Integrating Engineering & Literature, to teach STEM(Science, Technology, Engineering, Mathematics)

Using the engineering design process & skillful questions, teachers can engage students in PreK-5 grades the opportunity to probe, poke and peek into the mysteries of science & mathematics while reading literature.

What do we know as teachers?

- What engineers do.
- What is the engineering design process as defined in the science framework, 2006
- How to engage students while studying literature with questions

Why Use Literature?

- Literature is a integral part of all existing school curriculum.
- Stories have the potential to present situations that can challenge children's imagination.
- Some stories can serve to encourage students to begin to generate design proposals and connect to STEM
- Literature is an area of the curriculum that all teachers are familiar with and thus the design process can start from a position of strength within the classroom.

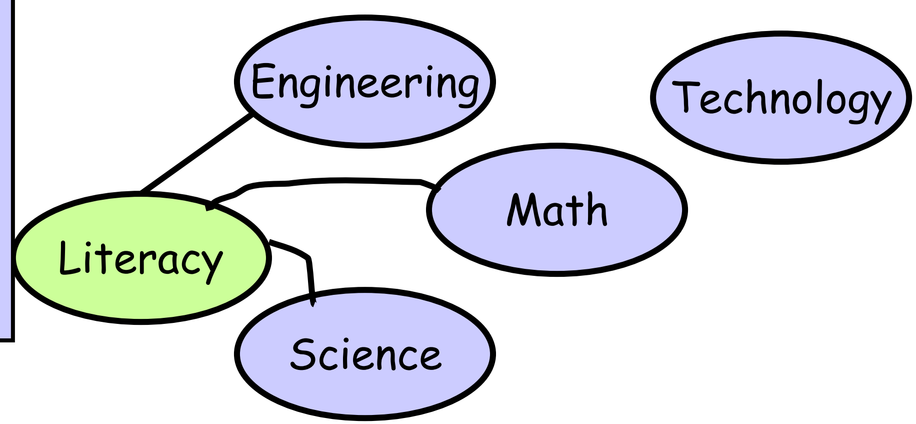
Our program discussion will be on integrating STEM learning with literature using fiction & non- fictional literature.

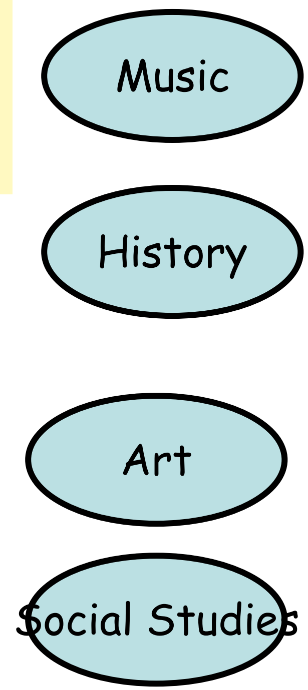
Simplified engineering design process

- Identify a need
- Research
- Develop and communicate
- Design Logistics
- Build and Test
- Evaluate & Resign

Students become the forensic STEM Engineers of Literature.

Teachers become the Engineers of Learning.





Program

Literature, Current Events

1. Teachers & students look for markers based on the Massachusetts Frameworks & the Engineering design process within a story.
2. Teachers use questions that motivate and encourage students learning.
3. Students/Teams do independent design project, while having a conversation with the books author.
4. Student/Teams report and use rubrics for assessment to other students.

Engineering design process

- Identify a Need
- Research
- Develop and Communicate
- Design Logistics
- Build and Test
- Evaluate, Redesign

Foundation Learning:

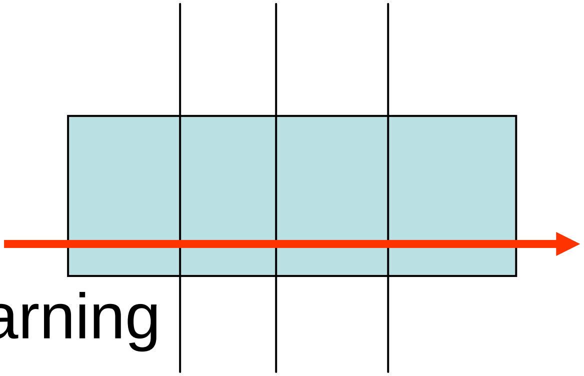
Group	Learning
Teachers:	•Understand and promote incremental theory of intelligence •Design process./ Roles of an engineering •Skillful thinking.
Students:	•Design process./ Roles of an engineering Skillful thinking process

Why is this important ? …

Learning Outcomes

- Content Standards
- Collaboration
- Skillful Thinking
- Oral Communications
- Written Communications
- Career Preparation
- Citizenship & Ethics
- Technology & Engineering Literacy
- Mathematics & Science Literate

What do we see?



- Silo’s of each discipline
- Similarities of processes
- Need to include the process in our learning

Why can’t we teach across disciplines to engage our students & simplify the K-5 teachers work load?

Process around Learning

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	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	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	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

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

Student-Centered Teaching, Learning, and Assessment

Students need:

- to participate in many different kinds of activities to gain a broad knowledge base, develop thinking skills, and take responsibility for their own learning.

Activities should:

- include independent reading on and investigation of topics identified by the teacher and by the student, foster curiosity, performances that require in-depth understanding, complex questioning and thinking, and opportunities to present conclusions in new ways. Curiosity , Fun, Learning

Assessment tasks should:

- be embedded in learning activities to mesh instruction and monitoring students' progress toward the attainment of learning goals.

(Grant Wiggins, "Assessment to Improve Performance, Not Just Monitor It: Assessment Reform in the Social Sciences," *SocialScience Record*, Vol. 30, No. 2, Fall 1993, p. 10.) Using this approach at all levels is supported by recent studies showing that students can conceptualize and employ complex thinking skills at a very young age.

Intellectual and Practical Skills Improvement

- Written and oral communication "Good writing skills and good public speaking are crucial to business success."
- Inquiry, critical and creative thinking "We are reminded that the real challenge of today's economy is not in making things but in producing creative ideas."
- Quantitative literacy "Business wants new employees from the educational system who can do mathematics accurately...in the world of work it means dealing with real, unpredictable, and unorganized situations where the first task is to organize the information and only then calculate to find an answer."
- Information literacy "Workers are expected to identify, assimilate, and integrate information from diverse sources; they prepare, main, and interpret quantitative and qualitative records; they convert information from one form to another...."
- Teamwork "Extracurricular activities and college projects that require teamwork can help students learn to value diversity and deal with ambiguity."
- Integration of learning "Reading, writing, and basic arithmetic are not enough. These skills must be integrated with other kinds of competency to make them fully operational."

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LIBERAL EDUCATION OUTCOMES: A PRELIMINARY REPORT ON STUDENT ACHIEVEMENT IN COLLEGE. 2005

What do we need to teach?

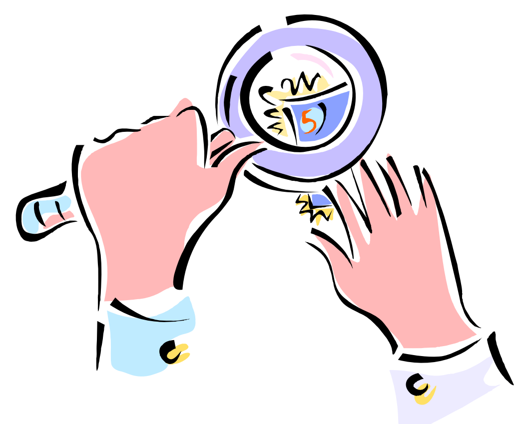
"Some vast fraction of what we know today is going to be so different technically tomorrow, five years from now, that we can't afford to teach the children any specific set of facts, beyond very basic math and physics and chemistry"

"So what we must teach, in some sense, is the process of innovation, the process of creation

Mark Yin professor of engineering, Univ. of Penn.

How can we connect?

Piggyback on their effort to teach Literature … Have the underline theme plus the excitement of the story to create passion in our students.



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

Strategy

Define an approach for what you want the leaning outcome to be.
Pick a science strand to connect to the design
With an engineer's perspective, use the normal teacher's skills to engage students in the story. … Look at "story map" for ideas, think of engineering key words
Develop design challenges, Document it.
Integrate the engineering design and the science
Use the 8 step design process

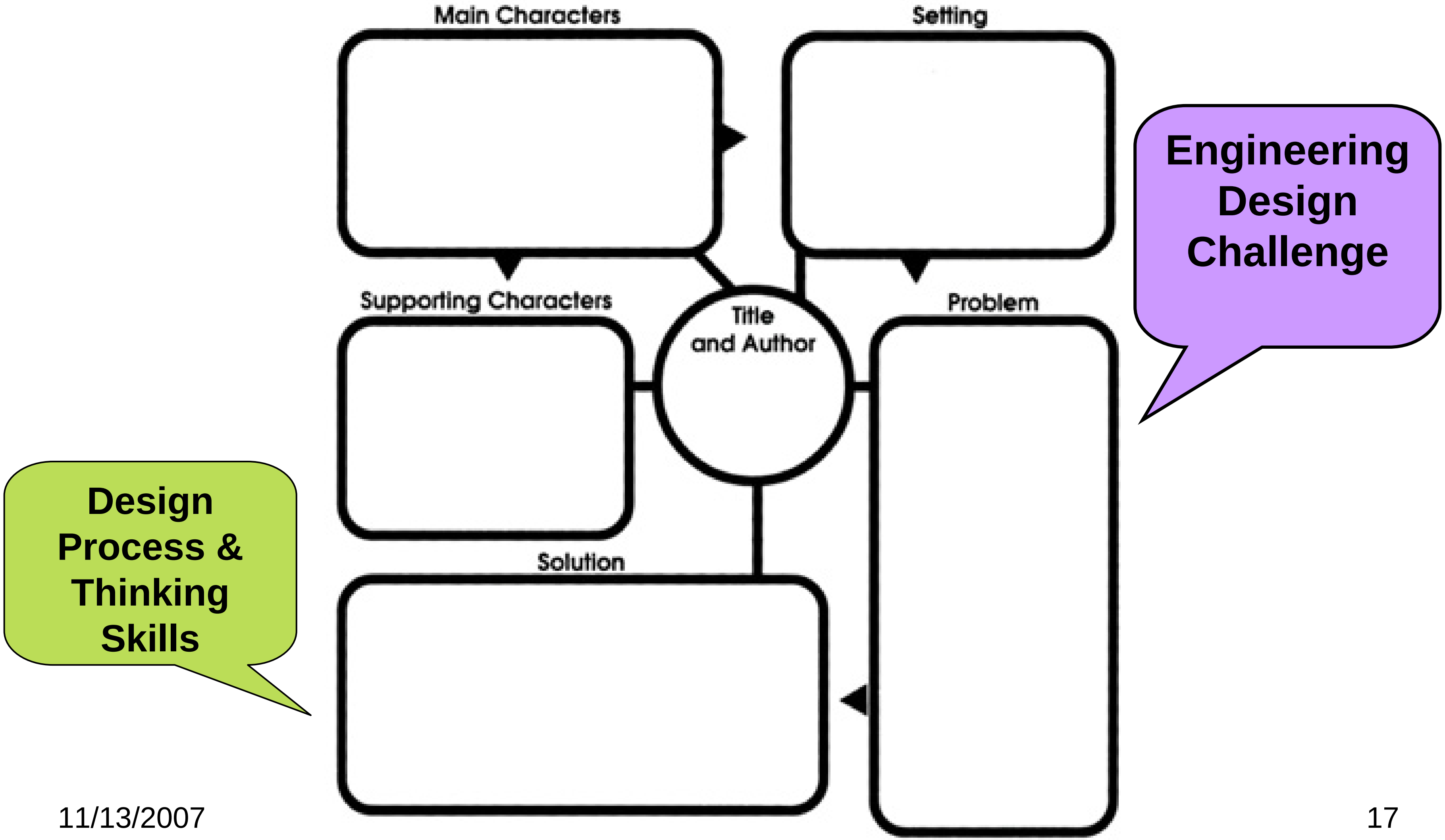
Goldilocks & Three Bears

Design a:

1. Security system for the door
2. Escape method for Goldilocks
3. A stronger chair

The bears are your customers!

Story Map


Main Characters
Setting
Supporting Characters
Title
and Author
Problem
Solution
Engineering Design Challenge
Design Process & Thinking Skills

Modify the action based on grade level

PreK-2: Focus on using the 8 step design process (or a simplified one) and thinking skills questions to do the design challenges. Use mainly a talking process between the teacher and the students to do the design process. Students can learn the basic of scaling, paper modeling, and natural and manmade material and small group team operation.
Grades 3-5: Expand the activity around the design challenges with more focus on team collaboration and building artifacts within the group. More self-directed operation

When choosing your book, you can integrate Social Studies/History by picking books with themes that track the **Social Studies/History Framework**

Pre-Kindergarten–Kindergarten: Living, Learning, and Working Together
Grade 1 : True Stories and Folk Tales from America and from Around the World
Grade2: E Pluribus Unum: From Many ,One
Grade 3 : Massachusetts and its Cities and Towns: Geography and History
Grade 4 : North American Geography with Optional Standards for One Early Civilization
Grade 5 : United States History, Geography, Economics, and Government: Early Exploration to Westward Movement

Approach:

A teacher normal engages the students with the literature they are reading by asking skillful questions and using meta-cognitive thoughts to bring out interesting areas of the story line.

What we are adding is an Engineering lens on the process to focus those questions from an engineering designer's viewpoint.

Teacher Strategies	Student Activities
• Engage the students in the story by using questions that the students identify some **design challenges**. Look for conflicts, changes in the story line and places where a new item could help one of the characters. • How can someone’s quality of life be improved?, How can we make a certain task easier?, How can we improve upon an existing product? • Focus on key words that relate to science and engineering such as, habitat, weather, materials & tools, devices to help society, survival, plant material, and the environment. • Challenge the author’s assumptions in the story line by looking with the **engineering view**. • Have students brainstorm and decide on challenge they will work on. • **If the author was an engineer**, what would be added to the story? How can the students enhance this?	• Prior skills needed by the students to do this design challenge. • Understand the design process and what engineers do. • What science are we going to learn and teach to others

- **Form teams** based on strengths of the individuals to work together
- Have students select roles that they will do as part of the team. Focus on engaging the individuals.

Can we add **additional literacy skills** to this exercise? Keeping a design note book, making reports and presentations.

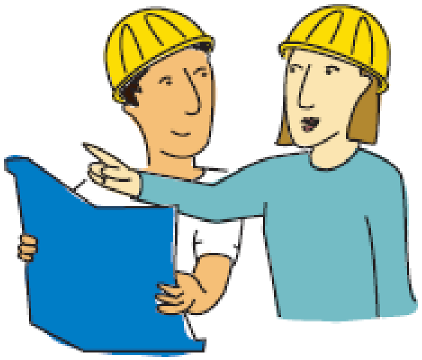
What are the major points of the author, **can we design something useful** that would help the story?

Add in other activities:

- budgeting constraints
- use of a timeline planning process
- how do we insure the quality of the product?
- fits the community needs
- What are the variables in the design and how do you control the tests?

Lets do a story!

Many versions of these stories



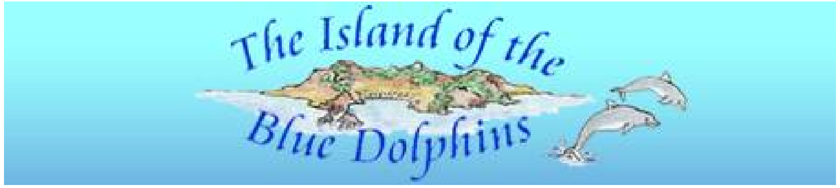
A fairy tale:

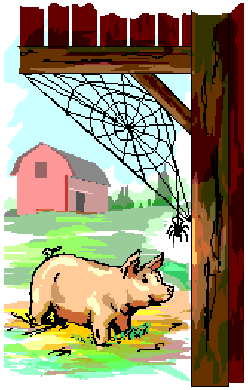
•Goldilocks & the Three Bears

•Wolf & the Three Pigs

A story:

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





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**

Other way to incorporate STEM

- Social analysis of the story to incorporate Math (Measurement Data analysis, statistics, probability) ..when story mentions average # of people
- Using the example to find all tools/mechanisms mentioned in the story and explain their use/design.
- Use map making as part of telling the story (symbols, legends, contour lines, scale measurements, etc)
- Looking for the design process in the story.
- Developing questions for doing things differently. … how would you do _____ ?
- Creating a theme about a particular item in the story. If story discusses an animal, develop its life cycle, do math about size, create questions about its genetics, what other books, what about social studies?

Rubric: / Assessments

How will we measure success?

How do we add Rubrics? *Assessments start with outcomes and provide the students with self-appraisal and direction in their own learning*

Best- used all the thinking skills and shows very good understanding of questions. Engage team members in activities and worked very well with them. Contributed a high level of content knowledge	**Very good-** Used a good portion of thinking skills and questions within the project. Provide team support and worked within the guidelines of the project. Contributed content knowledge.	**Adequate-** Used their thinking skills when other requested help. Provided team support when necessary and contributed adequate level of content knowledge	**Needs support-** Did not work at their level in using questions and thinking skills for the project. Did not support the team and contribute to its success. Did not know the content when called upon

Area	Assessment
Use of thinking skills	
Relating to the science	
Communication skills	
Team work	

What would we look for in science and math learning?

Propensity for lifelong learning

"So the industry requires a workforce that can keep pace with technology—

people who have the fundamental skills and an ability to continue learning....

They will need employees that can adapt, continue to learn, and keep pace with rapid developments."

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LIBERAL EDUCATION OUTCOMES: A PRELIMINARY REPORT ON STUDENT ACHIEVEMENT IN COLLEGE. 2005

Science Learning Methods

1 Hands-on Approach. Children need active opportunities to manipulate science, to handle science, and to get down and dirty with science. A hands-on approach to science has long been promulgated as one of the most effective instructional strategies for any elementary teacher.

2 Process Orientation. Focusing on the processes of science (e.g., observing, classifying, measuring, inferring, predicting, communicating, and experimenting) helps students appreci-ate science as a "doing" subject, one that never ends, but rather offers multiple opportunities for continuing examination and discovery.

3 Integrated Curriculum. When science is integrated into all aspects of the elementary cur-riculum, students begin to understand its relevance and relationship to their daily lives out-side the classroom. Children begin to comprehend the effect science has on daily activities, both in the present and in the future.

4 Cooperative Learning. When children are given opportunities to share ideas, discuss possi-bilities, and investigate problems together, they can benefit enormously from the background knowledge of their peers, as well as from the strength that comes from a group approach to learning.

5 Critical Thinking. One of the issues classroom teachers have wrestled with for many years concerns the need to help students become independent thinkers. In other words, effective science instruction is not dependent on helping students memorize lots of scientific information, but rather on assisting them in being able to use that data in productive and mutually sat-isfying ways.

Source= principles of science instruction

Research shows that there are five strands necessary for mathematical proficiency:

1. **Understanding:** the comprehension of mathematical concepts, operations, and relations-knowing what mathematical symbols, diagrams, and procedures mean.
2. **Computing:** Carrying out mathematical procedures, such as adding, subtracting, multiplying, and dividing numbers flexibly, accurately, efficiently, and appropriately.
3. **Applying:** Being able to formulate problems mathematically and to devise strategies for solving them using concepts and procedures appropriately.
4. **Reasoning:** Using logic to explain and justify a solution to a problem or to extend from something known to something not yet known.
5. **Engaging:** Seeing mathematics as sensible, useful, and doable - if you work at it - and being willing to do the work.

The National Research Council recently released its findings on what constitutes mathematics proficiency in two publications: *Adding It Up* and *How Children Learn.*

The engineering sequence ensures that students are doing the thinking.

Inquiry-based Learning:

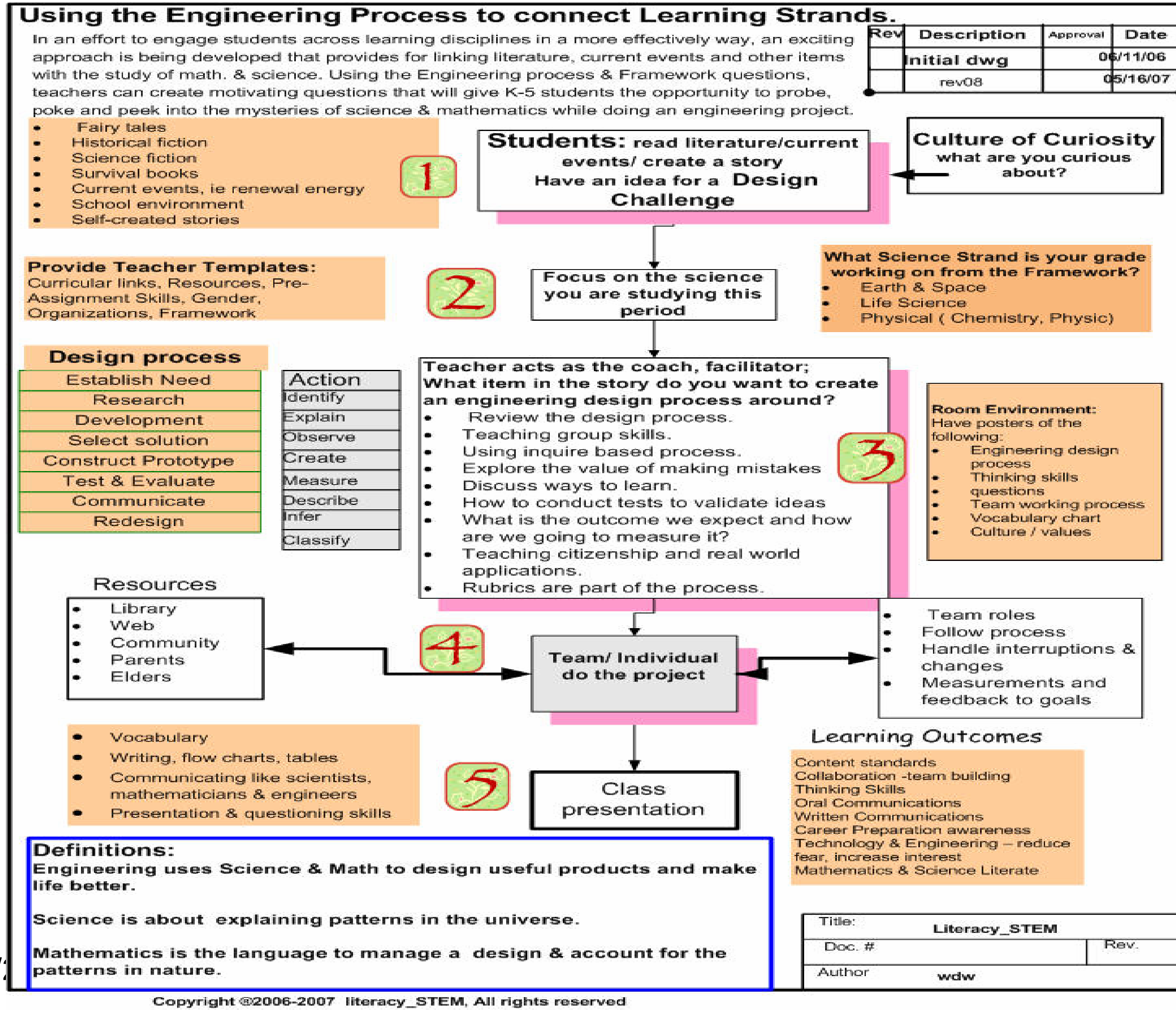
Invite students to find patterns and relationships, to become flexible problem-solvers, to articulate their reasoning, and to become meta-cognitive about their strategies.

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.

What Value will this have?

Teacher	Student
Engages & connects teachers with all their teaching subjects through a story.	Students see STEM learning through applications in the story.
Simplifies & saves time for the teachers in preparing children for learning the framework strands.	Gives students another way of learning … "Visual, Kinesthetic", activities associated with reading the story.
Ties together the 3 R's –Relationships –Relevance –Rigor	Students can have their own conversations with the author, questioning, learning, etc. They become life learners versus fact repeaters.
	Activities can be done within teams fostering group skills.

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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What's Next

Open discussion

Where do we go from here?

End