



CORPORATE MEMBER COUNCIL

**The Corporate Member Council is committed to the concept that:
Engineering Activities are for All Americans**

"Whenever the people are well-informed, they can be trusted with their own government;... whenever things get so far wrong as to attract their notice, they may be relied on to set them to rights." --Thomas Jefferson to Richard Price, 1789. ME 7:253

The Corporate Member Council is dedicated to the activity of Establishing a Common Language for STEM

The disciplines encapsulated in the acronym STEM have many elements in common and many that are unique. To achieve an understanding of how they interrelate is critical to being able to use engineering activities as an underpinning to integrated instruction. Because engineers use science, mathematics and technology, engineering activities offer a way of teaching these three disciplines (together with social studies, language arts, etc.) in an integrated and authentic fashion.

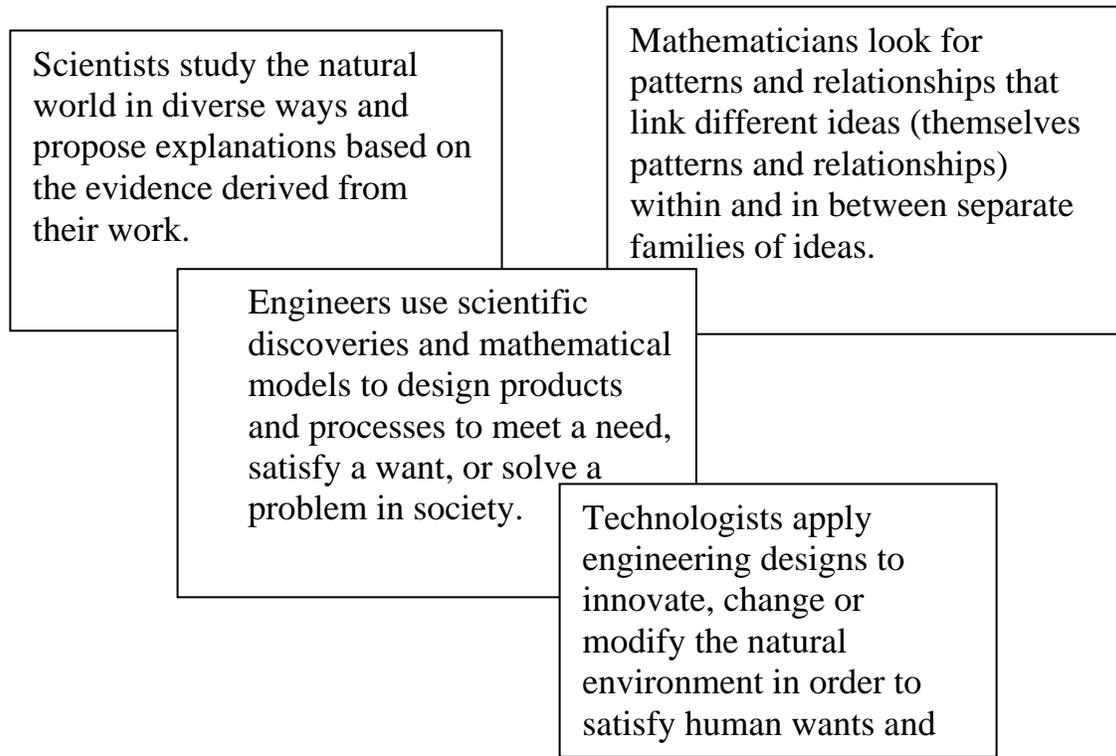
**The Corporate Member Council and its Guidelines Committee believe:
Engineering is a tool for integrating the other STEM disciplines.**

In many instances, the core subjects in our schools continue to be taught in isolation. Many teachers do not use updated teaching techniques, such as guided inquiry, in the classroom, because they are driven to teach the many required facts by end of year assessments. This means that relevance and application are all but unachievable in the K-12 classroom in many instances. We've also noted that time pressures often make the coverage of untested topics and goals, an impossibility.

Engineering activities naturally integrate various core disciplines. It is perhaps true that engineering might be considered the underpinning of the other three subjects in STEM. It is a vehicle to bring rigor, relevance and context to the teaching of the other three subjects in an integrated manner. Using engineering activities as a vehicle allows core subjects to be taught more efficiently, in a way that leads to increased retention, to the ability to apply diverse knowledge and concepts to different situations, to synthesis, creativity and problem solving...all vital to the necessary 21st century skills.¹

One of the hurdles to improved teaching in science in particular, and maybe math as well, is the perception by students that the activities lack relevance to daily life. This perception is historical and pervasive. Teaching in K-12 through use of engineering activities can be a stealth approach to reaching children that haven't and aren't being reached in the current methods of teaching of isolated subjects. Using engineering activities in the classroom can have the ultimate result, where more students learn more and understand the concepts better.

“Engineering as the Capstone” (A schematic – How Engineering serves to integrate STEM)



Engineering design mirrors Bloom’s Taxonomy

In the 21st century educational system, great emphasis is being placed on skills viewed as necessary for success in the new millennium. A report from the Partnership for 21st Century Skills in **Washington, DC on Nov. 7, 2007** says;

“Americans increasingly recognize that the U.S. education system can and should do more to prepare our young people to succeed in the rapidly evolving 21st century. Skills such as global literacy, problem solving, innovation and creativity have become critical in today’s increasingly interconnected workforce and society.”

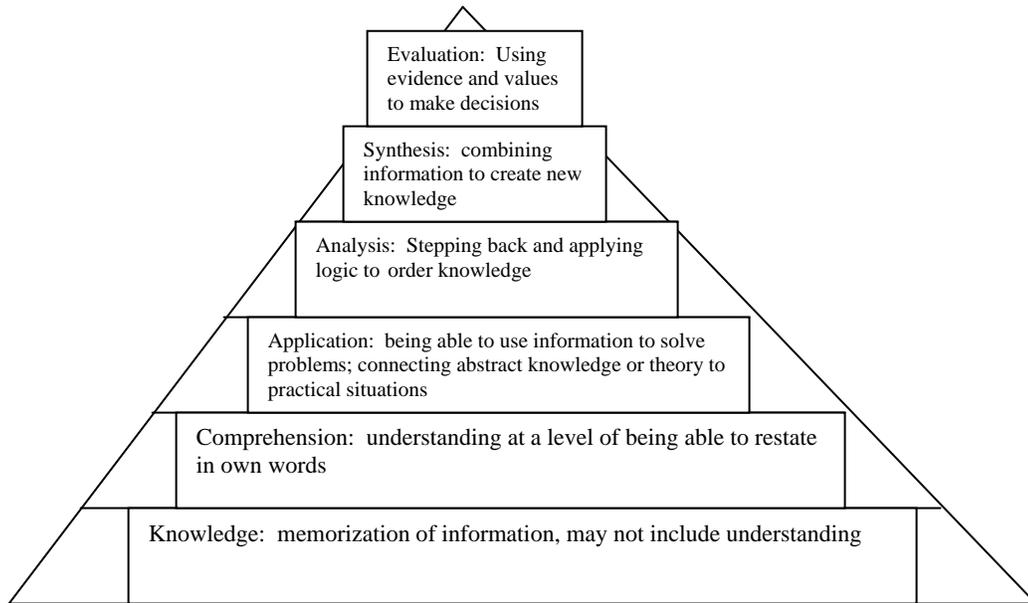
Many of the skills highlighted in reports such as the Framework for 21st Century Learning¹ mirror those expressed in the higher levels of a pyramid representation of Bloom’s Taxonomy².

Engineering activities as a vehicle for curricular integration presents a uniquely relevant way to reach the highest levels of the pyramid for children in K-12 schools where going beyond knowledge and comprehension may not have been the norm.

¹ <http://www.21stcenturyskills.org/>

² Bloom B. S. (1956). *Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain*. New York: David McKay Co Inc.

Bloom’s Taxonomy of Educational Objectives



A Table of Engineering Design Activities

The following table outlines a general comparison of the engineering design and activities process to the various levels of Bloom’s Taxonomy. In addition, a sample project from a 5th grade “forces and motion lesson” is used as a specific example.

The project involved having students bounce four different kinds of play balls on two different kinds of surfaces. The students took data on how high the balls bounced back after being dropped repeatedly. The class then averaged, graphed and interpreted the data to decide which ball bounced back best and which surface allowed the balls to bounce best overall. The students were then asked to recommend a surface to design a gym floor and to write their recommendations; this report was supported by data from their experiment. They then compared their results and recommendation to the gym floor design in their school and others that they had seen. Differences were explained from the data and from their own experiences; this included other concerns such as cost, maintenance, and other factors that they might consider.

<i>Bloom’s Levels of Thinking</i>	<i>Engineering design</i>	<i>Example from 5th grade class</i>
Knowledge	Gathering information, may include research or experimentation	Take data on ball bounce heights on different surfaces
Comprehension	Collate information from research or put experimental data in tabular or graph form for interpretation	Put data into spreadsheet; find averages, differences, etc.

Application	Identify how data/research apply to problem at hand	Compare results for different experiments
Analysis	Order results to search for solutions	Decide what results tell you about how balls rebound from different surfaces
Synthesis	Apply constraints to decide among various potential solutions	Decide which surfaces would make the best gym floor base on your data
Evaluation	Evaluate final solution with respect to requirements, constraints, social implications, etc.	Compare to current gym design; do your results help you understand why schools are designed the way they are?

A Rationale for Engineering Activities

The current status of American society requires an understanding of our technological world in a way that is not addressed in the Standards for Technological Literacy. Engineering literacy not only appreciates and focuses on the designed world, but understands what technology is and is not capable of, how technology comes into being and what relevance it has to every day life through the environment and its liabilities as well. This means that these ideas are for all children, not just those whom we hope would go on to become engineers.

Workforce Issues

Several nationally recognized studies report the likely decline of the nation’s science, technical, and engineering workforce, and cite this decline as a serious issue facing today’s educational system.³ Globalization and failure to recruit a diverse population to the study of STEM subjects threaten the numbers of future scientists, mathematicians and engineering, where our society and the fabric of that existence is at risk as a future scenario.

Among the well-documented challenges faced by today’s K-12 educational system is the under-representation of minorities, women, and low income students in higher level mathematics and science courses. The resulting effect of the few in numbers of these students pursuing careers in STEM fields is of enormous concern. In addition, the poor performance of American students, including reports of limited success of our best and brightest, on international comparative assessments is alarming. But retention of knowledge is not the measure of most concern. Rather, it is the lackluster performance of American 15 year olds on the two most recent PISA (Program for International Student

³ National Science Board, The Science and Engineering Workforce: Realizing America’s Potential, 2003, <http://www.nsf.gov/nsb/documents/2003/nsb0369/>.

Assessment) assessments⁴, which measures how well students can apply the knowledge they have gained, that is the strongest indicator for major changes in the way K-12 students are taught.

The Corporate Member Council has for a long time accepted the methods of pedagogy practiced in today's classrooms. After considerable review in the last 5 years we now realize that these practices were developed for an industrial revolution era society. Relying on traditional direct instruction to effectively teach all students is now considered an erroneous generalization whose lack of efficacy is demonstrated in lower "No Child Left Behind" (NCLB) test scores for certain subgroups and a persistent achievement gap between higher performing Caucasian, Asian and non economically disadvantaged students and their minority and economically disadvantaged classmates.

All students should be encouraged to keep their future options open and discouraged from self-selecting out of possible futures, particularly where this self-selection is influenced by the circumstances of race, ethnicity or gender. All of these factors combine to make it abundantly clear that new pedagogical approaches are not just desirable but necessary to reach all students, but particularly those from the subgroups falling behind.

Workforce issues such as these will certainly have an impact on the global competitiveness of this country, but they also impact national security: "The inadequacies of our system of research and education pose a greater threat to U.S. national security over the next quarter century than any potential conventional war that we might imagine."⁵

The arguments presented to this point not only support the importance of STEM teaching for future engineers and scientists, but the need for a solid STEM education, most particularly engineering activities and is acute for all students. Thomas Jefferson had far-reaching views on the importance of education to the maintenance of liberty and democracy, "Whenever the people are well-informed, they can be trusted with their own government."⁶ The world is a different place in many ways than when Jefferson wrote those words, but the meaning is nevertheless vital.

Many issues face the United States today that have political and economic ramifications and require a diverse understanding of science and technology. The general public is called upon to make decisions both political and practical on applications of these issues. Without a thorough grounding in STEM knowledge, the mechanisms of democracy will not properly function. The paradigm for understanding and appreciating the designed world is rapidly changing. In many ways, the lifestyle we enjoy today depends on engineering through its engineers, technologists, and scientific research. Engineering education through the associated activities is not only practical, but vital for all children. This is done through:

⁴ Highlights from PISA 2006: Performance of U.S. 15-Year-Old Students in Science and Mathematics Literacy in an International Context, 2006, <http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2008016>.

⁵ Committee on Prospering in the Global Economy of the 21st Century. (2007). *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, DC: National Academies Press

⁶ Thomas Jefferson to Dr. Price, 1789

- i. Transforming/contextual learning
- ii. Leverages natural interests/proclivities of kids
- iii. State science assessments (and NAEP) have elements of technology and engineering in them.

Components of a STEM educational system: Engineering is already a part of K-12 education

A STEM educational system presents many opportunities for deep, authentic learning. At this writing mathematics, science and language arts are required to be tested as a measure of the efficacy of the educational system. Both this dependence on standardized testing and the weight of history tend to encourage teaching of these disciplines in an isolated fashion, and many times classroom education becomes a list of items to be imparted under time constraints.

Other subjects that one might consider important, such as social studies, are sometimes relegated to a less important status, and new subjects, such as engineering activities, are strongly resisted due to the lack of space in the educational calendar. Creating a true STEM educational system represents a paradigm shift from the traditional approach to instruction. Engineering activities are not totally disconnected or represent a new subject as some might think, but is in fact more familiar to students through their own experience than other subjects.

Schools across the nation are already looking to engineering activities as a platform for learning. Case studies of some of these schools are included in Opening the Gateway, School Districts Leading the Technology/Engineering Revolution.⁷ Rachel Freeman Elementary School in Wilmington, North Carolina⁸, Douglas Jamerson Elementary School in St. Petersburg, FL⁹, and many other schools who are incorporating engineering activities as an integral part of their curriculum.

The Standards for Technological Literacy¹⁰ produced from the Technology for All Americans project of the International Technology Education Association contain many aspects of engineering, as do the National Science Standards¹¹. “As used in the Standards, the central distinguishing characteristic between science and technology is a difference in goal: The goal of science is to understand the natural world, and the goal of technology is to make modifications in the world to meet human needs. Technology as design is included in the Standards as parallel to science as inquiry (NAEP Science Framework, p. 24).”¹²

⁷ Center for Technological Literacy, Museum of Science Boston, Opening the Gateway, School Districts Leading the Technology/Engineering Revolution.

⁸ <http://www.nhcs.k12.nc.us/freeman/>

⁹ <http://www.jamerson-es.pinellas.k12.fl.us/>

¹⁰ ITEA, Standards for Technological Literacy, 2000, www.iteaconnect.org/TAA/PDFs/xstnd.pdf

¹¹ National Committee on Science Education Standards and Assessment, National Research Council, 1996, http://www.nap.edu/catalog.php?record_id=4962.

¹² NAEP Science Frameworks 2009, http://nagb.org/frameworks/naep_science_framework_2009_re.doc

What are the Corporate Member Council Guidelines?

The Corporate Member Council, one of the four councils in the American Society for Engineering Education (ASEE), and its members over the past ten years have made many contributions to the development of guidelines, criteria, and requirements to the field of Engineering Education at the collegiate level. The members have volunteered as un-paid members and contributors to ABET and other accreditation organizations for the improvement of college and university programs. Most recently through its activities in the ASEE with the “National Collaborative Task Force” with the Graduate Studies Division, and in presentations at national conferences entitled “Industry speaks with one voice.”

With concern that the US may not be preparing a sufficient number of students, teachers, and professionals in the fields of science, technology, engineering, and mathematics (STEM); and the evidence of poor performance with respect to subject matter knowledge by students in math and science in the middle schools and high schools across the nation; and that many reports have been written in the last three years decrying the ensuing shortage of engineers, technologists, scientists, and mathematicians; the Council offers these guidelines to assist in what it considers a means for improvement in our countries K -12 system.

With these guidelines go the emphasis that first and foremost the Council’s interest is for the improved quality and performance of the student. The “Guidelines” as introduced are a means to the curriculum writer and teacher to emphasize the characteristics and qualities of a STEM event that should be fostered. Focus should be on the “Outcomes” affected upon the student through the activities. Note that the activities promoted are in the form of objectives allowing for some teacher interpretation of how they should develop the activity for the student, but it must be emphasized that the Engineering Activity will be the meaningful event to support the math, science, or technical concept in the process.

The outcomes emphasized are those which industry requires of all its candidates for career positions from the most desired technical roles to those in management and leadership positions. The activities expected in the developed curriculum should provide for the ability to apply their knowledge of mathematics, science, technology, and engineering. The student exposed to this set of guidelines should be able to design and conduct experiments and analyze or interpret the data, they should be able to design a system, component or process to meet the needs of the conditions with realistic constraints relating to the environment, social, political, ethical, health, safety, manufacturability, and sustainability.

Other outcomes expected are those of the ability to function on multidisciplinary teams, to identify, formulate, and solve engineering problems, to understand professional and ethical responsibility and to communicate effectively. These guidelines are expected to express a broad understanding of the impact of engineering solutions in a global, economic, environmental and social context recognizing the need for and ability to engage in life-long learning. While the guidelines will encourage knowledge of contemporary issues, they will develop an ability to use the techniques, skills, and modern tools necessary to understand our global economy and technological world.

Those who have functioned in the engineering fields for several years will recognize these outcomes as those fostered by the ABET Criteria, A – K. The Council is not trying to reinvent the world of education at the K-12 levels, but to introduce a method of instruction that can excite and interest the student in the same fashion that they were interested as they grew from baby to inquisitive child. That interest has never passed; it has only changed in its means and methods to learn.

The guidelines focus on five dimensions: (1) Engineering Design, (2) Connecting Engineering to Science, Technology and Mathematics, (3) Nature of Engineering, (4) Communication and Teamwork, and (5) Engineering and Society. Each dimension has a set of declarative statements which point to what the student is expected to understand, and a set of procedural statements, what the student should be able to do.

The guidelines are offered to the K – 12 education community with an interest that they review them, ask questions of each other as to how they might be able to use them in their curriculum development to improve the science, technology, and mathematics instruction, and how we of the Corporate Member Council can help to improve these criteria for their use. The Council has determined that it will call together an expert committee each year for the next four years to review these guidelines and to improve them as a result of your input and that of the fiscal committee's expertise.

With that, we offer on the following pages the “CMC – K-12 Engineering/Engineering Technology Guidelines” for your use and development.