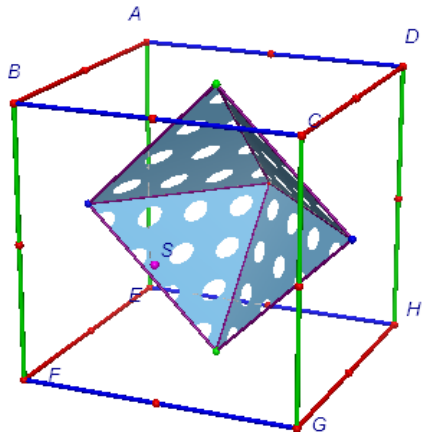


The Future...Engineering and Technology Education



Engineering as the core for
Technology Teacher Education
for the 21st Century

Michael A. De Miranda, Thomas J. Siller and
Todd D. Fantz
Colorado State University

Engineering Education at Colorado State University

- BS degree in Engineering Science with a concentration in engineering education
- Leads to teacher licensure in technology education
- Stress strong STEM background with emphasis in design, application and synthesis
- Balance between technical content and broad liberal education

For program details see:

Siller, T.J., De Miranda, M.A., and Whaley, D.C. (i2007). Engineering Education Partnership. *International Journal of Engineering Education*

<http://mycahs.cahs.colostate.edu/michael.demiranda/engineeringed.htm>

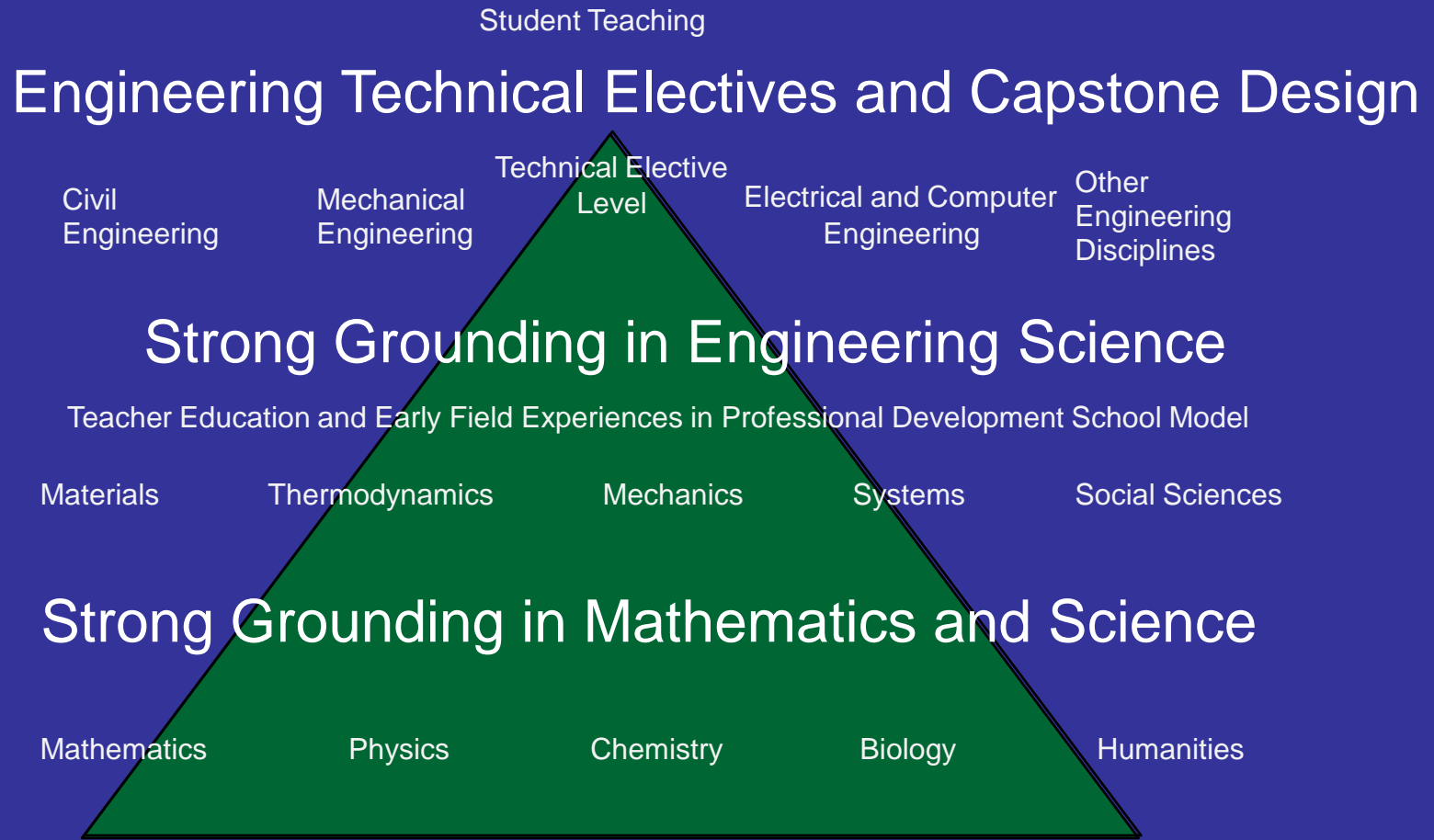
Preparing a new Generation of World Class Teachers in a 21st Century Curriculum



Next Generation Technology Teacher Skill Set

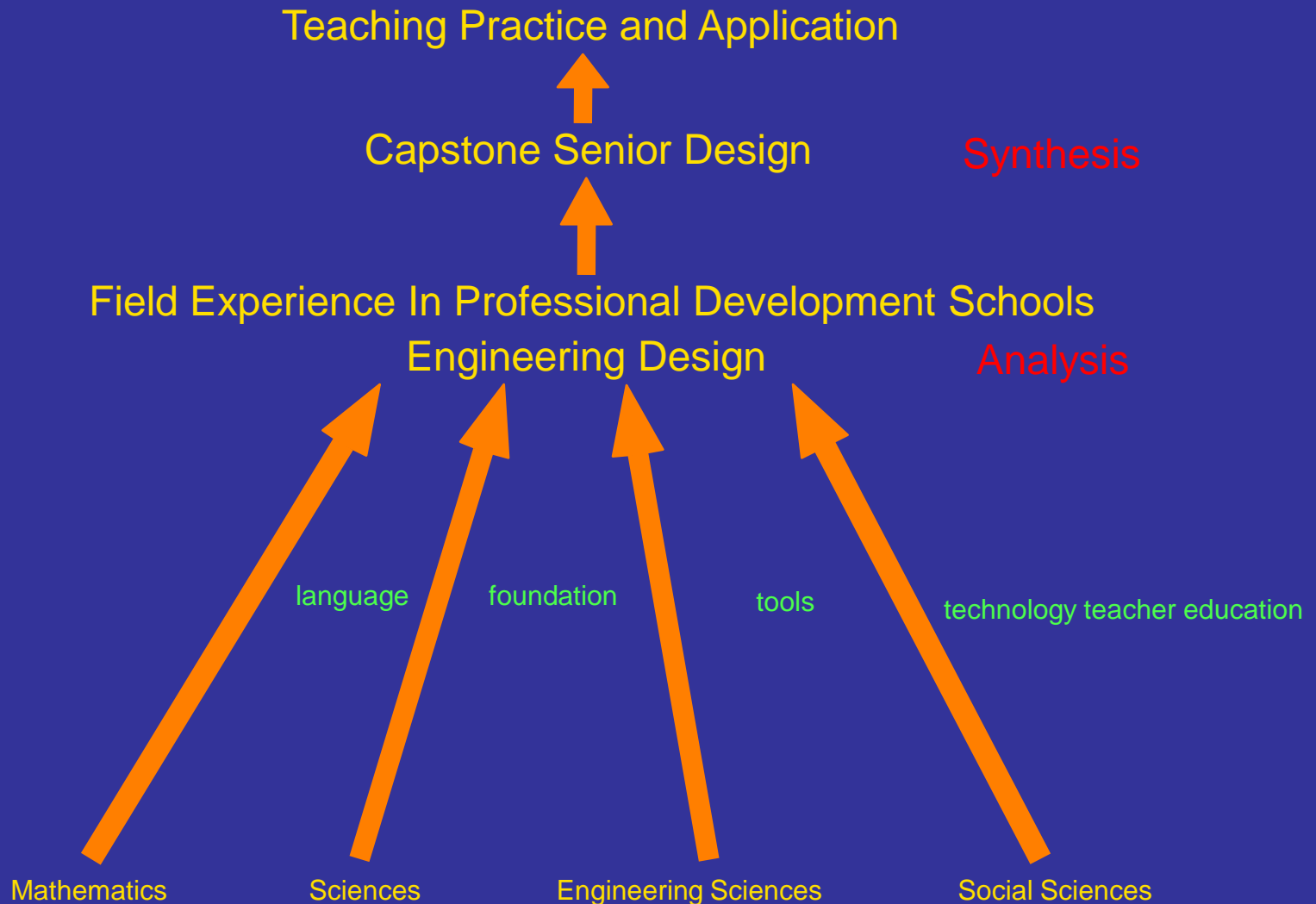
- **Systems integration; synthesis**
- **Engineering science; analysis**
- **Problem formulation as well as problem solving**
- **Engineering design**
- **Ability to realize products**
- **Teaching facility with intelligent technology to enhance creative opportunity**
- **Ability to manage complexity and uncertainty**
- **Teamwork; sensitivity in interpersonal relationships**
- **Realizes strength through diversity in K-12 classrooms**
- **Language and multi-cultural understanding**
- **Ability to advocate and influence**
- **Entrepreneurship; management skills; decision making**
- **Knowledge integration, education and mentoring**

Colorado State University Engineering Education Program Model



The Engineering Science and Technology Teacher Education Pyramid

The Engineering Education Curriculum



Engineering Education “Core” Curriculum

Course Topic	Credits
Composition	3
Calc I and II	8
Speech	3
Statistics	3
Chemistry I	5
Physics I and II	10
Arts and Humanities	3
Social/Behavioral Science	3
Historical Perspectives	3
Global & Cultural Perspectives	3
U.S. Public Values/Institutions	3
Health and Wellness	2



Engineering Education

“Engineering Science Core” Curriculum

Course Title	Credits
Engineering Mechanics	3
Fluid Mechanics	4
Mechanics of Solids	3
Structural Analysis	3
Intro to Electrical Engineering	3
Calc III	4
Differential Equations	4
Into to Engineering Design	3
Mechatronics & Measurement Systems	4
Intro to Engineering Materials	4
Thermodynamics	3

Engineering Education

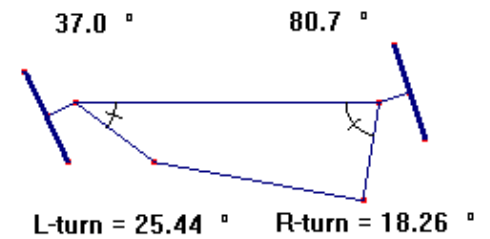
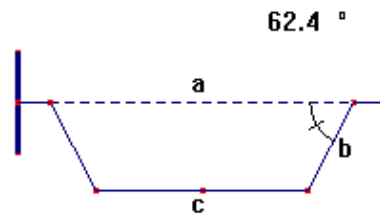
“Technical Elective” Curriculum

Course Title	Credits
Civil Engineering Principles I & II	6
Civil Engineering Design I & II	6
OR	
Intro to Manufacturing Processes	3
Mechanical Engineering Problem Solving	3
Mechanical Engineering Design Practicum I & II	8
OR	
Electrical Engineering Fundamentals	3
Circuit Theory	3
Electrical Engineering Design I & II	6
Technical Electives	1-3

Engineering Education “Professional Education” Curriculum

Course Topics	Credits
Schooling in the U.S.	3
Educational Technology & Assessment	3
Literacy and the Learner	3
PDS Instruction I & II	7
PDS Practicum-Instruction I & II	2
Assessment of Learning	1
Methods/Materials in Technology Education	3
Student Teaching Technology Education –Secondary	11
Seminar –Professional Relations	1

Early Results



Background

- Small investigation
 - **Small number of design problems (6)**
 - **Small number of reviewers (4)**
 - **Results should be examined cautiously**
- Research question: How do traditionally-trained technology teachers differ from engineering-trained technology teachers in utilization of the design process?

Design Processes

Engineering Design Process (Eide, Jenison, Mashaw, & Northup, 1997)

- 1. Identify the need
- 2. Define the problem
- 3. Search for solutions
- 4. Identify constraints
- 5. Specify evaluation criteria
- 6. Generate alternate solutions
- 7. Engineering analysis
(applications of math and science)
- 8. Optimization
- 9. Decision
- 10. Design specifications
- 11. Communication

Technology Education Design Process (Standards for Technological Literacy, 2000)

- 1. Defining the problem
- 2. Brainstorming
- 3. Researching and generating ideas
- 4. Identifying criteria
- 5. Specifying constraints
- 6. Exploring possibilities
- 7. Select an approach
- 8. Develop a design proposal
- 9. Building a prototype or model
- 10. Testing and evaluating the design
- 11. Refining the design
- 12. Make it – create it
- 13. Communicating results

Similarities and Differences in Design Processes

Similarities

- Identify need and who will benefit
- Search for solutions from various sources
- Identify restrictions on design

Differences

- Technology design process is quick to select an approach
- Engineering design uses analysis to determine optimal solution from many possibilities
- End goals:
 - **engineering: specifying optimal design**
 - **Technology: hands-on building of design**

Method

- Determined steps and definitions of the Engineering Design Process
- Created a 4-level scoring rubric for each step in the design process
- Solicited design problems of traditionally-trained technology teachers from around the country to compare to CSU design problems
- Design problems reviewed by professors and teachers familiar with design processes
- Analyzed with SPSS version 16 software

Rubric

	3	2	1	0	SCORE
Identify the need	Objectives are clearly identified. Acknowledged who will benefit and how.	Some objectives are listed. Acknowledged who will benefit and how.	Only one objective is listed or beneficiary is not identified.	No need is identified	
Define the problem	Broad definition of the problem with multiple solutions possible. Objectives are clearly defined. User requirements are established. Functions are established.	Somewhat defined problem with a couple of possible solutions. Objectives are listed.	Highly defined definition of the problem with only one possible solution. Objectives are vague.	No definition of the problem is given. No objectives are stated.	
Search for solutions	Many different pathways are researched. Less efficient paths are eliminated. Use of past problems or experiences to solve this type of problem. Use of creativity for new ways to solve the problem. Search findings are recorded for future reference.	A few different pathways are researched. Less efficient paths are eliminated. No use of past problems or experiences to solve this type of problem or no use of creativity for new ways to solve the problem.	At least one alternate pathway is researched. No use of past problems or experiences to solve this type of problem or no use of creativity for new ways to solve the problem.	Only one solution. No opportunities for searching for alternate solutions.	
Identify constraints	All possible physical and practical limitations are identified. Limitations are not overly restrictive to innovation. Examples include cost, codes, accommodations, and rules.	Some physical and practical limitations are identified. Limitations restrict some innovation.	At least one limitation is identified. Innovation is highly restricted by the limitations.	No constraints are identified.	

Results – Means and SD

Engineering Design Step	Engineering Trained			Technology Trained		
	M	n	SD	M	n	SD
Identify the Need	2.25	12	0.87	2.17	12	1.03
Define the Problem	2.33	12	0.78	1.83	12	1.03
Search for Solutions	1.83	12	1.03	1.42	12	1.00
Identify Constraints	2.25	12	0.87	1.42	12	1.00
Specify Evaluation Criteria	2.58	12	0.67	1.08	12	0.67
Generate Alternate Solutions	1.58	12	1.08	1.75	12	0.87
Engineering Analysis	2.17	12	1.03	0.17	12	0.39
Decision	2.00	12	1.04	0.75	12	0.45
Design Specifications	2.21	12	0.94	0.08	12	0.29
Communication	2.25	12	0.97	0.50	12	0.52

Results – t-tests

Engineering Design Step	M diff	t	df	p
Identify the Need	0.08	0.22	22	0.83
Define the Problem	0.50	1.34	22	0.19
Search for Solutions	0.42	1.01	22	0.33
Identify Constraints	0.83	2.19	22	0.40
Specify Evaluation Criteria	1.50	5.50**	22	< 0.001
Generate Alternate Solutions	0.17	0.42	22	0.68
Engineering Analysis	2.00	6.29**	14.08^a	< 0.001
Decision	1.25	3.80**	22	0.001
Design Specifications	2.13	7.48**	13.06^a	< 0.001
Communication	1.75	5.52**	22	< 0.001

^aThe t and df were adjusted because of unequal variances

**Statistically significant at the $\alpha = 0.01$ level

Conclusions

- Very preliminary investigation with limited resources
- Engineering-trained teachers are more likely to incorporate engineering design into the classroom
- Further research needed on technology teacher training



Example Design Brief

Engineering-trained technology
teacher



Hydroelectric Dam: Power for the Front Range

Principles of Engineering and Technology

Design Brief



Problem Statement

We have been charged by the Platte Rive Power Authority to develop a new hydroelectric dam to provide power to the front range. This dam needs to provide continuous and reliable power to residents at a reasonable cost.

Objectives

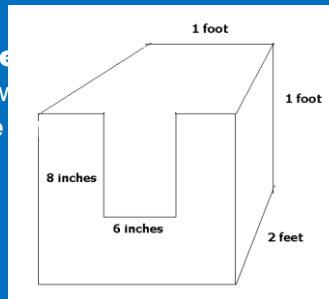
The objective of this design brief is to provide reliable and continuous power derived from flowing water. Our goal is to build a system that will be able to keep a 5W light bulb visibly lit for at least one minute.

Constraints

Materials provided to complete this task are limited to:

- 1 DC motor
- 10 resistors of varying resistance
- 2 diodes
- 2 LEDS
- 1 multimeter
- 1 0.5W light bulb
- Any wood, metal scraps, and fasteners

You need: of evaluation, the only device that will be provided is a home sitting 60/40 min. water "reservoir" bucket of the following dimensions:



$$\rho gh = \frac{1}{2} \rho v^2$$



In Order to Do Well

20% Engineering Principles: Evidence of use of engineering design principles and equations including: problem identification, constraint identification, and objective clarification

20% Engineering Methods: Evidence of use of fluid dynamics theory, electronics equations, and any other mathematics or predictive models to predict the outcome of the product.

20% Testing Protocol: Prototype should be tested to confirm predictions made during the engineering methods (mathematics) portion of the design process.

20% Engineering Communication: Team must present their design solution in a 15 minute presentation to the class using visual aids.

20% Design Efficacy: Completed product should be able to maintain power to light a 0.5W light bulb for at least one minute.

Bonus 1

A bonus of 5 percentage points will be added to the final score of any team able to maintain continuous lighting of a bulb as pictured to the right. Research outside of what we have done in class will be necessary to accomplish this goal.



Bonus 2

If your final project does not perform as well as predicted, write a one paragraph summary of the failure modes witnessed and why your math did not predict them.

Hydroelectric Dam: Power for the Front Range

Principles of Engineering and Technology

Solution Poster



Problem Statement

We have been charged by the Platte Rive Power Authority to develop a new hydroelectric dam to provide power to the front range. This dam needs to provide continuous and reliable power to residents at a reasonable cost.

Engineering Methods and Testing

In order to determine what RPM the turbine would need to run at to light the bulb, our team conducted a test by turning the turbine with a drill to light the bulb. We found the RPM needed was 150.

This RPM was then translated into angular velocity.

$$RPM = 150$$

$$\omega = \frac{RPM * 2\pi}{60s}$$

$$\omega = 15.7$$

$$v = \omega * r$$



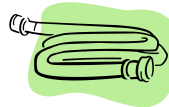
In order to determine what velocity, v , the water would come out of the pipe, we used conservation of energy from fluid dynamics.

$$\rho gh = \frac{1}{2} \rho v^2$$

$$gh = \frac{1}{2} v^2$$

$$9.81 \frac{m}{s^2} * 0.5m = \frac{1}{2} v^2$$

$$v = 3.13 \frac{m}{s}$$

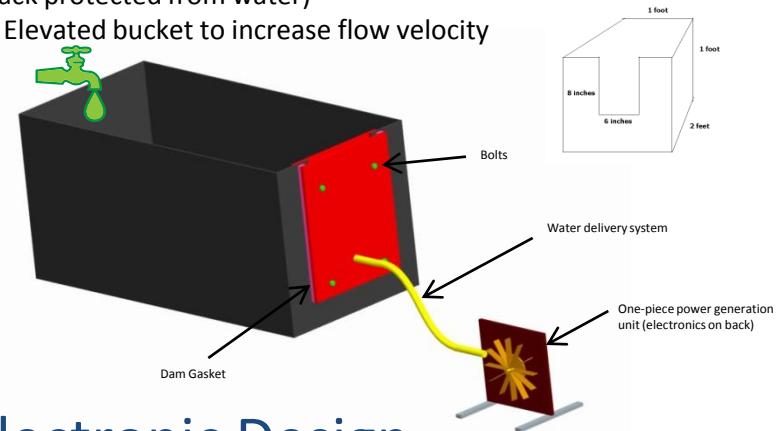


Solving this we find that r must be roughly 20cm on the turbine.

Mechanical Design

The mechanical design's most important features are

- Rubber gaskets on the dam
- Single piece power generation unit (electronics on back protected from water)
- Elevated bucket to increase flow velocity



Electronic Design

In order to capture continuous power from any kind of motor (DC or AC), and receive the extra credit related to lighting the bulb even with a diode in series, our group has decided to build a wave rectifier from diodes. Even with the voltage drops associated with diodes, we expect to see the light bulb remain lit for at least 1 minute. This assertion is a result of the fluid dynamic analysis to the right and testing with the generator.

