Integrating thinking skills learning with the Engineering Design Process

"Thinking Skills" are the tools used to achieve subject matter learning goals.

Why is this an issue to discuss?

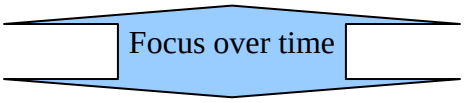
The Need (Industry) has changed. **The model of education based on the old industrial methods needs to change:**

Go From	Discipline and order, content knowledge, memorization
Go To	Thinking Power: new ideas, new ways of doing things, observing, experimenting, analyze, evaluate and try again. **Must learn**: raw creativity, critical analysis & assessment, experimentation and evaluation.

What do we do?

Improved thinking skills does not normally occur as an incidental outcome of subject-matter learning (newmann,1990)

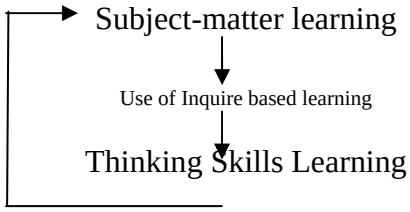
Start with basic skills: **comparing, classifying, sequencing and predicting in early grades.**



Subject matter skills: **decision-making, problem-solving, making conclusions, identify cause & effect relationships, critical thinking**

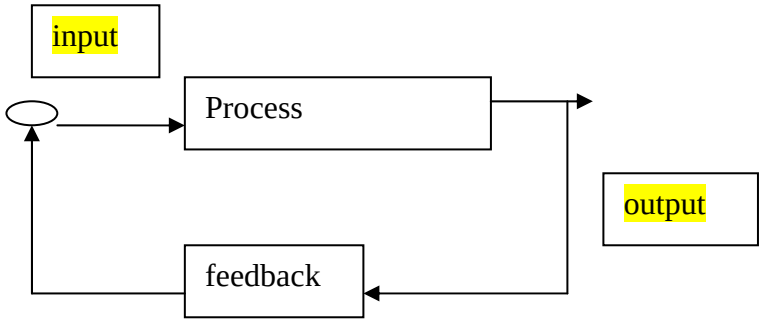
Items that need to be addressed:

Items	Description
Basic Skills needed **Comparing, Classifying, Sequencing, Predicting** **Source** - Pamela B. Tanguay	There are skills that can be developed even in young children in order to improve their visual processing and thinking skills, which include the ability to: ▸ Categorize (group like or related information together) ▸ Compare and contrast (how are things different, and how are they alike) ▸ Observe (watch carefully, study) ▸ Identify patterns (a sequence in which things occur) ▸ Look for cause and effect (does something specific happen as a result of a particular act or activity) ▸ Generalize (apply what is learned to a new or different situation) ▸ Problem solve (determine appropriate method to overcome a difficulty)
1. **Teachers need to model and coach to develop proficiency in applying thinking skills (explanation and demonstration)** 2. **Meta-cognitive reflections … How did you do that? We tend to find blame vs looking at our-selves. "We have met the enemy & he is us"…pogo** 3. **The ability to ask "Good Questions"**	
Subject manner learning	**Decision making, problem solving, making conclusions, identifying cause and effect relationships, critical thinking**
Scaffolding support:	• **Diagram or a series of written prompts**

	• **Procedure check list** • **Skill based graphic organizer** • **Process-structured questions**
Feedback:	**Use scaffold items to provide feedback**
Where and When	**Teaching thinking skills is best done in academic subject matter courses.**
Teachers Behavior: *"Act so as to elicit the best in others and thereby in thyself"* **Felix Adler** *…enabling student thinking* ***Young people are quick to initiate behavior***	• **Questions Purposely draw forth student's awareness and employment of thinking skills, cognitive tasks and dispositions.** • **Structuring the classroom for thinking** • **Modeling cognitive goals and objectives …** • **Value Differences**: accepting one another point of view • **Solving problems :** watching the teacher under stressful situation; making mistakes, being calm • **Enthusiastic about learning**: Show enthusiasm for challenges, puzzles, complex tasks • **Listens to one another**: teacher who listens • **Responding**
We need to focus on modeling for the students the way to ask questions based on the desired outcomes to demonstrate that learning is achieved by getting the students to understand how they gathered the data & use skillful thinking to make a conclusion. In addition, we need to model the meta-cognition aspects on how we arrived at a learning point. Examples & role playing need to be done to walk through how did we arrive at that particular point. **The teacher should understand what the expected outcome was and question the students on their achieving this point. In addition, the students should make sure that they complied with the ground rules that were established in the beginning of the exercise.** **The goal for the teacher is to teach the students how to learn and acquire knowledge. It is not about teaching but student learning. There is too much data to know it all.**	
Symbiotic relationships *Thinking skills are the tools for achieving subject matter learning goals.*	

System approach to thinking skill learning

From seeing just the parts to seeing the whole



Input: complete, count, define, describe, identify, list, match, observe, recite
Process: evaluate, judge, predict, infer, analyze, reason, explain, distinguish
Output: complete, imagine, predict, speculate, if/then, forecast, idealize, hypothesize, judge

Learning organization: an organization that is continually expanding its capacity to create its future.
We need to get beyond "problem solving" and change the thinking that produces the problems in the first place.
We tend to focus on the parts rather than seeing the whole, and to fail to see organization as a dynamic process. Thus, the argument runs, a better appreciation of systems will lead to more appropriate action.
Source *-Peter Senge*

Skillful Thinking

Infusing thinking skills into the Engineering curriculum for the K-5 course:
How: Provide teachers with professional development, scaffolding, and a collaborative web site for support.
Details of the elements of training:

Section	Description
Use of questions	Framing of thoughtful questions, and the follow-up of these questions for understanding.
Curiosity	Expanding the curiosity of students by creating an environment for learning.
Meta-cognitive skills	Teach and model the value of meta-cognitive skills for self-evaluation and improvement.
Higher-order thinking skills ***basic skills :****comparing, classifying, sequencing, and prediction*	Teach and model such skills as decision making, problem solving, critical thinking, brainstorm, compare / contract, classification, drawing conclusions

Mapping:

the development of general or higher order thinking skills is imperative to,

- develop basic competencies to gather, sort and select information,
- to effectively structure and organize ideas and reasoning, and
- to analyze and evaluate claims and arguments.

What about my taxonomy? www.austhink.com

Bloom's Taxonomy of Educational Outcomes

The Rationale™ argument mapping process ensures the various stages of cognition are developed as

Detailed in Bloom's (revised) Taxonomy.

The chart below arranges Bloom's levels of cognitive activity in a grid moving (left to right) from simple to complex, and it lists a number of verbs describing its activities for each mode of thinking. The chart may thus offer suggestions to teachers for varying the level of sophistication in what they ask students to do in writing assignments.

Bloom's Ranking of Thinking Skills

Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
List	Summarize	Solve	Analyze	Design	Evaluate
Name	Explain	Illustrate	Organize	Hypothesize	Choose
Identify	Interpret	Calculate	Deduce	Support	Estimate
Show	Describe	Use	Contrast	Schematize	Judge
Define	Compare	Interpret	Compare	Write	Defend
Recognize	Paraphrase	Relate	Distinguish	Report	Criticize
Recall	Differentiate	Manipulate	Discuss	Justify	
State	Demonstrate	Apply	Plan		
Visualize	Classify	Modify	Devise		

1. Knowledge The argument map requires that information is recalled to Demonstrate recognition of the content of a given topic.
2. Comprehension The argument map requires that information is organized to demonstrate sufficient understanding, description and comparison of the issue and the relationship of claims in relation to each other.
3. Application The argument map requires the application and selection of Relevant knowledge to solve a given problem.
4. Analysis The argument map requires that students analyze information by requiring them to identify supporting reasons and objections, other reasons and objections not already considered, and to determine whether there are hidden claims. This ensures a depth to the thinking process.
5. Evaluation The argument map has an evaluation mode with one or two steps depending on whether you are creating a Reasoning or Analyzing map. For Reason maps, a student rates the strength of a reason or an objection and the acceptability of a position. For Analyzing maps the student judges the truth of a claim, the strength of a reason and the acceptability of the position.
6. Synthesis the argument map facilitates higher order thinking by synthesizing a student's skills in the creation and communication of an argument – to demonstrate knowledge of a topic, comprehension in the organization of its claims, application in the selection of knowledge relevant to a problem, analysis in the inclusion of further reasoning and disclosure of co premises, and the evaluation of claims and judgment as to the acceptance or rejection of a proposition.

Conclusions;

1. **You can't hold everything in your head!** The more information we gather the more cognitive strain or 'brain burn' we experience. In the case of the

noughts and crosses game, we need to write the grid and our moves down because this relieves the burden of having to remember every move and its relationship to other moves. This allows more cognitive capacity to create a strategy about our future moves and to think about the other person's strategy. We play a better game when we have tools to record the moves and show relationships.

2. **Maps are easy to use.** The London prose and map show us the ease of using maps. This is not a mere learning preference but reveals something more about how our brains work. Whereas the London prose provides us the information we need, it requires a lot of sifting and brain power than a visual representation. Maps ease the cognitive strain because they make use of colour, shapes and symbols to identify objects and their relationship to each other. This certainly doesn't mean we want to eliminate prose. On the contrary, we want students to write or speak clearly, with structure and consideration, providing refined claims, language that is appropriate and indicator words and phrases. Argument mapping is the methodology which scaffolds this understanding and equips students with the ability to communicate effectively.

Thinking Skills are the tools for the engineering Design Process

Engineer design process*	Thinking skills
Identify the need or problem	• Compare / Contrast • Decision process • Drawing Conclusions
Research the need or problem	• Classification • Sequencing • Critical Thinking • Compare / Contrast • Root Cause
Develop possible solution (s)	• Brainstorm • Critical Thinking • Root Cause
Select the best possible solution(s)	• Compare / Contract • Classification • Drawing Conclusions • Problem Solving
Construct a prototype	• Classification • Drawing Conclusions • Problem Solving
Test and evaluate the solution(s)	• Compare / Contract • Classification • Drawing Conclusions • Problem Solving
Communicate the solution(s)	• Compare / Contract

	• Classification • Drawing Conclusions
Redesign	• Brainstorm • Compare / Contract • Classification • Drawing Conclusions

* Massachusetts Curriculum Frameworks, Science and Technology/Engineering October, 2006