Integrating Engineering into the PreK-5 Curriculum.

Executive Summary:

Need.

Engineering design process

- Establish Need
- Research
- Development
- Select solution
- Construct Prototype
- Test & Evaluate
- Communicate
- Redesign

Not teaching engineering but the thinking process that underlines engineering

Science is part of the Massachusetts Framework and its subset engineering will be part of the MCAS testing for students. The teachers' already have difficulty teaching existing science as a discrete subject (not connected to the other learning disciplines). There is a need to excite students around learning mathematics and science and to realize the importance of these subjects in their future. At the same time, teachers' confidence needs enhancement that they can do science & thinking skills associated with the learning process in their classroom. The engineering design process as defined in the Science Framework (strand 4) offers a way to connection literature where in the Prek-5 the teachers are generally more comfortable with math & science in a non-threatening way because of its commonality with higher order thinking skills, the science discovery process and the mathematical problem solving process.

Kids also must learn to think across disciplines, since that's where most new breakthroughs are made. It's interdisciplinary combinations—design and technology, mathematics and art—"that produce YouTube and Google," says Thomas Friedman, the best-selling author of The World Is Flat.

If students are to function successfully in a highly technical society, then they must be equipped with lifelong learning and thinking skills necessary to acquire and process information in an ever-changing world

This program addresses five aspects of science education: 1) hands-on science & engineering in the classroom, 2) integrating science, literacy, mathematics and other disciplines, 3) teachers becoming capable to integrate engineering into the science & math Curriculum, 4) students becoming excited to pursue careers in STEM and 5)thinking skills are integrated into the learning process.

Grant overview:

By definition, "Engineers design useful products or process for society based on math & science".

Our approach is to enhance the learning process by using the engineering design methodology as a connector between literature, science & mathematics, based on using thinking skills, such as the art of questioning as defined in the Bloom taxonomy.

The process begins with literature, such as fairy tales, starting in the lower grades and leading to more sophisticated stories at older ages – stories that engage students. The underlining skills of the engineering design process are related to the science process, mathematical problem solving (process) and critical thinking. Thus the student is taught how to think critically. "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. The "design challenge" to the students could be to design a system to make it easier for her to lower the canoe the next time. By definition, "engineers design useful products or process for society using mathematics and science". The teacher can tie physical science, math and design all together. Literacy can be expanded by

	creating reports, journals, presentations and modification to the story by the student. The concept works, as it starts from an existing comfort level of the elementary teachers and the student's natural engineering abilities. Both students and teachers see the connection between literacy, social studies, engineering, science and mathematics when doing an engineering design project. The projects are done as an inquiry based process, with the team experience being an additional learning experience. This proposal is to develop the methodology and implementation process of integrating engineering into the existing PreK-5 science and mathematics curriculum and make it sustainable with the following aspects: • Using a web repository of past projects and collaboration tools. • Continuing on-line update classes. • Bringing the concept into teacher college curriculum in Massachusetts schools. • Exposing engineering college students to this concept for support on the classroom environment.
Team	This proposed grant originated through the efforts of three individuals, an engineer and two teachers, who used a process similar to that being proposed in their classroom and saw the excitement in their students. They believe that by creating a professional development program (studies) for teachers, a defined methodology and a web site for sustainability, their success could be made portable to other teachers in the commonwealth of Massachusetts. In addition, Bridget Perry, Professor of Psychology and Philosophy at Framingham State College will be supporting the development of the program around skillful thinking and teacher engagement and Mark Somerville, Professor of Electrical Engineering, at Olin college will support the team. In addition to the individuals, the following organizations have seen this proposal and have added a letter of support: School district: Engineering company; Colleges:
Goals:	**Goal 1**: Engage PreK-5 teachers in the process of making the connections (using the engineering design process) with other subjects while teaching literature and current events. This will emphasize the process nature of learning. Show the similarities of skillful thinking, the science process, the engineering design process and the mathematical problem solving process. **Objectives:** • **Create a Professional Development program (PD)** for teachers and administrators to find design challenges in their school work where they can create engineering projects and become excited about STEM subjects. • Build & maintain a website that would allow communities of teachers to share their project and notes and collaborate with each other. • Incorporate this methodology into the PreK-5 teacher's daily routine without effecting current workload **Goal 2:** Assess changes in students regarding their capabilities in STEM

learning and excitement about the learning.

Objectives:

- Students see that learning is incremental in nature. They learn by doing and from their mistakes.
- Create a process to empower students to view learning as something they own and like to do. Develop their ability to have a "conversation with the author" of a story.

Goal3: Create a pre-service teacher program that builds on this concept.

- Collaborate with one teaching college to incorporate this process in their science methods course.

Benefits

If students experience design-oriented activities in all disciplines, they will be more likely to develop a deeper understanding of the creative process itself, independent of any discipline. By applying the engineering design principles to an activity, you get the following additional benefits:

- ***Promotes higher-order 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.*

Cost

To create this program, funds will be needed for three major functions; professional development, program development and web site hosting and creation. The following are the details:

Item	Costs
Stipends for teachers/ administrators	
Facilities/ meals	
Create the Professional development, templates and process.	
Create the web site	
Web site admin. & facilitator	
Supplies & Materials	
Independent evaluator; design & follow-up	

	Travel
Deliverables	The following items will be created in this grant request: • PD program for teachers in how to apply and use these concepts. This would be in the form of a one week summer workshop with three follow on days. • A set of models, projects & exercises by grade level to guide teachers in the process and demonstrate benefits. These processes would support the teachers in using the design process to connect literature to the math and science framework. • An on-line learning community such as blackboard or other web formats to provide teachers with a years' follow-up process. Web pages where teachers can find useful templates and documents that were created by teachers for specific literature or other themes (such as environment issues). • Creation of a community infrastructure to support the school districts with engineers' visits & parent involvement. • Independent evaluation of the benefits of this approach.
Measurement of Success	An assessment will evaluate the resulting process, professional development and documents to examine the student's abilities, appreciation for , awareness of science & mathematics as well as their ability to use processes for learning and improvement. Teachers will be assessed on their skills in using the engineering design process as a connector between literature and math and science curriculum as well as their ability in skillful thinking to motivate and lead the classes. Student's knowledge and skills will be assessed with pre and post tests.
Sustainability	To be sustained, this process has to be embraced by the school district as part of its learning culture for the K-5 grades. Master teachers will be trained who can continue this within the district. After the professional development course, the teachers will be re-enforced by additional one day or on-line training opportunities to build on their initial experiences with the process. In addition, the success of this process will be used to sustain the concept by incorporating this process with pre-service teacher training at teacher colleges to integrate this concept into their science methods course. Lastly, the creation of an engaging web site will allow teachers to share their work with others, rate the submitted designs and collaborate.
References: **Research in the benefits of this concept**	The use of an **inquiry based approach** in a science classroom leads students to realize the way science is authentically carried out. Many studies have found that inquiry-based science activities have positive effects on student achievement, cognitive development, laboratory skills, and understanding of science content as a whole when compared with students taught using traditional approaches (Burkam et al. 1997, Freedman 1997). **Engineering lessons** and activities are typically inquiry-based and incorporate problem solving, critical thinking and cooperative learning for all students. Research has shown that cooperative activities facilitated more active roles (Baker 1990, Johnson & Johnson 1999, Meyer 1998) and higher retention rates for female students

	(Kahle & Meece, 1994). Studies have also shown that African American and Hispanic students performed better in cooperative environments (Atwater, 1994, Bonangue 1992). **Engineering curriculum often involve hands-on activities that are open-ended (more than one *correct* answer).** Research has shown that students who participate in hands-on activities and perform their own science experiments learn more than those who do not (Burkam et al. 1997, Freedman 1997). Teachers who have implemented engineering activities have indicated that the open-ended, inquiry-based, and team-oriented approach encouraged the involvement of students who normally do not participate in class (Mooney & Laubach 2002). Teachers indicate that the hands-on inquiry approach is particularly appealing to students with disabilities, allowing them to learn using kinesic and verbal modalities, pictorial representations and creativity - traits that are strengths of students with learning disabilities (Mastropieri et al. 1999). And, the use of hands-on project based learning has been proven effective in educating English as a second-language students (Gersten & Baker 2000).

Project plan: Using the Engineering design Process as a connector between Literature and Math & Science.

Tasks/Owner	Date	Deliverable	Status
Build program concept			Defines the major deliverables, What's the "Big idea", process, content, stakeholders & organization
Create Team			Defines team, responsibilities Missy Taft – Wilbraham PS teacher Diana Mason Teacher Day School, , MA
Build advisory organization		Publish names and hold first meeting	
Sign-up two school districts			Creating criteria for what type of district,
Create the funding source process		Create a nonprofit public charitable organization under sec. 501 (c) (3) of the IRS code	Initially look at other possible ways of tying to an existing organization
Sign up partners in Higher Education.			Soliciting the following: • Wheaton College • Olin College • Northeastern College • Wellesley College
Create outline training plan for Professional development program / **Diane**		Curriculum	Preliminary outline done.
Relationship with teachers college			How do we integrate this into the curriculum of teaching pre-service