

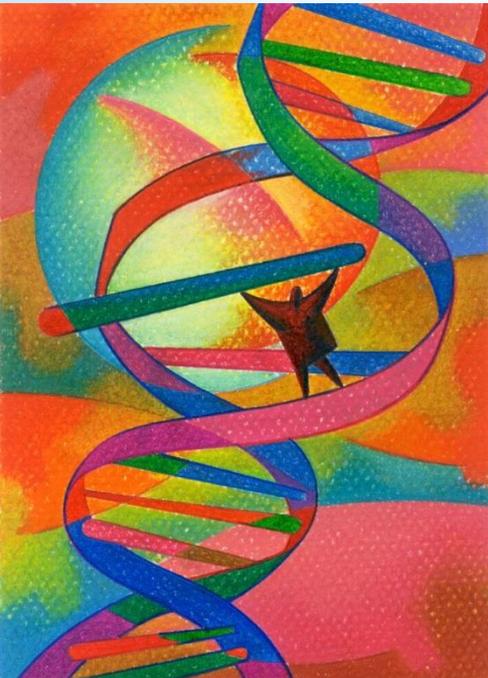
ENGINEERING A BETTER WORLD

Ann Kaiser

La Salle Academy

Providence RI

akaiser@lasalle-academy.org



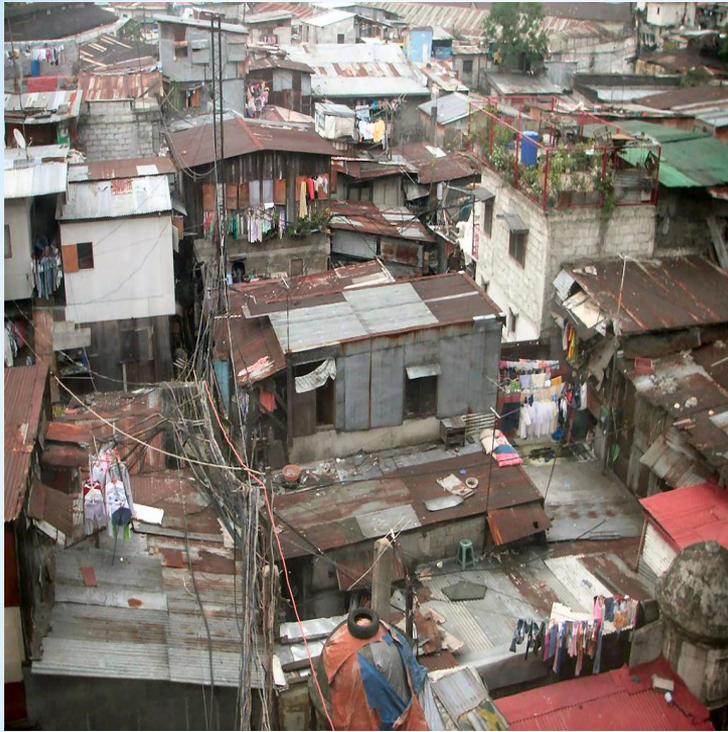


The students of today can engineer a better world for the future





**But are they
ready for all
the problems
ahead?**



In 2008, for the first time in human history, more people lived in cities than in rural areas. One-third of these urban dwellers—more than one billion people—resided in slums. That number is expected to rise substantially: the United Nations forecasts that the number of slum dwellers will double to two billion people within the next 25 years. In addition, 45 million people are currently *displaced*. (refugees)



is a future based on
capitalistic lifestyles, consumption
carbon, world-wide inequality, war
plastic, petrol, dollars, buiseness, hard work
the only possible future?

© 2010 HITBOSS



Did you know?

262 million people were affected by climate disasters in 2004, more than 98 per cent of them in developing countries



Engineering and Science

Scientists discover the world that exists;
engineers create the world that never was."

Theodore von Kármán

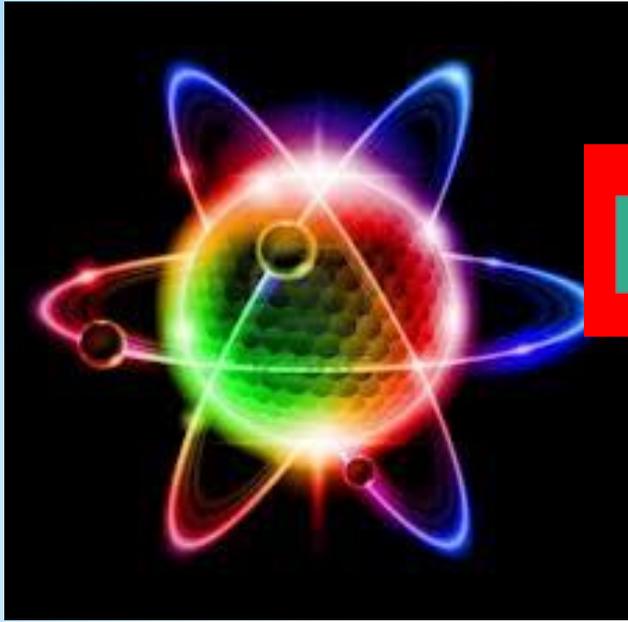
- **Science** provides a model of the natural world; **science** is simply about describing what is or what isn't.
- The modern world is highly **engineered** and much of our personal experience with **science** comes from our interactions with products, processes and systems that **engineers** have created.
- In developing solutions to problems by applying **science**, **engineers** face the questions of "What to do?" and "Should we do it?" on a regular basis. They face wide-ranging ethical issues and choices.

Science vs. Engineering

It is the job of the engineer to determine what people need or want and figure out the best way to provide it. Engineers put knowledge into practice.

Modern humans interact with two worlds at once. The first is the natural world—the components exist independently of human intervention. The second is the human-made world—all the things people have created for themselves in order to change and improve their lives.

Without engineers, this human-made world, for better or worse, could not exist.

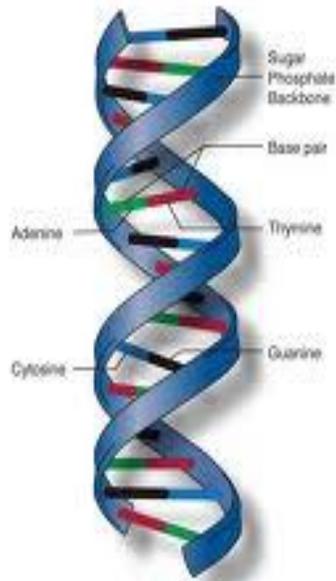


$$E=mc^2$$



"I made one great mistake in my life... when I signed the letter to President Roosevelt recommending that atom bombs be made; but there was some justification - the danger that the Germans would make them."

Albert Einstein



NO WARNING LABELS ON U.S. GM FOODS



The Pugwash Conference

How do we use our scientific knowledge?

“There lies before us, if we choose, continual progress in happiness, knowledge, and wisdom. Shall we, instead, choose death, because we cannot forget our quarrels? We appeal as human beings to human beings: **Remember your humanity, and forget the rest.** If you can do so, the way lies open to a new Paradise; if you cannot, there lies before you the risk of universal death.”

Russell-Einstein Manifesto

Using Engineering to Provide a LaSallian Context for Science

- Provides a way to keep science impartial; a pursuit to discover the natural world without judgment.
- Addresses the incorporation of engineering design principles and practices as referenced in the NGSS.
- Moves science out of the textbook and into the real world.
- Empowers young people with a vision for improving their world.
- Provides a vehicle for active, problem and project-based learning.
- Engineering “habits of mind” are 21st century skills!

Why Re-Engineer Science?

“Engineering is not just a collection of information. It is the ability to be observant, to identify problems, to be creative, to think about solutions and to have the skills to realize solutions.”

“Engineering is practice. It’s designing things that can improve our quality of life, things that can solve some of our problems.”

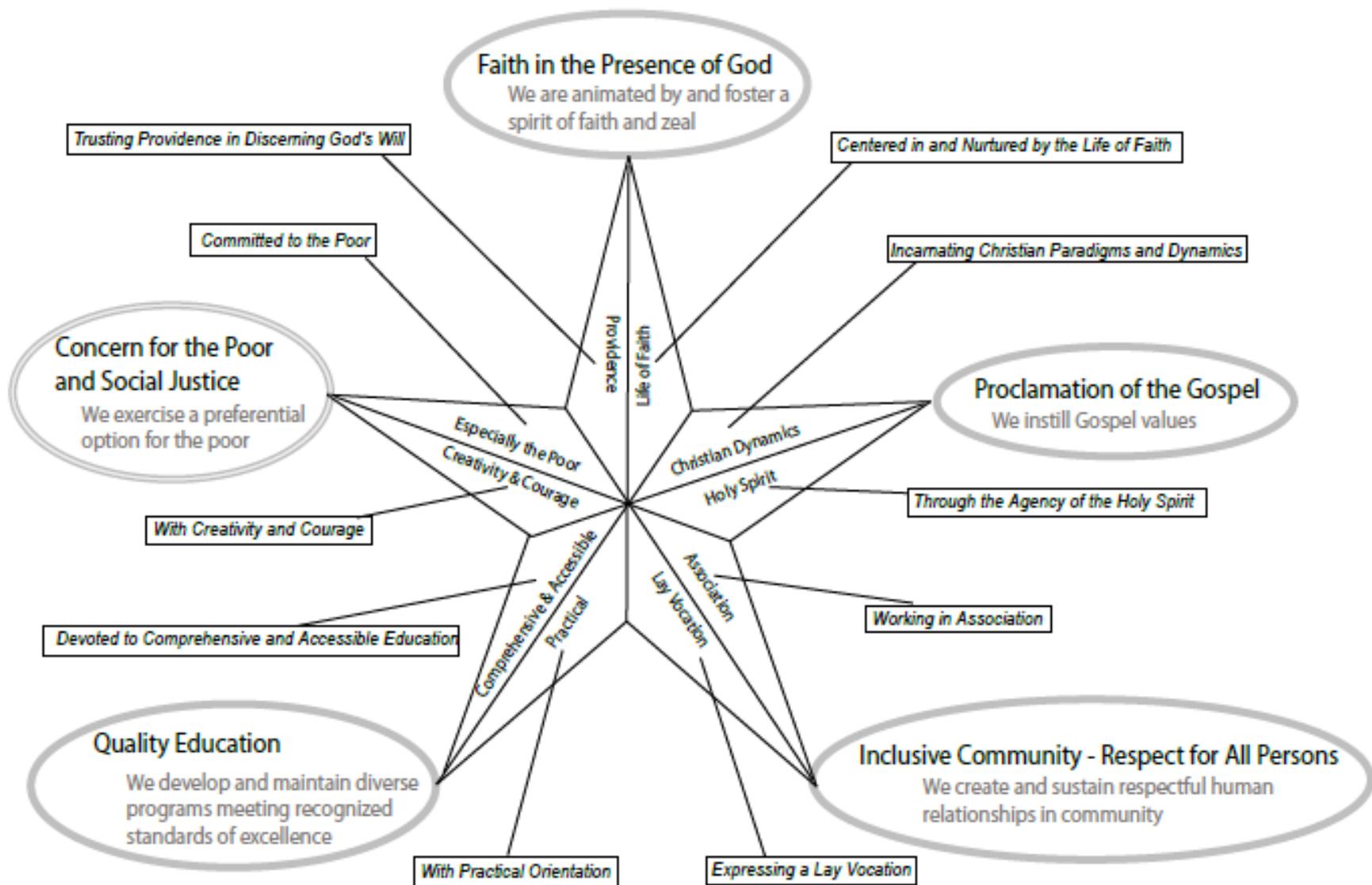
Linda Katehi

Chancellor, UC – Davis

“Educating Engineers”

NAE Forum 2013

Lasallian Core Principles



- The 21st century skills of creativity, critical thinking, communication and collaboration are paramount in the engineering design process.
- Engineering for the benefit of society calls for a sense of stewardship and the ability to make ethical decisions.
- By implementing engineering design projects and case studies in science classes, LaSallian educators can provide rich opportunities for students to develop 21st century life skills compatible with the LaSallian vision.
- Projects and case studies involving appropriate, ethical choices to deal with issues of sustainability, humanitarianism and cultural compatibility will focus students on the important question – “Just because we can do it, does mean we should do it?”
- Making students aware of and empowering them to believe that they can improve the world we live in is at the heart of what we do.
- Whether they become “engineers” or “citizens” of the future, they need to understand the world they will live in.

NAE Grand Challenges

Through the engineering accomplishments of the past, the world has become smaller, more inclusive, and more connected. The challenges facing engineering today are not those of isolated locales, but of the planet as a whole and all the planet's people. Meeting all those challenges must make the world not only a more technologically advanced and connected place, but also a more sustainable, safe, healthy, and joyous — in other words, better — place.

GRAND CHALLENGES

- Make **solar energy** affordable
- Provide energy from **fusion**
- Develop **carbon sequestration** methods
- Manage the **nitrogen cycle**
- Provide access to **clean water**
- Restore and improve **urban infrastructure**
- Advance health informatics
- **Engineer** better **medicines**
- Reverse-engineer the **brain**
- Prevent **nuclear terror**
- Secure cyberspace
- Enhance virtual reality
- Advance personalized learning
- **Engineer the tools for scientific discovery**

A NEW WORLD

- Our students already live in a world facing unprecedented problems.
- While we cannot not predict the future, its' promise will not be realized if we can't move beyond the problems of today.
- The 21st century is here. We cannot continue to teach the way we were taught – global crisis and issues are proof that it is not enough!

- The World Bank projects that the current world population of approx. 7.2 billion is growing at a rate of 1.2%. 95 percent of the growth is in developing or underdeveloped countries.
- This growth will create unprecedented demands for energy, food, land, water, transportation, materials, waste disposal, earth moving, health care, environmental cleanup, telecommunication, and infrastructure.
- The role of engineers will be critical in fulfilling those demands in various environments, ranging from remote small communities to large urban areas (megacities), mostly in the developing world.

**TRYING TO TEACH STUDENTS EVERYTHING THEY
NEED TO KNOW IS A FUTILE ENDEAVOR; TEACHING
THEM HOW TO SOLVE PROBLEMS IS A MORAL
IMPREATIVE!!**

We Need More Active Science Curriculum

- Students often have little recall of any learning that involved rote memorization or problem solving.
- Many students complain that science has not been any “fun” since elementary school. Many traditional science classes do not encourage exploration and creativity.
- Students are often intimidated by open ended activities – life’s problems do not come with instructions !!
- Most students cannot speak the language of math or science and see little need for it beyond class. Technological literacy requires a vocabulary !!

Eight Practices of Science and Engineering from the NGSS

1. Asking questions (science) and defining problems (engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

DO YOU EDUCATE TO INNOVATE? WHO IS RESPONSIBLE FOR ENABLING FUTURE SOLUTIONS?

- **Can your students use what they have learned to develop solutions?**
- **Do students see connections or are they continually dealing with “new” information?**
- **Are they big picture, systems thinkers?**
- **Are they willing to fail?**
- **Do they learn from their “mistakes”?**

Ways to Re-Engineer Science LaSallian Style

- Engineering Design Projects focused on appropriate and/or assistive technology, sustainability, and the impacts of technology
- Case Studies to enable discussion of ethical considerations

THE ENGINEERING DESIGN PROCESS

- Design is the approach engineers use to determine the best way to make a device or process that serves a particular purpose.
- Not a linear, step-by-step process. It is iterative; each new version of the design is tested and modified based on what has been learned up to that point.
- Finally, there is never just one “correct” solution to a design challenge. Instead, there are a number of possible solutions, and choosing among them inevitably involves a holistic approach

SCIENCE

- Ask a Question
- Do Background Research
- Construct a Hypothesis
- Test Your Hypothesis by Doing an Experiment
- Analyze Your Data and Draw a Conclusion
- Communicate Your Results

ENGINEERING

- Define the Problem
- Do Background Research
- Develop Criteria/identify Constraints
- Create Alternative Solutions/Choose the Best Solution
- Model/Build a Prototype
- Test and Redesign
- Communicate

Engineering Design Projects

Focus on Appropriate Technology

Appropriate Technology is

“technology “intermediate” between the
“indigenous technology of developing countries
and developed country or high capital intensive
technology” *Small is Beautiful E.F. Schumacher*

- ✓ small-scale technology
- ✓ simple enough that people can manage it directly
and on a local level
- ✓ makes use of skills and technology that are
available in a local community to supply
basic human needs

Design projects focused on Appropriate Technology encourage ethical decision making, empathy and service to those who are less fortunate.

The constraints and criteria involved in AT involve:

- Using technological choice to build a community's identity
- Assessing how a technology would impact a community's core values
- Modifying existing technology to minimize negative impact on a community's values

Projects Involving Appropriate Technology

Projects involving innovative ways to cook, heat and light.

Approximately 1.5 billion people have no access to electricity at all. 3 billion people rely on traditional biomass and coal for cooking and heating.

Chemistry – cleaner fuel for cooking, innovative use of materials for heating and cooling

Physics – Solar energy, non-grid electrification

Projects Involving Appropriate Technology

The World Water Crisis

- Some 1.1 billion people in developing countries have inadequate access to water
- 2.6 billion people lack basic sanitation
- 1.8 million children die each year as a result of diarrhea
- 443 million school days are lost each year from water-related illness
- Access to piped water into the household averages about 85% for the wealthiest 20% of the population, compared with 25% for the poorest 20%.
- Millions of women spending several hours a day collecting water
- 12 percent of the world's population uses 85 percent of its water, and these 12 percent do not live in the Third World.

Physics

Fluid flow and piping for water transport

Water transportation devices

Chemistry

Water contamination and purification processes

Sanitation issues

Biology

Eutrophication

Water- borne diseases

Housing and Infrastructure Issues

Inadequate and insufficient housing issues are escalating daily.

Unplanned communities and aging infrastructures present unique problems in planning, resource management and cultural issues.

All sciences can be involved in aspects of improving living conditions.

Sustainability Issues

- New material design
- Pollution solutions
- Life Cycle Analysis
- Nuclear power
- Transportation

Fig 1: Structure of the Life Cycle Assessment (LCA)



CASE STUDIES

- Introduce the profession of engineering
- Show what the real world is like; all decisions have consequences
- Help teach basic scientific principles
- Teach problem-solving approaches
- Help students gain experience in communication and argumentation
- Enrich student/faculty relations.

Issues for Case Studies

- Synthetic Biology
- Genetic Engineering
- Nanotechnology
- Biomimetics
- Artificial Intelligence
- Molecular /DNA/Quantum computing

- **Synthetic biology**—the application of engineering principles and designs -builds on advances in molecular and systems biology and seeks to transform biology in the same way that synthesis transformed chemistry and integrated circuit design transformed computing.
- **Synthetic biologists will soon design and build cells.**
- **They will be able to build new biological systems that are not found in the natural world and as such learn more about how biological systems function and enable the examination of new functions.**
- **But it is an ability to modify what we define as “life”.**

- Nanotechnology involves manipulating matter at the atomic level
- Artificial Intelligence deals with modeling and perhaps, altering, human thought processes
- Molecular, DNA and quantum computing all hold the promise of “zero-size” intelligence
- Biomimicry involves copying design from nature and, hopefully, getting it right

“...the century ahead poses challenges as formidable as any from millennia past. As the population grows and its needs and desires expand, the problem of sustaining civilization’s continuing advancement, while still improving the quality of life, looms more immediate. ”

“Applying the rules of reason, the findings of science, the aesthetics of art, and the spark of creative imagination, engineers will continue the tradition of forging a better future.”

“Foremost among the challenges are those that must be met to ensure the future itself.”

**Met theorie alleen
red je het niet**



Literal translation: With Theory Only, You Have Nothing