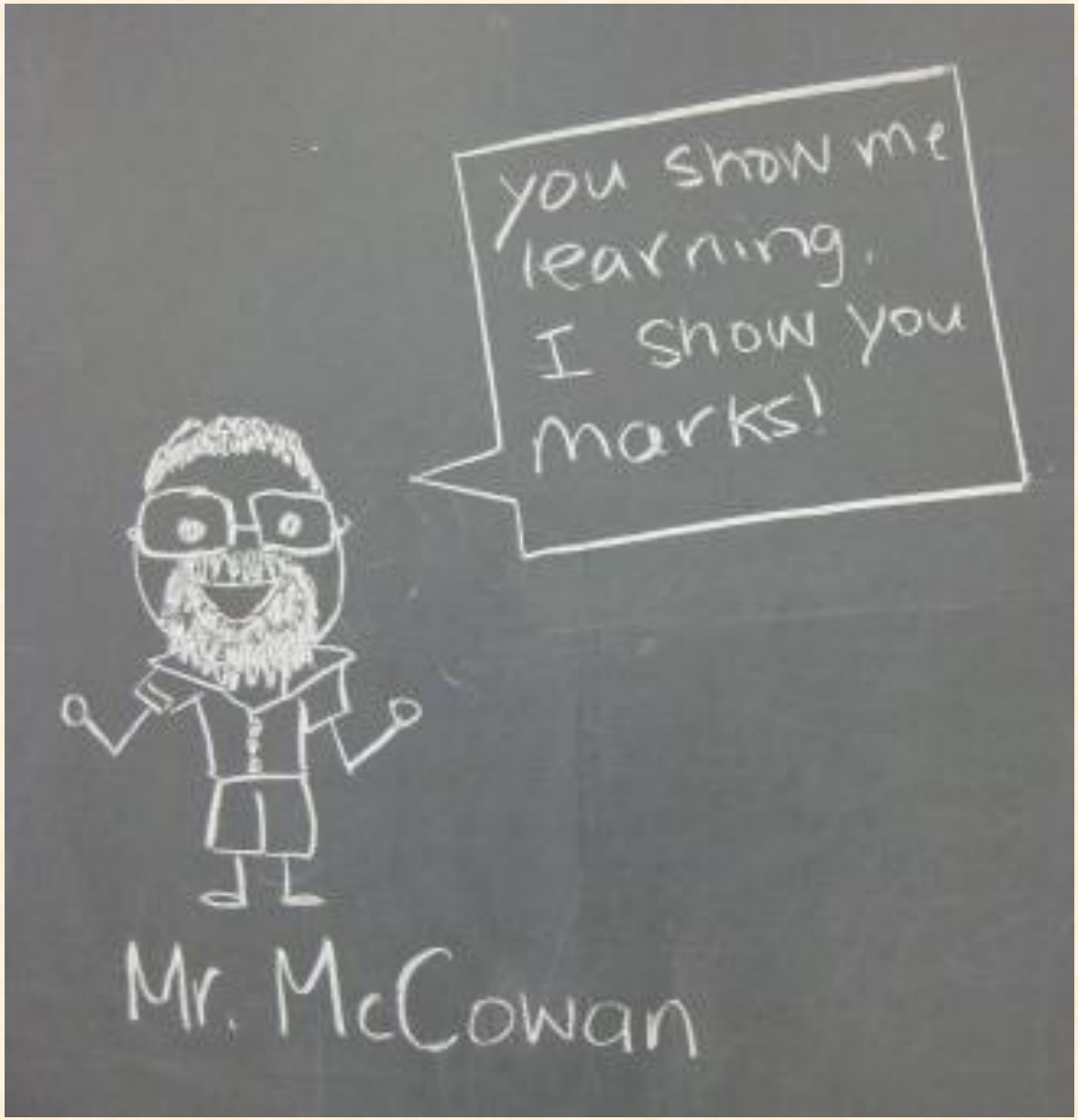
Introduction to Problem Solving

Supplement #1 to *The Scots of Scarborough* V1, #1

By D. B. McCowan, P. Eng., OCT

www.mccowan.org/DBMcCowanPapers.htm

- Technological Design Teacher, SATEC@W.A. Porter CI, TDSB
- Member, Professional Engineers Ontario (PEO)
- Chair, PEO Engineering Education Conference, 2008 (*What Students Want to Learn*) and 2009 (*Outreach Through Partnerships*)
- Chair, PEO Education Committee, 2010 to 2012
- Author, *Thinking Skills for Innovation and Problem-Solving*, Canadian Young Scientist Journal, 3.2011

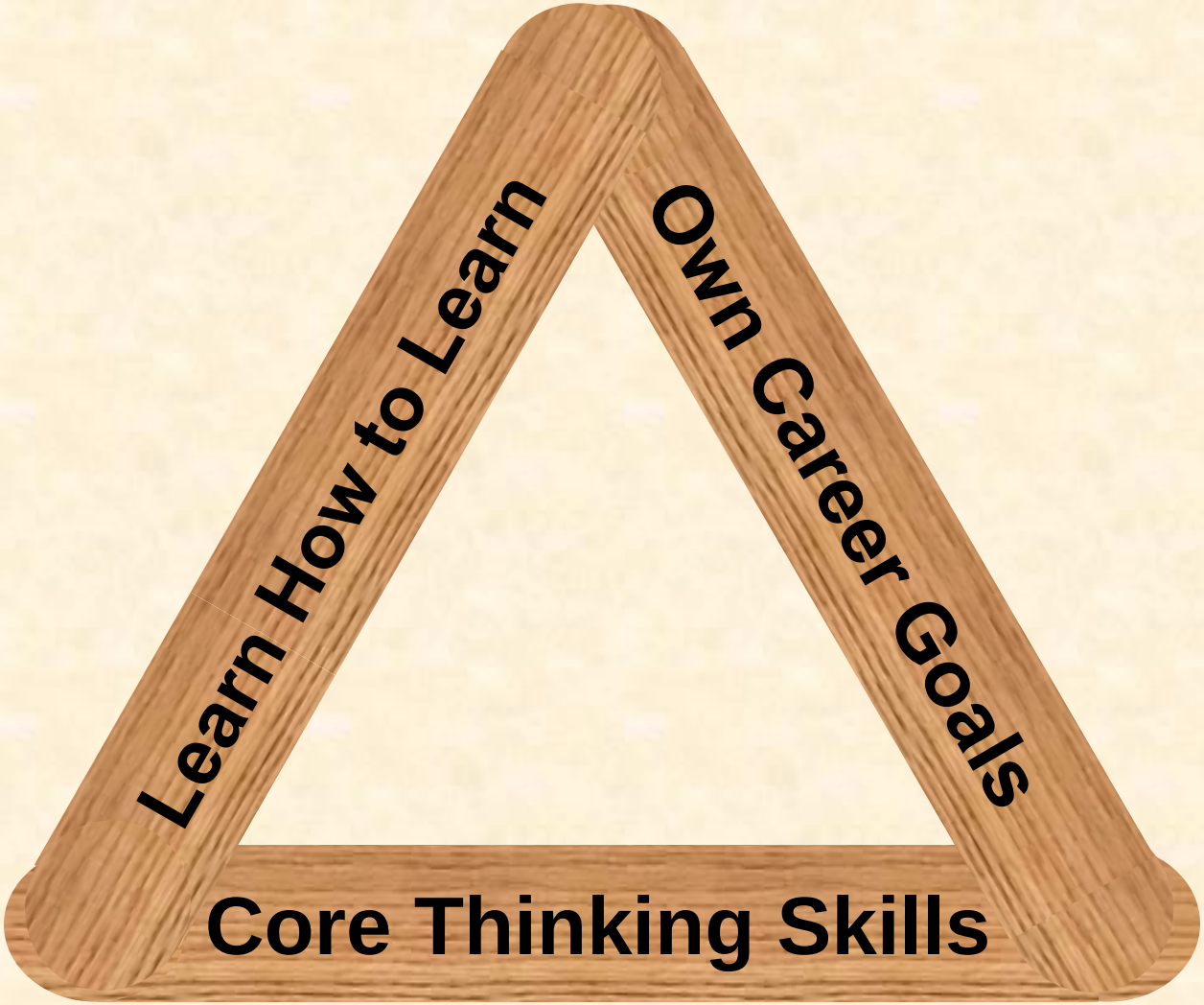

you show me learning. I show you marks!
Mr. McCowan

The Big Goals of Education

- To prepare students to do their part in making the world a better place… by helping the students become:
  - Good problem-solvers
  - Ethical opportunity-builders
  - Honest and caring citizens
  - Determined advocates of self and society
  - Dedicated lifelong learners
- *With this in mind, how do we guide students…*

Fundamental Building Blocks

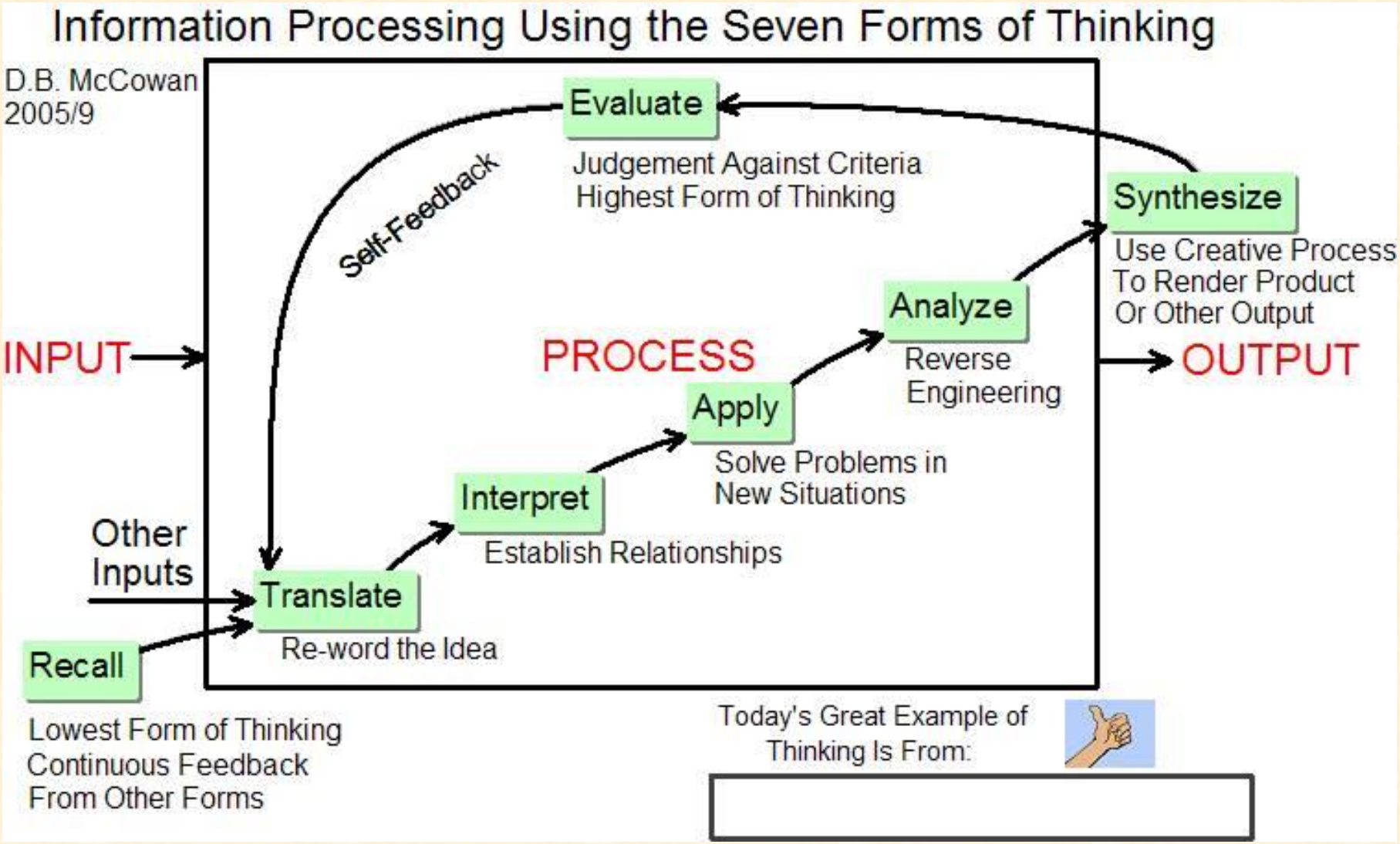
A Strategic Framework for Lifelong Learning



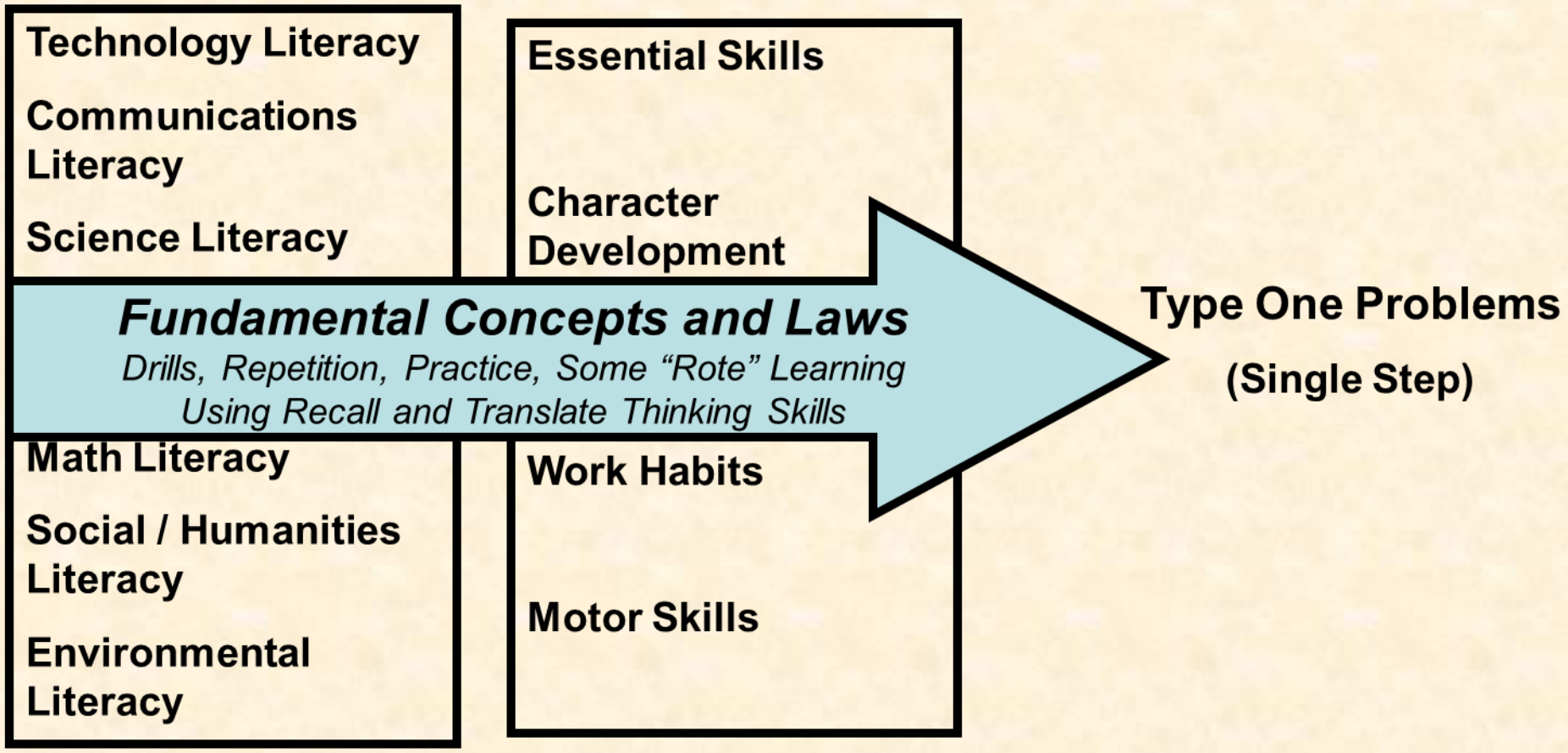
A Strategic Framework

1. *Lifelong Learning* should be the principle goal in secondary school classrooms
2. The *personal career goals* of the student, set in the context of essential skills and work habits and the course's fundamental concepts, should be a constant and major factor in the classroom
3. Make learning easier by focusing students on "***how to learn***" – the process of learning
4. Seven core thinking skills, based on Bloom's Taxonomy, should be explicitly taught and practiced in class in the context of progressively more complex problem-solving learning activities

Seven Core Thinking Skills



Fundamental Concepts and Laws

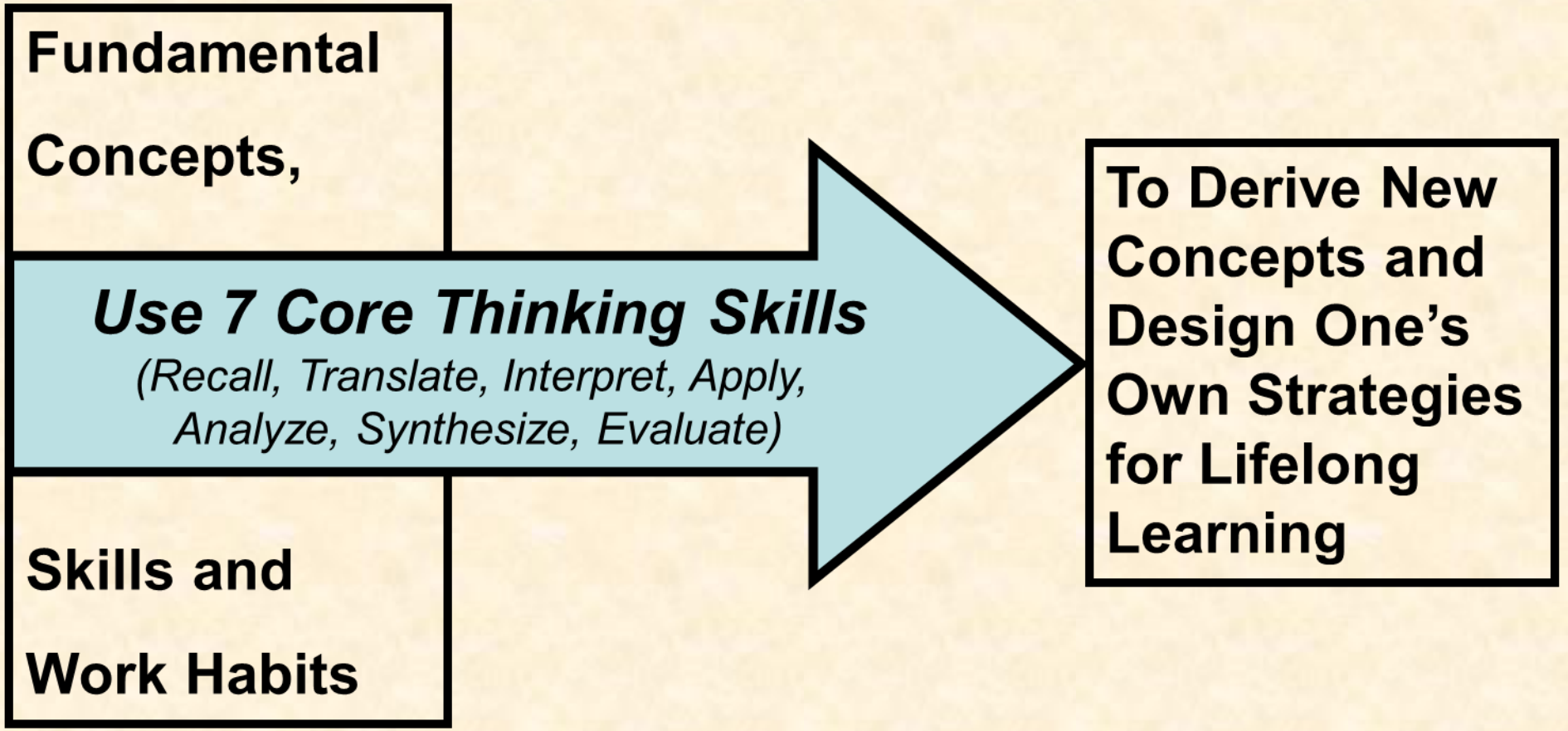


Old-Style "Subject Matter" – The Old "What to Learn"

"How to Learn" is much more important

Practice Simple Problem-Solving

The Goal – Lifelong Learning

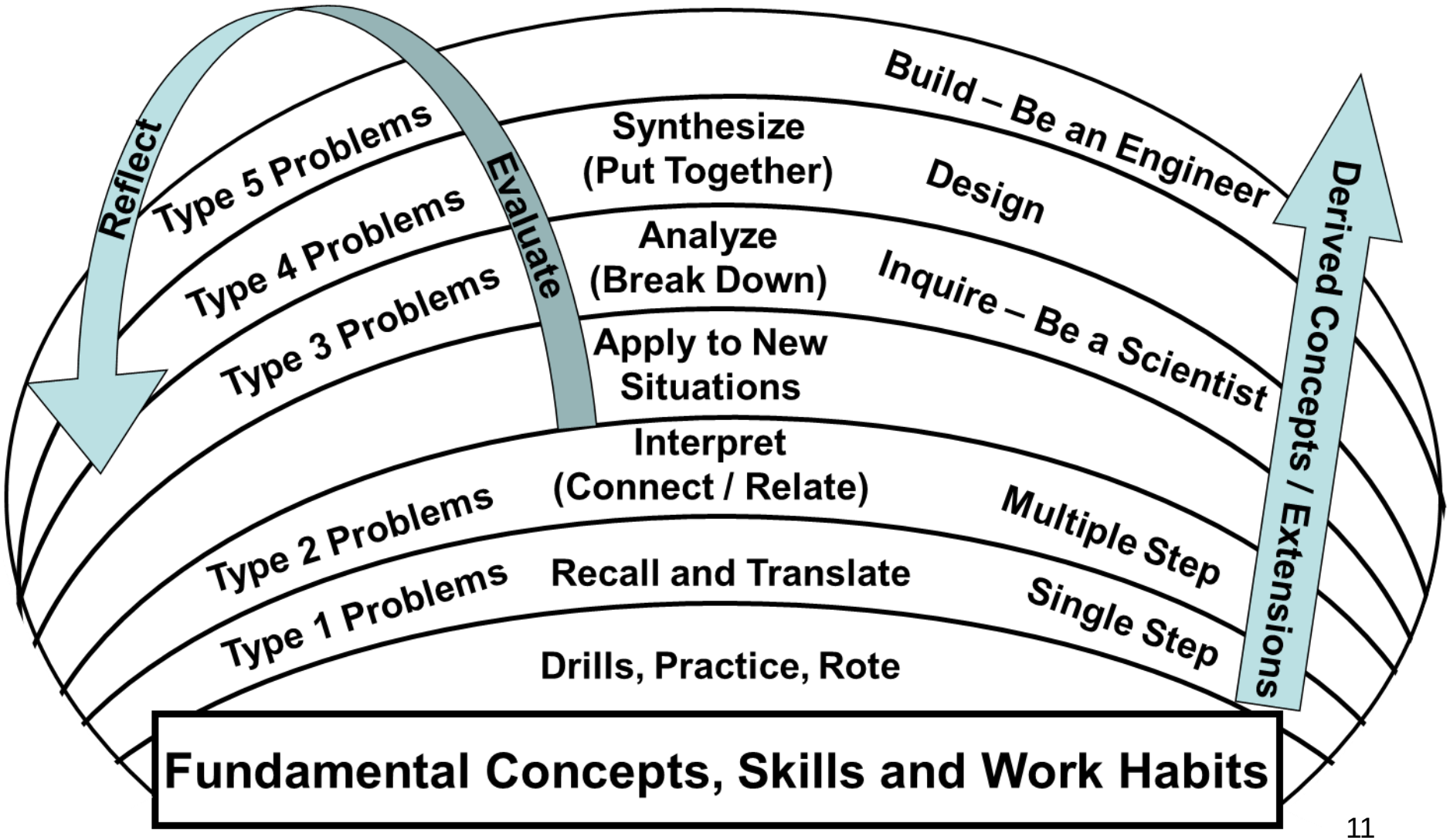


Derive New Concepts: For Example…

- In science, 3 fundamental quantities are mass, time and length – consider the many quantities and other concepts that are derived from these 3
- In Technological Studies, *Material* and *Structure* are two of the fundamental concepts – students must understand and appreciate these concepts
- A popsicle stick bridge is a great application project through which to guide students to derive a new concept, *Strength*
- This very simple relationship is useful in junior grades as a way to model the new concept of “strength”:

Strength = Material + Structure

Thinking Skills to Derive New Concepts and Solve Increasingly More Complex Problems



Five General Types of Problems to Solve

1. ***Simple Operation***: Single Step (common in math class; eg. Do I multiply or divide?)
2. ***Exploration***: Multiple Step / Linear System (common in math class)
3. ***Process***: Inquiry-Based (often connecting math and science or math and history)
4. ***Design***: Open-Ended Data-Gathering (often bridging math, science and tech studies)
5. ***Fabrication***: Open-Ended Inquiry-Design-Build-Assess (eg. Technological Design)

Critical and Creative Thinking

- Critical and creative thinking skills are at the root of problem-solving, especially for the more complex types of problems.
- Critical thinking is, very generally, a collection of skills, attitudes and concepts centred on the Analysis form of thinking.
- Creative thinking is, very generally, a collection of skills, attitudes and concepts centred on the Synthesis form of thinking.
- It is important that the use of all core thinking skills be emphasized in all problem-solving situations, regardless of complexity.

Problems vs. Opportunities

- It is not just *Problems* that we need to solve in the modern world
- There are many *Opportunities* out there as well
- Many of the same tools and strategies can be used for both Opportunity-Building and Problem-Solving
- Engineers don’t just solve problems. Engineers also work toward preventing problems.

Summary

- Learning activities such as good old-fashioned repetition, drills, practice, development of habits of mind, and other assessments to reinforce recall of information are critical in the domain of the fundamental concepts and laws for any particular subject matter.
- However, at a deeper level, students must be taught how to use and should practice higher forms of thinking so that they can “derive” new concepts and ideas from the fundamental concepts and laws.
- Assessments regarding these derived concepts must address the entire range of core thinking skills – recall, translate, interpret, apply, analyze, synthesize and evaluate.
- These 7 core thinking skills are based on Bloom’s Taxonomy and should be used in a cyclical manner in problem-solving scenarios of increasing complexity…

Ultimately to Enable Students…

- To at least partly design their own learning opportunities vis a vis certain curriculum expectations
- Curriculum says: "*learn about this*" or "*learn how to do this*"
- A problem statement is thus broadly outlined – students translate this into their own words and interpret it for their own career purposes
- **Note**: Students should be taught how to interpret Curriculum expectations in the context of their personal goals

Reference Materials

- *Growing Success: Assessment, Evaluation and Reporting in Ontario Schools*, Queen's Printer for Ontario, 2010.
- R. Case and L. Daniels, Preconceptions of Critical Thinking from a partial draft of *Tools for Thought*.
- Norris M. Sanders, *Classroom Questions: What Kinds*, Harper and Row, 1966, referring to Benjamin Bloom (ed.) *Taxonomy of Educational Objectives: The Classification of Educational Goals*, 1956. References to Bloom's Taxonomy abound, for example, https://www.thomasmorecollegebookstore.com /blooms-taxonomy-sample-questions-in-science.pdf
- R. Charles, F. Lester, P. O'Daffer, *How to Evaluate Progress in Problem-Solving*, National Council of Teachers of Mathematics, 1987
- Fostaty Young, S. & Wilson, R.J. (2000). *Assessment and learning: The ICE approach.* Winnipeg, MB: Portage and Main Press

Suggested Exercises -1

1. On slide 3 there are 5 dot-jots: "*helping the students become…".* Using a numbered list, re-arrange these dot-jots into your own personal order of priority in your life. Justify why you have placed them in this order, with #1 being your top priority.

Suggested Exercises - 2

2. Consider this statement: “The popsicle stick triangle on slide 4 ‘*Fundamental Building Blocks*’ is an inappropriate model to use in the context of this Presentation.”
   – Do you agree or disagree with the above statement? Explain your reasoning. Broaden your thinking into other subject areas. Connect your thinking to several fundamental concepts.

Suggested Exercises - 3

3. Do some research on "*Bloom's Taxonomy*". Compare and contrast the description you find on-line with the "*Seven Core Thinking Skills*" shown on slide 7 above.

Suggested Exercises - 4

4. Consider this statement: "*We can expect 'understanding' to easily happen immediately after 'remembering'.*"
   - Do you agree or disagree with this statement? Justify your position. What needs to happen before "understanding" is achieved? In your discussion, consider the core thinking skills "Translate" and "Interpret".

Suggested Exercises - 5

5. Consider this statement: "*Learning cannot happen if the teacher does not give me the exact definition of a new concept*".
   – Do you agree or disagree with this statement? Explain the role of the student in dealing with and learning about a "new" concept.

Suggested Exercises - 6

6. Search on-line for "*strength of materials*". In what way can "time" be a significant parameter or factor in the strength of a material in a given application. Discuss the application and the material that you are considering. What is it that "happens" over time -- describe the process that is involved. What else can you do to "grow" your understanding of the concept we call "strength"?