Integrating Engineering

- Engineering survey
- Engineering Values
- what is an engineer .. Discuss paper
- Framework … Design process + tools
- Thinking skills
- Connecting to Literature

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Integrating Engineering
BSEE; MS in Science

Course Goals:

- **By the end of this course, students(K-5 Teachers) will be able to:**
- Clearly articulate the nature of technology/engineering
- 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
- Be comfortable with what engineers do and their similarities and dis- similarities to teaching.

What do you want?

Definitions:

Generally, the following distinctions can be made:

- *Science* is the formal process of investigating natural phenomena. It produces information and knowledge about the world.

- *Engineering* is the goal-oriented process of designing and building tools and systems to exploit natural phenomena for a practical human means. *Engineers* work within the constraints of natural laws and societal needs to create technology.

- *Technology* is the consequence of these two processes and societal requests. Most commonly, the term technology is used as the name of all engineering products. As an example, the Wheel, Military hardware, Wireless, etc.

The Relationship Between Science and Technology/Engineering

In spite of their different goals, science and technology have become closely, even inextricably, related in many fields. The instruments that scientists use, such as the microscope, balance, and chronometer, result from the application of technology/engineering. Scientific ideas, such as the laws of motion, the relationship between electricity and magnetism, the atomic model, and the model of DNA, have contributed to achievements in technology and engineering, such as improvement of the internal combustion engine, power transformers, nuclear power, and human gene therapy. The boundaries between science and technology/engineering blur together to extend knowledge.

Science Framework, 2006

Reading … paint a picture

Please have the teachers who will be in the class read the following items from my web site for the class:

About engineering:

- http://www.integratingengineering.org/Bernard_Gordon_has_been_called_a.pdf
- http://www.integratingengineering.org/engineer_definition_careers.pdf

- Science framework:
- http://www.integratingengineering.org/Strand4_science_engineer_framework_0501.pdf

Values in our class

Discussed a lot at Engineering Companies

Risk taking	Excitement	Collaboration	Curiosity
Skepticism	Passion	Innovation	Listen first
Trust/ Integrity	Encourage constructive dissent	Respect	Continuous learning

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.

Discussion about Bernie Gordon

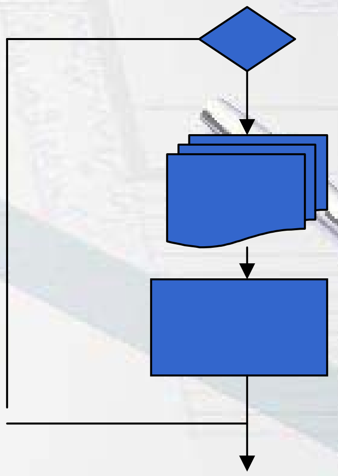
Can someone who read the article, give us a short summary about Bernie and his relationship to engineering?

"I derive satisfaction from doing something that is useful for other people. I was brought up that way, and I was trained that way."

Instead, Gordon says engineers need better communication and interpersonal skills, a sense of economic discipline and an "interdisciplinary" approach that will enable them to conceptualize solutions and follow those solutions through the manufacturing process. Gordon emphasized the immediacy of the engineering problem in a keynote address, "What Is an Engineer?" presented to the European Society for Engineering Education
Annual Conference in 1984, and now in its fourth printing. Here he proposes that the future depends in large measure on educating "real" engineers. A "real" engineer, according to Gordon, is not the "geek" or "nerd" who has sacrificed intellectual breadth and social ease for narrow expertise and introversion. Rather, it is a person who, because of his or her broad education and habit of thought, "can conceive and invent, who does not wait to be told to initiate, but imagines, conceives, proposes, pleads and debates for a cause and an impossible dream. Takes risks.

Engineering Process … Framework

1. Identify the need or problem
2. Research the need or problem
3. Develop possible solutions
4. Select the best solutions
5. Construct a prototype
6. Test & Evaluate the solution
7. Communicate the solution
8. Redesign & Renewal



What is an engineer?

Knowledge: The areas of required knowledge are not limited to those of science or technology, as a consideration of the role of the engineer as a leader will reveal. An understanding of societal evolution through study of history, economics, sociology, psychology, literature, and arts will enhance the value of the engineering contribution.

Skills: A real engineer's skills are essentially scheduled problem-solving techniques of design in which the concentrated disciplines of science and technology are exercised with the personal creativity and judgment developed from training and experience. In addition, because engineering accomplishments are achieved in a group environment, the communication skills are critical to the roles as follower.

Values

Successful team leadership implies a degree of self criticism, where egotism and modesty have counterbalancing influences. It requires a spirit of curiosity and courage that leads to creativity and innovation. It is characterized by a forcefulness that gives orders, as well as receives orders, and accepts the challenges of competition in the market place with a perseverance to succeed

Organization … typical technology company

Management

Engineering

Research
Hardware
Software
Mechanical

Sales

Sales engineer

Marketing

Customer engr.

Finance

Cost engineer

Manuf.

Test engr
Manuf. engr
Component engr.

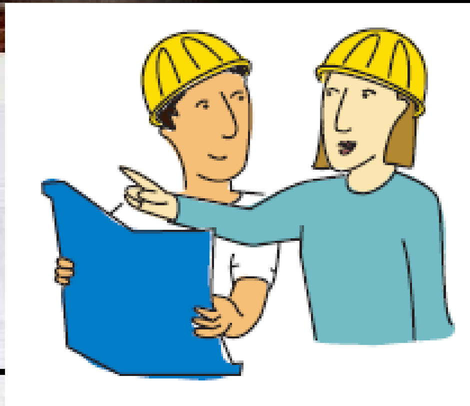
Customer Service

Service engineer

HR

Legal

Types of Engineering



Chemical Engr.	Bio Medical Engr.
Civil Engr.	Power Engr.
Aeronautical Engr.	Meteorological Engr.
Structural Engr.	Professional Engr.
Software Engr.	Electrical Engr.
Mechanical Engr.	System Engr.

Careers:

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

What do they do during the day?

- Check email
- Project planning their actions for the day
- Catching up with associates (water cooler)
- Working on their project or task
- Communicating about their project with others
- Documenting what they have done, drawing, reports.
- Learning new skills and technologies

Children's Engineering

Engineers are creative problem solvers who do not seek unique solutions, but optimum ones, the kind in which trade-offs have been made between competing factors, e.g. time, money, and materials. There are several ways to describe the design process, but all include constraints and specifications, research and investigation, brainstorming and creativity, trade-offs and optimization, testing and evaluation, and analysis applied in an iterative, non-linear fashion. In engineering education it is important to assess the process as well as the solution, as our goals are both, not either or. This is exactly the case in children's engineering.

M. David Burghardt, Ph.D., P.E., is a Professor in the Engineering Department at Hofstra University.

Question?

Why did the creators of the framework add engineering to the science framework?

Benefits:

Integrating engineering into the PreK-5 curriculum adds the following benefits to the total learning process:

- *Promotes higher-order critical thinking skills. Meta-cognitive and cognitive skills are multi-leveled and fully integrated into the design process.*
- *Invites the incorporation of instructional technology into the curriculum Excel, Word, and Power Point, along with Smart Board technology, and use of peripheral devices such as scanners and digital photography, are all easy to incorporate into engineering projects.*
- *Engineering is differentiated: offers an "in" for learners of all types. Due to its project-based nature, there are many roles that students can play on a design team. Students with widely differing skill sets and abilities all find a niche.*
- *Rich cross-curricular possibilities. Engineering and technology are always embedded in social contexts. Educators can use the rich social contexts of technology/engineering to tie in meaningful learning in related content areas.*
- *Integration with math is important way to show students how and why math is relevant and useful in the world. Engineering counteracts the "Why do we need to learn this?" question that students always complain about.*
- *Directly connected with improvement of living conditions/safety/health and welfare of people. Engineering can provide relevance to students' lives and the world outside the classroom. Students can explore authentic problems and issues, connect their learning to real issues in their local community, tap the knowledge and resources of local experts, and make a meaningful contribution to their school or town.*

Mary Taft

Questions

Need to translate to an age appropriate level

Identify the need or problem Compare / Contrast Decision process Drawing Conclusions Analysis	What are we looking to do? How would we judge success? What do we have to design to solve this issue? What is the purpose of this design? What would the goals and objectives be? Can we break the problem/design into parts?
Research the need or problem Classification Sequencing Critical Thinking Compare / Contrast Root Cause	What do we know? Any similar circumstance from the past that we can build on? Who are the stakeholders and their needs? What outside factors will affect this problem/need/design? What questions do we need to ask? How do we know the facts are true? What evidence do we have? What science do we need to understand to implement this design? How would we use the science?
Develop possible solution (s) Brainstorm Critical Thinking Root Cause Synthesis	What concepts, definitions, and principles do we need to utilize? Have we taking all assumptions, thoughts into consideration? What facts, data, observations and experiences are available? Can we combine elements into a novel design?

Select the best possible solution Compare / Contract Classification Drawing Conclusions Problem Solving	What interpretation and inferences can we make? How does it meet all the requirements of the design? How would we test the solution so we can provide information about the design?
Construct a prototype Classification Evaluation Drawing Conclusions	Do we need to build it or can we simulate it? What materials, skills & tools do we need? What plans are necessary to document the design? Can we break of the construction into modules?
Test and evaluate the solution	What test plan do we need to evaluate the design? What tools do we need to test it? How can we design this solution so we can easily reproduce it?
Communicate the solution	Who are our audience and what are they expecting to hear? Have we testing all our conclusions and facts? Have we presented it in a way people can understand it? How can we present the information in clear and concise graph ?
Redesign & Renewal	What have we learned and how can we do it better the next time? How can I do it better?

Engineering Framework K-5

Grades PreK-2

1. Materials and Tools

Broad Concept: Materials both natural and human-made have specific characteristics that determine how they will be used.

Identify and describe characteristics of natural materials (e.g., wood, cotton, fur, wool) and human-made materials (e.g., plastic, Styrofoam).

Identify and explain some possible uses for natural materials (e.g., wood, cotton, fur, wool) and human-made materials (e.g., plastic, Styrofoam).

Identify and describe the safe and proper use of tools and materials (e.g., glue, scissors, tape, ruler, paper, toothpicks, straws, spools) to construct simple structures.

Extensions to Learning in Technology/Engineering

Paper Bridge Challenge. Students create a bridge with a half sheet of regular 8-1/2" x 11" paper cut lengthwise. Adhesives may not be used for this project, but the students may fold, bend, or the cut paper to create their bridge. The students place the ends of their bridge on an even stack of books. Pennies are placed on the bridge to test its strength. (1.1, 2.1)

Testing Food Glues. This activity has students identify a simple machine, the lever, as a useful tool in testing glues and explore the properties of materials by finding out which food is the stickiest. The students assemble a balance scale with penny weights on one side and a cup glued to a paper plate on the other. The force of the penny weights separates the glued objects when enough pennies are added. After each test, students record their findings on a chart and share their results. (1.2, 2.1)

Which roof is tops? Explore the advantages of different roof shapes (curved, A-frame, flat) for different climates or situations. (1.3, 2.1)

2. Engineering Design

Broad Concept: Engineering design requires creative thinking and consideration of a variety of ideas to solve practical problems.

Identify tools and simple machines used for a specific purpose, e.g., ramp, wheel, pulley, lever.

Describe how human beings use parts of the body as tools (e.g., teeth for cutting, hands for grasping and catching), and compare their use with the ways in which animals use those parts of their bodies.

Grades 3-5

1. Materials and Tools

Broad Concept: Appropriate materials, tools, and machines extend our ability to solve problems and invent.

Identify materials used to accomplish a design task based on a specific property, i.e., weight, strength, hardness, and flexibility.

1.2 Identify and explain the appropriate materials and tools (e.g., hammer, screwdriver, pliers, tape measure, screws, nails, and other mechanical fasteners) to construct a given prototype safely.

Identify and explain the difference between simple and complex machines, e.g., hand can opener that includes multiple gears, wheel, wedge gear, and lever.

Extensions to Learning in Technology/Engineering

Using given insulating materials, try to keep an ice cube from melting. (1.1, PS 3)

Weather Station. Construct various weather station instruments, record data from them, and make conclusions based on the recorded data. (1.1, 1.2, 2.1, 2.2, 2.3; ES 7, 9)

2. Engineering Design

Broad Concept: Engineering design requires creative thinking and strategies to solve practical problems generated by needs and wants.

2.1 Identify a problem that reflects the need for shelter, storage, or convenience.

Describe different ways in which a problem can be represented, e.g., sketches, diagrams, graphic organizers, and lists.

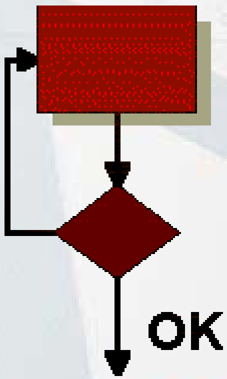
Identify relevant design features (e.g., size, shape, weight) for building a prototype of a solution to a given problem.

Compare natural systems with mechanical systems that are designed to serve similar purposes, e.g., a bird’s wings as compared to an airplane’s wings.

Interview an engineer

What is a typical days activities of an engineer?

http://www.integratingengineering.org/Assignment_engineer_052306.pdf



Learning to Think

Critical Thinking www.criticalthinking.org	**Science Method** **The art of making sense … Ruby**	**Engineering Process* From Framework page 53 May 2001**	**Mathematical Problem Solving Modified from George Polya's four step method in his book How to Solve it, by Pat Davidson**
What's the author's purpose?	Define the situation **Develop a Hypothesis**	Identify the need or problem	Understand the problem
What key questions or problems does the author raise?	The precise formulation of the problem **Design an Experiment**	Research the need or problem	List the key facts given and questions to be answered
What information, data and evidence does the author present	**Perform the experiment** Observation of the relevant facts	Develop possible solutions	Devise a plan or strategy such as: •Look for a pattern •Look at the basic foundation •Draw a picture or diagram
What key concepts guide the author's reasoning?	The use of previous knowledge	Select the best solutions	Solve the problem
What key conclusion is the author coming to? Are they justified?	Formulation of the explanatory hypothesis	Construct a prototype	Check the results and examine the solution
What is the primary assumption?	Deductions from the hypothesis **Form a Conclusion**	Test & Evaluate the solution	Communicate the complete solution with proper units and labels
What is the author's viewpoint?	Testing	Communicate the solution	Lock back to reflect on the process and other strategies that could have been used
What are the implications of the author's reasoning?	Conclusion: **Write a report**	Redesign & Renewal	Look ahead to think about how the problem could be extended

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

billwolfson

Thinking Skills … tools of engineering

Purpose: to create a learning environment:

Engaging strategy (questions)

Framing of thoughtful questions, and the follow-up of these questions for understanding.

An intellectual habit of thoughts

for students to learn across all areas, life learning, habits of mind

Meta-cognitive skills

Teach and model the value of meta-cognitive skills for self-evaluation and improvement. **Knowing what I know and don't know**

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

Connecting Literature to Science & Math using the Engineering Design Process

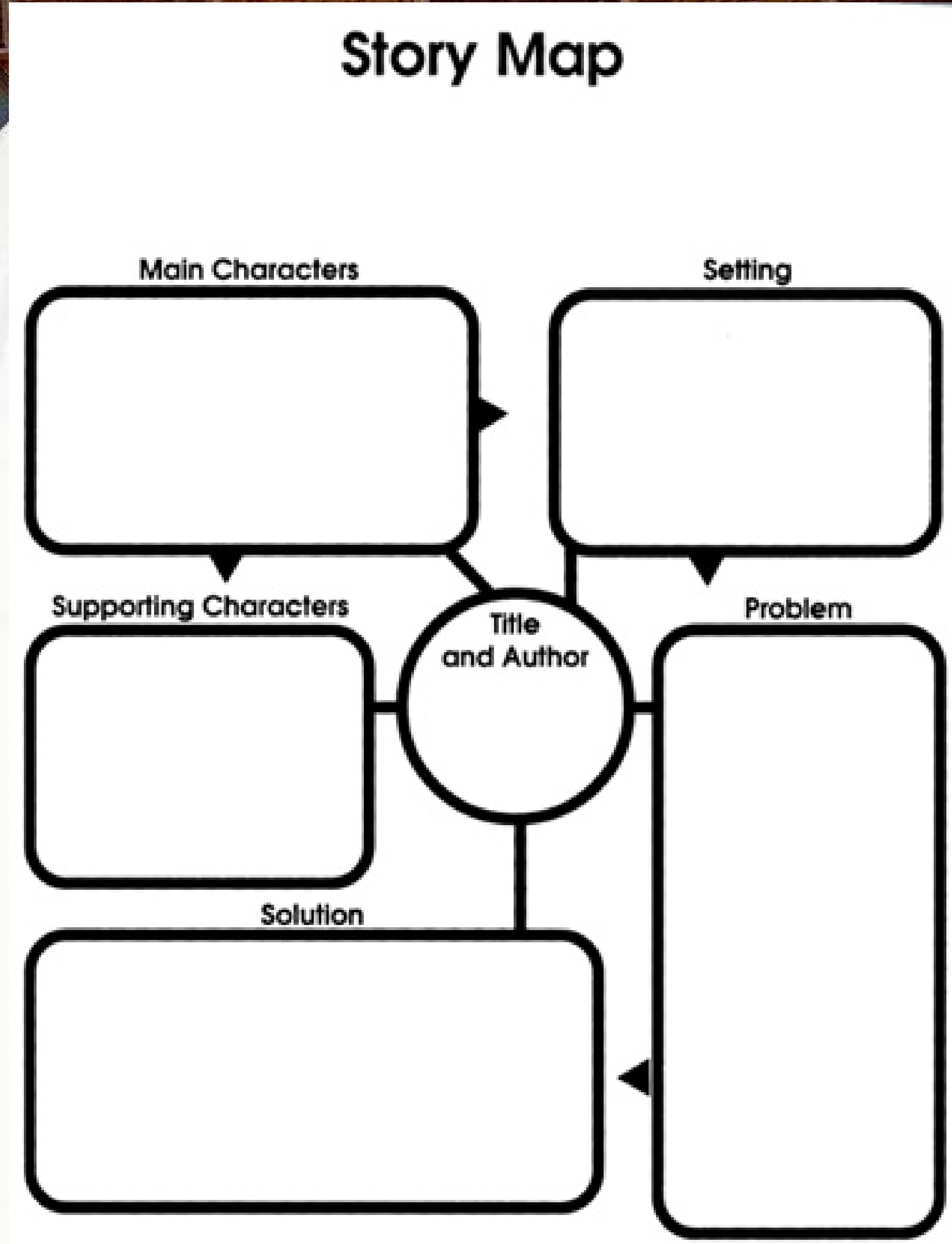
PreK-2	Major focus on the thinking process (questions & drawing models)
Grades 3-5	Focus on teams & products

Finding design challenges

Where in the story is there an opportunity to design something for a character that would help or change the story?

What science are we learning this school period?

Students need to be invested & empowered



Engineering Design Challenge

Design Process & Thinking Skills

Classroom Setting

Have the students participate in finding the design challenges based on their understanding of what the learning expectations are for Science and Mathematics.

Room Environment:

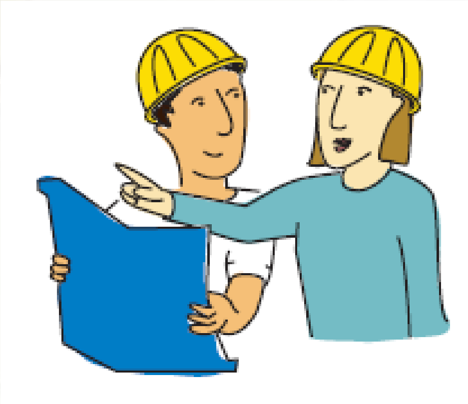
- Have posters of the following:
  - **Engineering design process**
  - **Thinking skills**
  - **questions**
  - **Team working process**
  - **Vocabulary chart**
  - **Culture / values**

What Science Strand is your grade working on from the Framework?

- Earth & Space
- Life Science
- Physical (Chemistry, Physic)

Number Sense	**Patterns, relationships, Algebra**	**Geometry**	**Measurements**	**Data Analysis, Statistics, Probability**

Lets do a story!



Many versions of these stories

A fairy tale:

•Goldilocks & the Three Bears

•Wolf & the Three Pigs

A story:

- Island of Blue dolphins by Scott O'Neil
- Charotte's Web by E.B. White

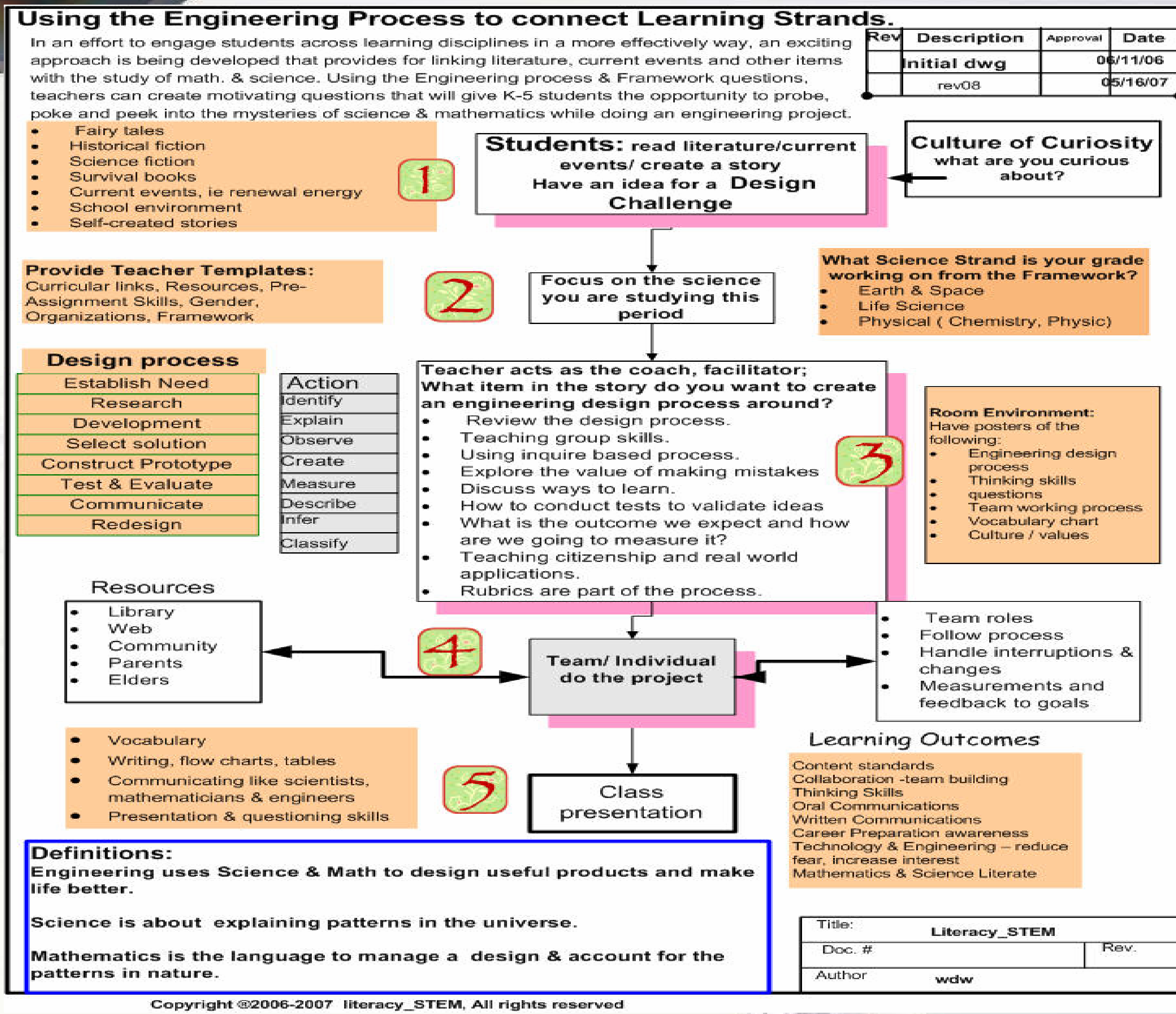
The engineering sequence ensures that students are doing the thinking.

Inquiry-based Learning:

Invite students to find patterns and relationships, to become flexible problem-solvers, to articulate their reasoning, and to become meta-cognitive about their strategies.

It begins with a complex problem, and continues with independent or group work, a mini-lesson based on what students are struggling with or have discovered, sharing/comparing problem-solving strategies, and a synthesis of the day’s learning.

Summary



Using the Engineering Process to connect Learning Strands.
In an effort to engage students across learning disciplines in a more effectively way, an exciting approach is being developed that provides for linking literature, current events and other items with the study of math. & science. Using the Engineering process & Framework questions, teachers can create motivating questions that will give K-5 students the opportunity to probe, poke and peek into the mysteries of science & mathematics while doing an engineering project.
Rev | Description | Approval | Date
Initial dwg | 06/11/06
rev08 | 05/16/07
Fairy tales
Historical fiction
Science fiction
Survival books
Current events, ie renewal energy
School environment
Self-created stories
1
Students: read literature/current events/ create a story Have an idea for a Design Challenge
Culture of Curiosity what are you curious about?
Provide Teacher Templates: Curricular links, Resources, Pre-Assignment Skills, Gender, Organizations, Framework
2
Focus on the science you are studying this period
What Science Strand is your grade working on from the Framework?
Earth & Space
Life Science
Physical (Chemistry, Physic)
Design process
Establish Need
Research
Development
Select solution
Construct Prototype
Test & Evaluate
Communicate
Redesign
Action
Identify
Explain
Observe
Create
Measure
Describe
Infer
Classify
Teacher acts as the coach, facilitator; What item in the story do you want to create an engineering design process around?
Review the design process.
Teaching group skills.
Using inquire based process.
Explore the value of making mistakes
Discuss ways to learn.
How to conduct tests to validate ideas
What is the outcome we expect and how are we going to measure it?
Teaching citizenship and real world applications.
Rubrics are part of the process.
3
Room Environment: Have posters of the following:
Engineering design process
Thinking skills
questions
Team working process
Vocabulary chart
Culture / values
Resources
Library
Web
Community
Parents
Elders
4
Team/ Individual do the project
Team roles
Follow process
Handle interruptions & changes
Measurements and feedback to goals
Vocabulary
Writing, flow charts, tables
Communicating like scientists, mathematicians & engineers
Presentation & questioning skills
5
Class presentation
Learning Outcomes
Content standards
Collaboration -team building
Thinking Skills
Oral Communications
Written Communications
Career Preparation awareness
Technology & Engineering – reduce fear, increase interest
Mathematics & Science Literate
Definitions:
Engineering uses Science & Math to design useful products and make life better.
Science is about explaining patterns in the universe.
Mathematics is the language to manage a design & account for the patterns in nature.
Title: Literacy_STEM
Doc. #
Rev.
Author wdw
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