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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

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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.


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从幼儿抓起：工程教育呼唤新模式

http://www.usqiaobao.com 2009-04-27 02:45:44 作者： 佐治亚州 骆南植 来源： 侨报

目前，各国中小学教育的一个缺陷就是工程教育严重不足。在全球化、数字化的大趋势下，工程人员短缺现象日益突出。因此，前不久在肯塔基路易斯维尔举行的国际技术教育协会第71届年会上，笔者指出，有必要加强各国中小学生的工程教育，培养新一代创新发明家。

笔者认为，各国应从幼儿园开始就强化工程技术课程教育，而不论种族、性别、社会阶层和学习能力。同时，加强幼儿园至高中工程科技课外课程，让学习能力较强的学生有额外机会进一步探索这块领域，同时让学习能力中等或中下的学生有补习和复习的机会。由此，笔者特提出如下培养模式设想：

即时新闻

- 哪些职业失去操守最严重？医生公安居前
- 美国报纸销量加速下滑 报纸网站流量上升
- “刺头”冠军分外抢眼
- 墨西哥6级地震首都有明显震感 屋漏偏逢连夜雨
- 几百元奥运门票炒至7000元 警方派便衣抓倒票者

时事评论

- 两岸合作渐去“特殊化”
- 上海车展讽刺了谁？
- 回归本真的人文交流
- 阅读可圆强国梦
- 硅谷之后谁能称雄IT领域？

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.

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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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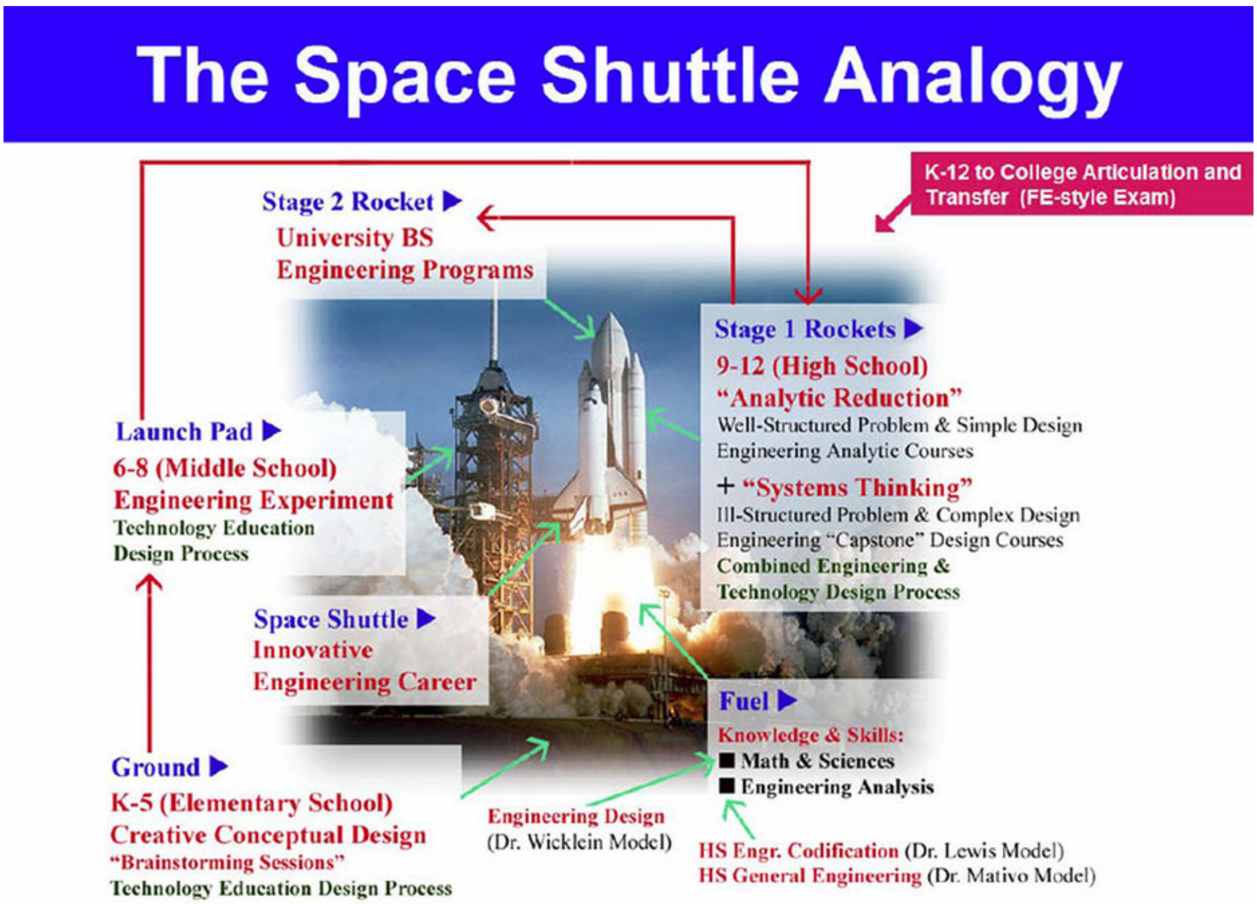
INFUSION OF ENGINEERING DESIGN THROUGHOUT THE K-12 EDUCATION

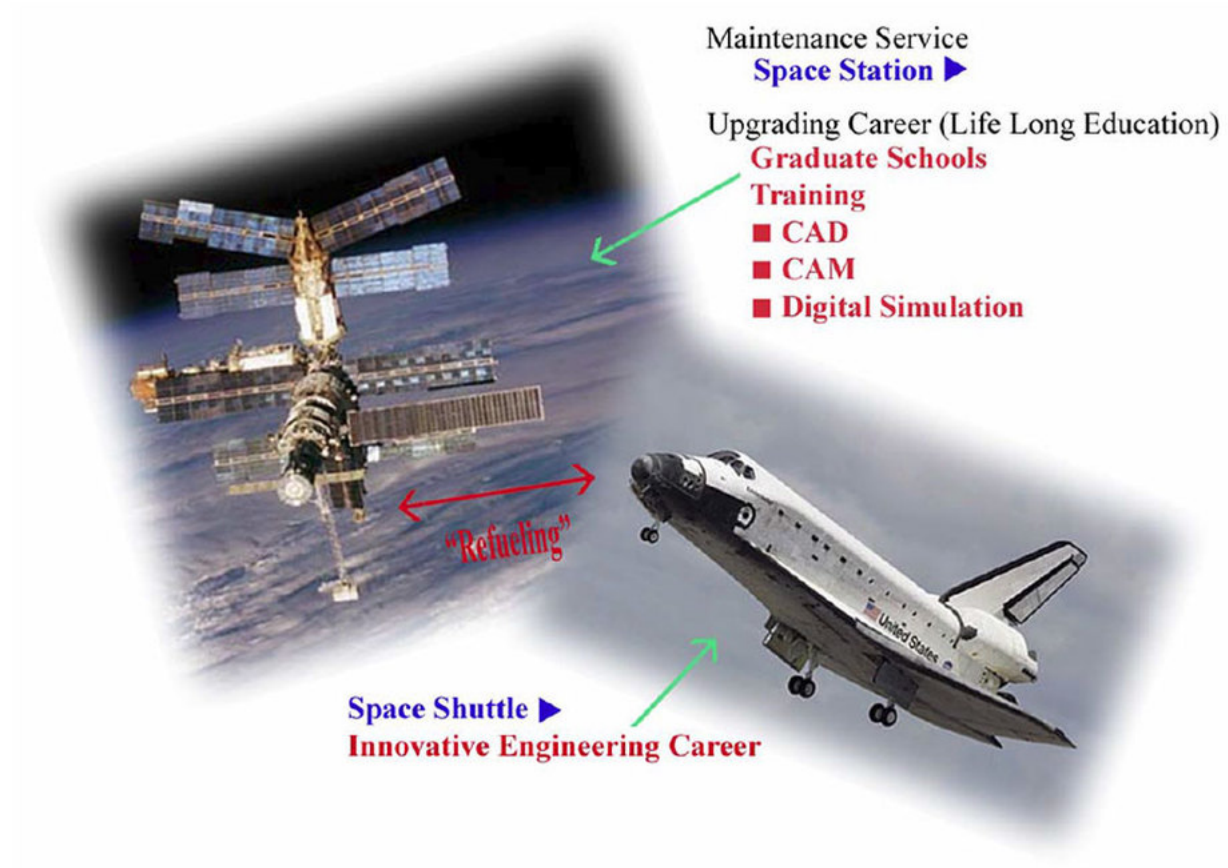
The infusion of engineering design throughout K-12 education could be divided into three stages, each transiting smoothly into the next; and this transition could be considered as analogous to the launch of a spacecraft into the outer space, where the birth of new generations of creative engineers are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

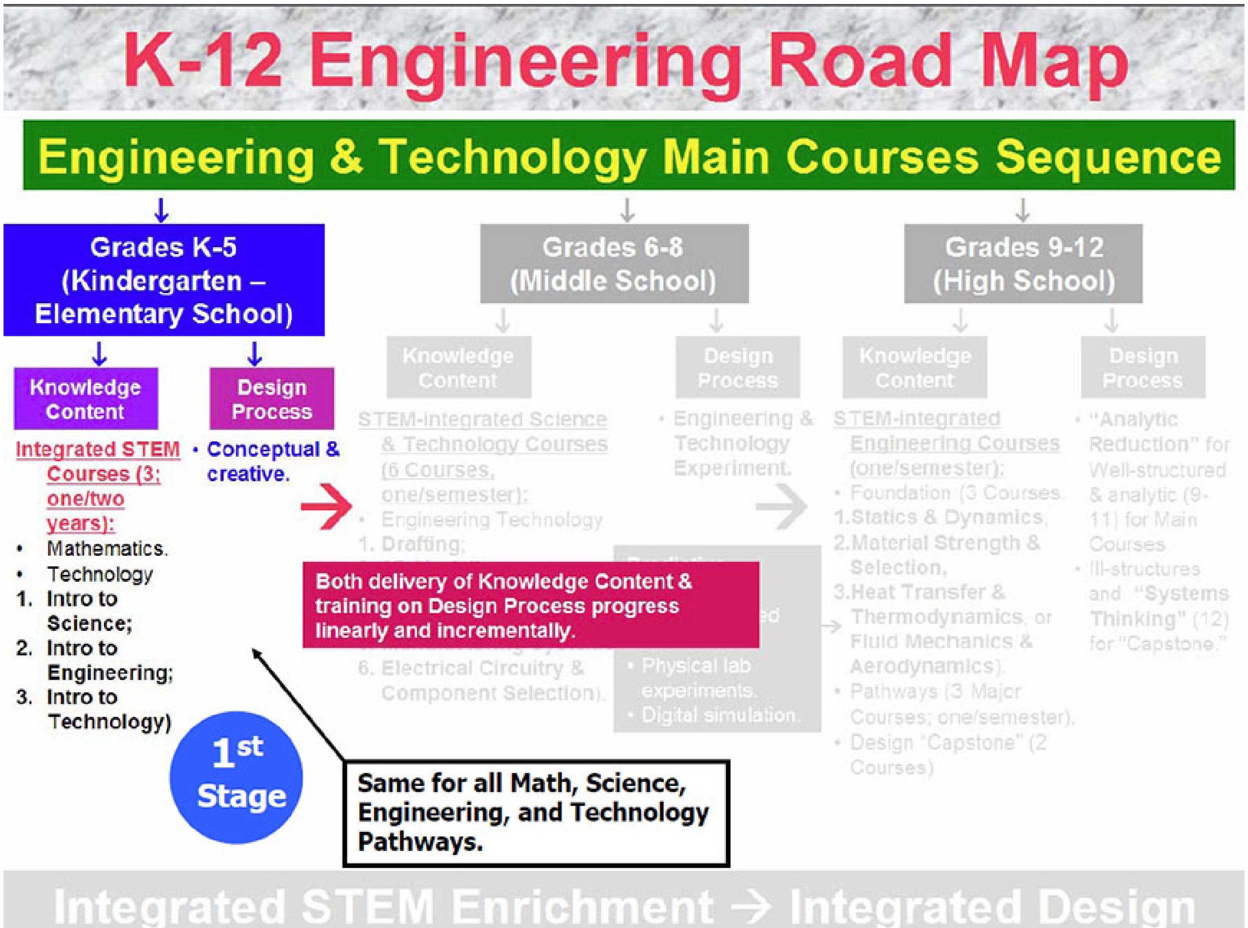
3. High school years: During this stage, students would be introduced to pre-calculus based engineering foundation courses, such as statics, fluid, materials strength and selection, mechanism design and selection. Infusion of engineering design could include: (1) conceptual and reasonably analytic design 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.

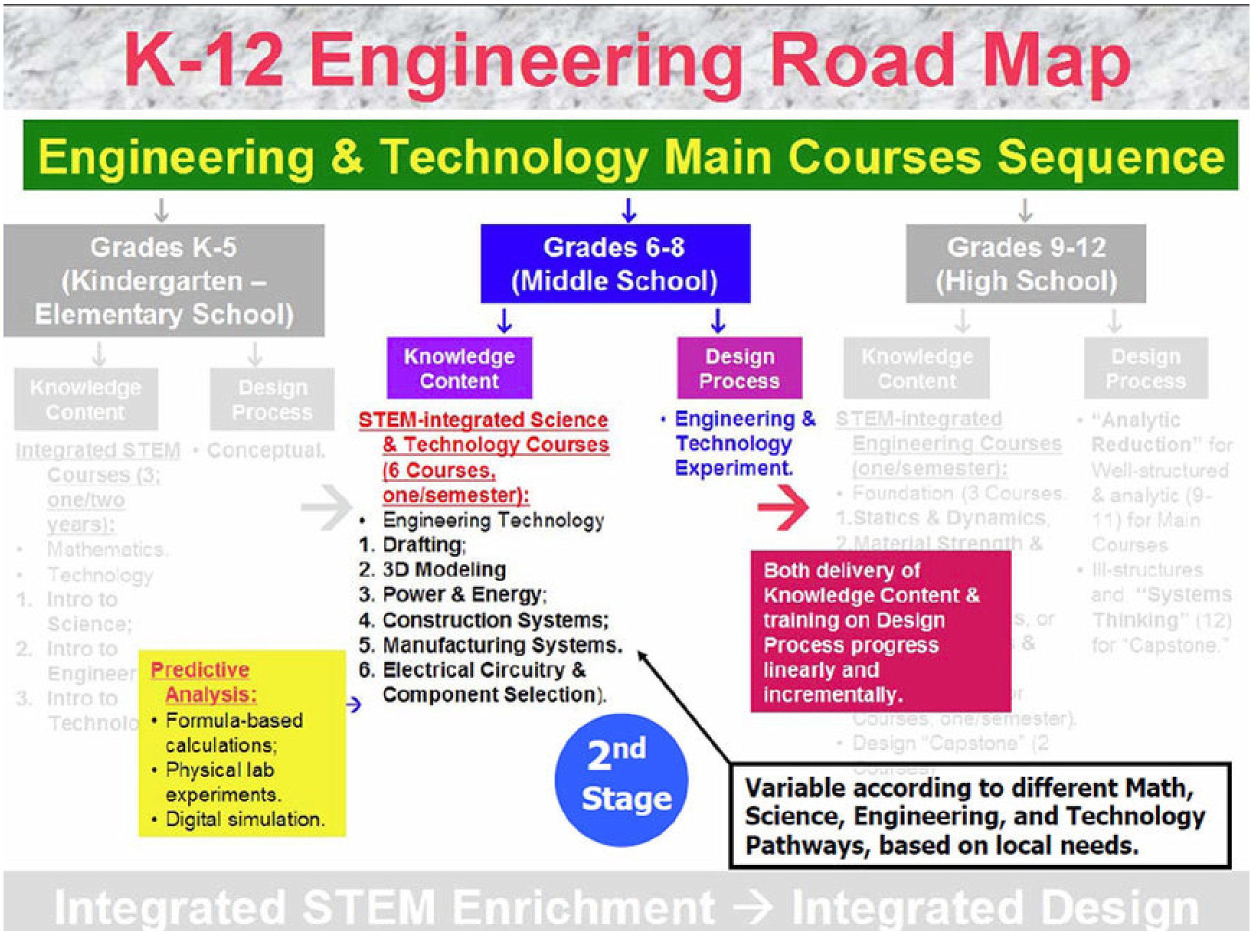
5. Post-university technological upgrades: The advance of digital technology, such as computer-aided-design/drafting (CADD), computer-aided-manufacturing (CAM), and computer simulation, will increasingly offer creative engineers possibilities to save time spent on tedious mathematical computations, to 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

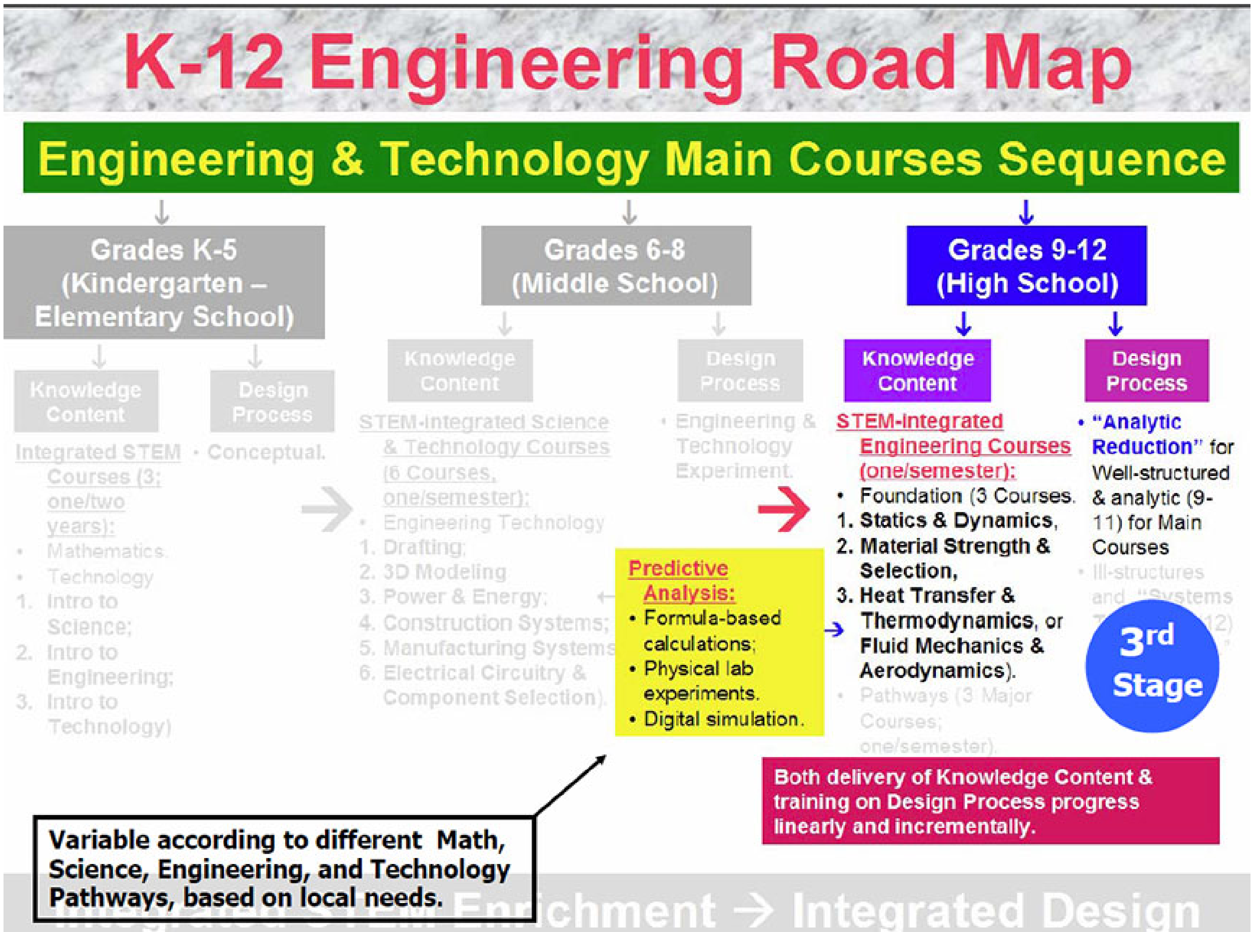
The illustrations below show the step-by-step progress in the Proposed Model of K-12 Engineering and Technology Education.



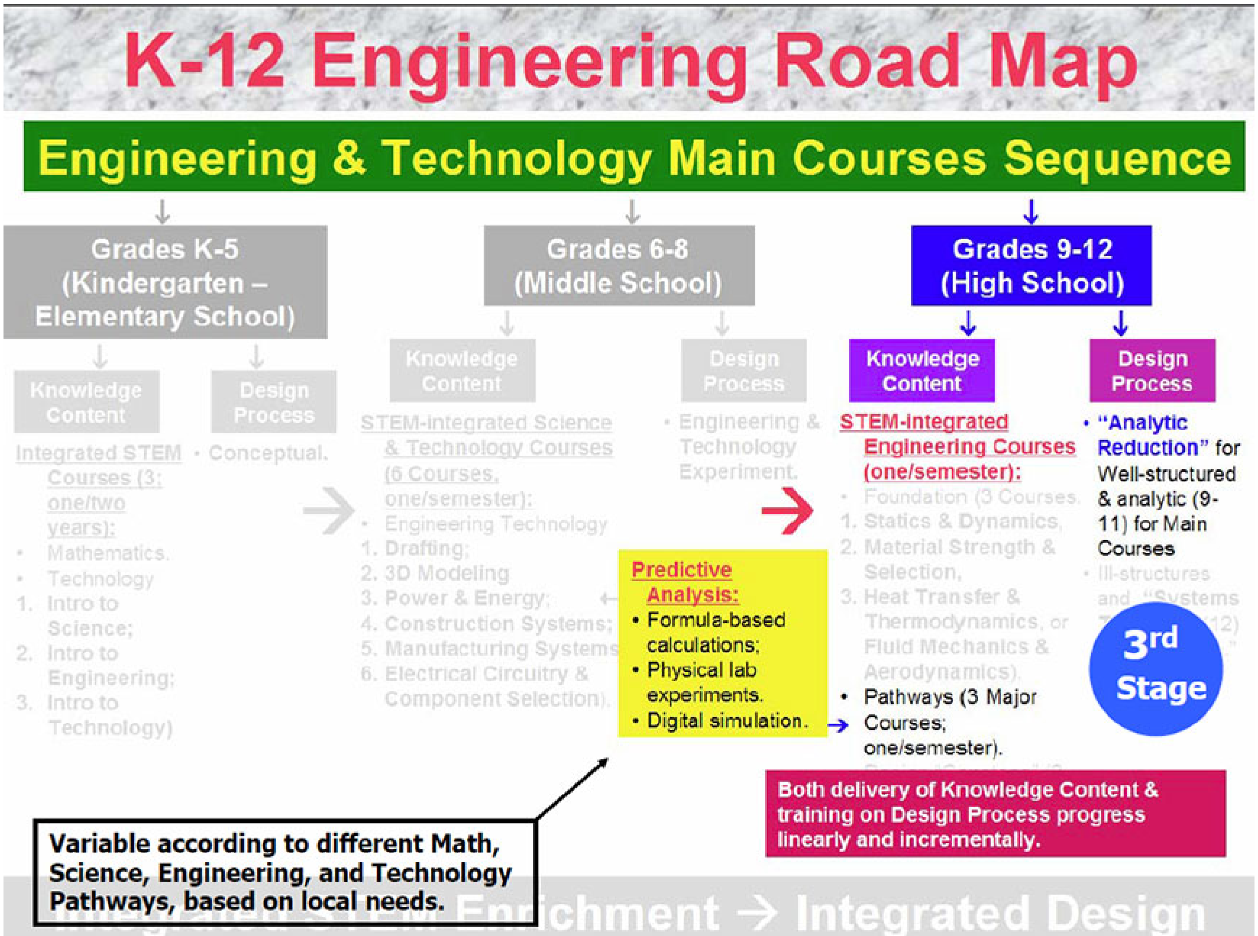
The task to be completed in the First Stage (Grades K-5 or Kindergarten to Elementary School).



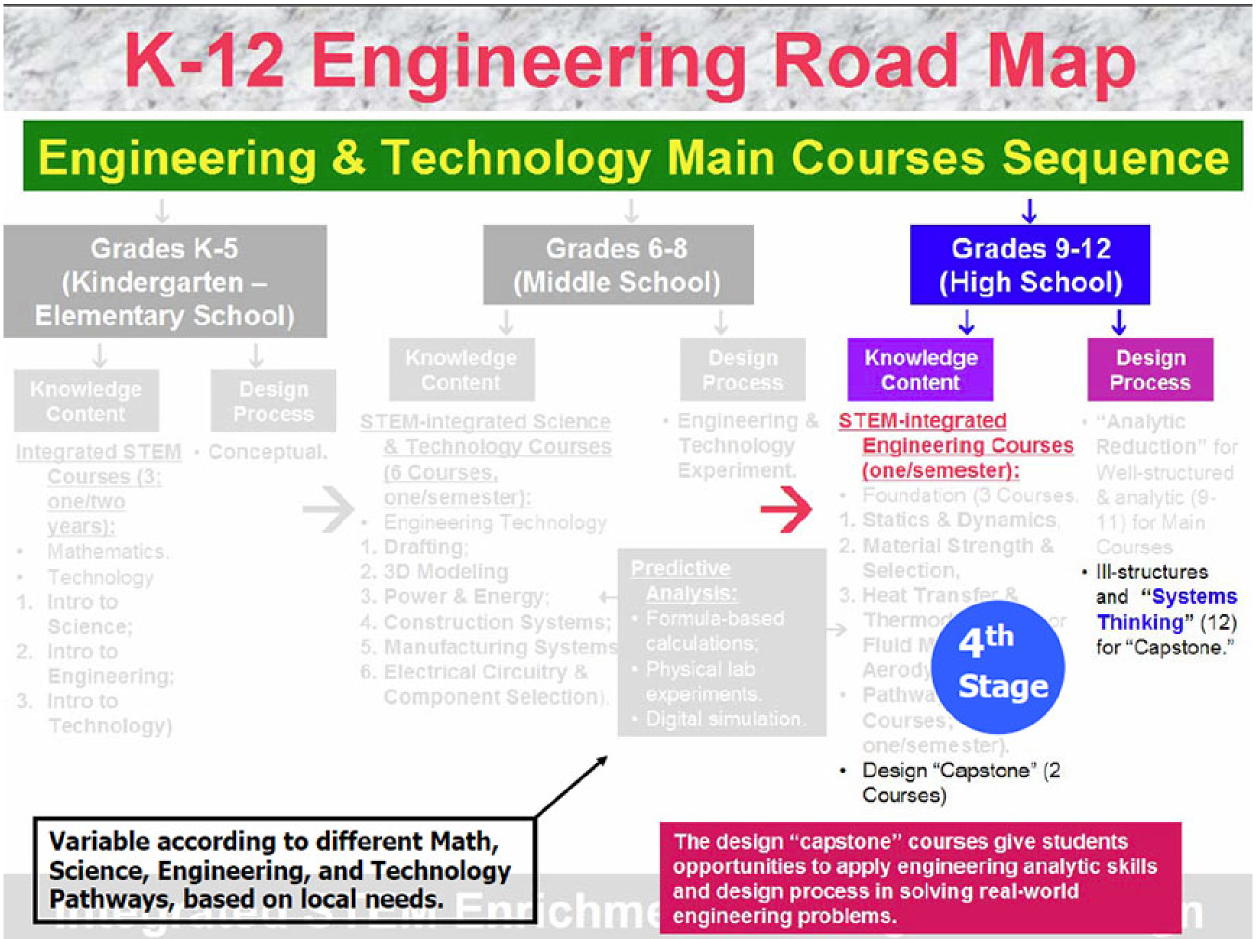
The task to be completed in the Second Stage (Grades 6-8 or Middle School).



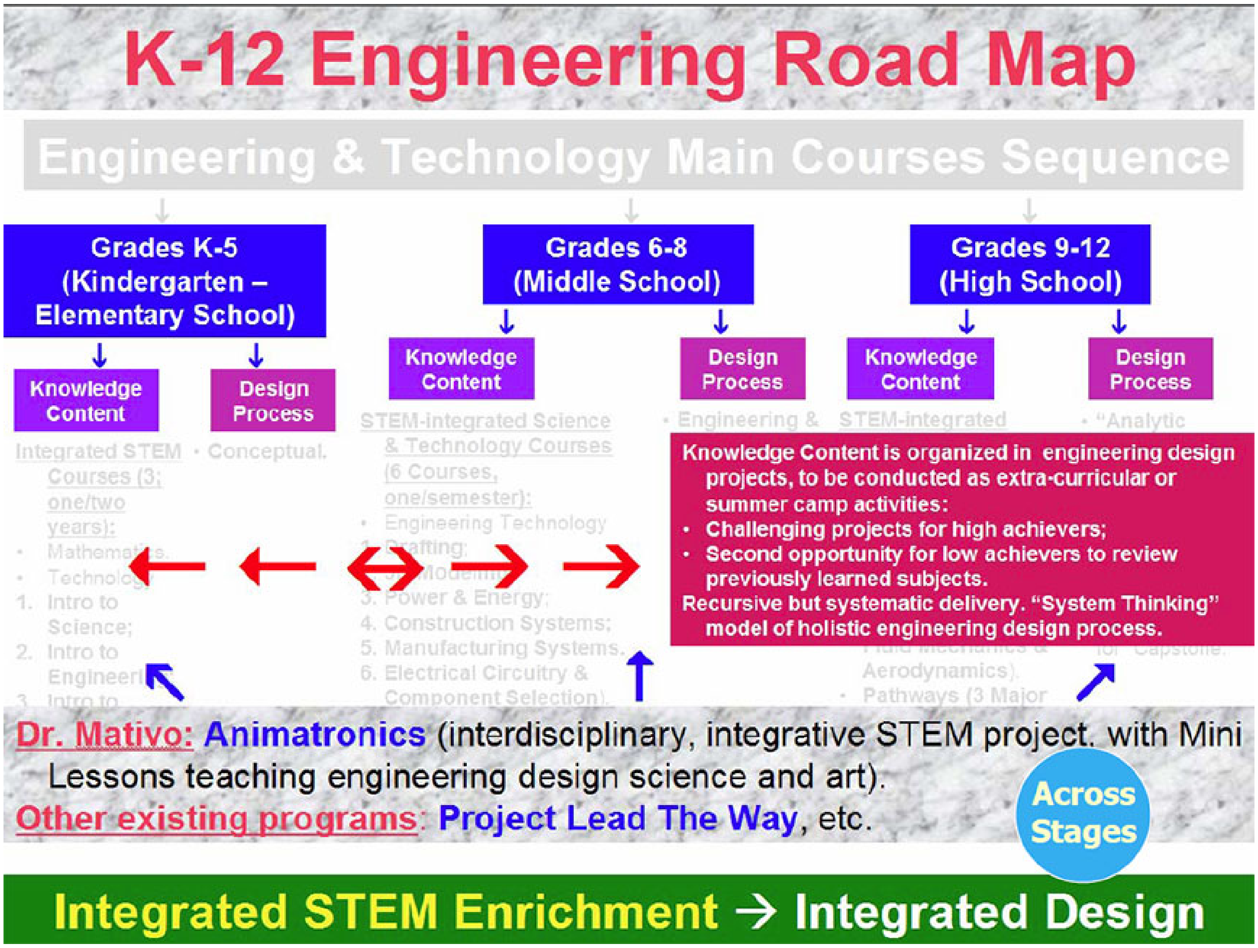
The task to be completed in the Third Stage (Grades 9-10 or High School, the Foundation Courses).



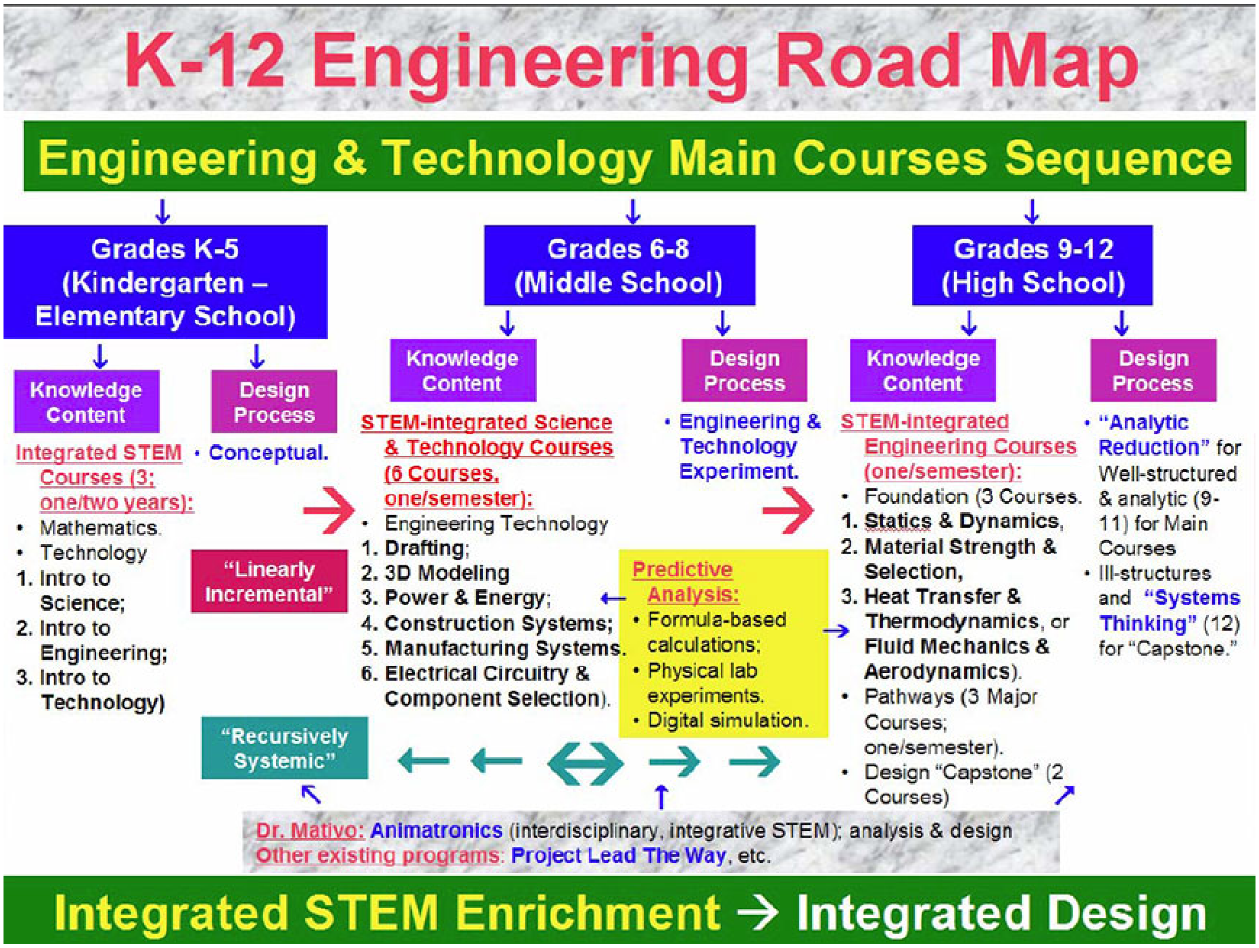
The task to be completed in the Third Stage (Grades 10-11 or High School, the Pathway or Major Courses).



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



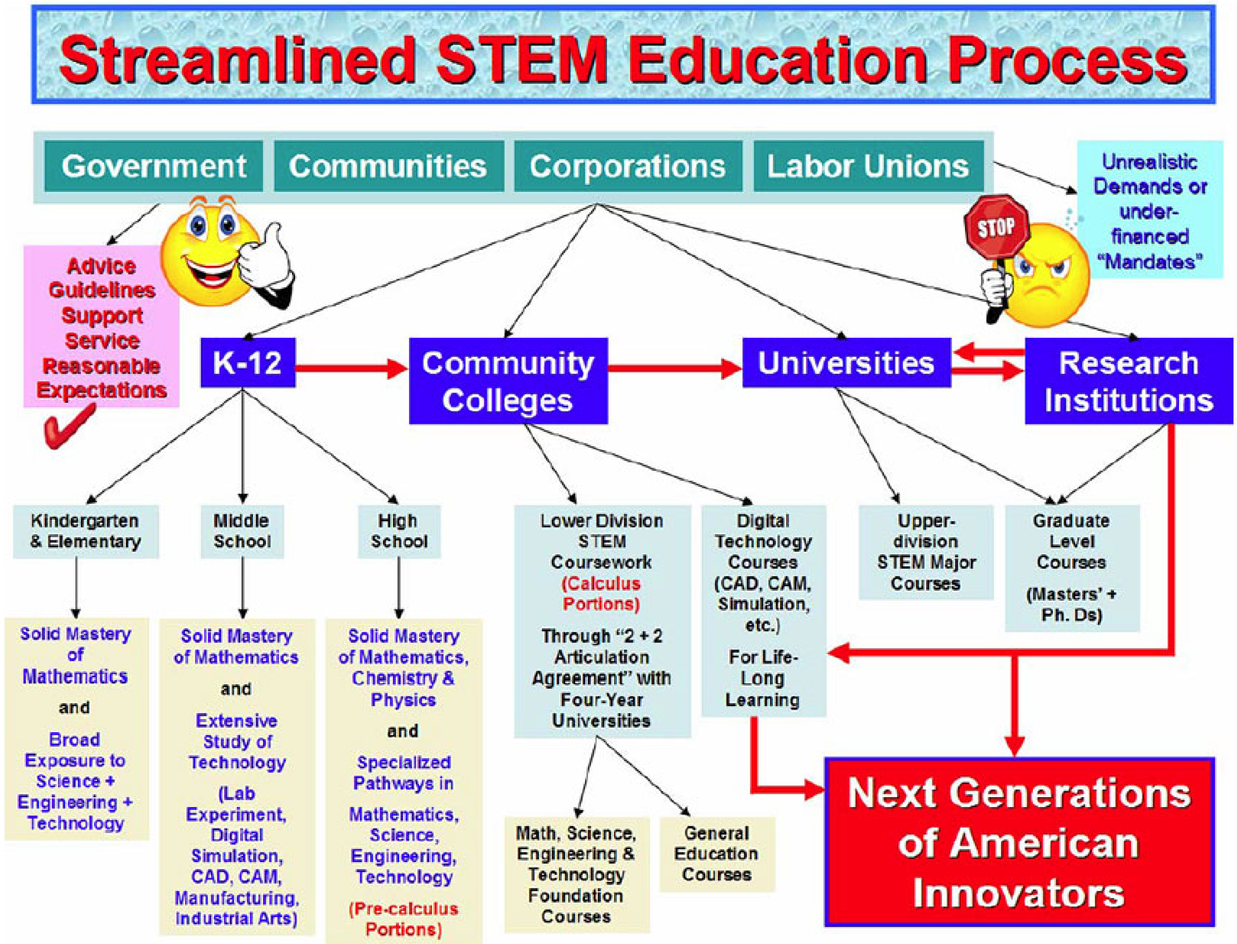
Integrated STEM Enrichment projects to be conducted as extra-curricular activities.



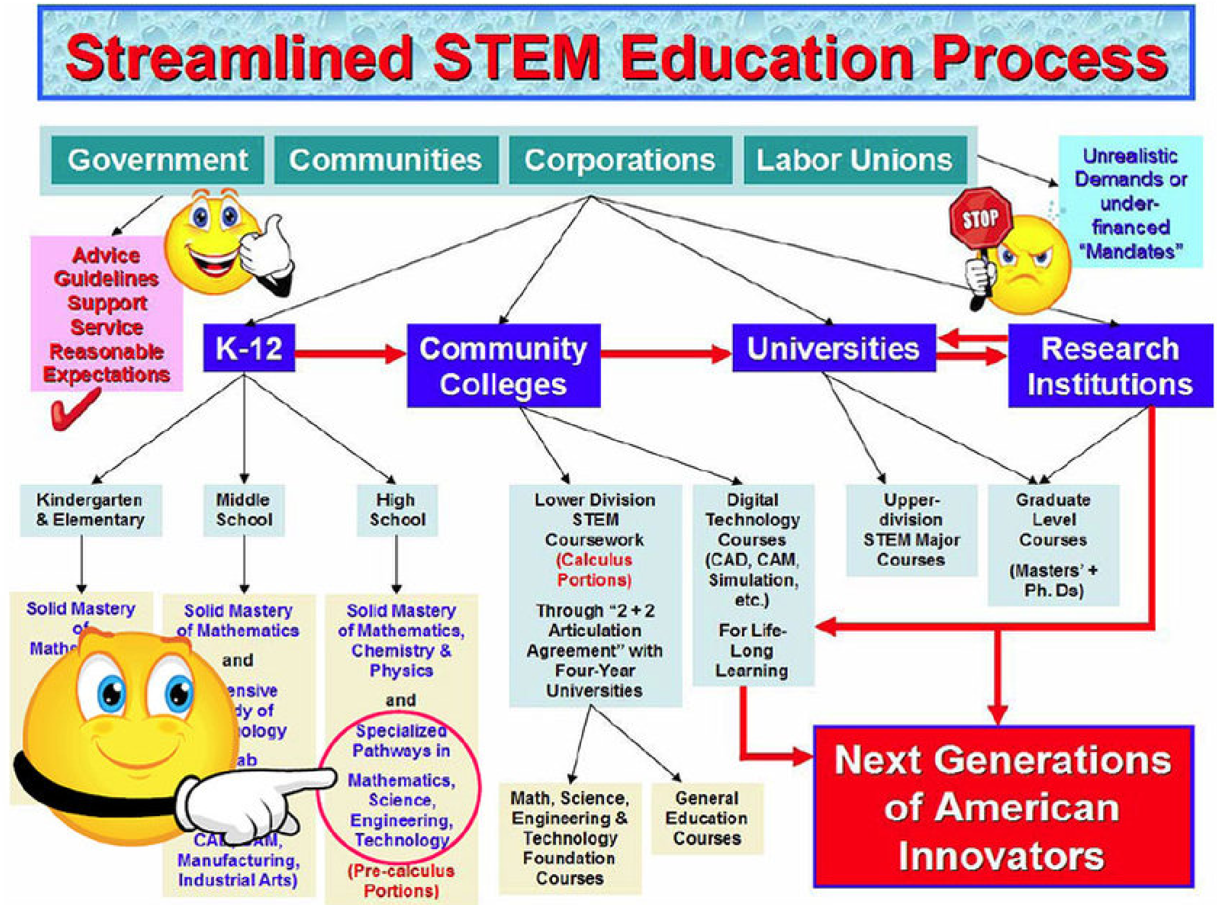
The whole picture.

THE STREAMLINED STEM EDUCATION PROCESS

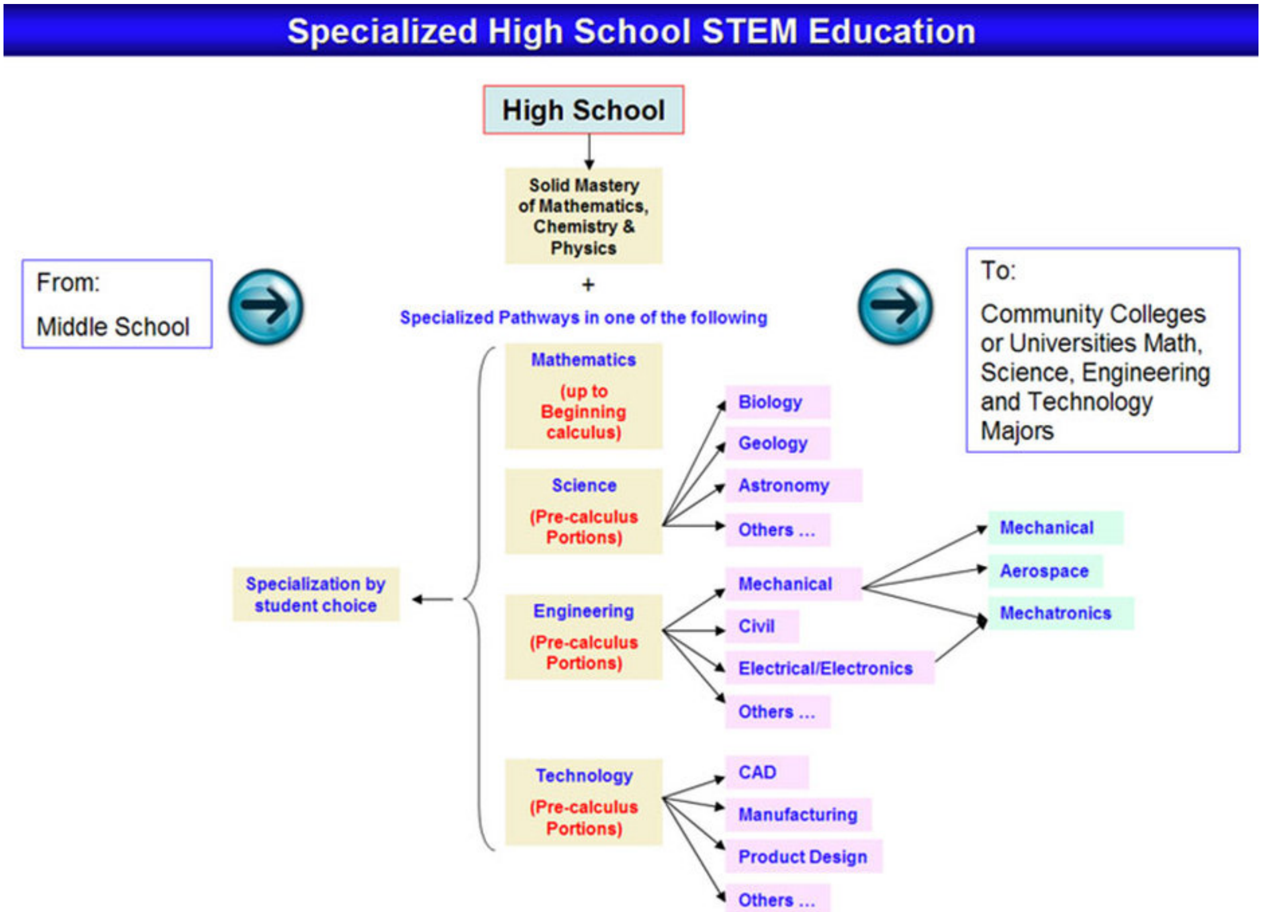
The illustrations below show how the vision explored in the Proposed Model of K-12 Engineering and Technology Education can be applied to all field of STEM (science, technology, engineering and mathematics), to create a streamlined education process, for the training of next generations of American innovators.



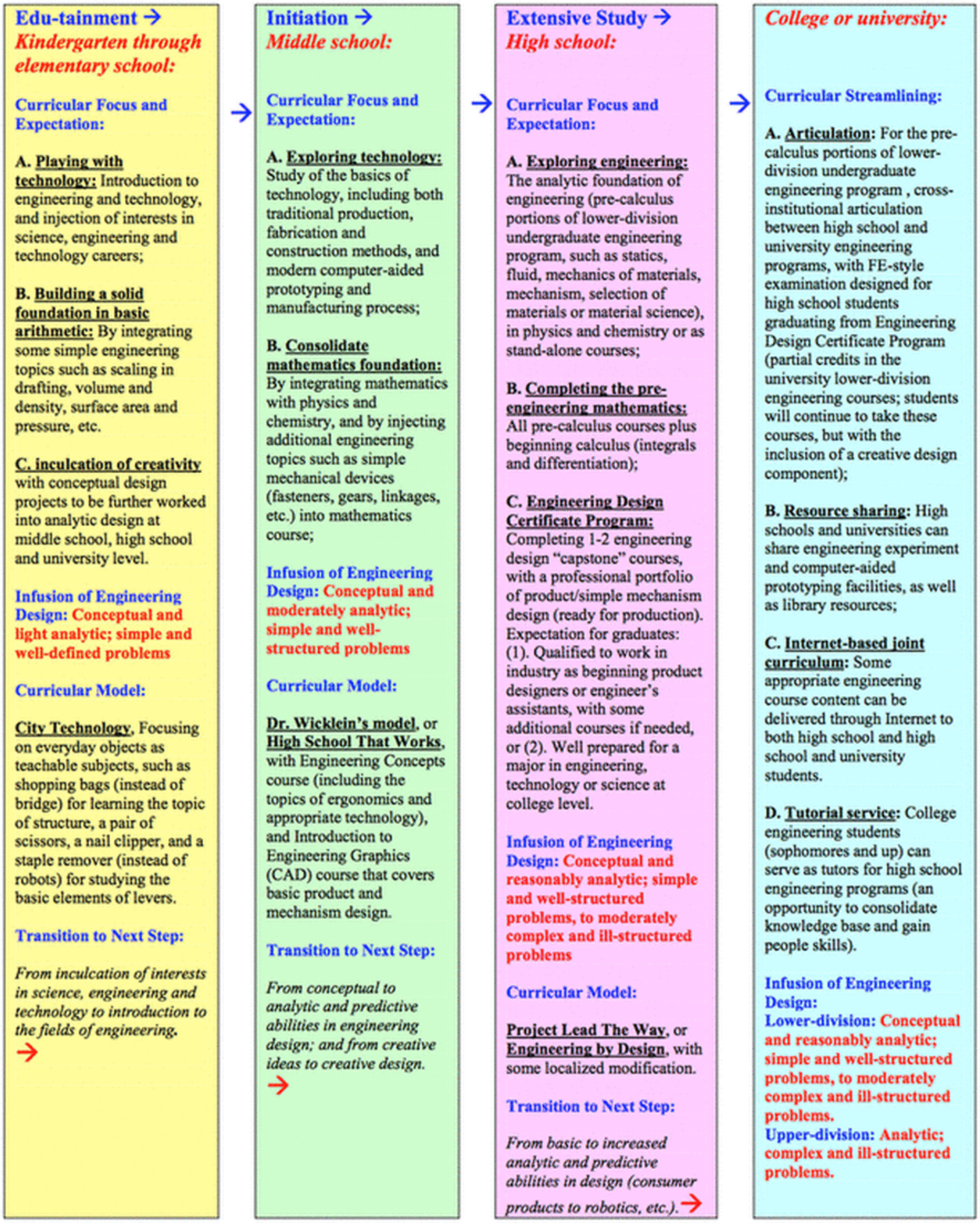
The Streamlined STEM Education Process.



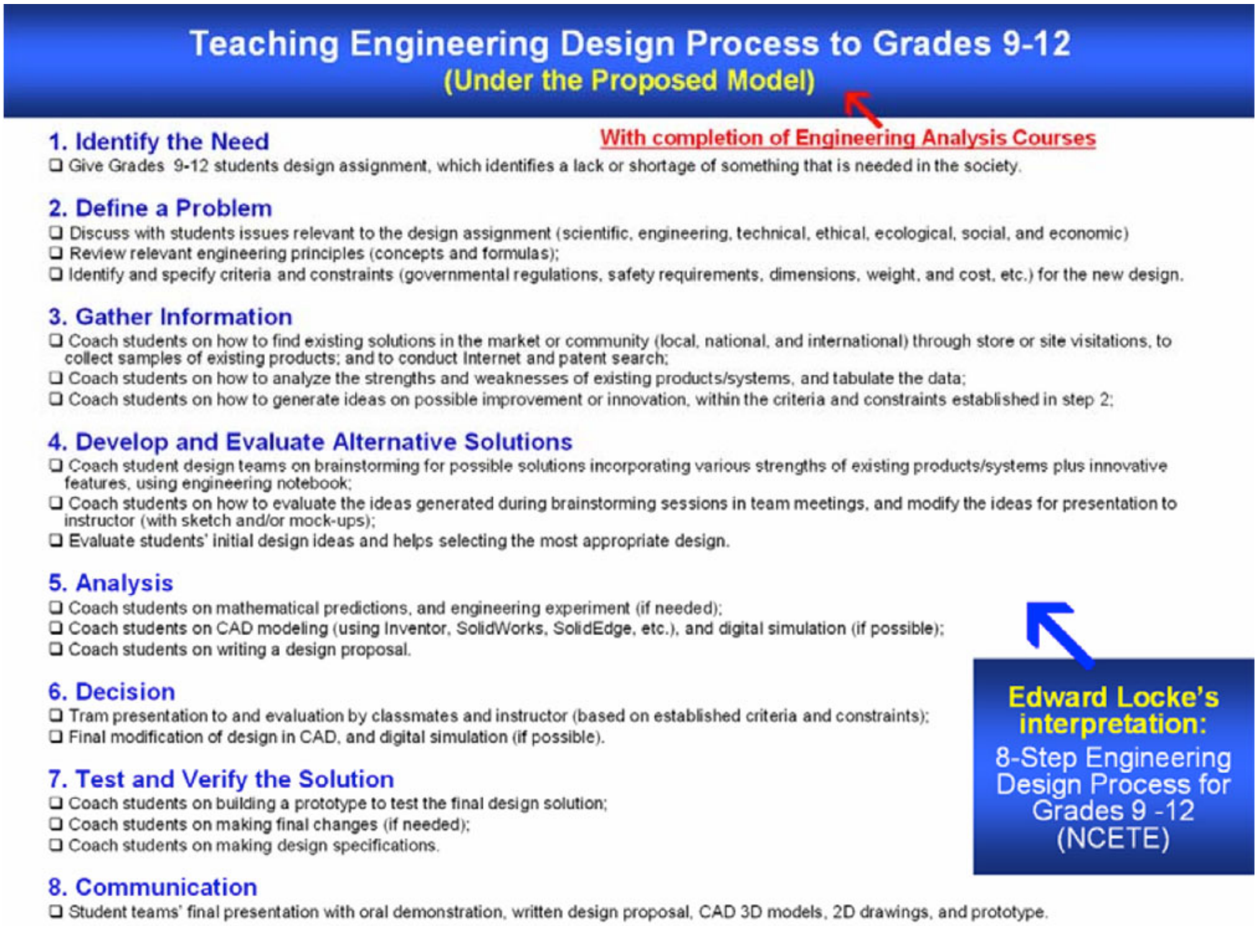
The Specialized Pathways or Majors in the Streamlined STEM Education Process.



Possible STEM Pathway courses for specialized magnet high schools.



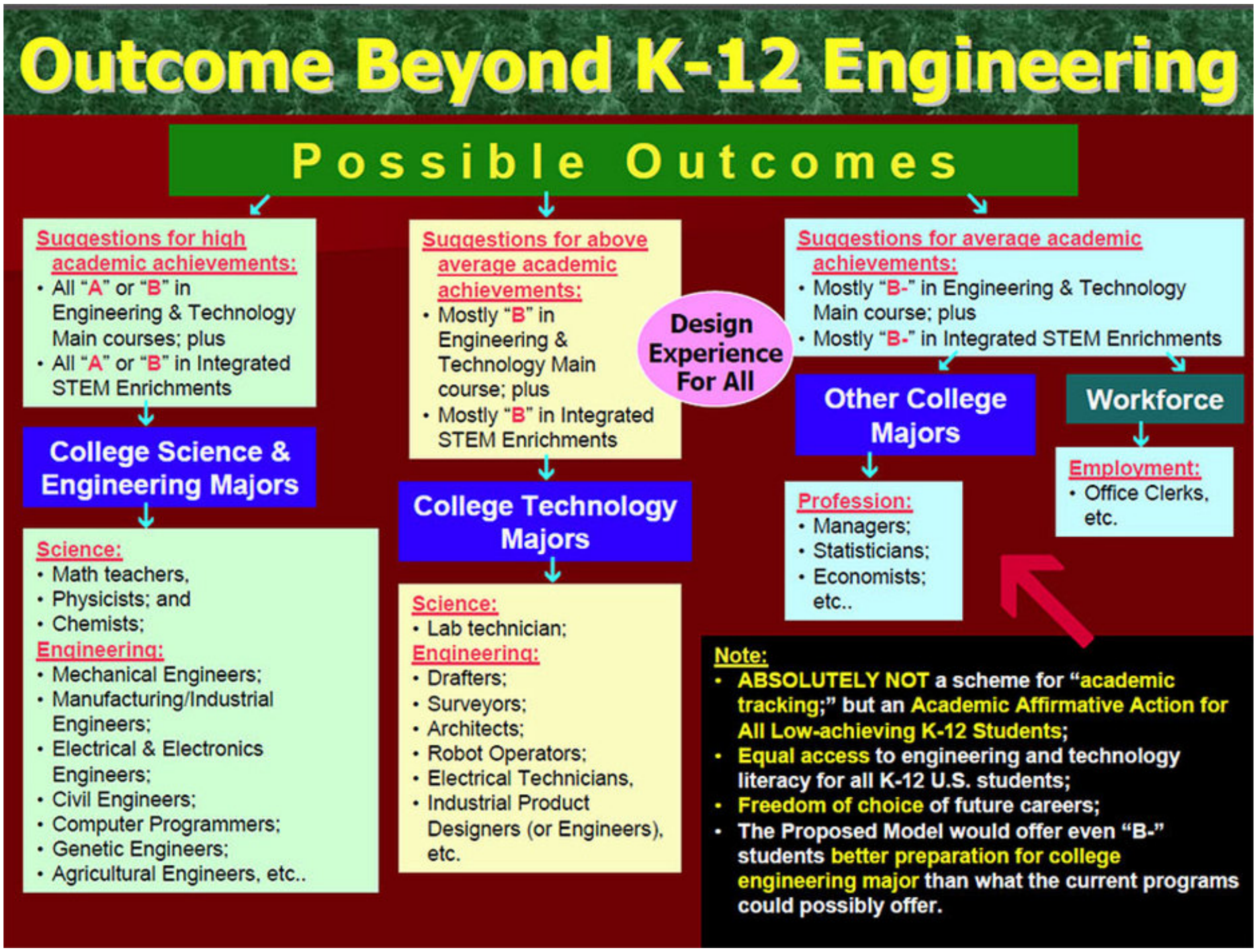
Roadmap for an Integrated Engineering and Technology Curriculum (K-12 to College) for the Mechanical Engineering Career Pathway, with a streamlined flow of infusion of knowledge content and mastery of design process.



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
❑ Defining a Problem →	❑ **Defining a Problem and/or Identify the Need for a Solution**	← ❑ Identify the Need
❑ Brainstorming →	❑ **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	← ❑ Define Problem
❑ Researching and Generating Ideas →	❑ **Generating Ideas** Through 3-4-5 Brainstorming Sessions for Better Solutions Incorporating Various Strengths of Existing Products/Systems Plus Innovative Features	← ❑ Search for Solutions
❑ Identifying Criteria →	❑ **Identifying and Specifying Criteria and Constraints for New Design**	← ❑ Identify Constraints
❑ Specifying Constraints →		← ❑ Specify Evaluation Criteria
❑ Exploring Possibilities →	❑ **Comparing and Evaluating Solution Ideas** from Brainstorming Sessions Against the Established Criteria and Constraints	← ❑ Generate Alternative Solutions
❑ Selecting an Approach and Develop a Design Proposal →	❑ **Initial Decision-Making:** Selecting the Most Suitable Approach to Solution and Developing a Design Proposal Based on Analysis of Engineering Design Factors	← ❑ Engineering Analysis
❑ Building a Model or Prototype → ❑ Testing and Evaluating the Design → ❑ Refining the Design →	❑ **Mathematical Predictions and Digital Simulation If Possible** ❑ **Final Decision Making and Design Specifications** ❑ **Building a Model or Prototype** ❑ **Testing and Evaluating the Design** ❑ **Refining the Design**	← ❑ Mathematical Predictions ← ❑ Decision Making ← ❑ Design Specifications
❑ Communicating Results →	❑ **Communicating Results** with CAD 3D Models and 2D Drawings	← ❑ Communication

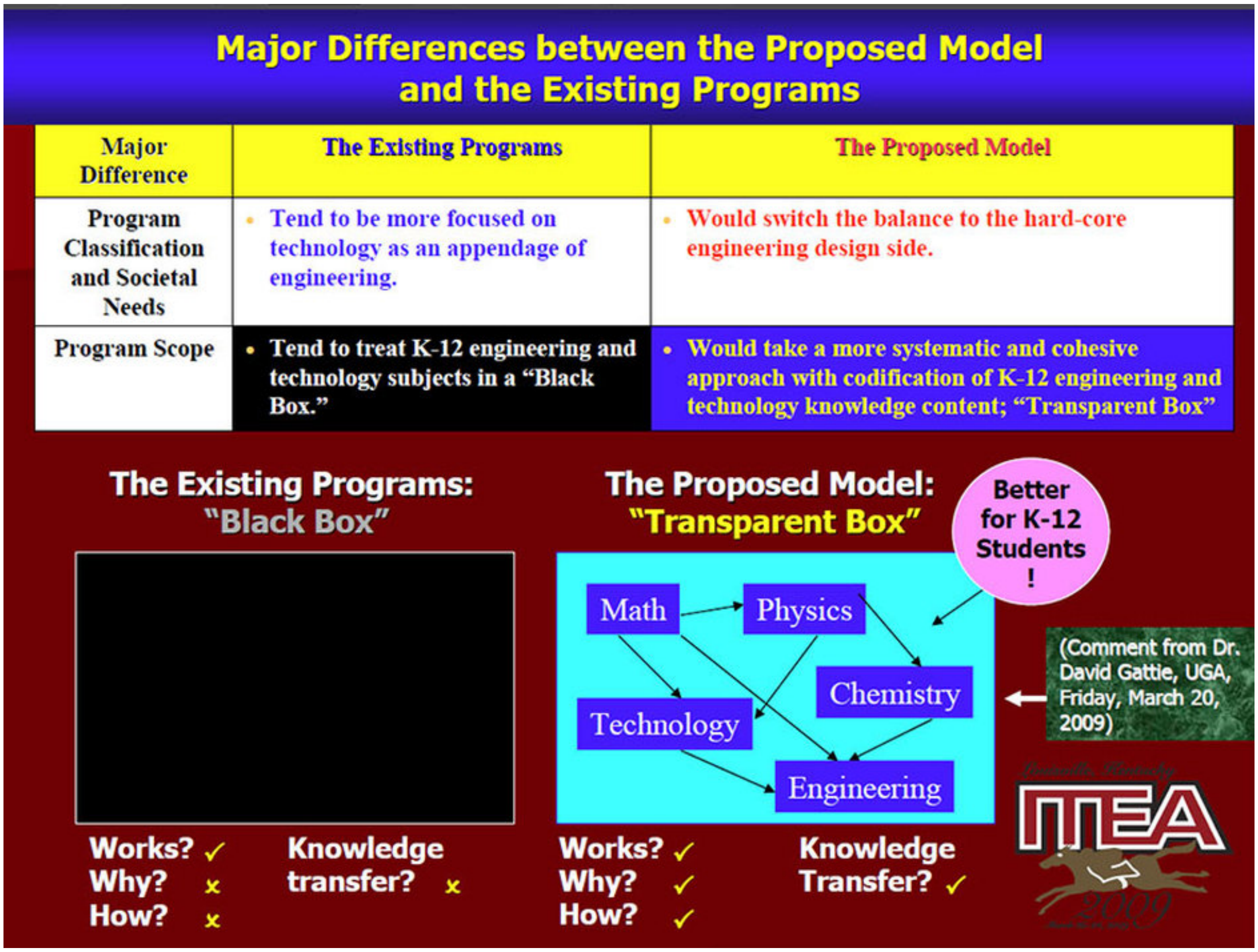
Combining the current Technology Education Design Process (left) and Engineering Design Process(right) into a futuristic but realistic Engineering and Technology Design Process.



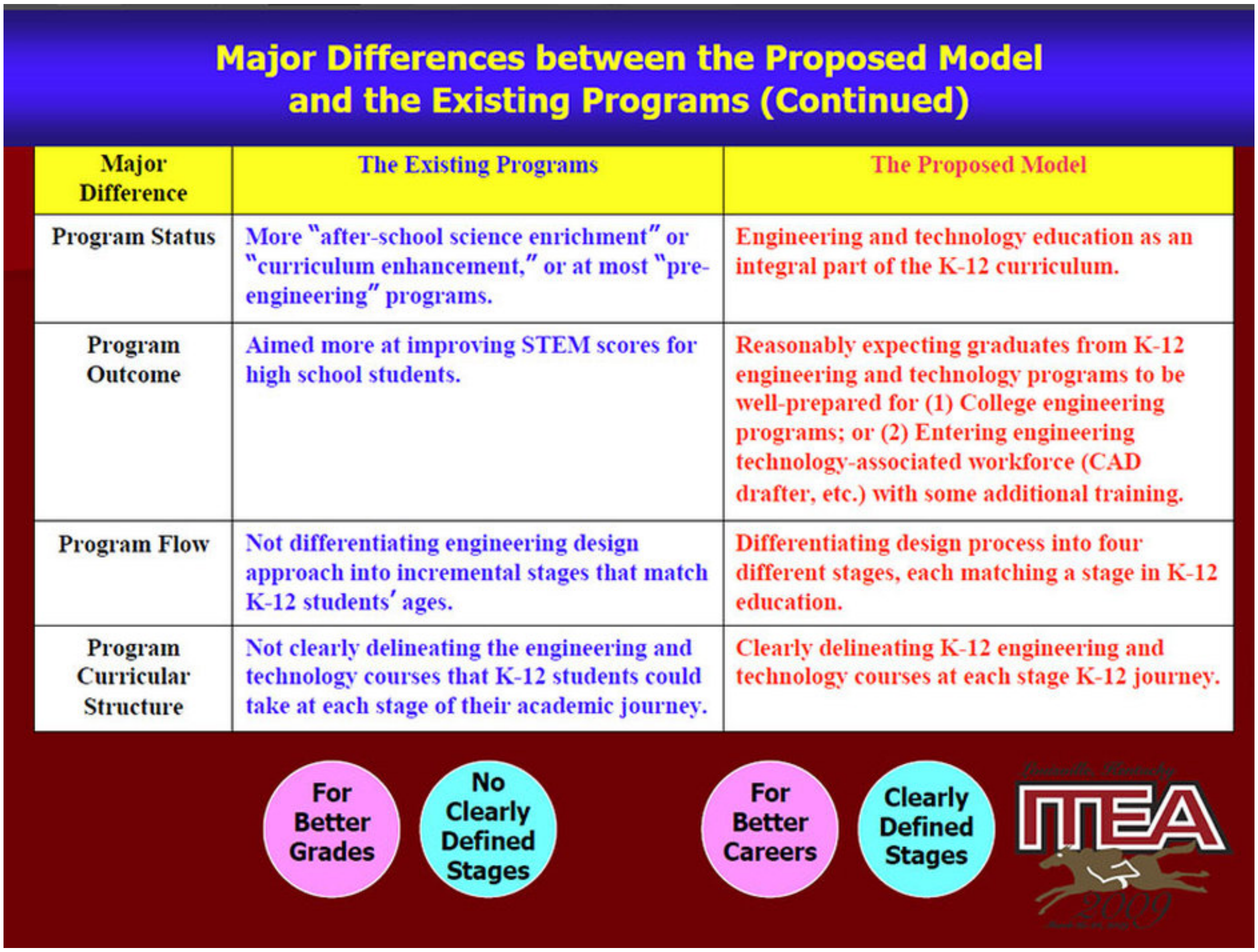
Possible career outcomes for high school graduates from the futuristic K-12 Engineering and Technology curriculum under the Proposed Model explored in my Vision Paper.

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.



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 theProposed 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.

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 "inter-disciplinary" 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:

Weaver, W. (1948). Science and complexity. *American Scientist*, 36: 536 (1948).

Wicklein, R. C. (2006). Five reasons for engineering design as the focus for technology education. *Technology Teacher*, 65(7), 25–29.

Wicklein, R. C. (2008). *Design criteria for sustainable development in appropriate technology: Technology as if people matter*. Retrieved January 18, 2009, from https://webct.uga.edu/SCRIPT/nceterw/scripts/serve_home

Wicklein, R. C., & Thompson, S. A. (2008). *Chapter 4: The unique aspects of engineering design*. Retrieved January 18, 2009, from https://webct.uga.edu/SCRIPT/nceterw/scripts/serve_home

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Freedom and opportunities! You will have the right to a high quality K12 science, technology, engineering, arts and mathematics (STEAM) education!
¡Libertad y oportunitades! ¡Usted va a tener el derecho a una K12 educación de alta calidad en ciencia, tecnología, ingenería, artes y matematica (CTIAM)!
自由和机会！你们将拥有接受高质量的、贯穿幼儿园到中小学阶段的科学、技术、工程、艺术和数学教育的权利！