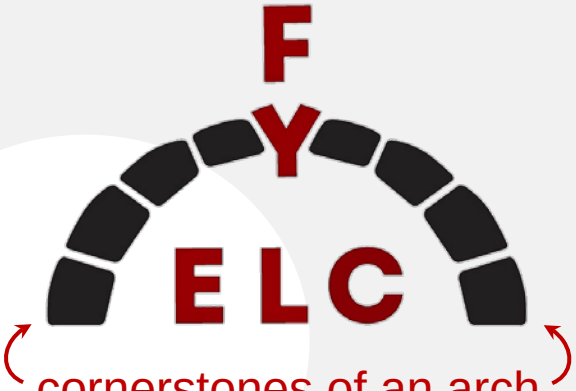
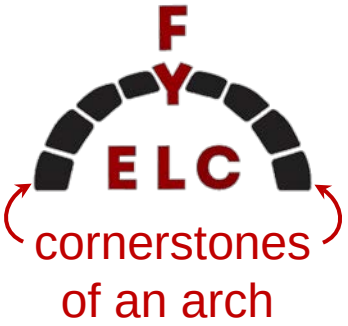
The Cornerstone Course: Projects and Progress

Supporting "Cornerstone to Capstone" in Undergraduate Engineering Education

Susan Freeman, PhD
Richard Whalen, PhD
Courtney Pfluger, PhD
Mark Sivak, PhD
Joshua Hertz, PhD
Bala Maheswaran, PhD
Jennifer Love, MS

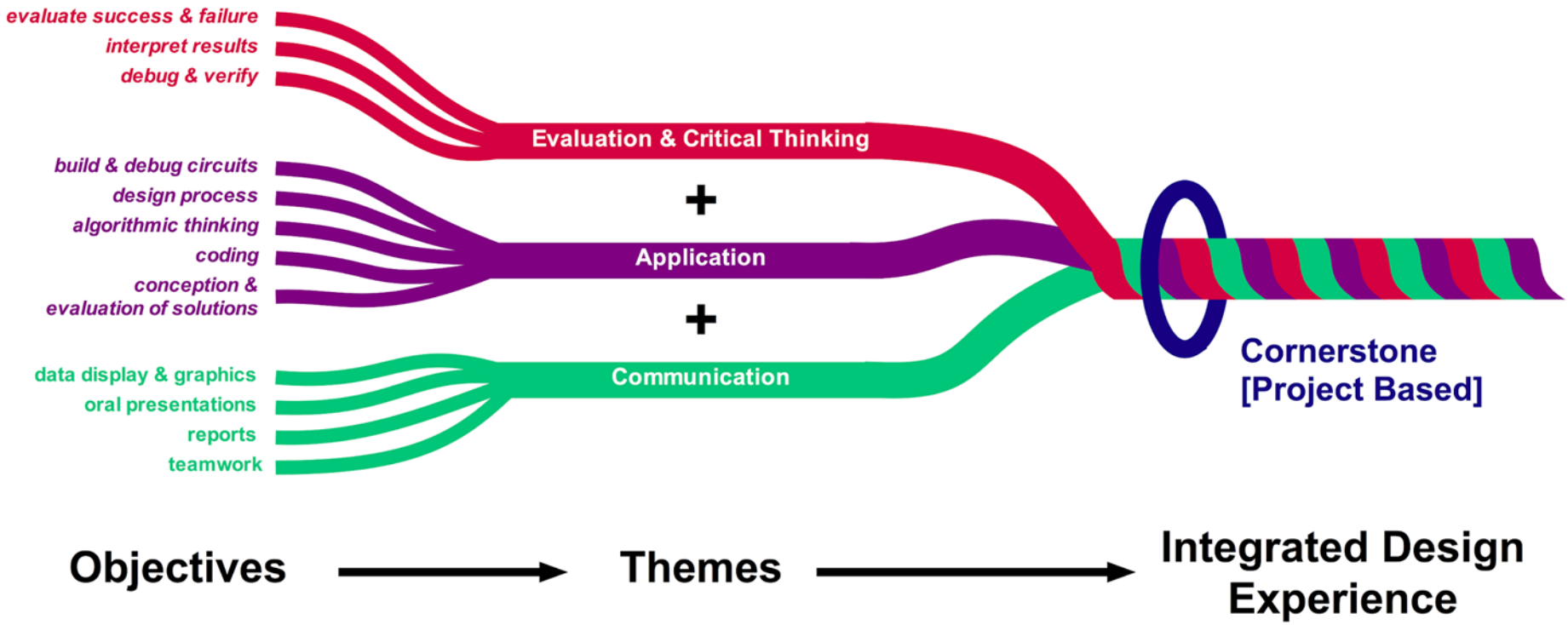


Goals of the Cornerstone Courses



1. Integrate design, programming, graphical communication and engineering analysis into 1 project-based course.
2. Expand real-world, hands-on design projects from existing 2 courses (Engineering Design course & Programming course).
3. Support the interdisciplinary & student-centered approach recommended by the NAE's *Educating the Engineer of 2020* report.
4. Support the College of Engineering's educational initiatives.

Conceptual Framework for Cornerstone



Identifying the Need

- Student feedback: more hands-on experiences and more real-world design challenges in the first year courses.
- Students interested in accelerating through the first year program with qualified AP credit.
- Departments interested in offering their sophomore-level courses in the spring of the first year to qualified students.

Bioengineering	Chemical Engineering	Civil & Environmental Engineering	Electrical & Computer Engineering	Mechanical & Industrial Engineering

Cornerstone Course Outcomes (2 course blend)

- Graphical communication (AutoCAD/SolidWorks), 3D printing.
- Application of the engineering design process.
- Establishing needs & meeting design specifications.
- Engineering a solution to a real problem (hands-on projects).
- Oral & written communication (technical writing too).
- Computational programming skills (C++, Matlab, Arduino).
- Integration of sensors, including calibration & data analysis.

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Cornerstone Course Logistics

- 1 semester format (8 credits) = “Full” Cornerstone
- 2-semester (4 credits each) = “Split” Cornerstone
- Flipped classroom elements with daily assignments.
- Pre-recorded, narrated “master lectures” ~ 10-15 minutes.
- CATME (team assignments & self-assessments)
- Theme-based sections (all with the same milestones):
  - Robotics
  - Energy Transfer
  - Game Design / Virtual Reality
  - Sustainability
  - Security

Cornerstone Course Milestones

- Research project – each team researches a topic of interest within their section's theme, including presentation to classmates & written research report to professor.
- Project proposal – presentation, peer review.
- Prototype – design, build & test with reflection about needed improvements.
- Final Design – demonstration, presentation & written report.

Typical "Split" Cornerstone

Fall	Spring
GE 1501	GE 1502
Design, AutoCAD	Design, SolidWorks
C++	Matlab
Teamwork, presentation skills, oral & written communication	Teamwork, presentation skills, oral & written communication
Projects with working components to demonstrate skills	Open-ended projects with working components to demonstrate skills

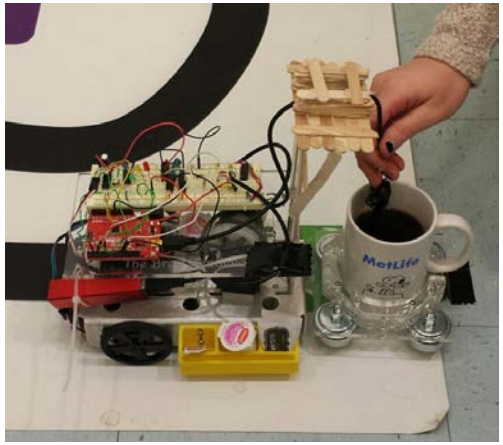
Logistics of Cornerstone

- “Full” cornerstone themes are Sustainability and Energy.
- All others are “split” (Robotics, Security, Game Design).
- 3-4 students per team (changed in Spring).
- CATME or other peer team assessment (Fall & Spring).
- Engineering design process (Fall & Spring).
- AutoCAD & some SolidWorks (Fall).
- SolidWorks & 3D printing (Spring).
- C++ (Fall) / Matlab (Spring).

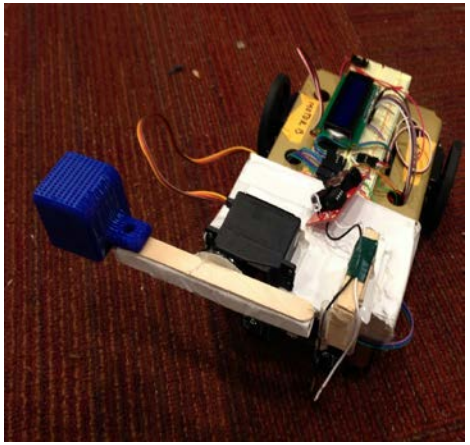
Robotics

- Research presentation incorporates every student's major
- Sumo Robot Project – Arduino programming only (no design)
- Sumo Robot with Open Design – 3D printing (Fall)
- Custom Robot Project – Mars rover, hazard detection (Spring).

Sumo Robots



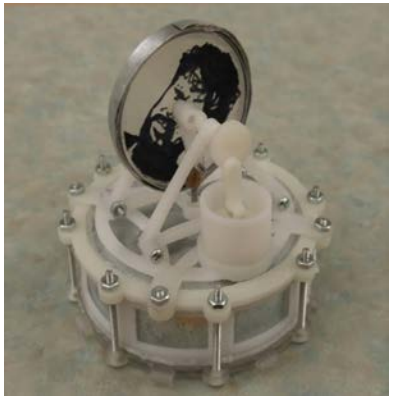
Beverage Dispenser Robot



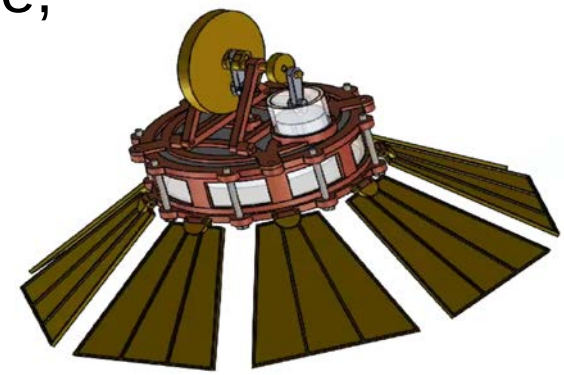
Mars Rover?

Energy Transfer System

- Case Study Project & Project Proposal on energy production & energy transfer systems.
- Design & build a 3D printed prototype or model of proposed project – stirling engine, wind turbines, regenerative braking elevator, regenerative pedaling, etc.
- Data collection & analysis with C++ & Matlab.



3D printed model of stirling engine



SolidWorks rendering of stirling engine with solar reflecting panels

Game Design & Virtual Reality

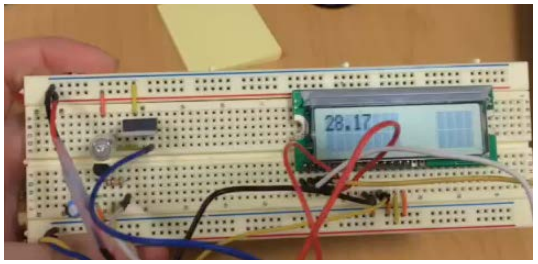
- Project proposal with CAD & project management plan (Fall)
- Miniature golf hole prototype & final design with sensors (Fall)
- Gaming input device – proposal, prototype & testing (Spring)
- Final project – 3D printed final input device (Spring)

Miniature golf hole

Game controllers

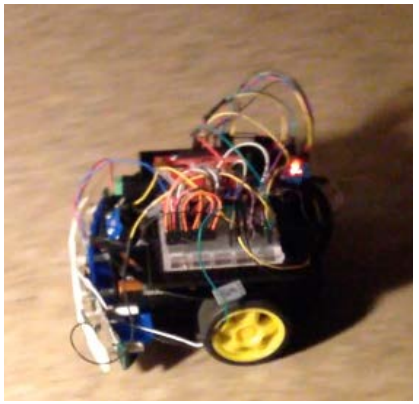
Sustainability

- Final design project - net zero energy sustainable home.
- Research project - residential energy needs & water use for an average home.
- 3 mini-design projects:
  - Solar water heater with temperature sensors & Matlab.
  - Arduino thermostat controller with C/C++.
  - Passive solar box with temperature sensors, Matlab, C++.



Security

- Project proposal & design project – Secret Spy Launch Device (Fall).
- Counterfeit detector project – SparkFun & Arduino (Fall).
- “Swarm to the Light” robot & 3D printed bump sensor – SparkFun & Arduino (Spring).
- “Alcohol sensor” robot – SparkFun & Arduino (Spring).



Cornerstone Course Student Feedback

- "It was FUN and HARD; it was WORTH IT"

- *"I personally found this semester in Robotics to have been one of the **most productive and knowledgeable semesters** in my schooling history. … Entering the class as a Mechanical Engineer, I was a little intimidated by the coding aspect, but was very excited about working with robots. I soon found out that this class properly **integrated** the two into a combination that truly peaked my interest and showed a new side of programming."*

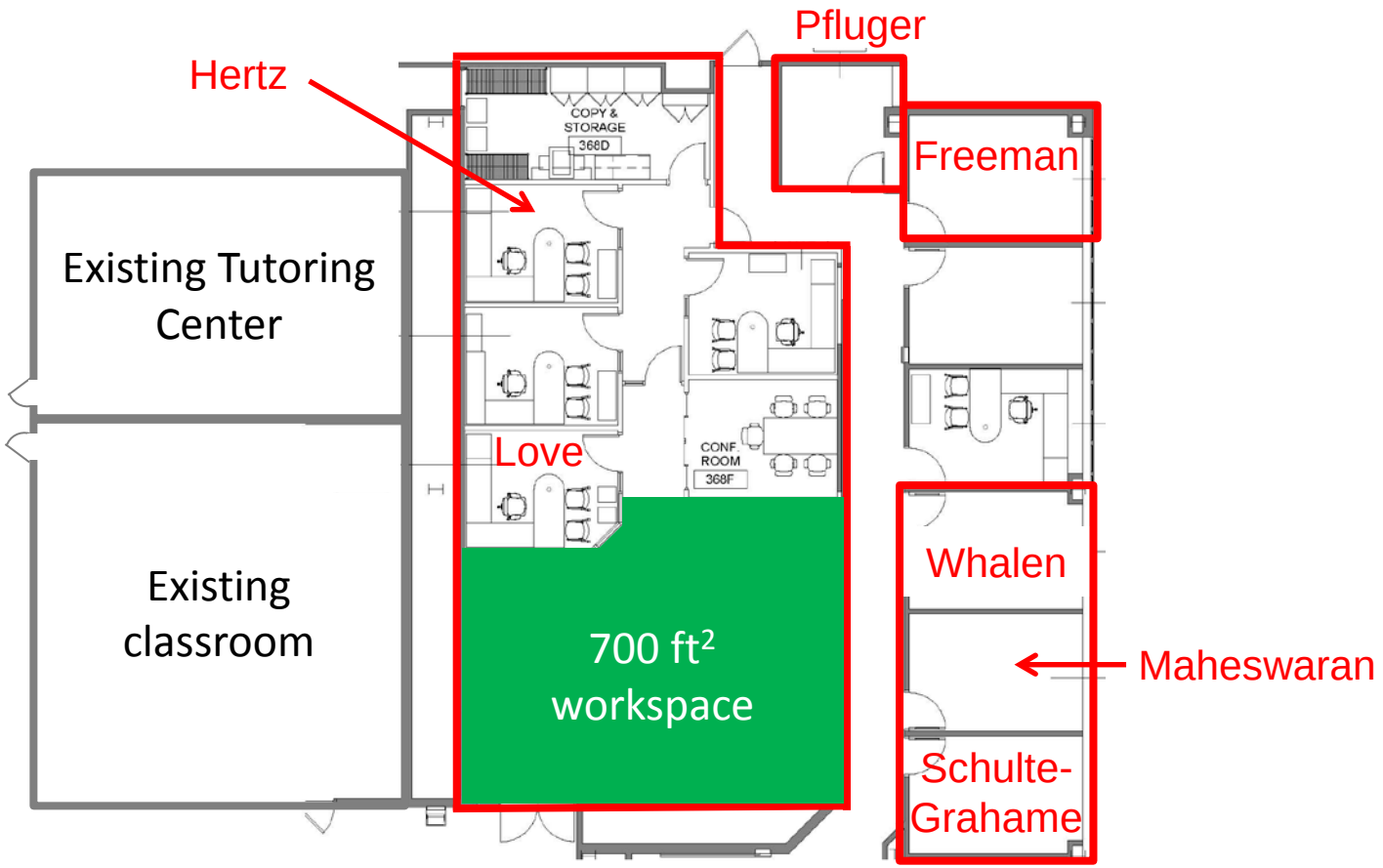
Cornerstone Course Feedback

- *"Engineering and computer programming are becoming **increasingly integrated**, as we depend on technology to make our lives and daily tasks more efficient."*
- *"As we found working on the minor design projects and semester design project in this class, there are often many **complicated factors and challenges** to look at when designing a sustainable future for our generation, and this is an issue in engineering through our generation."*

Future Work

- New bioengineering & music theme sections for Fall 2016.
- Student-purchased SparkFun kits ($50 each).
- Data analysis of existing data and additional assessments of all Cornerstone courses.

First Year Engineering Learning Center – 1,600 ft²



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