



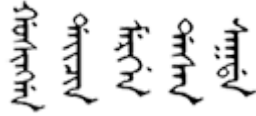
(Source: <https://scholarsteamk12plus.weebly.com/the-vision-paper.html>)

WORKING FOR AN INNOVATION DEAL USA IN THE 21ST CENTURY
TRABAJANDO POR UN TRATO DE INOVACIÓN EEUU EN EL SIGLO XXI
为实现 21 世纪美国创新之政而奋斗



THE VISION PAPER - "I HAVE A DREAM"

by Edward Locke
(Gosingga-Daicin
Mergen-Dasan
Sakda)



骆南植

(果新嘉岱清·默耕鞑山·萨克达)

First Draft: September 25, 2014
Final Revision: October 30, 2014

This page is reserved for online publications of research data, articles, and other documents, peer-reviewed or not, as well as any constructive criticism, comments and advice, in support of a new vision to improve K-12 engineering and technology education, as outlined in the vision paper titled [Proposed Model for a Streamlined, Cohesive, and Optimized K-12 STEM Curriculum with a Focus on Engineering](#). Please click the underlined titles of the documents to access the PDF files.



K-12 STEM Education Vision Paper (Published on Peer-reviewed Journal):

Proposed Model for a Streamlined, Cohesive, and Optimized K-12 STEM Curriculum with a Focus on Engineering

Abstract of the Vision Paper

This article has been published as a vision paper in *The Journal of Technology Studies*, a peer-reviewed scholarly journal associated with Virginia Institute of Technology (Winter 2009 Issue No. 2). The vision paper is available at <http://scholar.lib.vt.edu/ejournals/JOTS/v35/v35n2/pdf/locke.pdf>. The vision paper advocates comprehensively improvement of STEM (science, technology, engineering, and math) education with a new model of life-long process starting at K-12 level, with two-year community colleges as an important link. This article presents a proposed model for a clear description of K-12 age-possible engineering knowledge content, in terms of the selection of analytic principles and predictive skills for various grades, based on the mastery of mathematics and science pre-requisites, as mandated by national or state performance standards; and a streamlined, cohesive, and optimized K-12 engineering curriculum, in terms of a continuous educational process that starts at kindergarten and/or elementary schools, intensifies at middle schools, differentiates at high schools and streamlines into four-year universities through two-year community colleges, integrating solid mastery of particular analytic skills and generic engineering design processes. This article is based upon a "Vision Paper" that was presented at the International Technology Education Association's 71st Annual Conference held in Louisville, Kentucky under the sponsorship of Dr. John Mativo, an expert of mechanical and electronics engineering ("mechatronics") and a professor from the University of Georgia College of Education. It is hoped that many ideas explored in this article could provide answers to the problems in the current practice of K-12 engineering education, as discussed in the authoritative report issued several months later, on September 8, 2009, by the Committee on K-12 Engineering Education established by the [National Academy of Engineering](#) and the [National Research Council](#), titled *Engineering in K-12 Education: Understanding the Status and Improving the Prospects*, which included the absence of cohesive K-12 engineering curriculum and the lack of well-developed standards, issues that have been already addressed in the Vision Paper.

This article is also available at the website of the Institute of Education Sciences (the research arm of [the United States Department of Education](#)) at

<http://eric.ed.gov/?id=EJ906150>, at Virginia Polytechnic Institute website at <http://scholar.lib.vt.edu/ejournals/JOTS/v35/v35n2/pdf/locke.pdf>), and at EBSCOhost Connection website at <http://connection.ebscohost.com/c/articles/69712612/proposed-model-streamlined-cohesive-optimized-k-12-stem-curriculum-focus-engineering>.



The screenshot shows a Mozilla Firefox browser window with the address bar displaying <http://www.usqiaobao.com/comment/2009-04>. The page content includes a navigation menu with '时事评论' (Current Affairs Commentary) and '名家专栏' (Famous Columnists). The main article title is '从幼儿抓起：工程教育呼唤新模式'. Below the title, the author is identified as '佐治亚州 骆南植' (Zhouzhiyuan Luo Nanzhi) and the source as '侨报'. The article text discusses the lack of engineering education in schools and proposes a new model starting from kindergarten. A sidebar on the right contains '即时新闻' (Latest News) and '时事评论' (Current Affairs Commentary) sections.

On April 27, 2009, [China Press](#), a Chinese language (Mandarin) newspaper published in the United States, published an article on the Proposed Model, based on my vision paper and translated by the staff of the newspaper. The Mandarin text is display below; and the PDF version could be downloaded by clicking the link.



[Download File](#)

Please notice that the peer-reviewed and published vision paper is only the first part of the original vision paper, which also contains a second part, a proposed model dealing with the related teacher education program. The full text of my graduation thesis, a part of the requirements for my degree of Education Specialist in Workforce Education from the University of Georgia,

which contains the entire content of the original proposal, is displayed below; and the PDF version could be downloaded by clicking the following link.



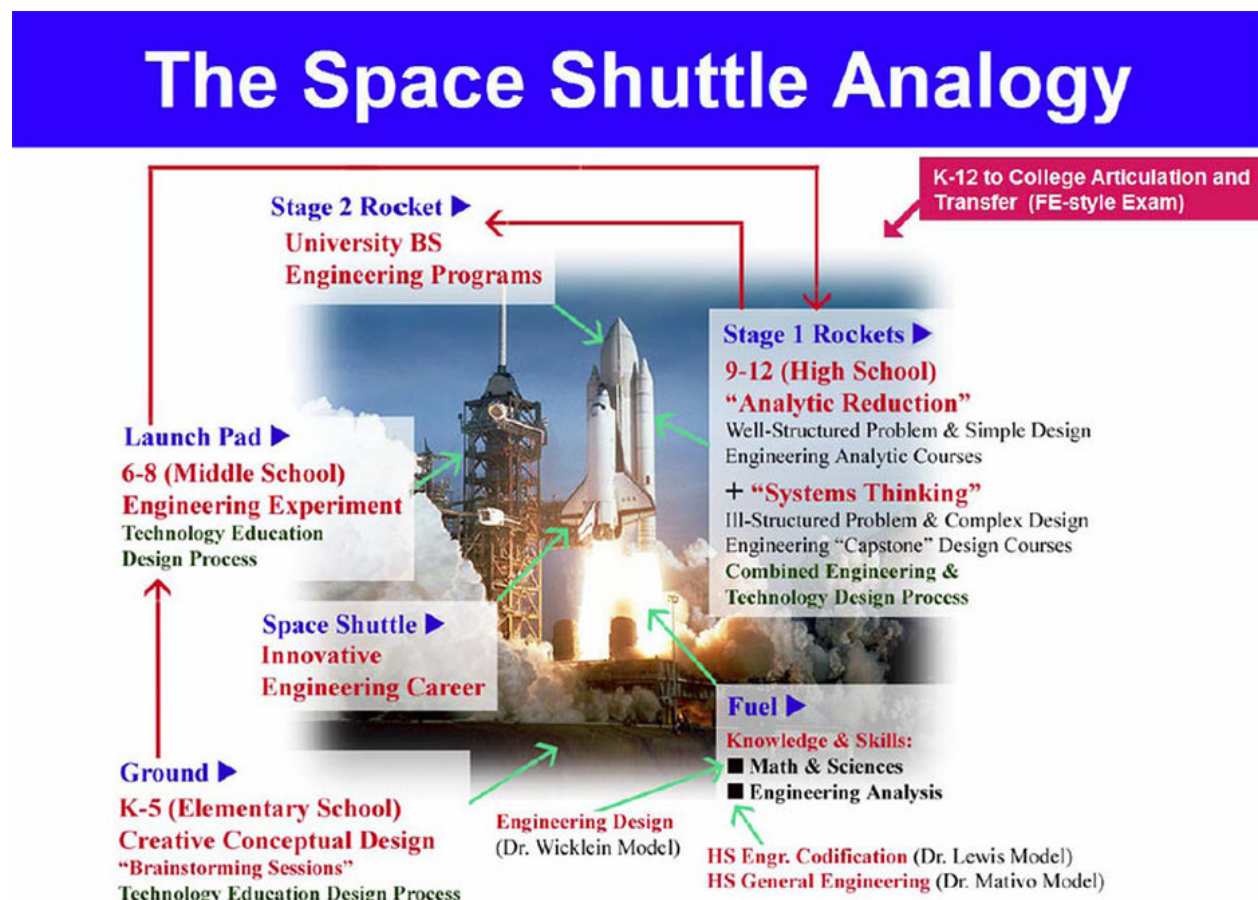
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INFUSION OF ENGINEERING DESIGN THROUGHOUT THE K-12 EDUCATION

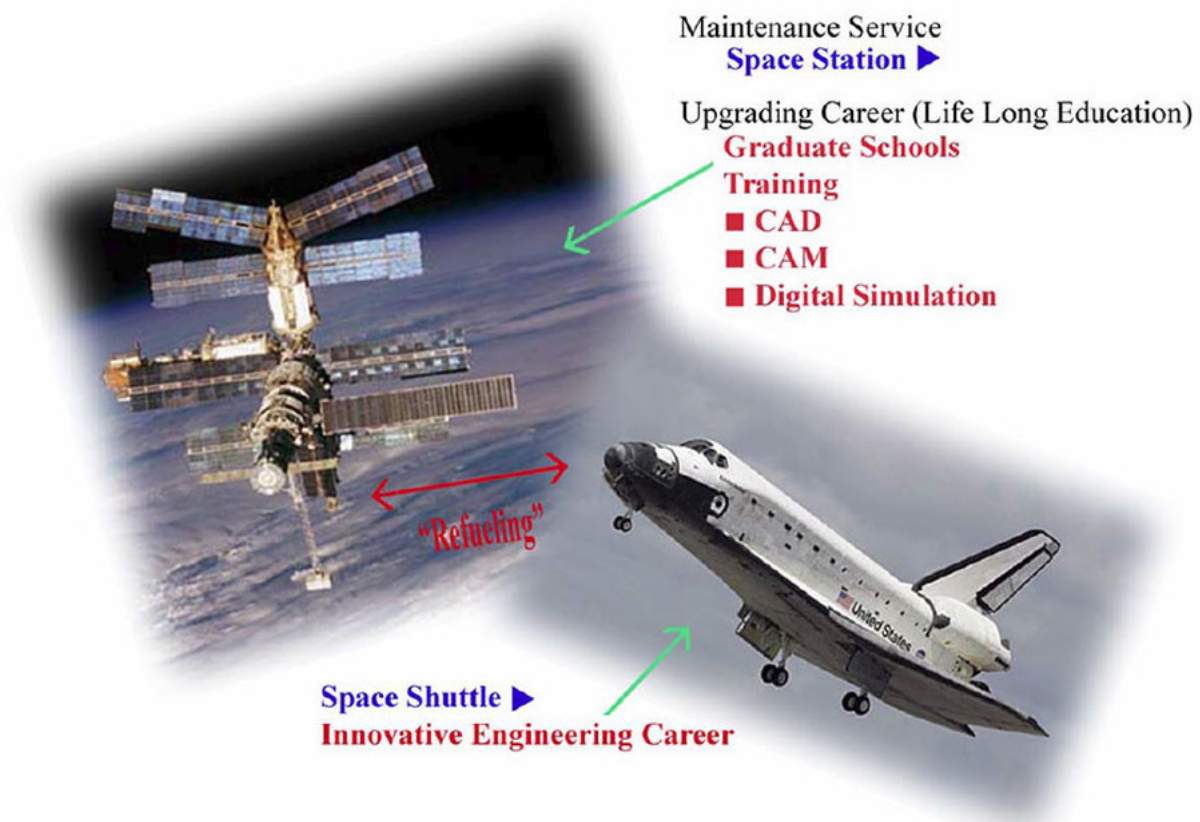
The infusion of engineering design throughout K-12 education could be divided into three stages, each transiting smoothly into the next; and this transition could be considered as analogous to the launch of a spacecraft into the outer space, where the birth of new generations of creative engineers are analogous to spacecrafts starting new journeys of discovery, as illustrated in the figures below.

1. Kindergarten and elementary school years: During this stage, students would be introduced to engineering and technology, through either a. stand-alone technology courses with entertaining educational projects that incorporate basic principles of science, engineering and technology; or b. incorporation of appropriate subjects of engineering design into regular arithmetic, science and English courses. Infusion of engineering design would be mostly conceptual and lightly analytic, using simple and well-structured problems. During this period, students should be given an opportunity to: (1) have a broad exposure to diverse aspects of science, engineering and technology (the “breadth”); and (2) foster ability of creative imagination, in a fashion similar to “science fiction” (the “wild”); and (3) foster a systemic and holistic view of technologies as interactive and interconnected, through either former courses or extracurricular enrichment activities. Conceptual brainstorming could start during these years, supplemented with very simple analytic skills. During this stage, pupils would master similar knowledge content that are traditionally required of college engineering and technology students in these courses: (1) Introduction to Science, Engineering and Technology; (2) Engineering Ethics; and (3) Appropriate Engineering and Technology. In addition, they would build a broad knowledge base on diverse branches of modern and traditional engineering and technology, plus the initial ability to conceptually imagine and to freely create (through brainstorming sessions). [This stage corresponds to the launching ground in the spacecraft analogy.](#)

2. Middle school years: During this stage, students would consolidate their mathematics and science foundations; and explore the basics of traditional and modern technology. Infusion of engineering design would be both conceptual and moderately analytic, using simple and well-structured problems. Students would master the fundamentals of modern technology which is associated with engineering design, such as CAD and 3D modeling, traditional and CNC manufacturing process, and others. This would prepare them for either engineering and/or technology majors at university level. In addition, they would master the basics of science and engineering experiments, using traditional Technology Design Approach. This stage corresponds to the launching pad in the spacecraft analogy.



The space shuttle analogy showing the K-12 engineering education process at all stages or grade levels and their corresponding analogies to the launch of a space shuttle into the outer space.



The space shuttle analogy showing the life-long engineering education process and its corresponding analogy to the maintenance of a space shuttle once launched into the outer space.

3. High school years: During this stage, students would be introduced to pre-calculus based engineering foundation courses, such as statics, fluid, materials strength and selection, mechanism design and selection. Infusion of engineering design could include: (1) conceptual and reasonably analytic design projects solving simple and well-structured problems in relevant engineering analysis courses; and (2) conceptual and reasonably analytic design projects solving moderately complex and ill-structured problems in “capstone” engineering design courses. Students would master the pre-calculus portions of many engineering subjects, which up to this point have been offered in the lower-division courses of undergraduate engineering programs. In the future, special examinations modeled after FE (Fundamentals of Engineering) could be designed to test the abilities of high school graduates to solve pre-calculus level engineering problems; and for those who pass the examinations, special accommodations could be granted such that, they would still be enrolled in regular lower-division undergraduate engineering courses to continue studying relevant topics beyond the pre-

calculus portions they have learned at high schools, but be exempted from the home works and quizzes related to the pre-calculus portion of course content, devoting their time and energy instead to the calculus-based portions and to engineering design and research projects. **This stage corresponds to the initial stage rocket propulsion in the spacecraft analogy.**

4. Transition to university engineering majors: Many streamlined transitional mechanisms across high-school and university levels could be developed together with the codification of K-12 engineering curriculum, to make the whole process of engineering and technology education more cost-effective and fruitful. **The stage of university level engineering and technology education corresponds to the second stage rocket propulsion in the spacecraft analogy, after which the new generations of innovative engineers could start their creative careers.**

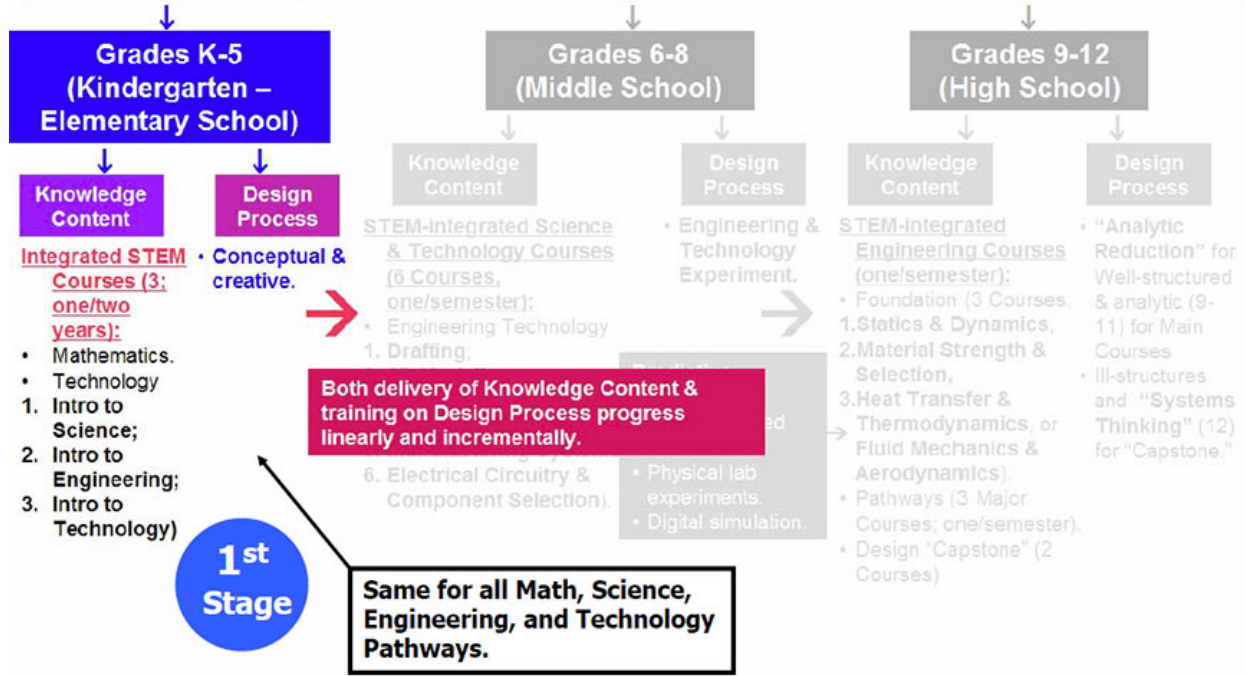
5. Post-university technological upgrades: The advance of digital technology, such as computer-aided-design/drafting (CADD), computer-aided-manufacturing (CAM), and computer simulation, will increasingly offer creative engineers possibilities to save time spent on tedious mathematical computations, to concentrate on creative design strategy, and thus, to increase efficiency in engineering design process. In many places in the United States, such as in Los Angeles and Orange Counties, California, two-year community colleges offer extensive programs to teach engineering-related digital technology skills. **The application of digital design and simulation technologies in engineering analysis and design processes could be analogous to a space station that provides maintenance service to spacecrafts.**

THE K12 ENGINEERING CURRICULUM ROADMAP

The illustrations below show the step-by-step progress in the Proposed Model of K-12 Engineering and Technology Education.

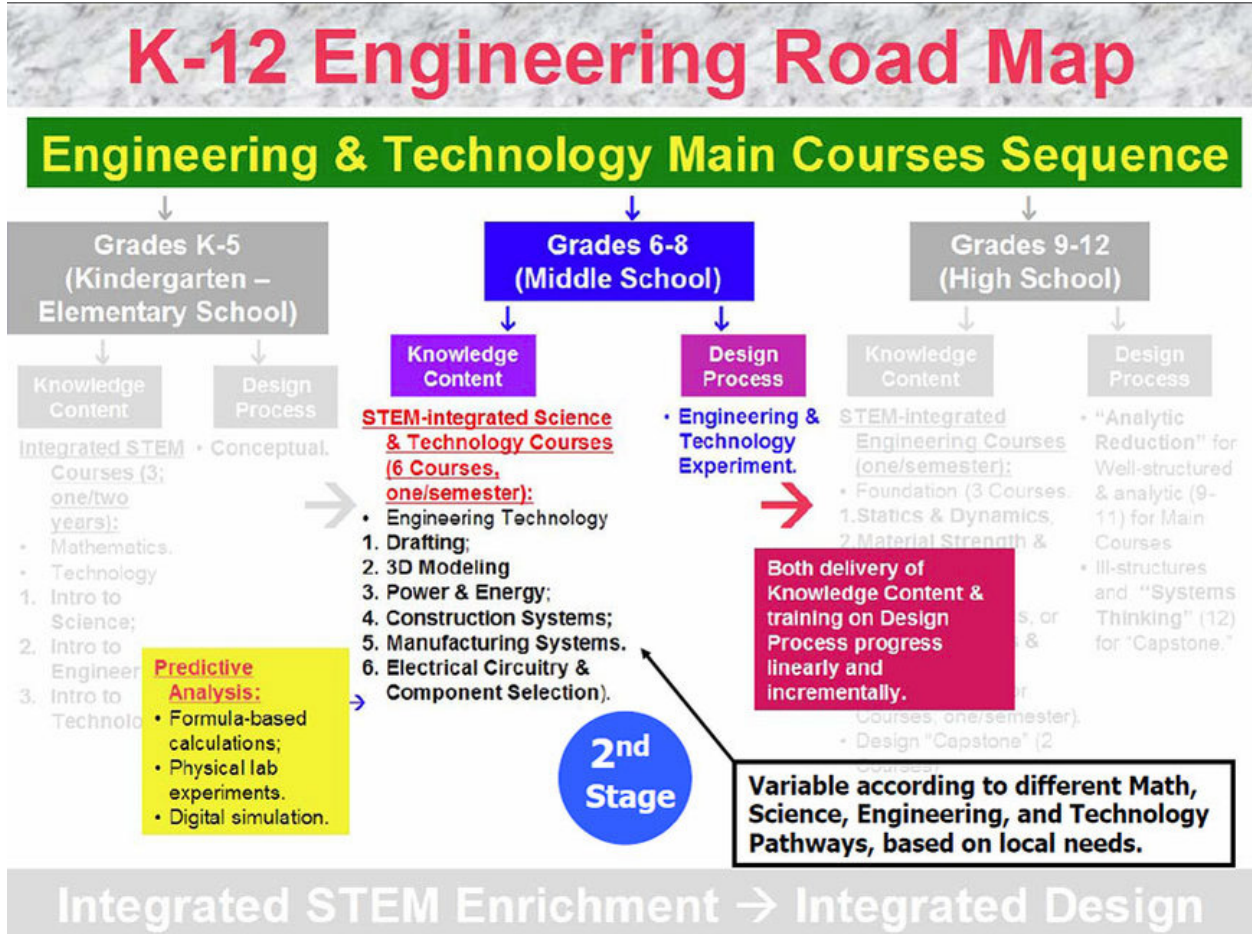
K-12 Engineering Road Map

Engineering & Technology Main Courses Sequence

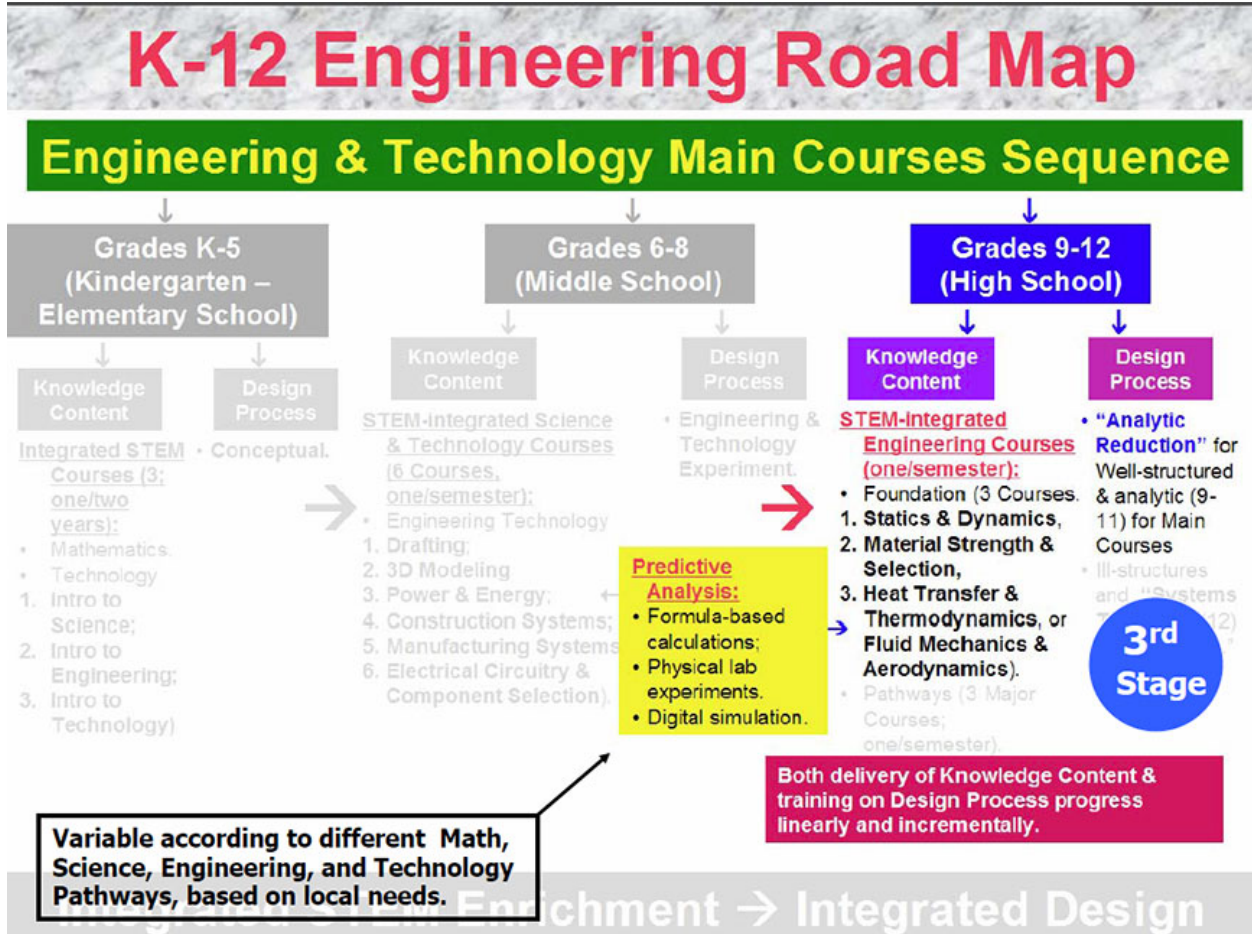


Integrated STEM Enrichment → Integrated Design

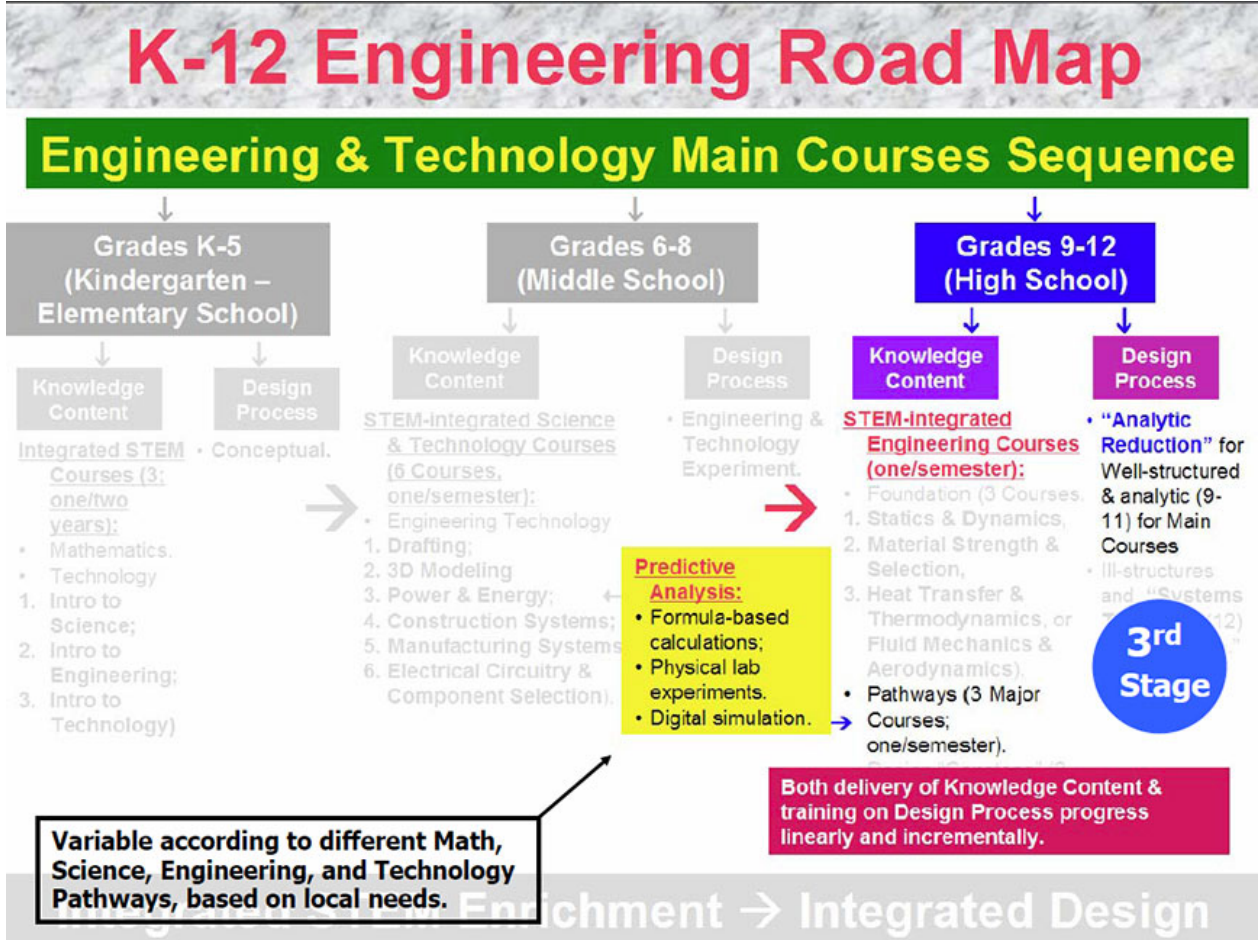
The task to be completed in the First Stage (Grades K-5 or Kindergarten to Elementary School).



The task to be completed in the Second Stage (Grades 6-8 or Middle School).



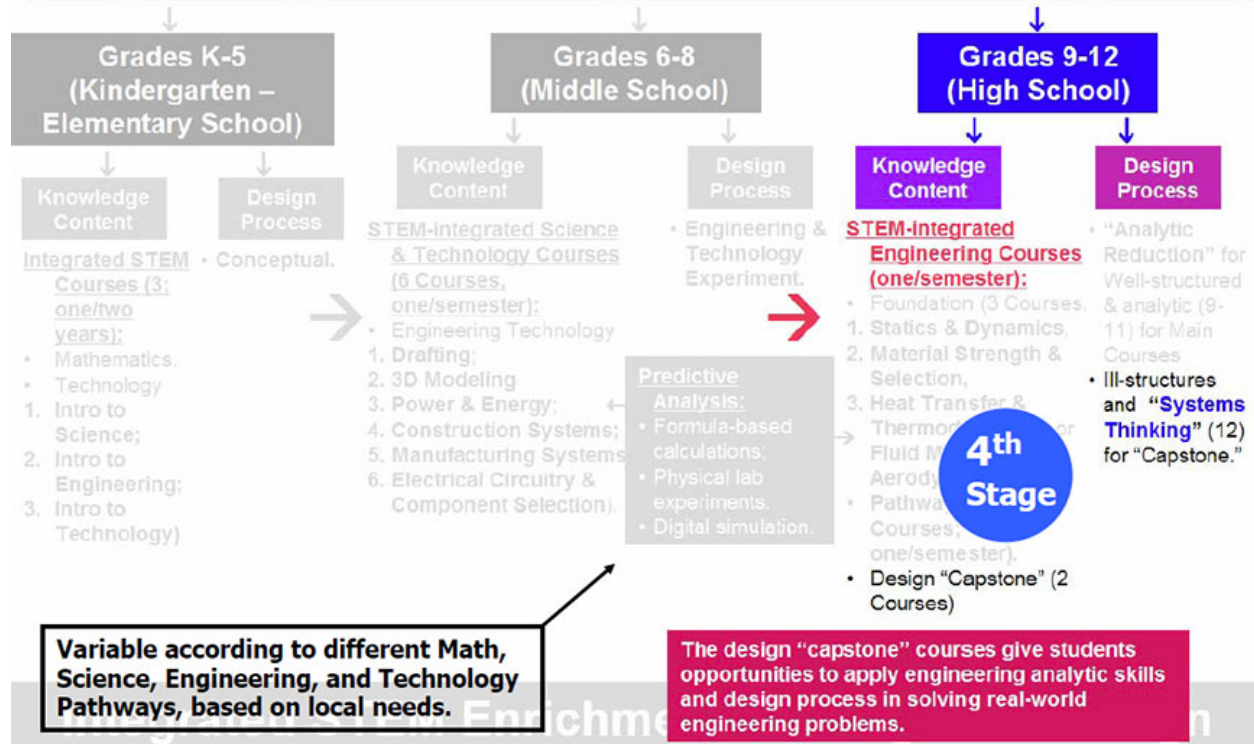
The task to be completed in the Third Stage (Grades 9-10 or High School, the Foundation Courses).



The task to be completed in the Third Stage (Grades 10-11 or High School, the Pathway or Major Courses).

K-12 Engineering Road Map

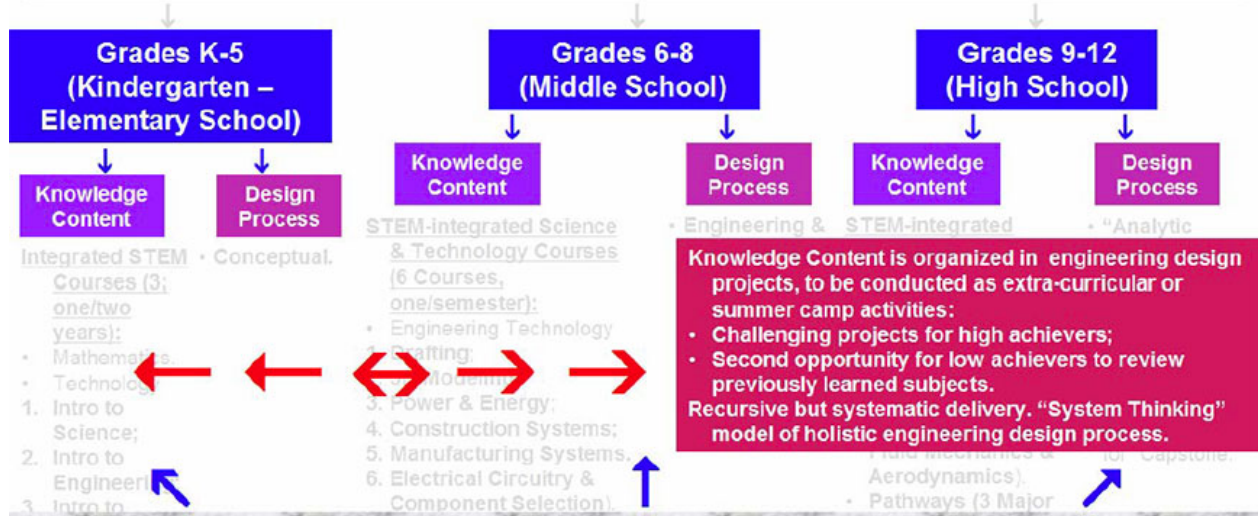
Engineering & Technology Main Courses Sequence



The task to be completed in the Fourth Stage (Grades 12 or High School, the "Capstone" Courses).

K-12 Engineering Road Map

Engineering & Technology Main Courses Sequence

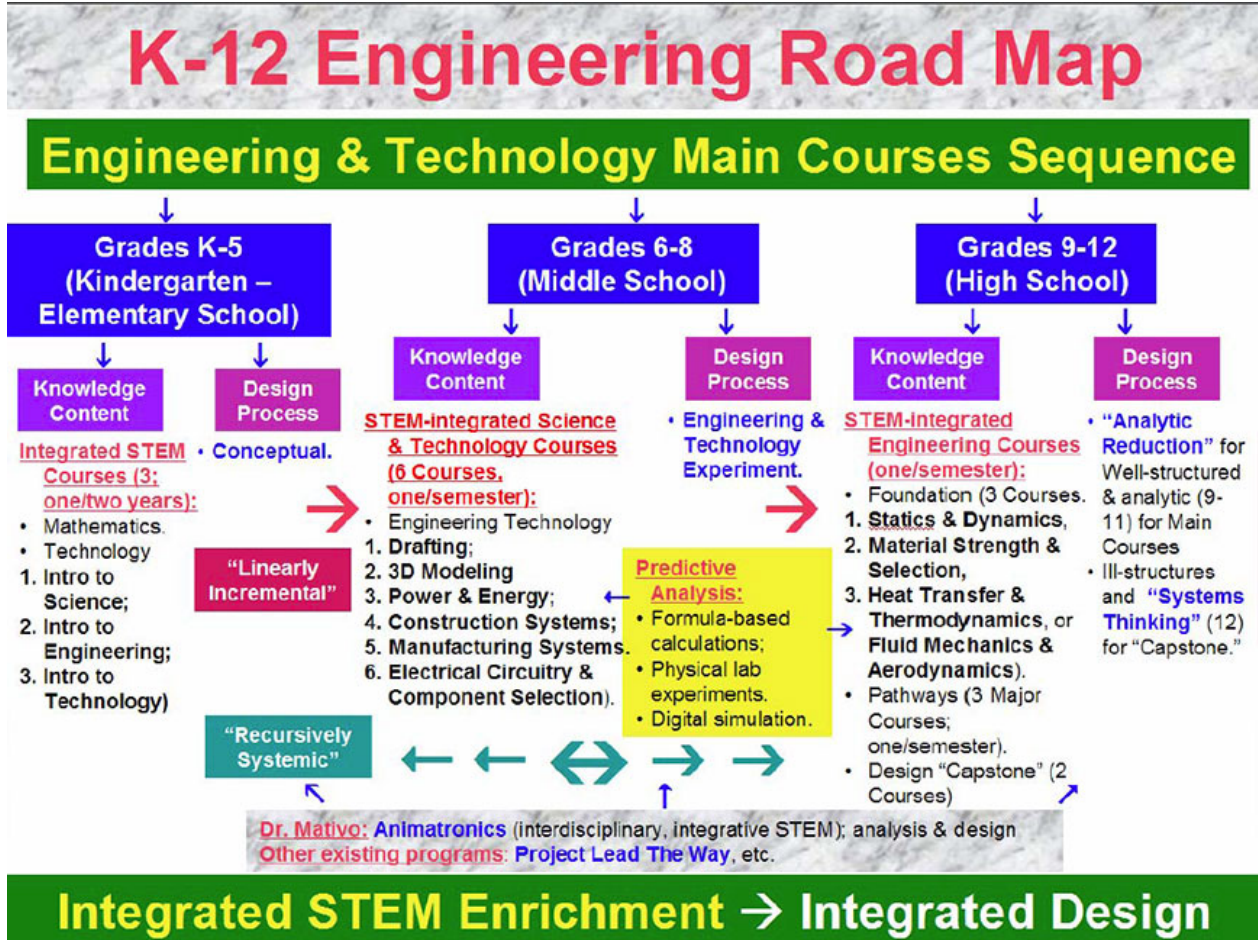


Dr. Mativo: Animatronics (interdisciplinary, integrative STEM project, with Mini Lessons teaching engineering design science and art).
Other existing programs: Project Lead The Way, etc.

Across Stages

Integrated STEM Enrichment → Integrated Design

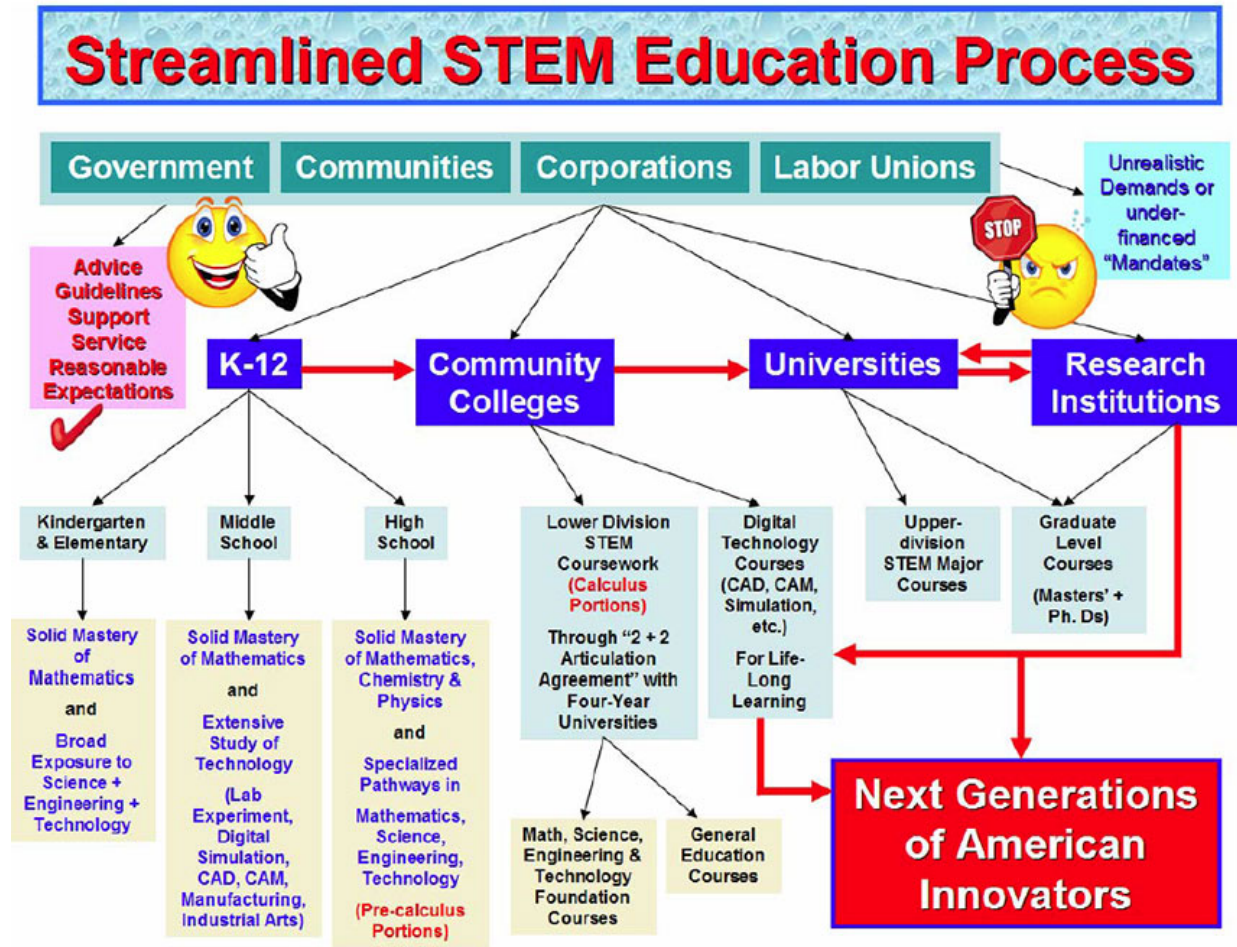
Integrated STEM Enrichment projects to be conducted as extra-curricular activities.



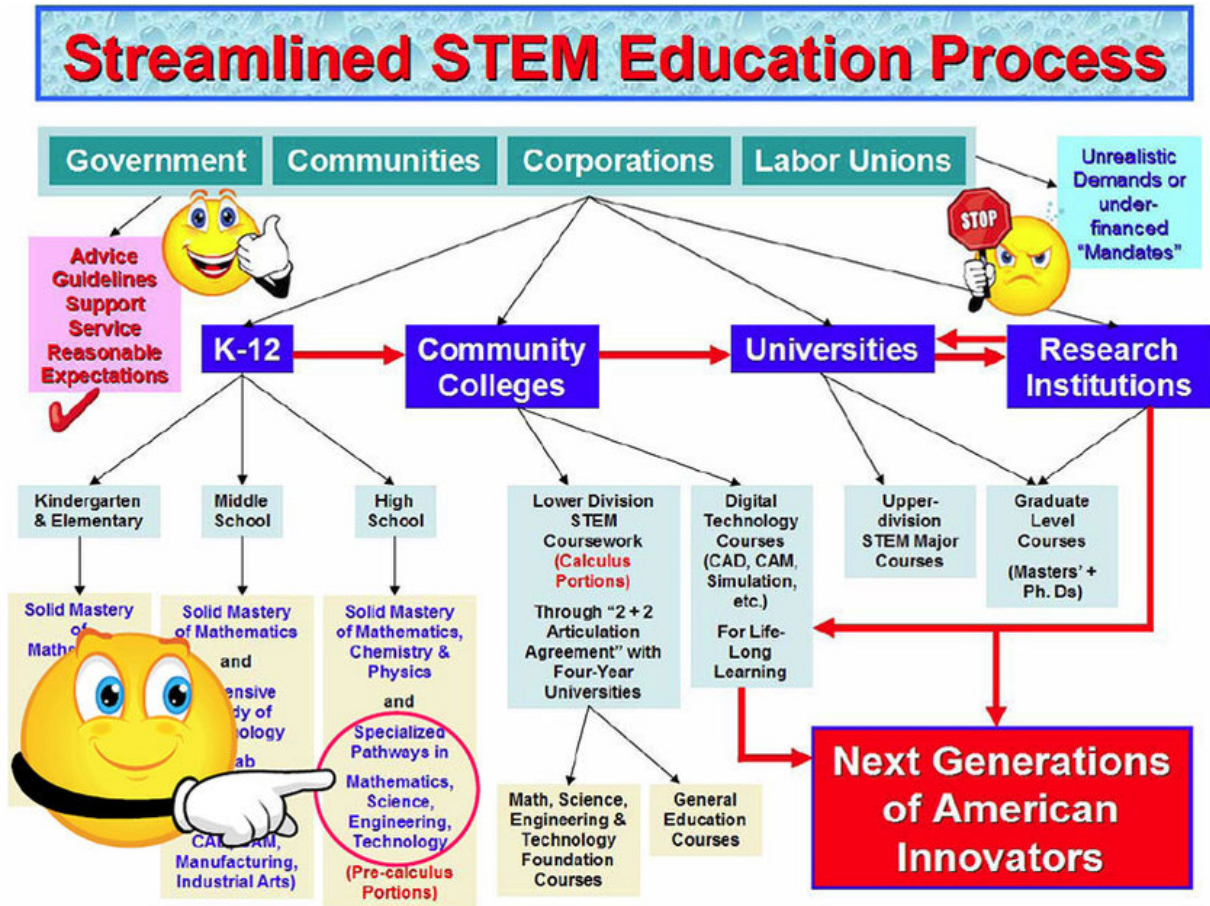
The whole picture.

THE STREAMLINED STEM EDUCATION PROCESS

The illustrations below show how the vision explored in the Proposed Model of K-12 Engineering and Technology Education can be applied to all field of STEM (science, technology, engineering and mathematics), to create a streamlined education process, for the training of next generations of American innovators.

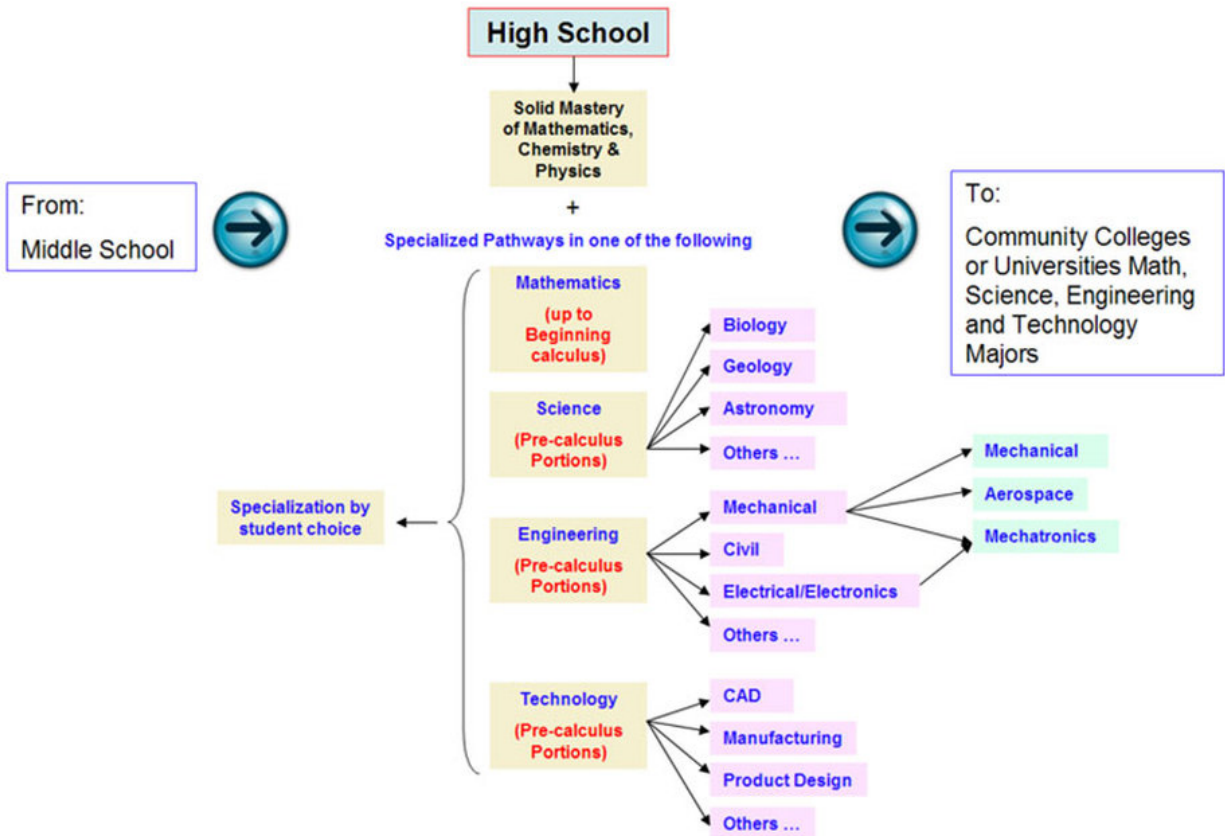


The Streamlined STEM Education Process.

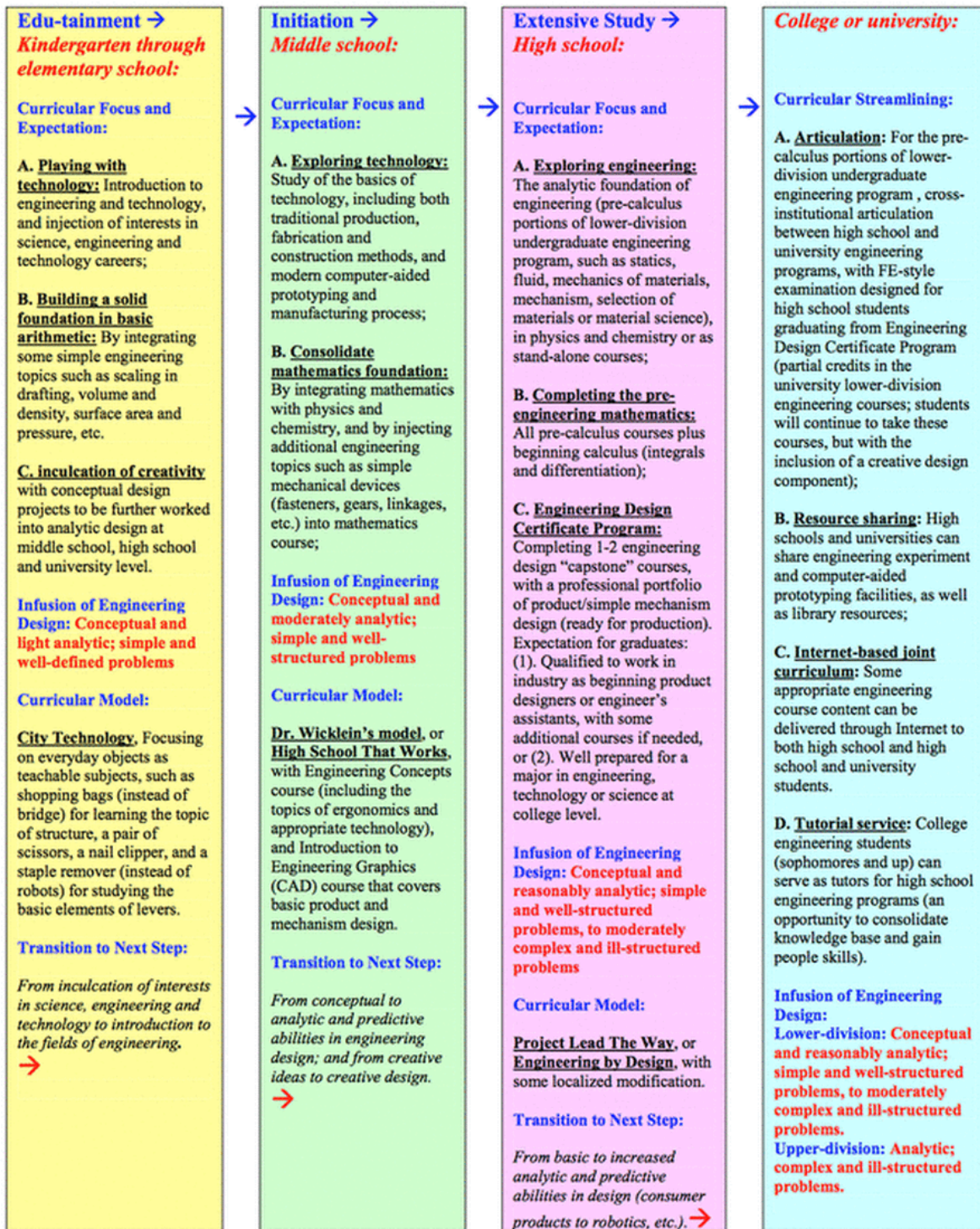


The Specialized Pathways or Majors in the Streamlined STEM Education Process.

Specialized High School STEM Education



Possible STEM Pathway courses for specialized magnet high schools.



Roadmap for an Integrated Engineering and Technology Curriculum (K-12 to College) for the Mechanical Engineering Career Pathway, with a streamlined flow of infusion of knowledge content and mastery of design process.

Teaching Engineering Design Process to Grades 9-12 (Under the Proposed Model)

1. Identify the Need

With completion of Engineering Analysis Courses

- Give Grades 9-12 students design assignment, which identifies a lack or shortage of something that is needed in the society.

2. Define a Problem

- Discuss with students issues relevant to the design assignment (scientific, engineering, technical, ethical, ecological, social, and economic)
- Review relevant engineering principles (concepts and formulas);
- Identify and specify criteria and constraints (governmental regulations, safety requirements, dimensions, weight, and cost, etc.) for the new design.

3. Gather Information

- Coach students on how to find existing solutions in the market or community (local, national, and international) through store or site visitations, to collect samples of existing products; and to conduct Internet and patent search;
- Coach students on how to analyze the strengths and weaknesses of existing products/systems, and tabulate the data;
- Coach students on how to generate ideas on possible improvement or innovation, within the criteria and constraints established in step 2;

4. Develop and Evaluate Alternative Solutions

- Coach student design teams on brainstorming for possible solutions incorporating various strengths of existing products/systems plus innovative features, using engineering notebook;
- Coach students on how to evaluate the ideas generated during brainstorming sessions in team meetings, and modify the ideas for presentation to instructor (with sketch and/or mock-ups);
- Evaluate students' initial design ideas and helps selecting the most appropriate design.

5. Analysis

- Coach students on mathematical predictions, and engineering experiment (if needed);
- Coach students on CAD modeling (using Inventor, SolidWorks, SolidEdge, etc.), and digital simulation (if possible);
- Coach students on writing a design proposal.

6. Decision

- Tram presentation to and evaluation by classmates and instructor (based on established criteria and constraints);
- Final modification of design in CAD, and digital simulation (if possible).

7. Test and Verify the Solution

- Coach students on building a prototype to test the final design solution;
- Coach students on making final changes (if needed);
- Coach students on making design specifications.

8. Communication

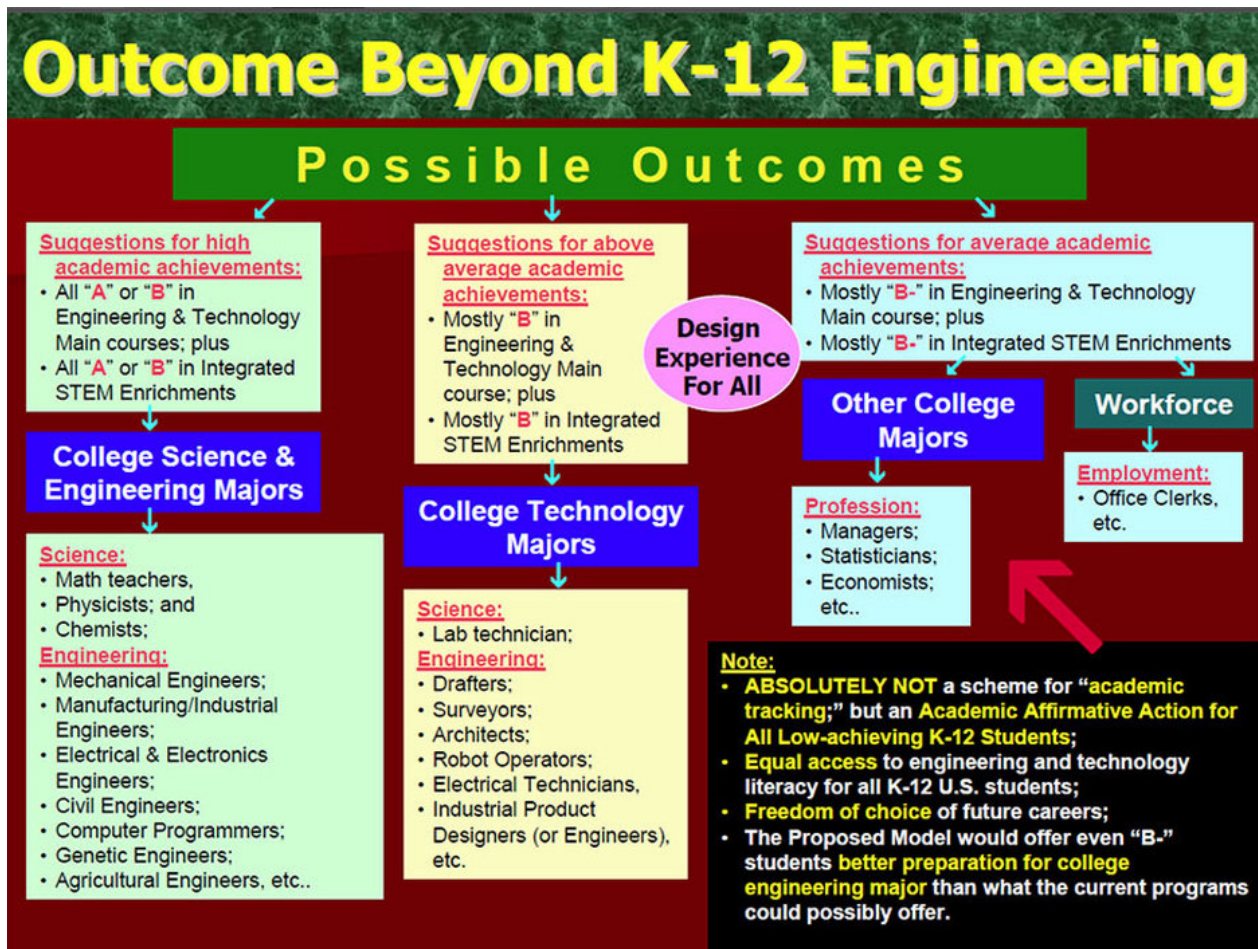
- Student teams' final presentation with oral demonstration, written design proposal, CAD 3D models, 2D drawings, and prototype.

**Edward Locke's
interpretation:
8-Step Engineering
Design Process for
Grades 9 -12
(NCETE)**

My interpretation of Grades 9-12 Engineering Design Process originally established by the National Center for Engineering and Technology Education.

| Technology Education Design Process | Combined Engineering and Technology Design Process (Edward Locke) | Engineering Design Process |
|--|---|---|
| <input type="checkbox"/> Defining a Problem → | <input type="checkbox"/> Defining a Problem and/or Identify the Need for a Solution | ← <input type="checkbox"/> Identify the Need |
| <input type="checkbox"/> Brainstorming → | <input type="checkbox"/> Researching Existing Solutions in the Market or Community (Local, National, and International) Through Visitation and/or Internet Search, Analyzing Their Strengths and Shortcomings for a Possible Better Solution | ← <input type="checkbox"/> Define Problem |
| <input type="checkbox"/> Researching and Generating Ideas → | <input type="checkbox"/> Generating Ideas Through 3-4-5 Brainstorming Sessions for Better Solutions Incorporating Various Strengths of Existing Products/Systems Plus Innovative Features | ← <input type="checkbox"/> Search for Solutions |
| <input type="checkbox"/> Identifying Criteria → | <input type="checkbox"/> Identifying and Specifying Criteria and Constraints for New Design | ← <input type="checkbox"/> Identify Constraints |
| <input type="checkbox"/> Specifying Constraints → | | ← <input type="checkbox"/> Specify Evaluation Criteria |
| <input type="checkbox"/> Exploring Possibilities → | <input type="checkbox"/> Comparing and Evaluating Solution Ideas from Brainstorming Sessions Against the Established Criteria and Constraints | ← <input type="checkbox"/> Generate Alternative Solutions |
| <input type="checkbox"/> Selecting an Approach and Develop a Design Proposal → | <input type="checkbox"/> Initial Decision-Making: Selecting the Most Suitable Approach to Solution and Developing a Design Proposal Based on Analysis of Engineering Design Factors | ← <input type="checkbox"/> Engineering Analysis |
| <input type="checkbox"/> Building a Model or Prototype → <input type="checkbox"/> Testing and Evaluating the Design → <input type="checkbox"/> Refining the Design → | <input type="checkbox"/> Mathematical Predictions and Digital Simulation If Possible <input type="checkbox"/> Final Decision Making and Design Specifications <input type="checkbox"/> Building a Model or Prototype <input type="checkbox"/> Testing and Evaluating the Design <input type="checkbox"/> Refining the Design | ← <input type="checkbox"/> Mathematical Predictions ← <input type="checkbox"/> Decision Making ← <input type="checkbox"/> Design Specifications |
| <input type="checkbox"/> Communicating Results → | <input type="checkbox"/> Communicating Results with CAD 3D Models and 2D Drawings | ← <input type="checkbox"/> Communication |

Combining the current Technology Education Design Process (left) and Engineering Design Process(right) into a futuristic but realistic Engineering and Technology Design Process.



Possible career outcomes for high school graduates from the futuristic K-12 Engineering and Technology curriculum under the Proposed Model explored in my Vision Paper.


COMPARING MY PROPOSED MODEL AND THE EXISTING K-12 ENGINEERING PROGRAMS

The illustrations below show the major differences between the futuristic but realistic K-12 engineering and technology curriculum under the Proposed Model explored in my Vision Paper.

Major Differences between the Proposed Model and the Existing Programs

| Major Difference | The Existing Programs | The Proposed Model |
|---|--|--|
| Program Classification and Societal Needs | <ul style="list-style-type: none"> Tend to be more focused on technology as an appendage of engineering. | <ul style="list-style-type: none"> Would switch the balance to the hard-core engineering design side. |
| Program Scope | <ul style="list-style-type: none"> Tend to treat K-12 engineering and technology subjects in a "Black Box." | <ul style="list-style-type: none"> Would take a more systematic and cohesive approach with codification of K-12 engineering and technology knowledge content; "Transparent Box" |

The Existing Programs: "Black Box"



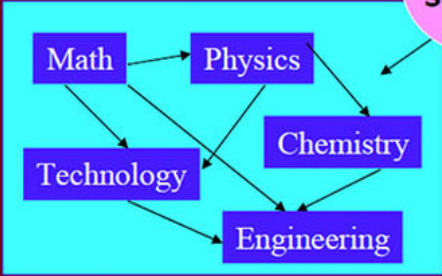
Works? ✓

Why? ✗

How? ✗

Knowledge transfer? ✗

The Proposed Model: "Transparent Box"



Works? ✓


Why? ✓

How? ✓

Knowledge Transfer? ✓

Better for K-12 Students !

(Comment from Dr. David Gattie, UGA, Friday, March 20, 2009)



The "Black Box" and "Transparent Box" analogies made by Dr. David Gattie, Engineering Professor at Driftmier Engineering Center, the University of Georgia, after I gave him a PowerPoint presentation on the Proposed Model.

Major Differences between the Proposed Model and the Existing Programs (Continued)

| Major Difference | The Existing Programs | The Proposed Model |
|------------------------------|---|---|
| Program Status | More "after-school science enrichment" or "curriculum enhancement," or at most "pre-engineering" programs. | Engineering and technology education as an integral part of the K-12 curriculum. |
| Program Outcome | Aimed more at improving STEM scores for high school students. | Reasonably expecting graduates from K-12 engineering and technology programs to be well-prepared for (1) College engineering programs; or (2) Entering engineering technology-associated workforce (CAD drafter, etc.) with some additional training. |
| Program Flow | Not differentiating engineering design approach into incremental stages that match K-12 students' ages. | Differentiating design process into four different stages, each matching a stage in K-12 education. |
| Program Curricular Structure | Not clearly delineating the engineering and technology courses that K-12 students could take at each stage of their academic journey. | Clearly delineating K-12 engineering and technology courses at each stage K-12 journey. |

For
Better
Grades

No
Clearly
Defined
Stages

For
Better
Careers

Clearly
Defined
Stages



Other major differences between the Proposed Model and existing K-12 engineering and technology curriculum.

The new version of the step-by-step implementation plan is explained in the Panning & Progress Report page of this website, and will be modified and updated during the implementation process, based on the outcomes of pedagogic experiment, and on the constructive feedback from other professionals, experts and stakeholders.

VITAL ISSUES AFFECTING CONTEMPORARY ENGINEERING DESIGN AND INNOVATION

Escaping our own Ivory Tower: Many established scholars, such as Weaver (1948, pp. 4-6), indicated that there is a need for scientific and engineering communities to break off from their own ivory towers and to embrace other vital aspects of human endeavors, with a deep understanding of the "interdisciplinary" and "complex" attributes of modern engineering design, believing that the future of the world requires science to make a third great advance, to learn to deal with these problems of organized complexity, citing as an

example the wartime development of new types of electronic computing devices which eventually gave birth to personal computers; and challenged the readers to think about a wide range of problems in the biological, medical, psychological, economic, and political sciences, posing interesting questions such as “with a given total of national resources that can be brought to bear, [...] what sacrifices of present selfish interest will most effectively contribute to a stable, decent and peaceful world?” Many scholars indicated that these problems are beyond the statistical techniques or even the whole of scientific methods, but involve other “rich and essential parts of human life,” such as code of morals, basis for esthetics, man’s love of beauty and truth, sense of value, or convictions of faith, “which are immaterial and non-quantitative in character, and which cannot be seen under the microscope, weighed with the balance, nor caught by the most sensitive microphone.”

Trashing the so-called “valueless education:” As a great advice for the appropriate application of scientific knowledge for human welfare, Weaver pointed out that “our morals must catch up with our machinery” (1948, p. 7). This challenged me to wonder that, due to serious problems that challenge our democratic society (such as inappropriate use of technology causing pollution and other human disasters), we need to reconsider the wisdom of “valueless education,” and strengthen ethical values, such as concern for the collective well-being of the society, and environmental protection, as important parts of K-12 engineering and technology education. While continuing our age-old American tradition of “rugged individualism” and “sovereignty of the individual,” we might think about better adapting to the new social, economic, technological and cultural conditions of the coming Age of Globalization, by embracing the ideas of inter-dependence of all human beings and of collaborative teamwork, across institutional, communal, state, and national borders.

Embracing global sustainability: Wicklein (2008) explained *Appropriate Technology* (AT) as “a concept which embodies providing for human needs with the least impact on the Earth’s finite resources,” and concluded that “advanced technology is often inappropriate for the needs that it is attempting to address within developing countries.” Reading this statement obliges me to reconsider my previous “common sense” faith that modern technology from the Western nations is always superior to traditional ones still in use in many developing countries, and that the promotion of modern technology is universally beneficial. Wicklein cited 7 items in *Design Criteria for Sustainable Development in Appropriate Technology*.

1. **Systems-Independence** (the ability of devices to stand alone, with minimal initial investment, available supporting infrastructure, and minimal need for improvement);
2. **Image of Modernity** (the need for the technology to convey a sense of modernity, progress, and dignity);
3. **Individual Technology vs. Collective Technology** (consideration for the local societal/cultural standards, i.e., more collectivistic cultures are more suitable for “group approach” to operating larger systems; while more individualistic cultures are more responsive to stand-alone systems such as using photoelectric solar panel to provide domestic electricity);
4. **Cost of Technology** (an important factor in the design and construction of appropriate technologies for developing countries);
5. **Risk Factor** (minimization of risk of failure, including *internal risks* of not fitting the local production system, and *external risks* of dependency on outside support);
6. **Evolutionary Capacity of Technology** (the ability to continue to develop and expand beyond its originally intended function);
7. **Single-Purpose and Multi-Purpose Technology** (The possibility to be used in more than one application, or multi-functionality).

Wicklein (2008) pointed out that the appropriate technology approach “has concern for people and the environment at its center,” and can “contribute to society, school aged children, and to developing nations around the world;” and placed emphasis on using renewable sources of energy and environmentally sound materials as the “crucial topic” for teaching the concept of sustainable development in the classroom. These ideas, together with the above-mentioned 7 criteria, clearly implied that K-12 engineering and technology curriculum should not be limited to teaching science, engineering and technology alone in a socially-neutral or value-less fashion, but should involve concern for the overall economic and ecological benefits of the society. Thus, technology should not be pursuit for its own sake, but rather as an instrument for satisfying human needs without damaging human habitat. Wicklein cited two case studies to support this multi-dimensional application of technology. *Case 1 (Domestic Technologies)* illustrated how an “intermediate technologies” of “hand operated wash tub which requires only a single

element from modern technology - the availability and popular pricing of detergent,” to be used for laundering clothes, using locally available resources, and creating jobs, could be a reasonable substitute to physically-exhausting way of washing clothes by hand, and to expansive power-operated washing machines, in an imaginary Third World country called Macudo. *Case Study 2 (Domestic and Commercial Technologies)* illustrated the use of photoelectric cells in low-cost operation of telephone system in Columbia, a country with mountainous topography, which makes normal telephone systems difficult to install and maintain, as well as its contribution to the growth of local photoelectric cells manufacturing companies.

Educating new generations of ethical and ecologically-conscious and yet profitable innovators and inventors

In the Age of Globalization, one of the keys to maintain American leadership in global marketplace is technological innovation, invention, design and development of new products and systems. The world is changing and America will have to adapt to such change as well. With rising awareness for environmental protection through the increasing use of non-polluting and renewable energy, for economical use of exhaustible natural resources, for the protection of consumer rights, the traditional practice of engineering design for profit alone has to be replaced by a new practice where profits and justice, consumption and environmental protection must be balanced. Therefore, the new generation of engineering innovators and inventors could be expected to demonstrate the following qualities:

- **National and global awareness:** They should foster: (1) American patriotism, or loyalty to American people’s ideals, traditions, values, interests and rights; and being willing to serve the needs of communities and of the Nation (this is very important in the Age of Globalization, when international competition is increasingly based on scientific discovery, engineering design and technological innovations; thus, awareness of the role science and technology play in national interests and national security should be fostered as well); and (2) global awareness, or an understanding of cultural diversity in the world and economic interdependence among the nations, and an open mind to absorb all beneficial scientific and technological achievements from all countries, regardless of the source.
- **Social consciousness:** They should understand the impact of engineering design on society, in terms of consumers’ rights and interests, safety and ergonomics, and other issues.

• **Ecological stewardship:** They should understand the impact of engineering design on environment, in terms of designing products and systems that consume as little natural resources as possible, that could be built using as non-polluting as possible manufacturing processes, and that are as multi-functional, space-saving and energy saving as possible. Other issues such as retirement, recycling and disposal of the products and systems should also be understood. *Figure 9* through *Figure 11* shows examples of such products and systems.

References:

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