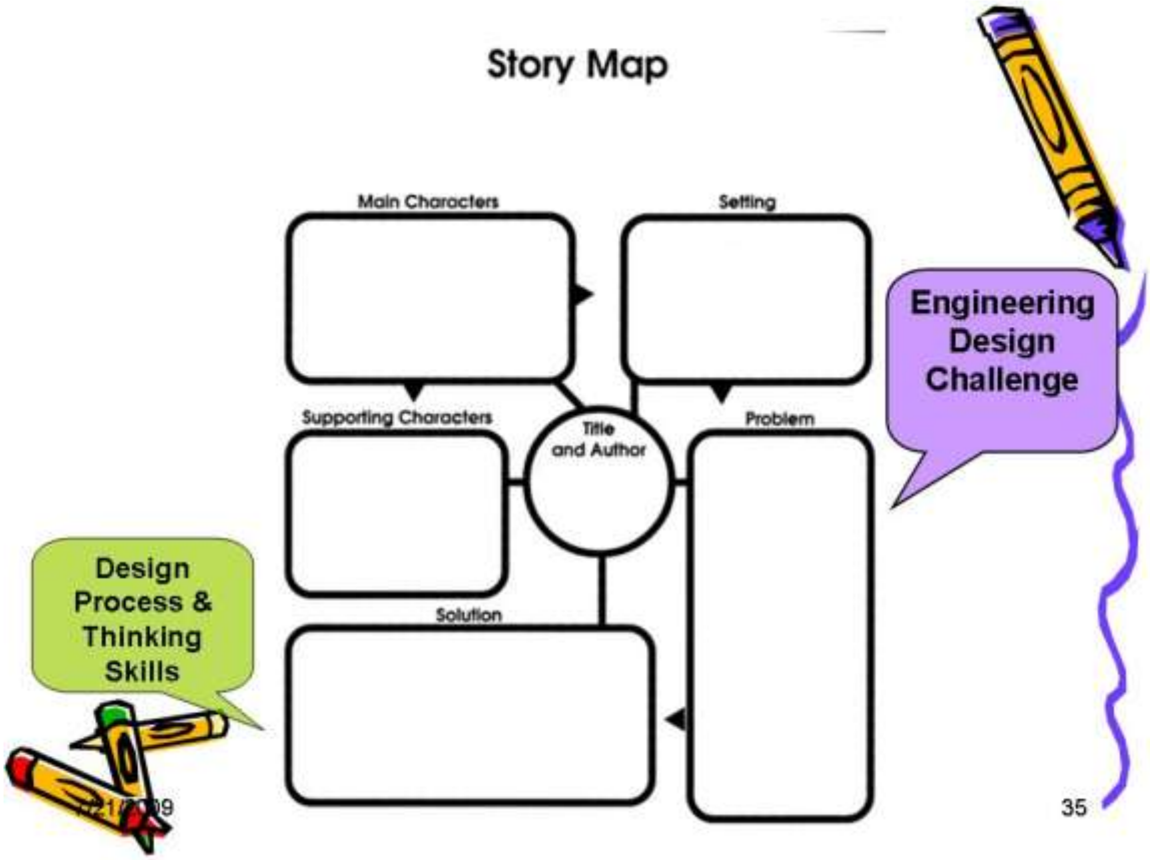
Finding Design Challenges in Stories



"Engineering design challenges" are created by actionable items in the story and lead to inquiry based team projects that have a design theme. As an example, in the story "Island of the Blue Dolphins", the village leaves canoes on the side of a hill for escaping a potential attack. The heroine in the story has a difficult time getting one of them down the hill and into the water. A "design challenge" for the students could be to design a system to make it easier for her to lower the canoe. Another example from Goldilocks would be for children to work for the Bears and design a security system to keep Goldilocks out of the house.

Approach:

A teacher normal engages the students with the literature they are reading by asking skillful questions and using meta-cognitive reflection 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.

Define an approach for what you want the leaning outcome to be.

- Do we want to emphasize the learning of the engineering design process?
- Do we want to focus on a science strand within a design process?
- Do we want to focus on teaching a thinking skill? Ie creative process

Pick a science strand to connect with, either one that you just studied (used for reinforcement) or one that you are going to study (great Segue).
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 (create, improve, identify, investigate, etc.). Think of the science you just studied.
Develop design challenges with the students. Have a few in mind to channel the students towards these.
Integrate the engineering design and the science. If you picked the science you just studied, you can ask the students to sort their design challenges around that science. If you are going to focus on the up-coming science lesson, guide your students to view the design challenges around that science. This will give you the teacher, a good segue into the new science lesson.
Use the 8 step design process or modified PreK-2 grade version. Remember that the design process is cyclical in nature and keep cycle you have additional knowledge to make better decisions.

What makes a good Design challenge?

- Fun to do.
- Serve a useful purpose.
- Fit with the science being studied.
- Have the tools and material to complete.
- Can do a lot with paper.

Teacher Strategies
• 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?
• 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?
Do we want to limit the materials used to the time period of the story? (brings in more historical understanding)

Science and Mathematics connections: Using the Massachusetts Frameworks

The elementary school day is a busy day, with many subjects that teachers have to cover in the curriculum. Engineering can provide an important role to build thinking skills as well as coordinate the connection of literature with the science and mathematics curricula.

How do teachers relate the design challenge to the science they need to teach? When we find a design challenge in a story and begin to develop it, we are doing the 4th strand of the science framework by utilizing the design process and tools. But generally we want to include one of the other three strands of science. We base this on the definition "***Engineering is about designing useful products & processes for society using all disciplines, but mainly science & mathematics".***

- earth and space
- life science
- physics and chemistry

What we know An engineering design project needs to use many other disciplines to create a design that provides useful value for society. Science is major contributor to most design projects. The Massachusetts Science framework provides the guidance for what science we should be learning based on the grade level we are at.
How does it fit into the engineering process? The engineering design process as defined in the framework is a higher order thinking skill that the students need to follow to create their product or paper design. In step two(2) we are asked to "Research the problem or need" where we determine what are the items we need to do to create our design. It is here where we begin to see the science that our design challenge is based on. When we get to step three(3), we start to understand the science to develop possible solutions. The students will begin to see the need to learn about the characteristics of the science to help develop solutions. They will develop the ideas of creating a hypothesis and design experiments to use the science. They will need to understand what a variable is and its effect on the design process.
Approach to create science learning through the design challenges. In many stories we sometimes have a common theme for the design challenge that we can help define the science about it. As an example, many stories will generate a design challenge around creating a habitant for an animal or humans. The habitant could be varied by making it stronger, better for the environment or other attributes. We can generalize about what the science is for this and thus port it to other appropriate stories.

Analytical analysis plays a different role in children's engineering than it does in traditional engineering, while engineering design and the design process play similar pivotal roles. For millennia, analysis was not part of engineering; rather custom and craft formed the analytical base. For a child to design and fabricate a toy car, a model of a whale, a terrarium, it is not necessary that they know static, dynamics, and strength of materials; rather that they consider the constraints and specifications of the problem statement and employ their knowledge and creativity. The analysis portion has it strongest links to science and mathematics; indeed that is a vital link between the disciplines. It is during this part of the design process, often when children reflect on their product's performance, that they apply their knowledge of scientific principles and mathematical conceptualizations. For instance, they will understand force and friction when constructing, testing and evaluating axles; diameter and circumference when checking how far their vehicle moves.

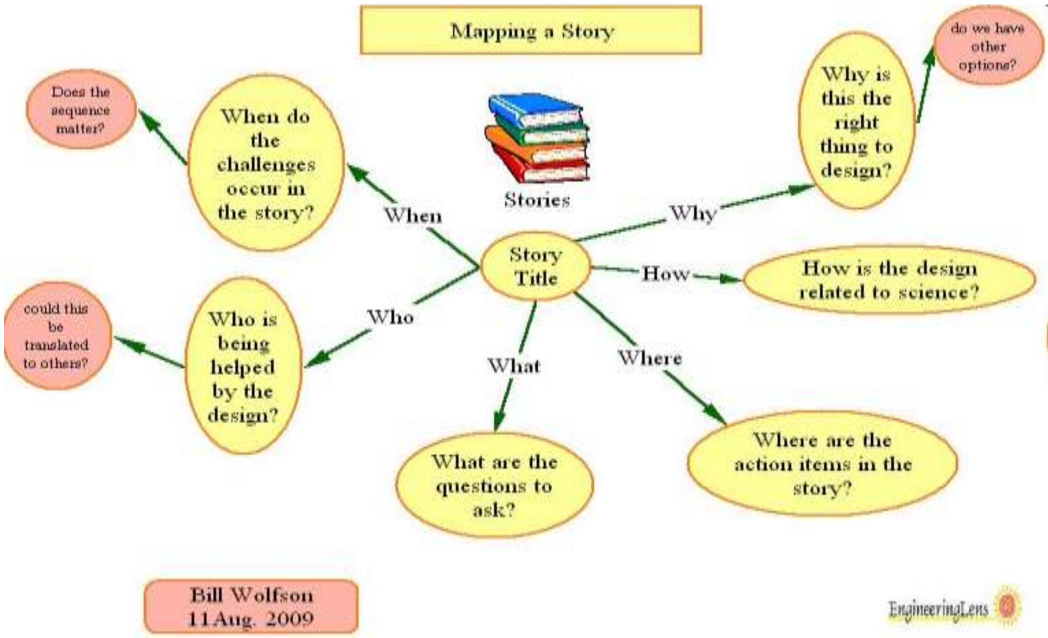
Engineering links most closely with the physical sciences, but the elementary program predominantly focuses on life and earth sciences and the human body; so we must not only interconnect with the physical sciences, e.g. electricity, magnetism and simple machines, but also with living things, by designing models of ants and butterflies, homes for snails, rain forest plants and animals. In creating the models, students will need to understand and apply their knowledge of say, the rain forest, its structure and the various plants and animals that live at different levels. The design itself may require scaling a 150-foot tree to 15 inches, or an anthropoid from ten centimeters to thirty centimeters. "Skills required for mathematical reasoning are also fundamental to the design and construction process. "Estimating and computing using formulas are examples of skills that can be meaningfully incorporated in the planning and testing of a design" (Dunn and Larson, 1990, p. 28).

The design and analysis of the product, the artifact, are components in which only part of the learning occurs. It begins as the student researches the problem, journaling questions and insights along the way. An important mathematical concept design brings to the forefront is geometrical understanding. Visualizing in two and three space and making sketches and drawings are part of the design process. It is also an important part of elementary school mathematics.

Using Existing tools:
Existing tools that the teacher uses within the classroom supports the use of the design process as well.

- The design can be guided through the use of a design portfolio. This is much more than a collection of student work; it provides a design process framework for the student as well as documenting key points of the process. The design project is developed to solve a problem whose genesis is often found in another area of the curriculum, such as reading, science, or social studies. This provides the context for the solution and creates a motivation for designing a device. Students in upper elementary are often required to write a short essay describing the context of their solution.

- The design map software tools that are used extensively in school also play a role to analyzing the story and finding the Engineering Design Challenges that play a central role. **Inspiration® and Kidspiration™**



The design process is inherently constructivist; it cannot be prescriptive and be designed. It is the belief of many elementary school science educators that a constructivist learning environment is most effective, fitting with students' developmental learning styles. Elementary school teachers use a variety of assessment techniques. Children's engineering requires assessment strategies that look to understandings, not memorizations, which are important for developing the thinking skills and problem solving skills necessary in a variety of academic disciplines.

Questions to spark the development of the Design Challenges in stories:

What action words can we find in the story? Can we list them? What physical items can these words relate too? Can we make sentences out of these action words combined with engineering words (Design, construct, create, make…)

Design challenges	Sciences	Details	Applications
	Earth & Space	Energy in the Earth System Materials and Energy Resources Earth process and Cycles Structure of the Earth Earth in the Solar System	
	Life science	Characteristics of Living Things Systems in living Things Heredity Evolution and Biodiversity Living things and their environment	
	Physic & Chemistry	State of Matter Position and motion of objects Forms of Energy	
	Engineering	Tools Materials Engineering Design	

List of generic design challenges versus the Science Framework

Science connections		
design challenges	**PreK-2**	**Grade 3-5**
shelter/ habitat	Weather, The sun as a source of heat & light Living things and their environment	Rocks, soil and their properties Materials and their properties Forms of energy Life cycles
garment to wear	Weather, Observable properties, earths materials	Form of energy, Properties of matter, Thermal properties
vehicle	position and motion of objects	motion of objects, Forms of energy, Energy Transfer
carry pouch, back panel Animals that carry their young	Earth materials, observable properties, living things & their environment	Form of energy, Properties of matter, Adaptation of living things

furniture, appliances	Earth materials, observable properties, living things & their environment	Form of energy, Properties of matter, Adaptation of living things, Alternative energy
Location determination	Planets, earth and space	Magnetism, Earth and Space
Recording motion change		Sensors, simple machines
Weather detection	Weather, design instruments	Simple machines, instruments
Air Movement		
Trap		
Escape device		
Creating a shoe		
Designing a biological device		
Chemical detector		

Do you have to be an expect in the science content? If the teacher is not already well versed in the science, it is the author's contention that you as the teacher do not have to be an expert in the content of the science but rather an active participant in learning about the science with your students. You need to understand the engineering design process and model the value of skillful questions in learning and seeking resources to support your learning for the students. You have to model meta-cognitive skills in asking your self how did you arrive at these learning standards. The learning needs to be in-depth with a clear understanding of how you can describe the science content.

Mathematic outcomes

Mathematical reasoning is fundamental to the design and construction process. Drawings and sketches including 2D, 3D and perspective are great starting points for a design.

In the lessons, we have the opportunity to ask mathematical thinking questions such as:

- How would I draw a diagram that shows the area, dimensions, etc. of what we are doing?
- How am I going to collect data to evaluate the design during the testing phase?
- How would I calculate ________?
- How would I calculate the cost of the material we need.

In general we can ask questions that get the students thinking and probing about the following:

Dimensions	Shapes
Patterns	Number sense
Colors	Functions

Area	Grouping/Comparing
Measurements	

Math Framework

- **Number sense** (How did you count and track its? How can you moves numbers to make it easier to add/ subtract, multiple and divide?)
- **Patterns, relations, Algebra** (What relationships do you see when looking at patterns?)
- **Geometry** understand the characteristics and properties of 2,3 dimension objects
- **Measurement** Understand measurable attributes of objects and the units, systems and processes
- **Data analysis**,
- **Statistics,**
- **Probability**