

The Missing Link: Using Engineering Design and Thinking Skills to Connect Literature, Science, and Math



Introduction:

This exciting program for grades PreK-5 introduces teachers and students to engineering and thinking skills (tools for engineering) in an interdisciplinary project based learning environment. The program uses the engineering design process, as defined in the Massachusetts Science Framework, as a connector between students' literature or history stories and their mathematics and science curricula. It infuses the development of thinking strategies with creative and critical thinking, provocative questions and meta-cognitive reflection, skills that are part of the engineering process. This approach is based on the definition, "**Engineering is about designing useful products & processes for society using all disciplines, but mainly science & mathematics**". The student take ownership of the learning activities because they are involved in finding the design challenges and doing a design project while the teachers role is to reflect, ask guided questions and bring to the surface the concepts and processes the student is discovering.

Elementary teachers are often more comfortable with language arts than with engineering, science and mathematics. However, many teachers know more about engineering than they think. Engineering design can be divided into three sections; the process portion, thinking skills and the analytical content knowledge. When teachers are shown they do processes and use thinking, they begin to break down their barriers to engineering. Engineering, like learning is a journey in constantly acquiring more knowledge and improving skills (What is an Engineer?, Bernard Gordon). This program models for the teachers how to do these items skillfully and presents an opportunity to integrate these skills into language arts, math and science instruction. The program encourages teachers to set high standards and see their students as apprentices in becoming owners of their learning. It involves the students in assessing and evaluating their own learning strategies.

In this program design, teachers model for their students the thinking skills and engineering concepts that will create excitement for learning and prepare the students for the 21st century world. The students work in collaborative teams to design, present and critic their results when working on the design challenges from the stories. This learning methodology supplements, but does not replace, the present curricula within the schools

The program goals for students entering the 6th grade are as follows:

- See learning as an exciting adventure.
- Understand the relevance of mathematics, science and engineering in their lives.
- Learn to work with 21st. century skills and be able to contribute content knowledge in the area in which they are working.
- Be comfortable with reflecting on the use of thinking skills in their lives.

The implementation plan is to pilot and assess this program in three districts: urban, rural and suburban. The goals of the design team are: 1) to make the program available free to any educational institution, 2) to build a sustainable model that focuses on both creating an interactive web site for teachers to collaborate and post literature for which they have created

design challenges and 3) to have Massachusetts Teacher Colleges introduce this concept as part of their teacher preparation.

A Problem in Our Schools

Many students entering the middle school grades do not have the skill foundation to be life long learners and to know that they can achieve success in any discipline they want. In addition, middle school students face many social related issues. In order to handle these issues as well as to continue learning, they need to develop a strong sense of themselves as learners in elementary school. Many students experience “learning in silos” by being taught discrete subjects. Students don’t see the relevance of what they are learning. We need to give them more opportunities to learn with different “learning styles” (Howard Gardner “Multiple Intelligences”). PreK-5 grade teachers are often more comfortable with language arts than with math and science, thus limiting the students’ exposure and understanding of these disciplines.

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

A Proposed Solution

Research of existing engineering programs (Sean Brophy, July08) suggests that the few schools and organizations that are creating programs with engineering components (mainly in middle and high school) are developing a set of fixed engineering projects for students, i.e. “build a bridge or house”. Lego robotics programs focus on teaching engineering by building designs using the tool set created by Logo Education programs. The Boston Museum of Science program “engineering is elementary” contains its own stories with engineering themes and has approximately 20 different sets available for purchase. What differentiates this program from the others is that the students are part of determining what engineering project they will do and engineering is introduced in an interdisciplinary project based environment versus another learning silo.

The process fosters the close connection between design and thinking skills. It shows the cyclical nature of the design process: to facilitate quick prototyping and learning from mistakes. It supports Professor Carol Dweck’s of Stanford University approach to intelligence as an incremental process rather than being born with a fixed amount of intelligence. We believe that education needs to be interdisciplinary rather than taught as discrete subjects. The interdisciplinary approach illustrates the relevance of each of the subjects and how they connect to each other. The program is based on the standards of the Massachusetts Frameworks, Common Core and 21st century skills as defined by the “Partnership for 21st century skills” organization <http://www.21stcenturyskills.org/>.

The process focuses around literature because:

1. Literacy is an integral part of all existing school curriculum.
2. Stories have the potential to present situations that can challenge children’s imagination.

3. Most stories can serve to encourage students to begin to generate design proposals and connect to science and math.
4. Literature is an area of the curriculum with which all teachers are familiar and thus the design process can start from a position of strength.

Conclusions

This interdisciplinary approach will have a strong impact on getting our students to be excited about learning and becoming interested in the STEM (Science, Technology, Engineering & Mathematics) subjects prior to entering middle school. It does not replace existing school curriculum, but supplements it by adding thinking skills and engineering to create cross-functional learning.

Some of the program benefits are:

- It illustrates that all subjects are interconnected.
- Teachers can integrate this in their existing work.
- Learning is project based rather than single subject oriented.
- It's OK to make mistakes; in fact it's a way of learning.
- It fosters innovation and entrepreneurship in the student.
- Students who experience design-oriented activities in all disciplines will be more likely to develop a deeper understanding of the creative process itself, independent of any discipline.
- It supports different learning styles.

References:

- Sean Brophy; Advancing Engineering Education in P-12 Classrooms, Journal of Engineering Education July08
Dweck, Carol Self-Theories, Psychology Press, 2000
Gordon, Bernard, What is an Engineer?, European Society for Engineering Annual Conference, 1984
Gardner, Howard, Multiple Intelligences, New Horizons, 2006