Course Title: **interdisciplinary learning from literature to math and science using "Thinking Skills and Engineering": An integrative Perspective for the preK-5 grade curriculum**

Credit: Professional Development Three credit course, to be giving ~~for the Millis School District, 4th grade teachers~~

Dates & Times: ~~Fall of 2009~~

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Office hours: none; just by email, phone or in class

Course Description: This professional development course will introduce teachers to the profession of Engineering and to the PreK-5 Engineering strand of the Science & Technology/Engineering Curriculum Framework. The course will model Interdisciplinary (cross functional) learning by using the engineering design process to connect literature to the math and science lessons. It will also provide teachers with exciting opportunities to integrate the engineering curriculum into their own lesson plans as part of project based learning. As the engineering design process is a thinking skill, the course will model for the teachers the use of thinking skills related around productive questioning, meta-cognitive reflection, creative and critical thinking, developing strategies and setting a learning environment to create excitement in learning.

This course will give you, the teacher, a great opportunity to work with your students to become self learners. The process will allow you to connect at least three or four subject together so you're teaching across the curriculum and your students will see the relevance of what they are learning. The students will be part of finding the design challenges in the stories, thus creating their own learning experiences.
They will not be learning in a silo but you will be working with the students in a constructionist approach. The concepts used are based on Vygotski's and Piagets' approach to early education.

Pedagogy skills will allow you to engage the students by; **Modeling, Scaffolding, Coaching, Reflecting and Fading.**

LEARNING OUTCOMES / OBJECTIVES:

By the end of this course, the PreK-5 Teachers will be able to:

- Clearly articulate the nature of technology/engineering as defined in the Framework
- Use creative design process such as Brainstorming, Brain-writing, and Morphological Analysis
- Create a learning environment that engages the students and excites them in learning.
- Explain the relationship between science and technology/engineering
- Provide examples of the types of tasks that engineers perform
- Describe the steps of the engineering design process
- Design lessons that are interdisciplinary and utilize the engineering design process
- Create a plan for integrating the engineering curriculum framework requirements into the classroom that is exciting and fun for children to learn
- Be able to model for students the use of productive questioning and meta-cognitive reflection, creative and critical thinking skills in the learning process.

- Create project based learning tasks for your students and help them design collaborative effort and assessment methods for the projects.

Knowledge: As a result of the learning experiences in the course, you will become more cognizant of:

- The state's education Science Framework strand 4
- Both creative and critical thinking methodologies
- Use of feedback and assessment in learning
- Using engineering design to create an interdisciplinary learning environment

Skill: As a result of the learning experiences in the course, you will become better able to:

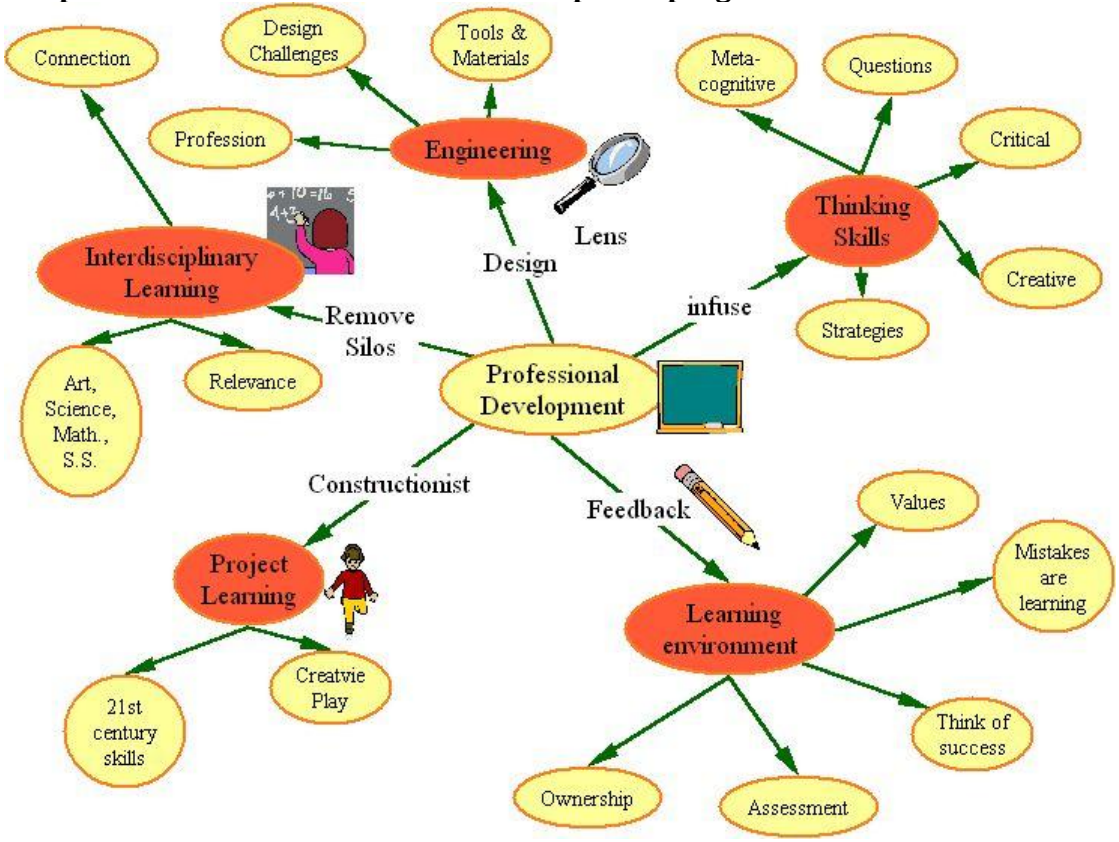
- Use of brainstorming, brain-writing and morphological analysis
- Using the design process as described in the Framework
- Finding design challenges in stories that students read

Caring: As a result of the learning experiences in the course, you will become more competent in your ability to:

- Acceptance of mistakes as a learning experience
- Work collaborative with your fellow candidates.

Ethical: As a result of the learning experiences in the course, you will become more competent in your ability to create a learning environment that fosters ethical relationships.

Graphical view of the Professional Development program:



Howard Gardner (Harvard professor and education authority) views education core challenge as getting people engaged in the "right things". He means that inculcating a sense of respect for knowledge and ethics is as important as improving cognitive abilities.
In other words, educators have to establish an ongoing linkage between learning and purpose.

Effective thinking-centered instruction aims to achieve two educational objectives:

1. To cultivate the active use of knowledge
2. To help students become self-regulated learners.

Course Requirements – Candidates will read all the assigned material and do the expected projects per the scheduled assignments. The quality of the work shall demonstrate a focus on improving thinking skills and the engineering methodology. Course participation and the use of questions for engagement will be evaluated during projects.
Course Expectations – Candidates are expected to participate in the discussion forum and complete the assigned projects on time. Students are responsible for making arrangements with the instructor when difficulties arise in completing an assignment on time. A set of Rules of Engagement for the class will be published for student use. Grading rubrics will be used for evaluating each of the assignments, team assignments and discussion board postings.
Course Rubric: See attached rubric for this course.
Grading Criteria: - Candidates will be assessed based on many classroom activities and their personnel effort put into both their success as well as supporting a learning environment. Major breakdown of these are shown below:

Activity	Discussion	% of total
Individual assignments	This includes developing lesson plans, writing a paper and creating design challenges from stories.	30
Team assignment	Ability to work with others, communication skills, being able to give constructive feedback.	25
Classroom discussion	This also includes on-line discussion boards.	25
Supporting a learning environment	This measures the attitude of the individual in making suggestions, taking risks in activities, and supporting the learning atmosphere.	20

Course outline: The course will focus on five major areas: 1) who are engineers and what do they do; 2) strand four of the science framework: 3), engaging in cross functional learning using the engineering design process as the connector:4), collaborative team learning in an inquiry based learning mode: and 5) the infusion of the use of skillful thinking across the learning environment. Modeling the engineering thought process and skillful thinking process will serve as the basis for exposing teachers to the use of these strategies in their classrooms. The use of questioning in the classroom will be modeled for teachers as a method for engaging students in the thinking process. Teachers will develop an engineering design process based on their own experiences rather that just copying the one from the frameworks. **Emphasis will be focused on developing curriculum for PreK-2 including more hands on and think, pair and share approaches while for grades 3-5 a more analytical analysis will be added to the projects.**

Major area	Theme	Time
Introduction / Creating a	Attributes, Values, Teacher Skills and the	4 hours

learning collaborative in the classroom / pre-Assessment of engineering knowledge and thinking skill awareness	relation to excellence in academics and the larger world of work. Developing the outcome goals for the class.	
Who are engineers?	Careers and work effort, interview an engineer	4 hours
Engineering framework • Design process • Tools • Man made/ Natural Materials	Develop a design process without looking at the Framework	4 hours
Creative and critical thinking skills around the design process	Learn the tools of Brainstorming, Brain-writing, Morphological Analysis and Pugh analysis for divergent and convergent processing skills	4 hours
Cross functional learning design	The use of literature as a basis to create an engineering design. Creating an interdisciplinary connection between the science framework requirements and literature. Create lesson plans for stories.	4-8 hours
Inquiry based learning, the development of a design	Develop Candidates centered learning and assessments, planning and interpretive investigation, Observation, Communication	4 hours
Infusion of thinking skills	Create an appreciation for life-long learning by providing opportunities to develop creative and critical thinking skills	4 hours
Conclusions , Post Assessment	Teachers as the engineers of education The take home lesson: What are you going to bring back to your classroom?	4 hours
On-line community support	Provide on-line follow up for the teachers to share, collaborate work effort in their classroom. We will use an on-line teaching tool such as Blackboard or Moodle. The teacher will have to create a Design Challenges from stories or other items using templates provided.	4-8 hours
		Total time = ~36-44 hours

Related standards

The Partnership for Twenty first Century Skills highlight the skills and thought processes children need in order for them to	The expectation of teachers who incorporate these teaching strategies into their classrooms is that they will be able to facilitate the skill development their students need to use integrative thinking. Learning and innovation skills increasingly are being recognized as the skills that separate students who are_ prepared for increasingly complex life and work environments in the 21st century from those who are not. A focus on creativity, critical thinking, communication and collaboration is essential to prepare students for the future. This statement, from the Partnership for 21st Century Skills, highlights the importance of instilling thinking skills into our youth.

be competitive in today's ever-changing society	Other components related to learning and innovation skills of the students include: (1) Being open and responsive to new and diverse perspectives, (2) Making complex choices and decisions, (3) Identifying and asking significant questions that clarify various points of view and lead to better solutions (www.21stcenturyskills.org). These three objectives are descriptors of the process of integrative thinking.
MA Framework	MA Framework Science (2006) Standard (Strand 4) & Mathematics,

Pre-Assessment Survey

- What is your exposure to the engineering requirements in the Framework?
- How do you use open ended questions to engage students?
- What approach do you use to integrate thinking skills in your lessons?
- How much cross functional learning do you use in your classroom?
- How do you use a constructionist approach in your class room?
- Do you feel comfortable in describing what engineers do?
- Could you describe one learning strategy you use in your teaching?

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Introduction Phase: 4 hours
We can guarantee what we say, but not what you hear.
Description

- It is not about teaching but student learning. There is too much data to know it all.
- Isidore Rabi Nobel Prize Physicist… Every other mother would ask after school " So? Did you learn anything today? But my mother always asked me a different question. "Issy' she would say, "Did you ask a good question today"
- Discussion of Values in the School

Class introduction:

Student will:

- Introduce yourself
- What you teach and grade level?
- What you are hoping to gain from the course?
- What in your childhood engaged you in the learning process?

Creating a class rubric: Candidates will work as teams and develop what the goals for the class learning should be and then craft a rubric and feedback methods to be used in the class.

Setting the learning environment.

This PD will model for the teachers the learning environment that should be established in their classroom. The student is not going to be engaged unless there is an atmosphere in the classroom of caring and respecting the student. The environment is a combination of the values and the following attributes:

Belief that all children can learn, but not always the same time and way	*Effort is what gets results not native intelligence. … Carol Dweck* *http://dww.ed.gov/learn/learn.cfm?PA_ID=8&T_ID=18&P_ID=34&rID=1* *Fixed intelligence, malleable intelligence*
Developing more curious minds … John Barell **Curiosity & Skepticism**	*Education is not a factory model and the children are not a vassal to fill but come with pre-knowledge .. Dave Perkins*
Children need to believe they control their learning environment	*Challenge students to grapple with ideas, rethink their assumptions and examine their mental model of reality.*

Teacher skills:	
• Thinking aloud (their own intellectual journey)	• Setting high expectations
• Wait 30 seconds	• Creating questions and responses
• Acknowledge each student	• Raising the quality of peer interaction
• Allowing the students to be part of the assessment strategy	• Using teacher modeling
• Taking Student's own ideas seriously	

Create a Wall of learning; which includes Questions to be asked by the students; items that are developed by the students such as the design process, and Key vocabulary words,
Course values (My expectations for how we should approach this Learning): Part of the Learning environment.

- To be encouraged, modeled, and explored
- Values are deeply held beliefs about what is important or desirable. They are expressed through the ways in which people think and act.
- Every decision relating to curriculum and every interaction that takes place in a school reflects the values of the individuals involved and the collective values of the institution.
- The values on the list below enjoy widespread support because it is by holding these values and acting on them that we are able to live together and thrive. The list is neither exhaustive nor exclusive.

Excitement	Continuous learning	Learning is through work	Collaboration
Measurements are for improvement	Renewal/ Celebration	Trust/ Integrity	Listen First
Encourage Constructive Dissent	Respect for all	Risk Taking	Process is what you do
Remove stereotypes	Be passionate	Innovation	Enthusiasm

Nothing is ever achieved without enthusiasm … Emerson

The most important attitude that can be formed is that of the desire to go on Learning … John Dewey

"Education is not the filling of a pail but the lighting of a fire." …W. B. Yeats

"Children must be taught how to think, not what to think." Margaret Mead

Mistakes and failures teach students what *doesn't* work, so they can find what *does* work.

Reading / Assignments

Review Components of a Well Developed Thinking Skills Program by Arthur L. Costa, Ed. D.

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. By providing examples & engaging students in role playing we can demonstrate how we arrived at a particular point.
The teacher will be able to identify the expected outcome and question the students on how they achieved this outcome.. In addition, the students will assess themselves on their compliance with the ground rules that were established in the beginning of the exercise.
The goal for the teacher is to create an environment that supports learning and construction of knowledge by the student. **It is not about teaching but student learning.** There is too much data to know it all**.**

Overview … working as teams

Activity: General rule: there will be at least one activity in each half day session where the teachers will build, interact and compare results.

Activity #1; Ask teachers to get into small groups and write down on large pieces of paper what their goals are for their students each year. Have them note down what grade they teach. Groups share their goals and see whether there are any that are grade/subject specific. (approx. 30 mins)

Break;
Pre-Assessment to see what the teachers understand about engineering

Activity#2; Teachers will complete an activity in small groups. For example, they may build a tower for a mini teddy with only paper and tape. This type of activity will be followed by a discussion of identifying need. Allow 20/30 mins to make it and then review. Teachers will explain how and why the process worked or did not.. This activity will be used to introduce evaluation of a design. Teachers will be encouraged to assess their own strategies for completing the process (e.g. design first or just build). Evaluation of designs will be introduced.

Activity #3 : Ask teachers to develop What are the desired results? Understanding by Design is particularly helpful because you begin by looking at the "desired result." What do you want your students to know and be able to do? What student learning to you want to take place as a result of this lesson? What standards are you trying to meet? Look for information on what is called "backwards design." Start with the desired result - the final assessment - and go backwards through what needs to be done to get there!

Second unit … About Engineering

- Session objectives:

By the end of this session, participants will be able to:

- Distinguish between what engineers, scientists and mathematicians do
- Reflect on some of the stereotypes and gender issues within the Engineering Profession

- Activities:

1. Why do I need to know about engineering as an educator?
2. Draw a picture of an engineer and write a short paragraph of what the engineer is doing in the picture.
3. **Classroom discussion:** What are some stereotypes around engineers? What causes society to have stereotypes?
4. Working as teams, generate definitions of what Engineers, Scientists, Entrepreneur, Artist and Mathematicians do.

Note: each session will have objectives and activities

Discuss what activities we can do with our students to see what they know of the engineering profession.
Draw a picture of an engineer.

Engineer Career(discipline):

- Engineer
- Senior Engineer
- Principle Engineer
- Chief Engineer

Project Engineer
Test Engineer
Component Engineer
Product Engineer
Industrial Engineer
Quality engineer
Manufacturing Engineer
Software designer
Service Manager/Engineer

Reading:

Life story of a great engineer
Bernard_Gordon_has_been_called_a.doc

What does an engineer do and what should their skill sets be?
engineer_definition_careers.pdf (31.835 Kb)

Why use Engineering in Education?
good_scource_engineering as a connector.doc (115 Kb)
Good article on how the concept of integrating engineering design into our curriculum will help our students.

Application Engineer Sales Engineer **Assignment 1.1:** Interview an Engineer you know about one day in his/her work life (the teacher will help in finding one if needed) Using the engineering design process from the Framework, describe which step your engineer was working on the day you conducted the interview Understanding of the Engineering disciple. **How would we define?** • Engineering • Science • Mathematics	**Stand 4 Section of the Framework** *Enabled: Statistics Tracking* Strand4_science_engineer_framework_0501.pdf (48.106 Kb) This is the major portion of the framework that explains the Engineering Strand. It is taken from the whole framework for your convenience. It is in a PDF format **Review the rules of engagement , add your ideas & comments to our rubric.** Using Bernie Gordons "what is an engineer" booklet, we will explain the following: • What do you think an engineer does? • What does an engineer study • Why are values important? • How is it similar and dis-similar from other jobs? • What is the engineering design process and tools? • Review the ABC nightline video … designing a shopping cart. Review Richard Feynman and Faraday's "Chemical History of a Candle"
Third unit … **Understanding the Science Framework Strand 4**	
Understanding of the Engineering Strand of the Massachusetts Framework. Lets create a design process using your experience from a project around the house or office. **Discussion Board:** **What Stereotypes are there about Engineers?** **Are they different by gender?** **Documents;** http://www.integratingengineering.org/critical_learning/question_engineering_table_071207.pdf	**Reading:** • Science, Technology/Engineering • Framework posted • Engineering in the K-12 Classroom • The Design Process, how does it related to critical thinking, problem solving and the science discovery process? **Tools:** Materials, Tools and the Design process Links: • Engineering design process

Unit 4 Creative and critical thinking skills around the design process

Learn the tools of Brainstorming, Brain-writing, Morphological Analysis and Pugh analysis for divergent and convergent processing skills.

Activity: The students start the course by keeping a bug (list of items that you encounter that bother you) list. From this list, teachers are introduced to the creative side of designing.

***How does the program teach innovation or entrepreneurship?**

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Unit 5 … How do we bring cross functional holistic learning using the design process

A Synergy Between Engineering and Literature: The core idea of our approach is that engineering need not "stand alone" in the curriculum, but can and should leverage existing curricular elements -- in particular literature. We envision a curriculum in which students respond to literature through engineering design projects by identifying needs that the characters have, by identifying multiple possible solutions, and by exploring and refining those solutions through prototyping and revision. For example, kindergarteners might respond to a common fairy tale by designing a house for one of the little pigs (or perhaps a means of blowing down a house for the wolf!); fifth graders might respond to the book Island of the Blue Dolphins by identifying needs and solutions for Karana, the marooned main character of the novel.

http://www.integratingengineering.org/example_literature_081307.htm

Define a story map.

Integrating the engineering framework into the K-5 curriculum and its connection to other disciples.

Discussion Board:
Explain what you believe the "Learning to Think" Matrix is saying?

Create an engineering design challenge for a children's literature book that you use in your classroom.

Reading:

Bring Engineering to the K-5 classroom
bring_engr_elem021505.pdf (392.444 Kb)

Using a simplified design process
word document (35 Kb)
This is a write-up by a colleague of mine, who teaches Science in the 5th grade. It shows some of the details that need to be thought of by the student when doing a design process. It re-enforces our thoughts of integrating the engineering into the Math & Science curriculum.

Development of Inquiry-based learning
Scaffolding the Development of an Inquiry Based

Show how this starts with an engineering theme and then integrates Math & science from the Framework.

How do we integrate a science lesson and mathematics into the design Challenge?
Use Template-design challenge

Developing the methodology of finding "Engineering Design Challenges" in the literature being read.

- Engaging students with engineering in their stories
- **Picking literature:** *use books to also cover the social studies themes as defined in the framework.*
- Have this years Science requirements on a poster and review it with the children.

Pick a design challenge that uses the science requirement for the year.

(Science) Classroom.htm (24.218 Kb)
This is a paper that describes a learning project at College of
Computing, Georgia Institute of Technology. This team was developing a concept called Learning by Design (LBD) for students in middle school. It re-enforces the concepts we are discussing.

Bring Engineering to Elementary School
Enabled: Statistics Tracking
Tufts University (392.444 Kb)
developing a toolset for the students to use.

Assignment 1: How can we teach engineering through other subjects (History, Social studies, Art, Music, PE) to our class? Explain and give examples.
Assignment 2: using the story" The Three Little Pigs" describe how you would show Science, Math & Engineering principles
Assignment 3: How can we build excitement, fun, and creativity into the classroom with engineering? Explain and give examples
Assignment3.3: Pick a story from your grade level and create a learning plan that connects the engineering elements with Math & Science.
Assignment 4; connecting the grade level science to the engineering project

Unit 6 Collaboration, Teams, Assessments, and Reports

Team members learn to ask questions like the following as the plan passes through the stages of development:

- Do we have the right goals?
- Have we identified the critical factors influencing this situation or have we fallen into the trap of addressing symptoms rather than root causes?
- Has our problem identification process been comprehensive?
- What is still missing?
- Who else should we consult who might guide us well?
- Is the action plan well grounded in past practice while forward-looking and innovative?
- Have we learned of and from the mistakes of others?
- What could possibly go wrong?

- What's the worst that might happen?
- What obstacles, barriers and surprises might block our success?
- What can we do to prepare for them?

Model for the students the process of Observation, Investigation and to communicate their thinking and development of ideas.

Creating lessons using literature combined with STEM.

Target five Socratic Questions to incorporate into a lesson you will use with your students. Present the framework for the lesson with the questions. Suggest an anticipated response to each question.

Consider three types of communications; various types of discussion; using notebooks (journal) or folders; and drawing, painting, and modeling.

Presentation Outline:

- What did we know?
- What did we need to learn?
- How did we approach this design challenge?
- What did we learn?
- What would we do differently the next time and why?

http://www.integratingengineering.org/literature/inquire_process.htm

Discourse and student learning:
How did the discussion help you as a teacher?
How did the discussion help you as a learner?

Focus is on the importance of communication in everything we do and setting goals and assessments for our work.

How do we know we are successful?

Guidelines for Teams

- Decide on role for team members
- Develop program plan
- Questioning process
- Engineering journal
- Decide on team culture & operating guidelines

•Students tutoring other students.

Set up all female teams, all male teams them switch … don't want to stereotype female roles

Discuss student assessment of the project.
What was their strategy?
Have them create a rubric of the desired outcome.

Integrate writing within the project activities.
Use simple format of

- Introduction
- Thesis/ focus statement
- Points 1, 2
- Conclusion

Working together to accomplish a common project.

- Learning the process of experimentation and mistakes
- Learning to organize and handle interruptions & changes
- Measurements and feedback to goals

Unit 7

Infusing Thinking Skills in our lessons. How do we re-connect teachers to their previous learning in Skillful thinking?
Researchers have found, for example, that mastery of at least four thinking skills—**comparing, classifying, sequencing, and predicting**—is essential for students to become effective readers, writers,

and learners (Commission on Reading, 1985; Hayes &. Flower, 1981; Jones, Amiran, & Katims, 1985; Paris, Wixon, & Palincsar, 1986; Siegler, 1998). Youngsters who do not master these basic cognitive skills in the primary grades rarely achieve grade-level performances in reading comprehension and independent learning (Siegler, 1998).

'Thinking skills' is a term often used to refer to the many capacities involved in thinking and learning. These skills are seen as fundamental to lifelong learning, active citizenship and emotional intelligence. **Research shows that thinking is developed through cognitive challenge, and opportunities for collaborative work and meta-cognitive discussion and reflection.**

1. Concrete preparation stimulus to thinking, introducing the terms of the problem

2. Cognitive conflict creates a challenge for the mind

3. Social construction dialogue with others, discussion that extends thinking

4. Meta-cognition reflection on how we tackled the problem

5. Bridging reviewing where else we can use this thinking and learning

Successful approaches to teaching thinking include cognitive acceleration, brain-based and philosophical approaches. These and other teaching strategies can help raise standards of achievement and create thinking children, thinking classrooms and thinking schools.

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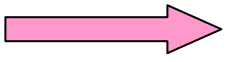
1. Engaging students
2. Productive questions
3. Meta-cognitive refection

Three teaching methods (Mortimer Adler)



- **Didactic instruction** … good, clear presentation of information by teachers and texts
- **Coaching…** observes and provides feedback
- and guidance
- **Socratic teaching …** learn the art of

Creating rubrics and assessments	inquiry, • the teacher poses a conceptual conundrum or snags one from the ongoing conversation. • The teacher urges exploring of the issues

New Bloom's Taxonomy	**Inquiry Example**
Remembering	Define variables (experimental, dependent, controlled)
Understanding	Identify variables in an experiment
Applying	Study example of experiment, then apply same "rules" to new experiment
Analyzing	What does the data tell you?
Evaluating	Defend conclusions
Creating	Write new experiment

Thinking Strategy (based on David Perkins work)

Culture of Thinking: There is great value of attitudes of curiosity, inquiry, and playing with ideas in the development of important thinking dispositions. They may put an open-ended problem on the table and engage students in wrestling with it, without coming to any final solution that day. They may lead Socratic dialogues that unpack a complicated issue. Then, as the school year unfolds, they continue and extend these practices.	**Visible Thinking** ***We need to hold up the mirror so we can see and learn how we are improving our thinking skills*** Visible thinking helps to make concrete what such a classroom should look like and provides a kind of compass to point the way. At any moment, we can ask, "Is thinking visible here? Are students explaining things to one another? Are students offering creative ideas? Are they, and I, using the language of thinking? Is there a procon list on the blackboard? Is there a brainstorm about alternative plans on the wall? Are students debating interpretations?"
language of thinking There are many ways to make thinking visible. One of the simplest is for teachers to use the language of thinking (Tishman & Perkins, 1997). English and all other natural languages have a rich vocabulary of thinking consider terms like hypothesis, reason, evidence, possibility, imagination, perspective and routine use of such words in a natural intuitive way helps students catch on to the nuances of thinking and	**Model, Scaffolding, Coach, Reflecting and Fading** Powerful Questions can be used in quite a elaborate way, but in its simplest version the teacher provokes students to address in turn three kinds of questions about an important topic: **questions of exploration, connection making, and conclusion.** The aim is to encourage the students themselves to formulate and then pursue the questions. The teacher facilitates the process without either providing the questions or answering them. Teachers who do not expect instant answers, who **display their own honest uncertainties,** who take a

thoughtfulness that such terms represent. For another example, teachers with whom we have worked have had good success with the "**circle of viewpoints.**" This routine fits situations that involve multiple viewpoints, as with political controversies, interpretations of history, understanding works of art, and interpersonal disputes. Often working in small groups, students brainstorm different points of view for a topic.	moment to think about "What if" or "What if not" or "How else could this be done?" or "What's the other side of the case?" express respect for the process of thought and implicitly encourage students to notice problems and opportunities and think them through. One thinking routine that we have found to be useful in many settings involves two key questions: "**What's going on here?" and "What do you see that makes you say so?"** (Tishman, 2002)
System Thinking **U**sing feedback and assessments to aid the thinking process… see word doc.	**Meta-cognitive Reflection.** Classroom research has demonstrated that two specific techniques prove especially useful in these introductory lessons; modeling and metacognitive reflection (Brown, Campione, & Day, 1981; Posner & Keele, 1973; Rosenshine & Meister, 1992; Stem-berg, 1984; Taba, 1965). In fact, this research indicates that metacognitive reflection is an extremely powerful technique because it encourages students, by reflecting on and sharing with others how they just earned out a skilled operation, to become more aware of the cognitive procedures they employ and thus be better able to modify them if necessary. Doing this each time they apply the same skill helps them gradually construct, reconstruct, and internalize effective procedures (Brown, Campione, and Day, 1981; Brown et al., 1983; Cognition and Technology Group, 1993; Hudgins, 1977; Larkin, McDermott, Simon, & Simon, 1980; Nickerson, 1989; Nick-erson et al., 1985; Papert, 1980; Paris & Winograd, 1990; Vy-gotsky, 1962; Whimbey, 1980).
De Bono According to Edward de Bono we tend to think in restricted and predictable ways. To become better thinkers we need to learn new habits. His teaching strategy known as 'thinking hats' helps learners try different approaches to thinking. Each 'thinking 'hat' represents a different way to think about a problem or issue. Children are encouraged to try on the different 'hats' or	

approaches to a problem to go beyond their usual thinking habits (de Bono 1999). The 'hats'or thinking approaches, together with questions you might ask, are as follows:

White hat = information *What do we know?*

Red hat = feelings *What do we feel?*

Purple hat = problems *What are the drawbacks?*

Yellow hat = positives *What are the benefits?*

Green hat = creativity *What ideas have we got?*

Blue hat = control *What are our aims?*

De Bono claims the technique is widely used in management but little research has been published on its use in education. Some teachers have found it a useful technique for encouraging children to look at a problem or topic from a variety of perspectives. It encourages us, and our children, to think creatively about any topic and to ask: 'Is there another way of thinking about this?'

Session 8 **4hours**

What will you bring back to your classroom? …
see attachment

- How is skillful thinking connected to engineering? Explain your view point.
- Candidates will detail some ideas that they would incorporate into their lesson plans?
- Candidates will provide feedback to other teachers on their lesson plans.
- Candidates will design what they would do to evaluate the knowledge that their students have of their thinking strategy and what engineers do.

Post assessment survey

- Do you believe what you thought about learning strategy coming into the class is the same as what you know now?
- Does cross functional learning add value to your classroom students?
- Will skillful thinking learning help your students do better in understanding the content portion of classroom activities?

Follow-on session:

Develop two stories that you are using in your class connecting the science and math to the design challenge. Show how you will integrate the science from the framework into the design process. These will be discussed and graded as part of the class for credit. Develop a rubric for your students input and show how it can support their learning.

Copies of some of the assignments

Assignment … Interview an Engineer

Action	Description
Recall your interview: *Was the engineer excited about what they were doing? Why did they feel that way?*	Anything you learned that you want to share? Knowledge, Skills, Attitudes?
Does the items done during the day, fit into the Design process described in the Framework 1. Identify the need or problem 2. Research the need or problem • Examine current state of the issue and current solutions 3. Develop possible solution(s) • Brainstorm possible solutions • Draw on mathematics and science • Articulate the possible solutions in two and three dimensions • Refine the possible solutions 4. Select the best possible solution(s) • Determine which solution(s) best meet(s) the original requirements 5. Construct a prototype	Which of the 8 elements was she/he doing and why do you think that?

• Model the selected solution(s) in two and three dimensions 6. Test and evaluate the solution(s) • Does it work? • Does it meet the original design constraints? 7. Communicate the solution(s) • Make an engineering presentation that includes a discussion of how the solution(s) best meet(s) the needs of the initial problem, opportunity, or need • Discuss societal impact and tradeoffs of the solution(s) 8. Redesign • Overhaul the solution(s) based on information gathered during the tests and presentation	
Engineers who work in other roles versus just a design engineer use a modified process that fits their needs. Listed below are some of the other jobs for engineers: • **Manufacturing and Support Engineering** • **Development of future tools, planning, etc.** • **Training** • **Developing cost models, component analysis.** • **Customer service planning and execution for general products** • **Management** • **Sales Engineering** • **Reliability & Safety engineering**	Does your Engineer fit here? Explain your thoughts.
What are the similarities and	Explain your thoughts?

dis-similarities of Engineering profession the education Profession/	
Did you discuss any of the values with them?	Describe what you heard.
end	

Assignment … Integrating Engineering with Science and Math through a fairytale.

This assignment combines what you know about Science, Engineering, Mathematics and the fairytale … **Three little Pigs.**
You need to pick a grade level and take what the framework states as requirements for a Science, Mathematics and Engineering and put it together as a matrix of items to teach.
This is not a lesson plan, but just a foundation of ideas.

Web sites for your use;
http://www.shol.com/agita/pigs.htm
http://www-math.uni-paderborn.de/~odenbach/pigs/pig2.html

Action	**Description**
Complete the matrix below. If you have a better way of showing this assignment, please use it.	In the matrix below, show how you can integrate the story with the Framework.
Pick a Grade level	=

Add as many elements as you need in the table.

Element of the Story	**Engineering**	**Math**	**Science**	**Comments**
Example	**Designing a house to with stand lots (**	• **Drawing** • **Dimensions** • **Area**	**Force**	**How could the pigs build a stronger house? What does it mean to be**

	need to define) of wind			**a stronger house?**

What supplies would you need to engage the students?	
How would this be exciting to the children?	
Would this be helpful to the teacher?	
How would you use a vocabulary chart in this lesson	
How can you use the requirements to steer the learning in a known direction?	
end	

Assignment: What will you bring back to your classroom?

Background	At the beginning of the course, we said we would do the following: • What is the profession of engineering all about • Review of the engineering framework (one of the strands of the science framework). • How the engineering methodology fits into the whole learning process? • How do we integrate the engineering process into math and science using non-fiction literature? • Designing a learning environment.
Summary of some of my key points	That the engineering design process can be used as a learning tool for Math and Science as well as by itself. Since the definition of Engineering is to design a useful product using Math and Science, we can ask our students to design something or we can incorporate it into our literature studies by charging our students to design something at various points while reading fictional literature. We can empower them to collaborate on these projects as mini-design teams. As an example, in "Goldilocks and the Three Bears", the children may identify a need to do the following:

	• Design a system for the Bears to know someone is in their house • Design a stronger chair for the Baby Bear • Design an escape system for Goldilocks. By reviewing the table "Learning to Think" , we can see the similarities in the processes of Critical thinking, Science, Engineering and Mathematics. This provides us with the opportunity to use the critical thinking process of questions to support our use of engineering as part of the learning process.
Assignment:	1. Tell the group how you will incorporate within your class the use of the engineering process as a vehicle to teach math, science and engineering? 2. Can you pick at least two fictional books for your grade level and describe a few jumping off point to empower the students to use the engineering principles? 3. How would you empower the students to work on the projects and what deliverables would you set for them? 4. What items in your plans are getting the students to be excited about learning?
Supported Framework documents	• Math framework outline • Appendix I Science Framework • Strand 4 Science Framework(Engineering)