Mathematical Knowledge for Teaching with Technology

+

6th Grade School

Lecture 4 – 04/10/2024 – part two

Technology in Mathematics Education

Learning outcome format

WHICH VERBS?

Bloom's taxonomy (1956)

KNOWLEDGE

List | Define
Recall | Arrange
State | Order
Label | Repeat
Memorize
Name | Select
Record

COMPREHENSION

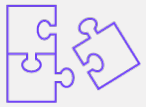
Translate
Paraphrase
Discuss | Report
Locate | Explain
Restate | Describe
Express | Identify
Generalize
Recognize | Classify
Summarize

APPLICATION

Operate | Apply
Use | Solve
Demonstrate
Prepare | Choose
Show | Sketch
Employ | Practice
Dramatize
Interpret
Illustrate
Produce
Schedule

ANALYSIS

Analyze | Question
Differentiate
Experiment
Examine | Test
Categorize
Distinguish
Calculate | Inspect
Contrast | Outline
Infer | Compare
Discriminate
Appraise | Criticize
Diagram | Debate
Inventory | Relate



SYNTHESIS

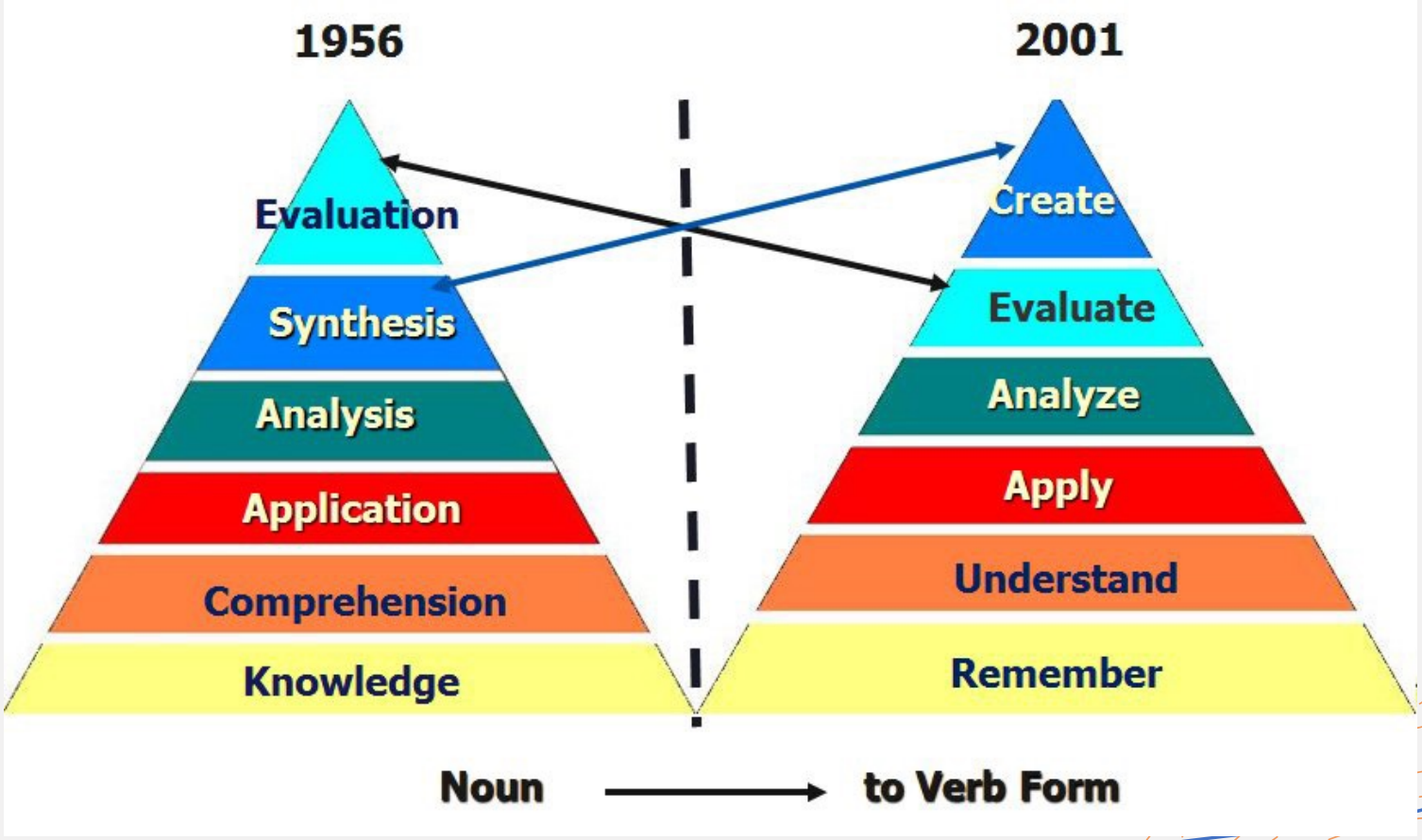
Create | Compose
Argue | Design
Plan | Support
Arrange | Collect
Revise
Formulate
Propose
Construct
Set up
Organize
Manage
Prepare
Assemble
Rearrange
Develop

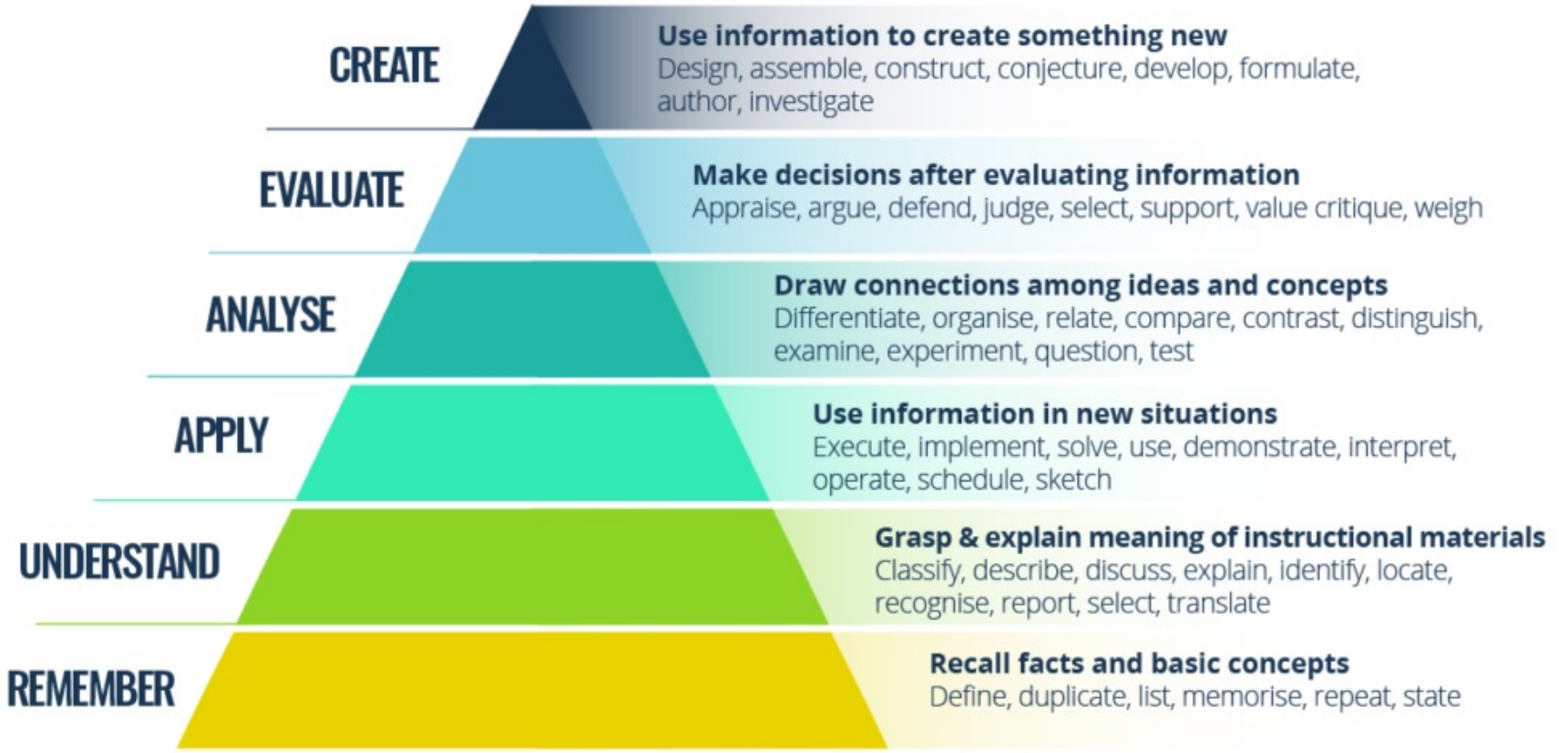
EVALUATION

Rate | Evaluate
Assess | Judge
Value | Revise
Justify
Recommend
Conclude
Defend
Interpret
Predict
Estimate
Appraise
Compare
Score
Select
Choose
Measure

LOWER ORDER THINKING SKILLS → **HIGHER ORDER THINKING SKILLS**

Bloom's taxonomy revised (2001)




CREATE
Use information to create something new
Design, assemble, construct, conjecture, develop, formulate, author, investigate
EVALUATE
Make decisions after evaluating information
Appraise, argue, defend, judge, select, support, value critique, weigh
ANALYSE
Draw connections among ideas and concepts
Differentiate, organise, relate, compare, contrast, distinguish, examine, experiment, question, test
APPLY
Use information in new situations
Execute, implement, solve, use, demonstrate, interpret, operate, schedule, sketch
UNDERSTAND
Grasp & explain meaning of instructional materials
Classify, describe, discuss, explain, identify, locate, recognise, report, select, translate
REMEMBER
Recall facts and basic concepts
Define, duplicate, list, memorise, repeat, state

The Knowledge Dimension

(Bloom's Revised Taxonomy)

Factual Knowledge

The basic elements that students must know to be acquainted with a discipline or solve problems in it.

- Knowledge of **terminology**
- Knowledge of specific **details** and **elements**

Conceptual Knowledge

The interrelationships among the basic elements within a larger structure that enable them to function together.

- Knowledge of **classifications** and **categories**
- Knowledge of **principles** and **generalizations**
- Knowledge of **theories**, **models** and **structures**

Conceptual Mathematics

Procedural Mathematics

Procedural Knowledge

How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods.

- Knowledge of subject-specific **skills** and **algorithms**
- Knowledge of subject specific **techniques** and **methods**
- Knowledge of **criteria** for determining when to use appropriate **procedures**

Metacognitive Knowledge

Knowledge of cognition in general as well as awareness and knowledge of one's own cognition.

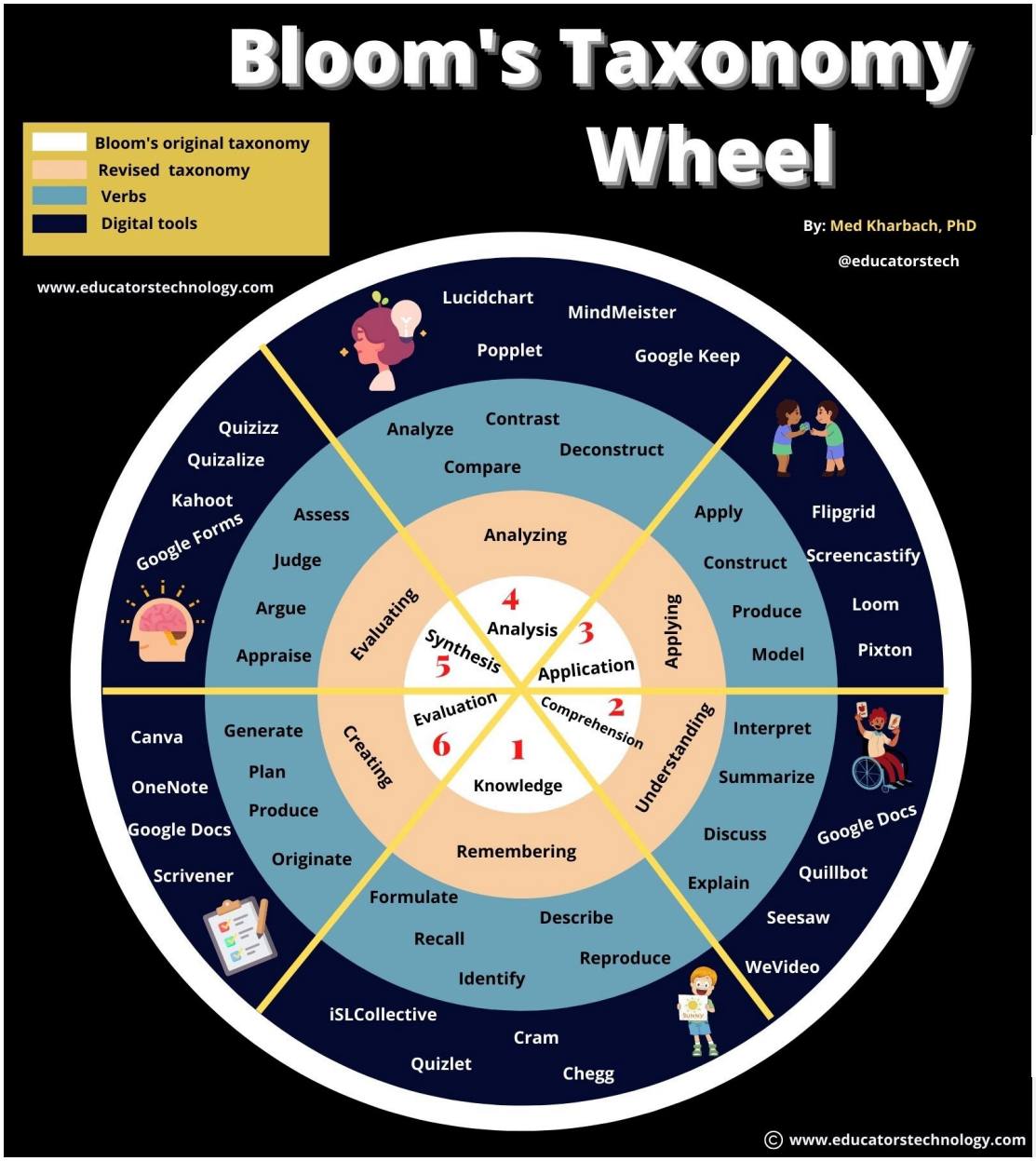
- **Strategic knowledge**
- **Knowledge about cognitive tasks**, including appropriate contextual and conditional knowledge
- **Self-knowledge**

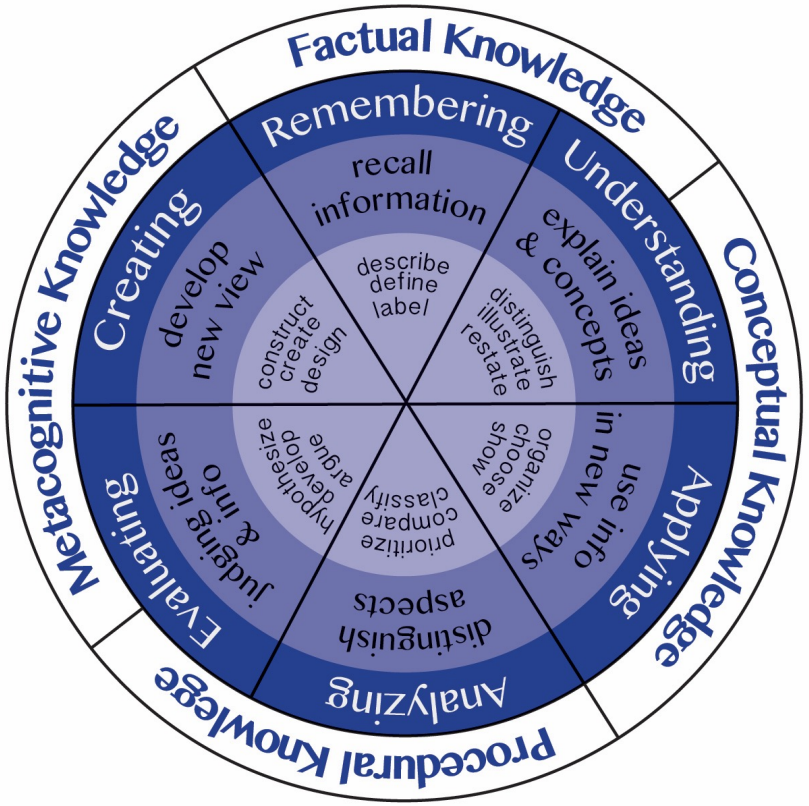
the kind of knowledge to be learned

Bloom's taxonomy revised towards the knowledge dimension (2002) - example

Cognitive Process Dimension ↓ / Knowledge Dimension →	**FACTUAL** The basic elements a student must know to be acquainted with a discipline or solve problems in it.	**CONCEPTUAL** The interrelationships among the basic elements within a larger structure that enable them to function together.	**PROCEDURAL** How to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods.	**METACOGNITIVE** Knowledge of cognition in general as well as awareness and knowledge of one's own cognition
REMEMBER Retrieve relevant knowledge from long-term memory.	**List** primary and secondary colors	**Recognize** the symptoms of exhaustion	**Recall** how to perform CPR.	**Identify** strategies for retaining information.
UNDERSTAND Construct meaning from instructional messages, including oral, written, and graphic communication.	**Summarize** the features of a new product	**Classify** adhesive by toxicity	**Clarify** assembly instructions	**Predict** one's response to culture shock
APPLY Carry out or use a procedure in each situation.	**Respond** to frequently asked questions	**Provide** advice to novice	**Carry out** pH tests of water sample	**Use** techniques that math one's strength
ANALYZE Carry out or use a procedure in each situation	**Select** the most compels list of activities	**Differentiate** between writing registers	**Integrate** compliance with regulations	**Deconstruct** one's biases
EVALUATE Make judgments based on criteria and standards.	**Check** for consistently among sources	**Determine** relevance of results	**Judge** efficiency of sampling technique	**Reflect** on one's progress
CREATE Put elements together to form a coherent whole; reorganize into a new pattern or structure.	**Generate** a log of daily activities	**Assemble** a team of experts	**Design** efficient project workflow	**Create** a learning portfolio

Note: These are **learning objectives** – not **learning activities**. It may be useful to think of preceding each objective with something like, "students will be able to…:


Bloom's Taxonomy Wheel
Bloom's original taxonomy
Revised taxonomy
Verbs
Digital tools
By: Med Kharbach, PhD
@educatorstech
www.educatorstechnology.com
Lucidchart
MindMeister
Popplet
Google Keep
Analyze
Contrast
Deconstruct
Compare
Quizizz
Quizalize
Kahoot
Google Forms
Assess
Judge
Argue
Appraise
Analyzing
Evaluating
Synthesis
5
4
Analysis
3
Application
Applying
Evaluation
6
Creating
1
Knowledge
2
Comprehension
Understanding
Apply
Construct
Produce
Model
Flipgrid
Screencastify
Loom
Pixton
Canva
OneNote
Google Docs
Scrivener
Generate
Plan
Produce
Originate
Remembering
Formulate
Recall
Identify
Describe
Reproduce
Interpret
Summarize
Discuss
Explain
Google Docs
Quillbot
Seesaw
WeVideo
iSLCollective
Cram
Quizlet
Chegg
© www.educatorstechnology.com


Factual Knowledge
Conceptual Knowledge
Procedural Knowledge
Metacognitive Knowledge
Remembering
recall information
describe define label
Understanding
explain ideas & concepts
distinguish illustrate restate
Applying
use info in new ways
organize show choose
Analyzing
distinguish aspects
prioritize compare classify
Evaluating
judging ideas & info
hypothesize develop argue
Creating
develop new view
construct create design

https://connectedtot.com/2020/07/08/lesson-planning-using-blooms-taxonomy-for-math/

Applying Bloom's Taxonomy in Mathematics		
Creating	Putting together ideas or elements to develop an original idea or engage in creative thinking.	• Designing • Constructing • Planning • Producing • Inventing • Devising • Making
Evaluating	Judging the value of ideas, materials and methods by developing and applying standards and criteria.	• Checking • Hypothesizing • Experimenting • Judging • Testing • Detecting • Monitoring
Analysing	Breaking information into its component elements to explore relationships.	• Comparing • Organizing • Deconstructing • Attributing • Outlining • Structuring • Integrating
Applying	Using strategies, concepts, principles and theories in new situations.	• Implementing • Carrying out • Using, Executing
Understanding	Understanding of given information.	• Interpreting • Exemplifying • Summarizing • Inferring • Paraphrasing • Classifying • Comparing • Explaining
Remembering	Recall or recognition of specific information.	• Recognizing • Listing • Describing • Identifying • Retrieving • Naming • Locating • Finding

+ How can technology support and promote thinking mathematically?

Main Goal:
Developing Students' Mathematical thinking

Mathematical thinking gives attention to the processes rather than content, although both are important for learning mathematics, and both are typically represented in school mathematics curricula, specially referred to as problem-solving.

TWO FONDAMENTAL PROCESSES:

1	• specialising • generalising
2	• conjecturing • convincing

Cognitive technologies for Mathematical Education

Purpose functions

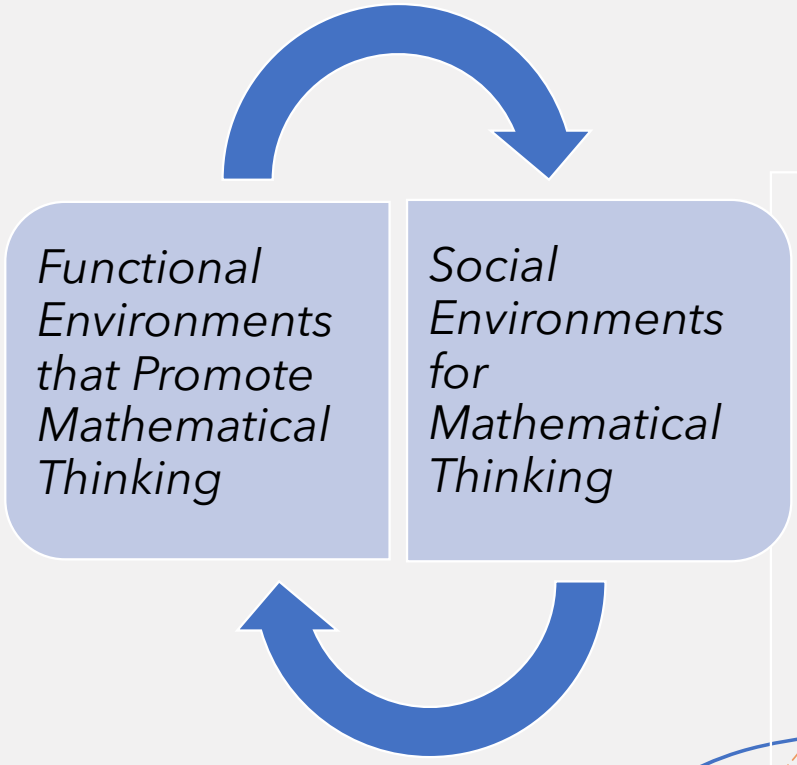
Process functions

(Pea, 1987)

Purpose functions

Promoting the formation of pro-mathematics belief systems in students and thus ensure that students become mathematical thinkers who participate in and own what is learned. Students benefiting from purpose functions are no longer mere storage bins for or executors of "someone else's math. (according to Dewey's and Piaget's theories)

- *Ownership*
- *Self-worth*
- *Knowledge for action*



(Pea, 1987)

Process functions

Helping students understand and use the different mental activities involved in mathematical thinking. Process Functions that can be clearly identified for cognitive technologies in math education. Each provides important cognitive support:

- tools for developing conceptual fluency
- tools for mathematical exploration
- tools for integrating different mathematical representations
- tools for learning how to learn
- tools for learning problem-solving methods.

(Pea, 1987)

Tools for developing conceptual fluency

Fluency tools are programs that free up the component problem-solving *processes* by helping students become more fluent in performing routine mathematical tasks that could be laborious and counterproductive to mathematical thinking. Computer technologies can promote fluency by allowing individually controlled practice on routine tasks, thus freeing students' mental resources for problem-solving.

Tools for mathematical exploration

Learning by Discovery

The computational discovery learning environment provides a rich context that helps students broaden their intuition.

Tools for integrating different mathematical representations

These tools help students develop the languages of mathematical thought by linking different representations of mathematical concepts, relationships, and processes.
Their goal is to help students understand the precise relationships between different ways of representing mathematical problems and the way in which changes in one representation entail changes in others. The languages of mathematical thought, which become apparent in these different representations

Tools for learning how to learn

This category refers to software programs that promote reflective learning by doing. They start with the details of specific problem-solving experiences and allow students to consolidate what they have learned in episodes of mathematical thinking.

Tools for learning problem-solving methods

This category of tools encourages *reasoning strategies* for mathematical problem-solving.

Tool: Mathigon - Polypad

https://mathigon.org/polypad

Tool's exploration

Curriculum interrogation

Activity planning