Alternative Energy
February 27, 2015

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Background

- IMSA offers an “Engineering” class—a one-semester, project-based class, in which students apply concepts and principles of science in constructing their projects.
- One of the projects traditionally required for all students was a wind turbine project. Students optimized the design with the goal of producing maximum sustained power.

Goal

- Expand the wind-turbine project to an alternative energy project which addresses the four Engineering NGSS standards.

How did we do this?

- Students divided into 6 groups of 3-4 students
- 3 technologies available: wind; solar-electrical; microbial fuel cells (MFC)—2 groups per technology
- Time of project expanded from 2 weeks (for old wind unit) to 4-1/2 weeks.
- Students:
  - 1) learn basics of all 3 technologies;
  - 2) learn the principles of their technology;
  - 3) create an alpha-version;
  - 4) design and build a scale-up beta version;
  - 5) measure the power production for both alpha and beta;
  - 6) present and report their findings.

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NGSS Engineering Standards

HS-ETS1-1 (Analysis)	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
HS-ETS1-2 (Design)	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS1-3 (Evaluation)	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
HS-ETS1-4 (Modelling)	Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Activities: Preliminary

Activity	Approximate Class Time (hrs)	Standard Addressed
Lesson: Energy introduction; issues; electrical circuits and power; solar, wind, MFC technology basics	1	Analysis
Exploration Stations: Wind turbine; electrical generator; hydrogen spectrum; solar panels; galvanic cell, MFC	1	Analysis, Design
Discussion and development of evaluation rubric	0.5	Evaluation

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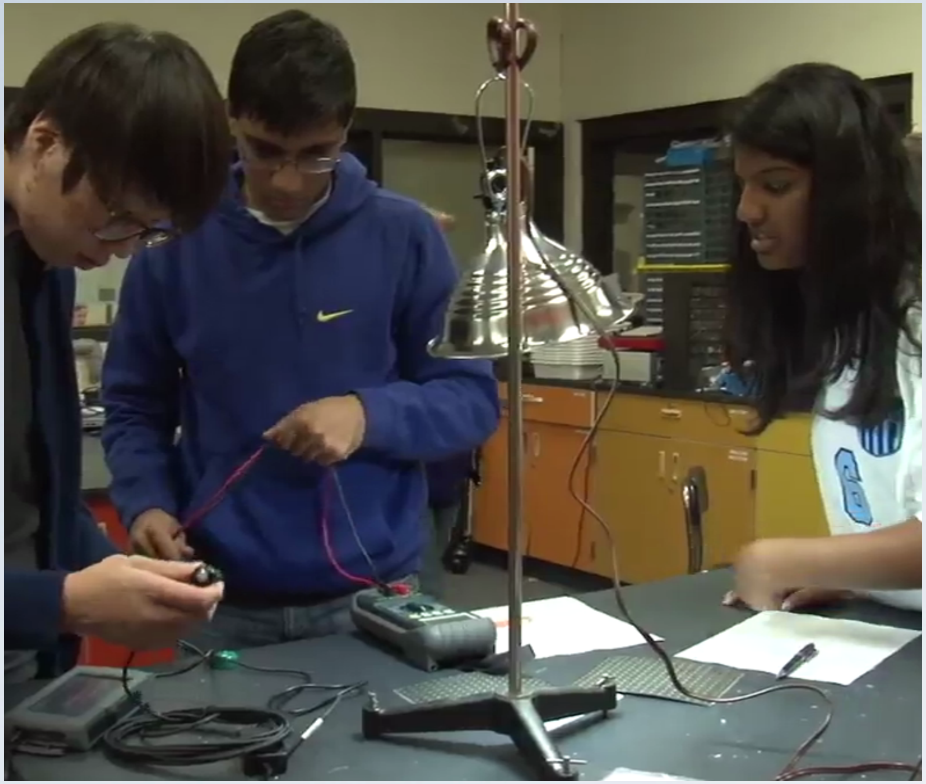
Activities: Preliminary



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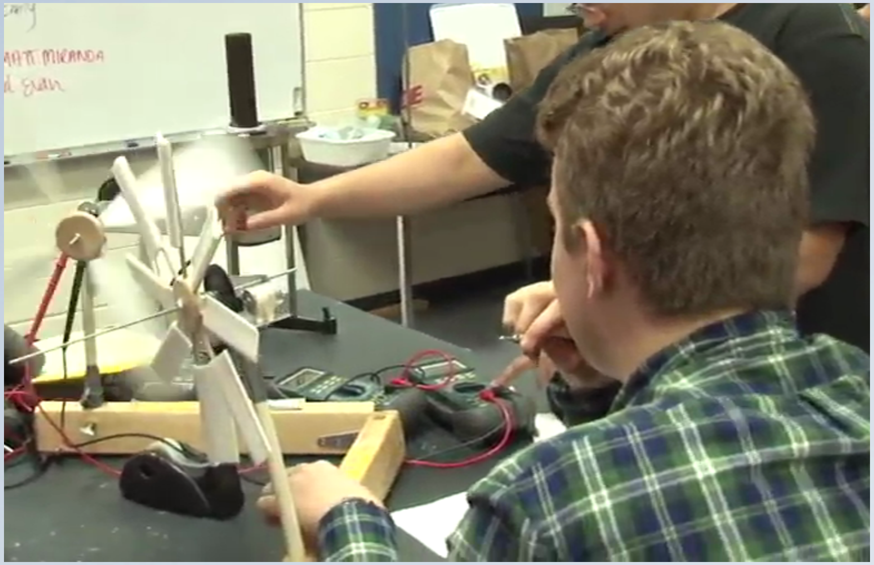
Activities: Preliminary



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Activities: Alpha

Activity	Approximate Class Time (hrs)	Standard Addressed
Alpha build: students build small/basic model and experiment with a few parameters to inform beta design and optimization.	6	Analysis, Design, Evaluation

Activities: Beta

Activity	Approximate Class Time (hrs)	Standard Addressed
Beta Design: Students lay out their plans for a scaled-up system. They report on performance and "lessons learned" from alpha.	0 (assignment)	Analysis, Design, Evaluation
Beta Build/Test: Students construct scaled-up beta system; optimization continues; energy production measurements	8	Analysis, Design, Evaluation
Final Presentations: students present results, further scale-up calculations, and environmental impact assessment.	2	Analysis, Design, Evaluation, Modelling
Final Report: students assess performance and efficiency; report on CO_2 savings; assess issues of scale-up	0 (individual assignment)	Analysis, Design, Evaluation, Modelling

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Student Evaluation Criteria

- Students tasked to create a rubric
  - Small group brainstorming
  - Listing of top criteria
  - Grouping into manageable categories
  - Building consensus on category weights

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Student Evaluation Criteria

- Example:
  - Performance 30%
  - Improvement 25%
  - Health and Safety 15%
  - Nuisance and Aesthetics 15%
  - Marketability & Global Impact 15%

Performance Evaluation

- How should success be measured?
  - Technologies have different capabilities.
  - What would constitute a fair comparison?
- How should efficiency be defined?
  - What is most valued?
  - What are the real costs?

Microbial Fuel Cell Data

Group	Beta Energy 10 min (J)	Beta Notes	Alpha Energy 10 minutes (J)	Alpha Notes
1	0.642	2 MudWatts + 1 shoebox	0.295	1 MudWatt
2	0.048	2 MudWatts + 1 shoebox	0.077	1 MudWatt
3	0.003	2 MudWatts + 1 shoebox	0.023	1 MudWatt
4	2.310	2 MudWatts + 1 shoebox	0.003	1 MudWatt
Average V=570mV; Average R=1230 ohm; Average (Voltage) Efficiency = 26%				

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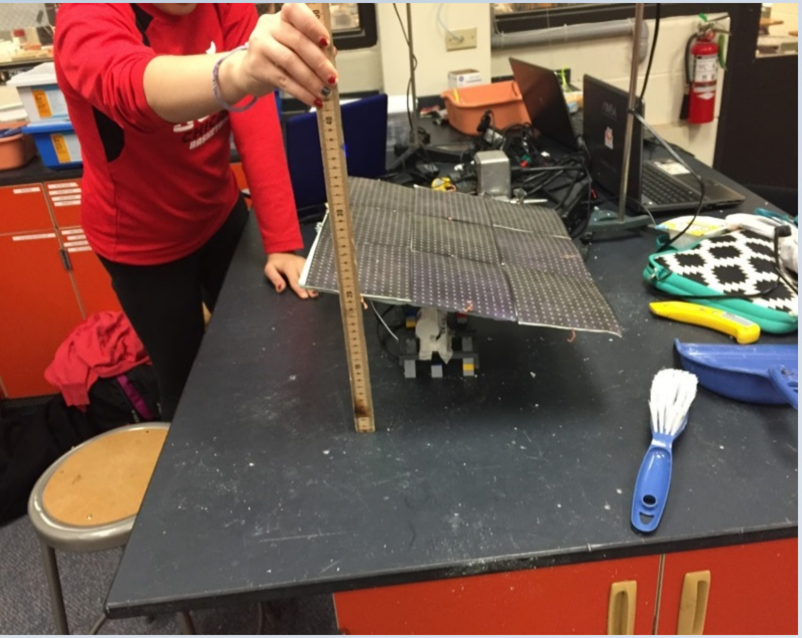
Solar Data



Group	Beta Energy 10 min (J)	Beta Notes	Alpha Energy 10 minutes (J)	Alpha Notes
1	93	0.25 sq meters	11	2 Panels
2	265	0.25 sq meters	14	2 Panels
3	57	0.25 sq meters	14	2 Panels
4	345	0.25 sq meters	8	2 Panels
Average V=2.9V; Average I=89 mA; R=33 ohm; Average Efficiency = 16%				

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Wind Data

Group	Beta Energy 10 min (J)	Beta Notes	Alpha Energy 10 minutes (J)	Alpha Notes
1	230	0.25 sq meters	30	1 mill; 1 generator
2	94	0.25 sq meters	48	1 mill; 1 generator
3	39	0.25 sq meters	19	1 mill; 1 generator
4	49	0.25 sq meters	38	1 mill; 1 generator
Average V=2.9V; Average I=580 mA; R = 33ohm; Average efficiency = 2%				

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Fall Semester—Self Assessment

- What worked well
  - Exploration stations
  - Beta design and build
  - Final report
- What didn't work
  - Alpha presentations and rubric development
  - Alpha testing was an extended exploration—could use focusing questions developed by groups

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Revisions & Future Plans

- Revisions from F14 to S15
  - Add Discussion of Motivation
  - Eliminate Project Proposal
  - Add Discussion of Criteria and Rubric
  - Alpha Prototype Report from Oral to Written
- What could be improved (F15 and beyond)
  - Add parallel vs series exploration station
  - Alpha phase—have groups develop focusing questions
  - Optimizing load for all technologies
  - Add summative discussion

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Materials

- Wind
  - Wind turbine kit
  - Styrofoam meat trays
- Solar
  - Solar panels
  - Copper solder wick ribbon
- Microbial fuel cells
  - Microbial fuel cell kit
  - Electrode material?
  - Potting soil or topsoil
  - Titanium wire
  - 6 quart “Shoebox” storage totes

Tools/Equipment

- Cutting blade (Exacto Knife)
- Hot glue guns
- Blower
- Grow lights with metal lamp reflector
- Pyranometer (to measure radiant energy density)
- Ring stand
- Lego Mindstorm (optional)
- LoggerPro current/voltage sensors OR multimeter
- Resistors
- Nutrients for MFC (sugar, corn syrup, GatorAde, etc.)

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