the hint if it is given) and turn a right angle to form a net of the 1-4-1 pattern. Record your findings.

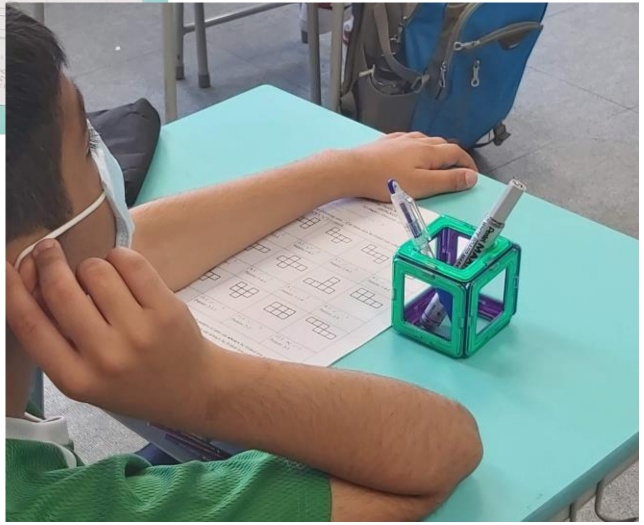
	Can the original nets be turned into the new nets?	Can the new nets be turned into the cubes?
		
		
		
		
		

Lesson Episodes





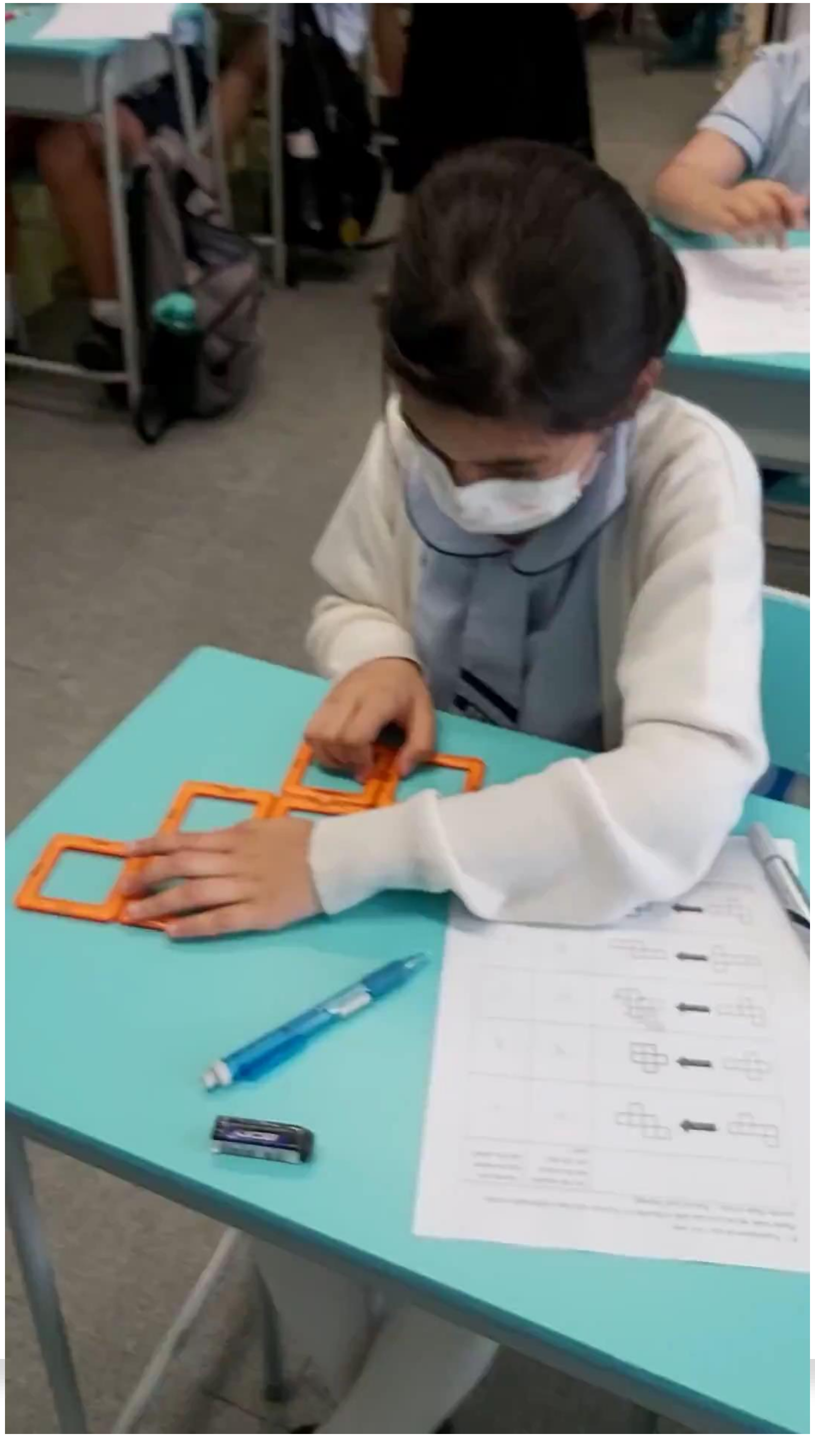




Lesson Episodes

Video 4

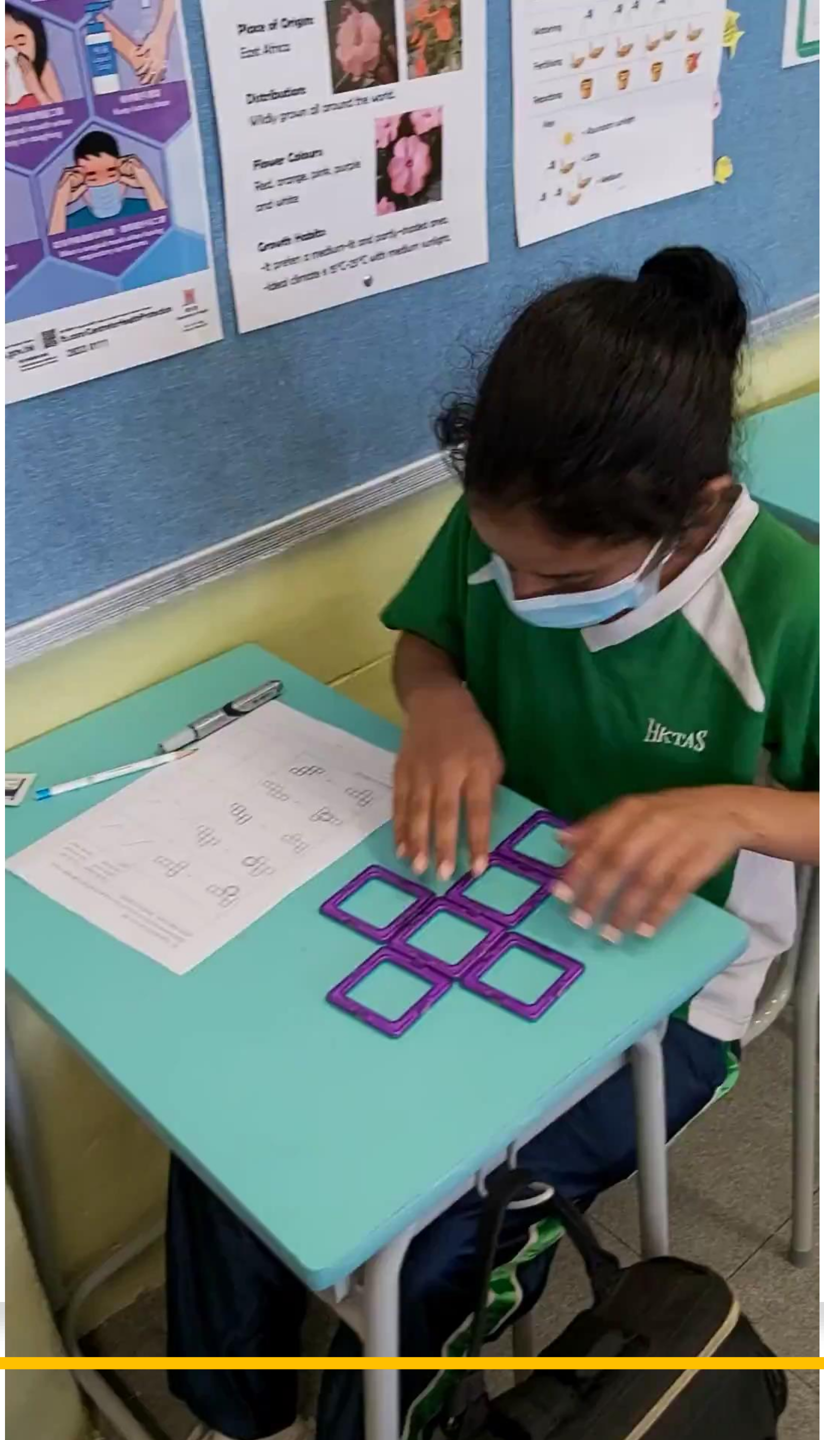
Student was verifying whether a hexomino can be folded into a cube.



Lesson Episodes

Video 5

Student was trying the 'Break-and-Turn' rule.



Design of the Task

Task 1

- Hands-on activity with magnetic plates and students can work on it instead of memorizing the result in their textbook.
- Different examples lead to the observation that all 1-4-1 patterns of hexomino can be folded into a cube.

Design of the Task

Task 2

- Try out the ‘Break-and-Turn’ rule
- Confirm that the nets formed by the 1-4-1 pattern with the ‘Break-and-Turn’ rule can be folded to form a cube.

Design of the Task

Task 3

- Use the ‘Break-and-Turn’ rule to change the net of a cube from a non-1-4-1 pattern to a 1-4-1 pattern
- Confirm that once a hexomino can be turned into a net in 1-4-1 pattern, the original net can be folded into a cube.

Classroom Arrangement

- Because of the pandemic situation, students should minimize their interaction with peers. The tasks were designed for individual exploration.
- It would even be better if the activities are conducted in pairs or in groups.
- Each student had a set of 6 magnetic plates to explore.

Teachers’ good practices

- Clear explanation and instruction before allowing students to work on the tasks.
- Allow students to explain their results.
- Confirm the learning objective of a task with students *before* moving on to the next task.
- In the planning, teachers tried it out on their own to ensure smooth implementation.
- Different questioning techniques were used in teacher-led discussion, e.g. ‘Explain why’, ‘Re-voice’, ‘Press for reasoning’, etc.

What students say about games and activities in math lessons?

General consideration in using games and activities in class

- Good task design
- Choosing suitable tools (most preferably, students can own their tools)
- Giving clear instructions to students / demonstrating in the front of the class
- Allowing time for students to get used to the tools
- Allowing room for exploration (teachers do not need to give too much explanation when students are working on the task)
- Allowing student talk – among peers, presentation, teacher-led discussion

Implications on task design

- It would be better if there are no more than two learning objectives in the lesson.
- Simple and similar exercises with slight variation.
- Exercises lead to mathematical concepts.
- With the aid of the given tool, students can complete the exercises on their own.
- The questions in the same section can easily lead to the observation of a general pattern.

Choosing Tools

- Easy to manipulate
- Instructions on how to use the tool is a must
- Facilitate self-exploration
- Help to verify one's work or conjecture
- Choose suitable tools for students to play with

Promoting Student Talk

- Features of NCS students (Eager to share; don't like exercise, enjoy fun activities)

- Suggestions for teachers

- Allow students to work in pairs or in groups
- Invite students to explain their ideas in front of the class
- Allocate class time for group presentation and/or teacher-student discussion, which facilitates 'Assessment for Learning'

Learning outcomes

Activities First leads to other 3 ‘A’s.

- Agency – Learner agency was evident in the lesson. 100% students stayed on task for the whole lesson.
- Assessment – ‘Assessment as Learning’ (作為學習的評估) was also evident in the lesson. There were some cases that students got the wrong answer in the first trial, but they corrected it after trying it out again.
- Achievement – Self-belief, enjoyment, intrinsic motivation to learn.

Learning by Doing in Mathematics Classrooms

Problems (driven by learning objectives) →

Suitable tools →

Inquiry →

Learning mathematical concepts →

Creating something on students' own

It turns out that the tools can become a self-assessment tool. It would be desirable if students own the tools. They can start creating their own knowledge.

Learning by Doing in Mathematics Classrooms

- Facilitate an inductive way of learning
- Promote learner agency
- Help student in exploration and self-assessment

The End

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