WELCOME TO THE

ENGINEERING FOR ALL

WORKSHOP

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The century ahead poses challenges as formidable as any from millennia past. Engineering can and should be seen as a route toward attaining prosperity, sustainability, and social equality.

Advance health informatics

Restore and improve urban infrastructure

Make solar energy economical

Provide access to clean water

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ENGINEERING FOR ALL

AGENDA

- Is TechEd up to the challenge?
- Conceptualizing an *Engineering for All* program
- Establishing Curriculum Criteria for Engineering and Technology
- Moving beyond Standards: Overarching Curricular Themes
- Instructional Contexts for Engineering and Technology Education
- A pedagogically enriched approach to design: *Informed Design*
- Implications of new mathematics Common Core Standards
- Example of an Engineering for All Activity
- Group brainstorming
- Small group work: redesign of an existing activity
- Debriefing

What About *Engineering and Technology Education?*

- **Continues technology education's mission: general education, integrative, design-based**
- **Provides a new vision for teachers**
- **Understood by the public**
- **Will have broad public and professional support**
- **Will bring status as a discipline that supports academic learning**
- **Will more easily become a core discipline**

Can we do it?

What does ABET require of engineers?

- **Develop an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.**
- **Identify, formulate, and solve engineering problems.**
- **Design and conduct experiments, and analyze and interpret data.**
- **Design a system, component, or process to meet desired needs.**
- **Function on multidisciplinary teams.**
- **Understand professional and ethical responsibility**
- **Communicate effectively**

ABET requirements, continued….

- **Understand the impact of engineering solutions in a global and societal context.**
- **Develop a knowledge of contemporary issues**
- **Recognize the need for, and develop an ability to engage in lifelong learning.**
- **Engage in an engineering design experience that builds on fundamental concepts of mathematics, basic sciences, the humanities and social sciences, engineering topics, and communication skills. It is essential to include realistic constraints, such as economic factors, safety, reliability, aesthetics, ethics, and social impacts.**

Conceptualizing Engineering and Technology Education for All

The century ahead poses challenges as formidable as any from millennia past [1].

In addition to the workforce and economic imperatives, engineering can and should be appreciated as a *contributor to sustainable development and transformative improvement in quality of life*.

NAE's Grand Challenges engendering a vision of engineering as "seeking solutions to broad realms of human concern—sustainability, health, vulnerability, and joy of living. The UN *Millennium Development Goals* inspire curricula that prompt learners to seek solutions to human needs—access to potable water, sanitation and waste disposal, energy, sustainable transport, and regulated food production.

Many students wish to use their education to influence the future, and school-based engineering meets the needs of "millennial students who are civic-minded, team-oriented, and want to make a difference." [2]

1. National Academy of Engineering. (2008). *Grand Challenges for Engineering.* www.engineeringchallenges.org
2. Gleason, Paula. Meeting the needs of millennial students. *In Touch Newsletter*, Volume 16, Number 1. Student Services, CSULB. Winter 2008.

Uniqueness of Engineering for All

A preK-12 *engineering for all* approach stands in stark contrast to school-based engineering initiatives whose main focus is on career preparation. In addition to the workforce imperative, an *Engineering for All* program should:

- Portray engineering as a means through which we can achieve prosperity, sustainability, and social equality
- Develop learning experiences related to personal and global concerns, sustainability, and societal issues
- Provide an effective way to reinforce mathematics, science, social science, and language skills
- Mobilize engineering thinking as a way to engage young people in addressing design challenges in social contexts that are personally meaningful to them.

Curriculum Design Criteria

Three types of curriculum design criteria are suggested:

Curriculum design criteria should maximize appeal of materials to all students, including females, who tend to be drawn to topics and contexts related to people's needs and concerns, interpersonal relationships, environmental issues, and real-life settings.

Table 2. Curriculum Design Criteria

1. Learner-Centered Criteria

- Avoid gender bias/eliminate narrow stereotypes.
- Ensure personal relevance
- Place emphasis on personal mastery, creativity, and building self-esteem

2. STEM-Related Criteria

- Use design-based activities to promote inquiry about real-world problems
- Use ETE conceptual themes in real-life contexts
- Use the "informed design" approach to integrate key STEM knowledge and skills

3. Pedagogical Criteria

- Ensure that enduring understandings and desired results guide the design of activities.
- Engage students in collaborative projects
- Promote interpersonal relationships that build leadership skills.

Publication of STL was a leap forward in identifying knowledge needed for life in a technological world.

- **However, hundreds of benchmarks have been written in national and state STEM frameworks, and standards have been criticized as vague, repetitive, and poorly coordinated [3].**
- **Donovan and Bransford concluded that factual knowledge must be placed in a conceptual framework to be well understood [4].**
- **To facilitate learning transfer, students should encounter the same concept in a variety of contexts ; and schemata (or knowledge structures) are needed for them to transfer learning to new situations and develop conceptual understanding [5].**

3. National Research Council. (2008). *Common Standards for K-12 Education? Considering the Evidence.* A Workshop Series. Alexandra Beatty, Rapporteur. Center for Education, Division of Behavioral and Social Science and Education. Washington, DC: National Academies Press.
4. Donovan, M. S., and Bransford, J. D. (2005). Introduction. In M. S. Donovan and J. D. Bransford (Eds.). *How students learn: History, mathematics, and science in the classroom* (pp. 1–28). Washington, DC: National Academies Press.
5. Bransford, J. D., Brown, A. L., and Cocking, R. R. (Eds.). (2000). *How People Learn: Brain, Mind, Experience, and School*. Washington, DC: National Academies Press.

THEMES AND CONTEXTS

We suggest:

A major departure from other curriculum projects - in that *EfA* curriculum, instruction and assessment should be underpinned by a set of overarching common themes (big ideas) that are fundamental to all engineered systems.

These themes should be revisited in various social contexts that are personally meaningful to young people and will provide them with a holistic understanding of engineering and technology.

International Study Results (2009)

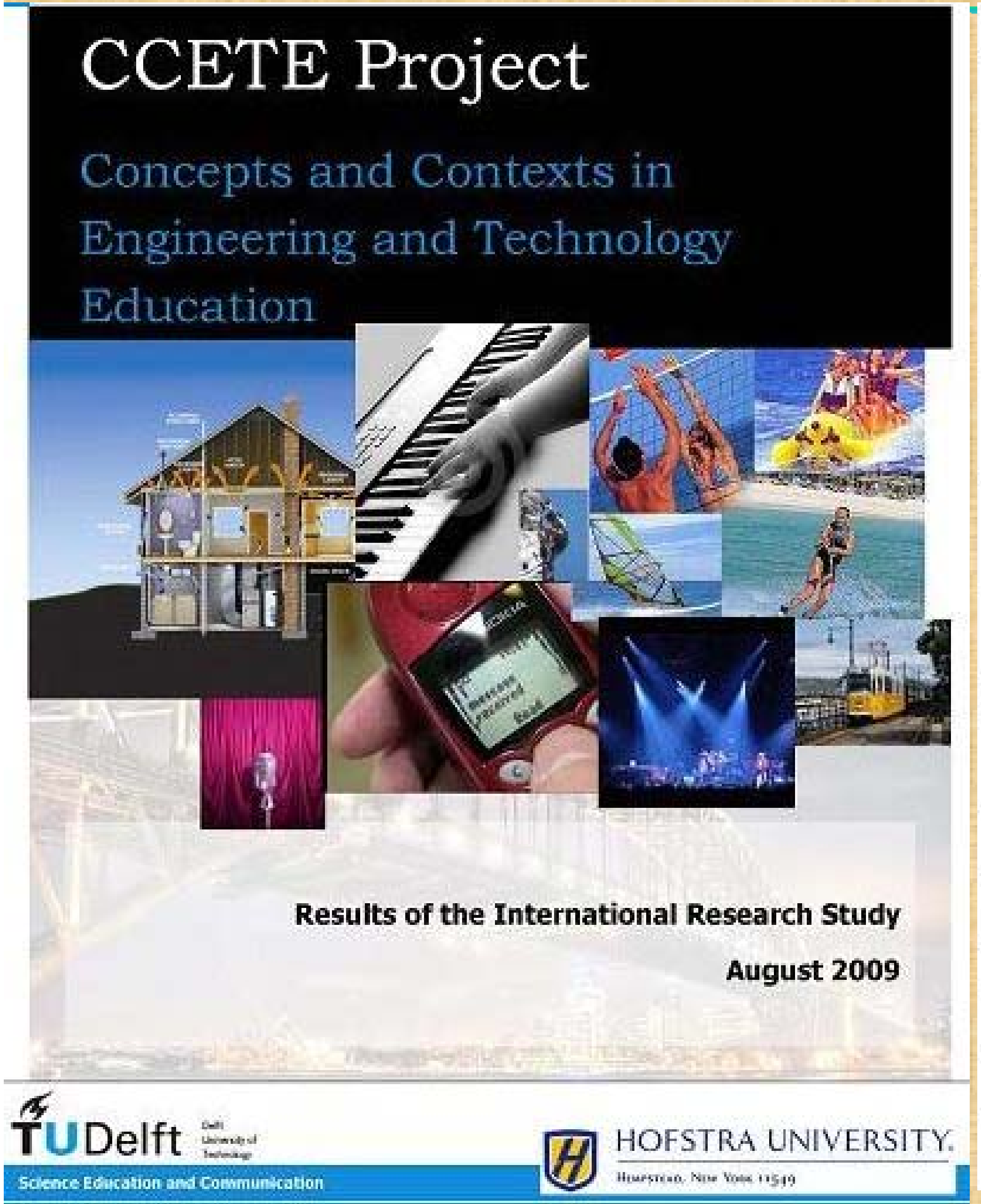

Table 1. Themes and Subconcepts

Themes	*Subconcepts*
Design	Optimization and Tradeoffs; Specifications/Constraints; Technology Assessment
Modeling	Representational, Analytical, Predictive
Systems	Function and Structure; Feedback and Control
Resources	Materials, Energy, Information
Human Values	Sustainability; Creativity and Innovation; Social Equality

Table 2. Contexts Based on Personal and Global Concerns

Food
Energy
Health and Safety/Security
Mobility
Shelter
Water

CONCEPTUAL THEMES AND CONTEXTS MATRIX

Table 3. EfA Themes and Contexts Matrix

Conceptual Themes →	Design				Modeling				Systems				Resources				Human Values			
	K-2	3-5	6-8	9-12	K-2	3-5	6-8	9-12	K-2	3-5	6-8	9-12	K-2	3-5	6-8	9-12	K-2	3-5	6-8	9-12
Contexts																				
Food																				
Energy																				
Health/Safety																				
Mobility/Transport																				
Shelter																				
Water																				
DESIGN TASKS AND ASSESSMENTS WILL BE DEVELOPED FOR EACH MIDDLE SCHOOL MODULE																				

In each cell, STL, AAAS, NRC and NAEP grade level benchmarks/ standards will illuminate the themes in context.

EXAMPLE: Relating Conceptual Themes, Contexts, and Standards

This is a Grades 6-8 Example

CONCEPTUAL THEMES → / CONTEXTS ↓	Design	Modeling	Systems	Human Values	Resources
	NRC. ET2.C. P. 7.60 Optimizing a solution involves making tradeoffs (i.e., decision to include more of one quality at the expense of another) in order to arrive at the best possible design with respect to a weighting of the various criteria. A solution that only optimizes one of the criteria is seldom the best all-around solution, although it may be the best in a certain situation or test.		NAEP D.8.11: Technological systems are designed to achieve goals. They incorporate various processes that transform inputs into outputs. These processes may include feedback and control. STL 2.O. An open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback. NRC. ET3.A. P. 7-61 Most systems can be broken down into subsystems and also are part of larger systems (e.g., cars have subsystems (engine, drive train, etc.) and they are also part of the larger transportation system). The output from one technological system or subsystem (material, energy, or information) can become the input to other systems or subsystems.		
Energy NRC PS Core Idea 3: Energy cannot be made or destroyed. STL 16.E. Energy is the capacity to do work.	NAEP p. 2-20. Eighth graders should know that energy is generally needed to solve problems and meet design challenges.		NAEP, D.8.11. All technological systems use energy in some form. STL 16.H. Power systems are used to drive and provide propulsion to other technological products and systems.		
Water	NAEP p. 2-20.In the drive to satisfy human needs and wants, people have developed and improved ways to provide safe water.		NAEP T.8.6: Resources such as oceans and fresh water, which are essential for life and shared by everyone, are protected by regulating technologies in such areas as transportation, energy, and waste disposal.		
Food	NAEP p. 2-20. In the drive to satisfy human needs and wants, people have developed and improved ways to provide nutritious and safe food. NAEP 2-10. At the eighth grade, students could study the trade-offs involved in using paper or plastic to carry groceries.		NAEP Table 3.3 p. 3.13 How do the physical and human components of the school cafeteria food service system work together? NRC LS3.B. p. 7-16. Chemical energy is transferred from one organism in an ecosystem to another as the organisms interact with each other for food.		
Shelter	STL 20 F. Designs for structures is based on factors such as style, codes, convenience, cost, climate & function.		STL 20.I. Buildings generally contain a variety of subsystems.		

The main function of the standards is to illuminate the themes in context.

Continuity and Progression

As students continue their study through the grades, contexts and themes become more complex, more abstract, more analytical, and more focused on global (as opposed to personal) concerns.

Easily Intelligible Themes/Contexts	More Complex Themes/Contexts
• Personal	• Global
• Informal	• Formal
• Intuitive	• Abstract
• Descriptive	• Analytical
• Here and Now	• Future-oriented

K → 12

A Pedagogically Enriched Approach to Design

Informed Design

- ***Informed Design* is a pedagogical approach to design developed and validated through several NSF-Projects.**
- ***Students reach design solutions informed by prior knowledge*, as opposed to engaging in trial-and-error problem solving.**
- ***Students enhance their knowledge and skill base* by engaging in Knowledge and Skill Builders (*KSBs*) that provide STEM knowledge for designing (just-in-time learning). For example, math is taught in context.**

NEXT

Let's look at the mathematics.

…. Then let's deconstruct an example. (Emergency Shelter Design)

Then let's work together to identify your preferred curriculum criteria.

Then let's outline a sample ETE activity.

What about the mathematics?

- What mathematics do students require at various grade levels?
- Of the standards-based mathematics, what content can be contextualized?
- Do our teachers understand that mathematics?
- What pedagogy should be used to teach the mathematics?

Thanks for your kind attention

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