

POWERUP TEACHER'S GUIDE



PowerUp Teacher's Guide Overview:

This guide is for one of six lessons developed as a classroom companion to PowerUp, a free, online, educational video game that allows students to experience the excitement and the diversity of modern engineering.

The lessons are designed to be flexible and scalable to meet your students' needs. Facilitation tips, extension activities and resources for learning more can be found in this Teachers' Guide. For these resources, as well as to download and play PowerUp for free, go to <http://powerupthegame.org>.

PowerUp was created by IBM and TryScience/The New York Hall of Science with scientific content and expertise provided by the Tech Museum of Innovation, the Bakken Museum, Idaho National Laboratory and the National Renewable Energy Laboratory.



Dear Teachers,

Do you dream of a learning resource that will grab your students' attention and engage them as thoroughly as the video games they play at home and on their mobile phones?

Are you looking for a classroom resource that will motivate your students to creatively apply science and math concepts to tackle pressing, real world problems?

Would you like to spark in your students an interest in pursuing a career in Science or Engineering?

Enter the world of PowerUp a free, online, multiplayer game that allows students to experience the excitement and the diversity of modern engineering. Every student should be able to see a possible role as an engineer contributing to a better community. Playing PowerUp, students work together in teams to investigate the rich, 3D game environment and learn about the environmental disasters that threaten the game world and its inhabitants.

Players meet Expert Engineer characters and experience the great diversity of the field. Conversations with these experts and engaging interactive activities allow players to explore ways engineers design and build systems to harness renewable energy sources as alternatives to burning fossil fuels. Players take on the role of Engineers, working together designing and building energy solutions to save the world.

This guide is designed to be a classroom companion to PowerUp, providing background information for teachers and standards-based lesson plans that give students opportunities for more in-depth exploration of science and engineering concepts addressed in game play.

Each of the lesson plans is designed to be flexible and scalable. Feel free to use the lessons and activities as raw materials and break them up, combine parts, skip parts and extend lessons with your own content. Extension activities and resources for more information are suggested. This flexibility will allow you to best adapt the lessons to your students' needs.

The two lessons based on the Orientation Center (Lessons 1 and 2) act as a review of concepts that are integral to the game's back story and provide students an insight into the diversity of the Engineering field.

In the three lessons based on the game's missions (Lessons 3, 4, and 5) students will take on the role of engineers and work in groups to solve a challenge. Students will design, prototype, test and revise their solution using a low-cost collection of recycled school and household materials. A sample assessment rubric and other resources for facilitating effective Project Based Learning are included in this Teachers Guide.

Finally, working on the research project (Lesson 6) students have the opportunity to investigate how issues that are critical in the game world impact their own communities. Research projects will also provide a context for students to meet local Engineers. Students will work in groups to create presentations that can be published on TryScience.org and shared with other classrooms.



The teacher notes for each lesson list a number of connections between academic standards, classroom activities and game activities. Please log in and play PowerUp yourself in order to experience these synergies first hand. Using these notes as a guide you can determine how to best structure the incorporation of the game to support your students' learning.

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WHAT IS ENGINEERING?

There is a persistent and inaccurate stereotype of the Engineer in our popular culture in which an Engineer is white, male, socially inept, alone in a lab engaged in esoteric research. Playing PowerUp and using the companion curriculum materials will encourage your students to have a broader, more accurate concept of who an Engineer can be, including someone just like them!

Engineering is equal parts:

- analytical problem/puzzle solving
- tinkering/exploring
- imagining/visual thinking
- collaborating/ working as a team

Engineers have diverse:

- specializations
- cultural, ethnic and social backgrounds
- career paths
- interests outside of engineering

Engineering is for ME, it:

- involves skills that I have and activities that I like
- is about solving today's biggest problems that matter to me
- is an attainable profession for a person like me

Students may expect that Engineers have studied a lot of Science and Math but they may not realize that Engineers are also excellent creative thinkers who work to solve all sorts of new problems that require innovative solutions.

Students may have a sense that Engineering is a solitary endeavor – when in fact Engineers often work in teams because today's complex problems require a variety of expertise and perspectives.

Students may think Engineering is one thing, say, working with computers and writing computer code or designing bridges, in fact there are many diverse specializations within Engineering.



TIPS FOR FACILITATING PROJECT BASED LEARNING

Excerpted from the Tech Museum of Innovation's overview of its signature leaning model Design in Mind Learning™.

Design Challenge Learning represents an essential aspect of The Tech's Design in Mind Learning™ pedagogy where students engage in the design process to solve a relevant, authentic, real world problem. Student teams apply and reinforce their Science as well as Mathematics, Social Studies and Language Arts content knowledge, through an open-ended design process that results in an original solution. Design Challenges are framed by a problem statement, list of materials, and constraints. Learners do not follow a linear path from problem to solution, but rather weave in and out of conceptualizing, constructing and testing, and acquiring knowledge, all the while applying multiple skills and habits of mind of innovators. The diagram below represents the phases of Design Challenge learning:

Conceptualizing

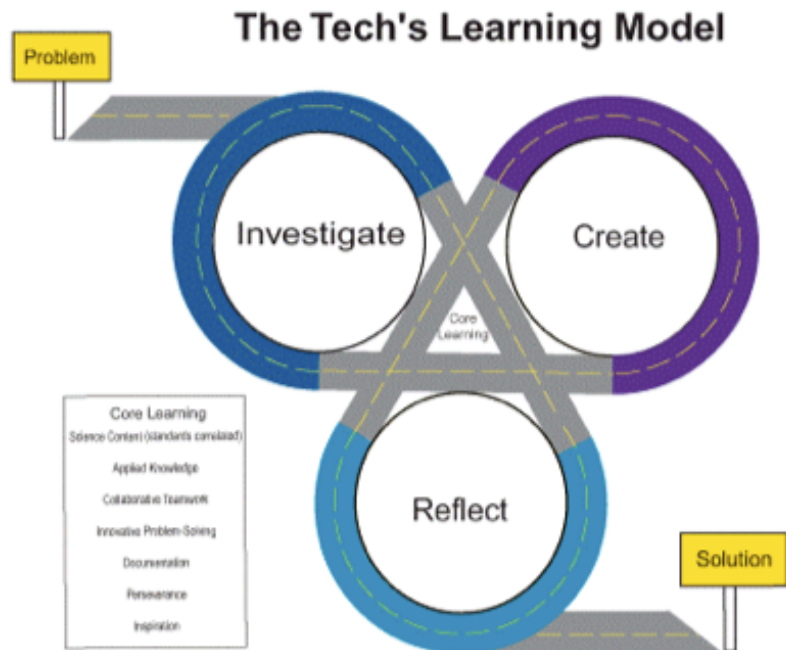
- Identify problem, materials and constraints
- Brainstorm ideas and possible solutions

Constructing & Testing

- Select a solution
- Design and Construct
- Prototype
- Redesign or modify
- Retest

Acquiring Knowledge

- Research
- Share solutions
- Reflect and discuss



Through the phases of Design Challenge learning, students have the opportunity to build broad skills useful throughout their lives, regardless of the specifics of the challenge. In using this open-ended approach that leads to the creation of numerous designs, students are challenged to apply their domain knowledge, personal experiences, interests and talents to the process of creating an inventive, team driven solution. This approach creates a powerful learning experience, where students are intrinsically inspired to learn and have pride in achieving a goal as a team.

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CREATING THE ENVIRONMENT

To transform your learning space into one that encourages students to be inventors and to work in teams, there are some simple things you can do. The following is a short list of suggestions:

Research Station: Help to direct your student's inspiration by creating a research station, where students can go to browse through books, magazines, toys or other related materials that can provide examples of the content and concepts that relate to the challenge.

Construction Station: Create a specific area in your room where students who choose to use construction tools can use them safely and under the supervision of an adult.

Tables: Help encourage student collaboration by arranging desks or tables so teams can work together in a common space.

Materials Station: Centralize all of the materials that students might use in one or two areas of your room. Make sure that the materials are separate from your "cut and bleed" area. Separating materials into their own containers or bins is helpful for students and for clean up.

Questions Board: Create an area where students can post anonymous questions so that you and the other students can identify problem areas, common questions, etc.

"Commercials": If you come across a question whose answer would be beneficial to the entire class, interrupt their work for a brief "commercial." Address the question to the entire class, and solicit ideas/answers from the students themselves. This is also an opportunity to clarify the challenge or constraints, address any common issues related to tool use, etc.

TEAMWORK

As an educator, there are certain issues that you should keep in mind as your students work in teams. The following are some basic challenges that students may face:

Teamwork: If your students are unfamiliar with group work, it is important to spend time doing short activities or icebreakers to help your students understand the benefits and challenges related to teamwork. In Part III, Supplemental Materials, we have included ideas to help your students with teamwork.

Equity in engagement: When students work on teams, it is easy for some students to rely on certain members to carry the weight for the entire team. One approach to encourage equity in student project engagement is to have teams assign/identify specific roles for each team member. By giving each student a specific responsibility, students can feel more ownership in the project. However, do not let students get "stuck" in a certain role that limits their participation in all aspects of the design and engineering process.

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Communication: Helping students to understand ways in which they can clearly communicate with one another will assist in the peer design review. Useful suggestions like offering constructive criticism that is based on facts rather than personalities will help focus student feedback. Teams may also need assistance in learning how to convey an idea. Some suggestions you can offer your team include: sketching a picture, acting out the idea, drawing a series of pictures in a cartoon fashion to convey the idea of a process.

Gender roles: As students determine their roles as a part of the team, keep an eye on which roles boys and girls take on. Ultimately, each team member should have experience in all facets of the project. (i.e. each student should have a hands-on experience in using tools) If it appears that the roles seem to be based on gender, step in to switch those roles so that all students have an equal chance to practice new skills.

Procrastination: About mid-way through the project, students may begin to show signs of procrastination or lack of motivation to finish their projects. Often this behavior is a manifestation of the team feeling “stuck.” As a facilitator, try to help them see paths around, through, over, under their problem. Help them look elsewhere for inspiration, both from their original brainstorm (hopefully recorded in their notebooks) and from external resources (books, toys, other teams, etc.).

PROJECT ASSESSMENT

Rubric: For project-based learning, developing a rubric is an appropriate tool to use for assessment of student understanding. Determine what your rubric is before the project starts, so that you can share this with your students as they begin their projects. One good resource for building a rubric can be found here (<http://rubistar.4teachers.org/>).

Self-reflection: To gain insight on the each student’s sense of how his/her team solved the problem, asks individual students to write a reflection on his/her perspective on the experience. Some examples questions that could be asked are:

- What was your role in the project?
- How did your team come up with its solution?
- What was something that challenged your team?
- How did you overcome this challenge?
- If you had more time, what changes would you make in your design?

This self-reflection in combination with reviewing the team’s design journal will give you good insight into how the team members worked together.

Peer assessment: Have students write a short assessment of their peers projects based on the rubric that you design. (A sample rubric for the Wind Turbine design & Build Challenge follows)



SAMPLE GRADING RUBRIC

Lesson 3: Wind Turbine Design and Build Challenge

Example Rubric for Design Portfolio page 1/2

Category	Excellent	Good	Fair	Needs Improvement
Effective idea generation in brainstorming session	Students generated a broad range of design ideas. More than 50 ideas were listed.	Students generated a broad range of design ideas. More than 35 ideas were listed.	Students generated design ideas, many were similar to each other. More than 20 ideas were listed.	Students generated fewer than 20 design ideas. Many ideas were similar to each other.
Gathering & incorporating scientific information into design	Accurate scientific information taken from 4 or more sources and integrated well into design process.	Accurate scientific information taken from 3 or fewer sources and integrated well into design process.	Accurate scientific information taken from 3 or fewer sources but not fully integrated into design process.	Scientific information taken from only one source and/or information not integrated into design process.
Incorporating community input in turbine design	Students' wind turbine design includes 2 or more features that respond directly to the concerns raised by community members who opposed original wind-farm plan.	Students' wind turbine design includes 1 feature that responds directly to the concerns raised by community members who opposed original wind-farm plan.	Students' wind turbine design includes features that indirectly respond to concerns raised by community members who opposed original wind-farm plan.	No evidence that students' design includes features that respond directly to the concerns of community members who opposed original wind-farm plan.
2D Drawing of Design for large-scale wind turbine	Drawing depicts complete design for large-scale wind turbine. Scale and materials are indicated. Mechanical and electricity-generating parts are drawn and labeled. Special design features are drawn, labeled and explained when necessary. Color enhances drawing. Overall quality of drawing is excellent.	Drawing depicts complete design for large-scale wind turbine. Scale is indicated. Materials are indicated. Some but not all of the mechanical and electricity-generating parts are drawn and labeled. Special design features are drawn and labeled. Color enhances drawing.	Drawing depicts incomplete design for large-scale wind turbine. Most of the following are drawn and labeled: Scale, materials, mechanical and electricity-generating parts, special design features.	Drawing does not depict complete design for large-scale wind turbine.
Construction of 3D prototype of wind turbine	Turbine functions extraordinarily well, surpassing design specifications	Structure functions as specified	Structure does not function as specified, but students have good ideas about how to make improvements, given more time.	Structure does not function as specified.

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SAMPLE GRADING RUBRIC

Lesson 3: Wind Turbine Design and Build Challenge

Example Rubric for Design Portfolio page 2/2

Category	Excellent	Good	Fair	Needs Improvement
Testing and revision of prototype	Clear evidence of troubleshooting, testing, and refinements based on data and/or scientific principles.	Clear evidence of troubleshooting, testing and refinements.	Some evidence of troubleshooting, testing and refinements.	Little evidence of troubleshooting, testing or refinement.
Science understanding - mechanics of prototype	Students use scientific concepts to clearly explain how their prototype harnesses the kinetic energy of the wind into mechanical power to do work.	Students use some scientific concepts to explain how their prototype turbine harnesses the kinetic energy of the wind into mechanical power to do work.	Students use layman's terms to explain how their prototype turbine harnesses the kinetic energy of the wind into mechanical power to do work.	Students are not able to explain how their prototype turbine harnesses the kinetic energy of the wind into mechanical power to do work.
Science understanding - energy in the earth's system	Students use scientific concepts to clearly explain that wind energy is a renewable energy resource that can be traced back to solar energy.	Students use some scientific concepts to explain that wind energy is a renewable energy resource that can be traced back to solar energy.	Students use layman's terms to explain that wind energy is a renewable energy resource that can be traced back to solar energy.	Students are not able to discuss wind energy as a renewable energy resource that can be traced back to solar energy.
Teamwork	All students contributed notes and drawings to the portfolio. All team members contributed a fair share of the work.	All students contributed notes and drawings to the portfolio. Most team members contributed a fair share of the work.	Most students contributed notes OR drawings to the portfolio. Most team members contributed a fair share of the work.	Some team members did not contribute a fair share of the work to the design portfolio.
Understanding of the design challenge	Clear evidence that students understand the two main aspects of the design challenge: to design a wind turbine that is powerful enough to lift a 10 gm mass 1 meter in 5 seconds, PLUS has a design more tolerable to some or all of the community members who oppose the plan to build a wind farm in Nantucket Bay as originally proposed.	Evidence that students fully understand one or the other, but do not fully understand both main aspects of the design challenge.	Evidence that students partially understand one of the main aspects of the design challenge	No evidence that students fully understand either of the main aspects of the design challenge



CORRELATION OF NATIONAL SCIENCE STANDARDS

Lesson 3: Wind Turbine Design and Build Challenge

	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
National Science Standards Grades 9–12						
NS-9-12.1 SCIENCE AS INQUIRY As a result of activities in grades 9–12, all students should develop understanding of:						
* Abilities necessary to do scientific inquiry			✓	✓	✓	
* Understandings about scientific inquiry			✓	✓	✓	
NS-9-12.2 PHYSICAL SCIENCE As a result of activities in grades 9–12, all students should develop understanding of:						
* Motions and forces	✓		✓	✓	✓	
* Conservation of energy and increase in disorder	✓		✓	✓	✓	
* Interactions of energy and matter	✓		✓	✓	✓	
NS-9-12.3 LIFE SCIENCE As a result of activities in grades 9–12, all students should develop understanding of:						
* Molecular basis of heredity		✓				
* Biological evolution		✓				
NS-9-12.4 EARTH AND SPACE SCIENCE As a result of activities in grades 9–12, all students should develop understanding of:						
* Energy in the earth system	✓		✓	✓	✓	✓
* Geochemical cycles	✓					
NS-9-12.5 SCIENCE AND TECHNOLOGY As a result of activities in grades 9–12, all students should develop understanding of:						
* Abilities of technological design			✓	✓	✓	
* Understandings about science and technology			✓	✓	✓	✓
NS-9-12.6 PERSONAL AND SOCIAL PERSPECTIVES As a result of activities in grades 9–12, all students should develop understanding of:						
* Natural resources	✓		✓	✓	✓	✓
* Environmental quality	✓		✓	✓	✓	✓
* Natural and human-induced hazards	✓		✓	✓	✓	✓
* Science and technology in local, national, and global challenges	✓		✓	✓	✓	✓
NS-9-12.7 HISTORY AND NATURE OF SCIENCE As a result of activities in grades 9–12, all students should develop understanding of:						
* Science as a human endeavor	✓	✓	✓	✓	✓	✓
* Nature of scientific knowledge			✓	✓	✓	✓
* Historical perspectives			✓	✓	✓	✓

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RESOURCES FOR MORE INFORMATION

Project-Based Learning

The Tech Museum of Innovation
Design Challenge Learning
www.thetech.org/education/teachers/curriculum.php

Edutopia
Research and Information of Project-Based Learning
<http://www.edutopia.org/projectbasedlearning>

Buck Institute for Education
PBL Handbook.
<http://www.bie.org/pbl/pblhandbook/intro.php>

Learning to Learn: Preparing Teachers and Students for Problem-Based Learning.
ERIC Digest.
<http://www.ericdigests.org/2002-2/problem.htm>

Assessment/Evaluation Tools

Buck Institute for Education Handbook—Sample PBL Rubrics
<http://www.bie.org/pbl/pblhandbook/tools.php#rubrics>

Sample PBL Assessment Checklists
<http://www.4teachers.org/projectbased/>

Authentic Assessment and Rubric Information and Samples
<http://school.discovery.com/schrockguide/assess.html>

The Role of Computer Games in Education

National Science Digital Library: Expert Voices
A roundup of pod casts, articles and research summaries related to the promises and pitfalls of video games and other new digital media for learning:
<http://expertvoices.nsdlib.org/webkids/>

The Education Arcade
Scholarly research on learning with video games and game development projects
<http://educationarcade.org/>

BBC News: Games Find Home in the Classroom
<http://news.bbc.co.uk/2/hi/technology/4189411.stm>



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Wind Power

State Wind Resource Maps
EERE Wind Powering America
www.eere.energy.gov/windandhydro/windpoweringamerica

Wind Web Tutorial
American Wind Energy Association
www.awea.org/faq

Exploring Ways to Use Wind Energy
EERE Consumer's Guide to Energy Efficiency and Renewable Energy
www.eere.energy.gov/consumer/renewable_energy/wind

Hydro Power

United States Geological Survey – Water Science for Schools Resources
<http://ga.water.usgs.gov/edu/wuhy.html>

Hydroelectric power: its importance and its ecological impact
Interview with Mike Sale and Chuck Coutant of Oak Ridge National Laboratories
<http://www.ornl.gov/ORNLReview/rev26-34/text/hydmain.html>

Solar Power

National Renewable Energy Laboratory: Solar Energy Basics
http://www.nrel.gov/learning/re_solar.html

Wikipedia, the free encyclopedia – Entry on Solar Power
http://en.wikipedia.org/wiki/Solar_energy

Renewable Energy Technologies Division at Sandia National Laboratories
http://www.sandia.gov/Renewable_Energy/renewable.htm

Engineering Careers

Engineers Week Online – Chock full of engineering information for students and teachers, including profiles of working engineers from different backgrounds
<http://www.eweek.org/>

The Fun Works – a careers website especially for middle- and early high school students developed by the Educational Development Corporation with funding from the National Science Foundation.
<http://www.thefunworks.org>

Learn about lots of different engineering specializations:
<http://www.discoverengineering.org/aboutengineers.asp>



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Engineering Professional Associations

American Association for the Advancement of Science
www.aaas.org

IEEE (Originally named "Institute of Electrical and Electronic Engineers, Inc." but now the scope of the interests and the work of its members is so broad, it is known by the acronym, pronounced "eye-triple-E")
<http://ieee.org>

National Society of Professional Engineers
<http://www.nspe.org>

American Indian Science and Engineering Society
<http://www.aises.org/>

Chinese Institute of Engineers
www.cie-usa.org

National Action Council for Minorities in Engineering
www.nacme.org

National Organization of Gay and Lesbian Scientific and Technical Professionals
www.noglstp.org

Society of Hispanic Professional Engineers
www.shpe.org

Society of Woman Engineers
www.swe.org

National Society of Black Engineers
<http://national.nsbe.org>

Women in Engineering Programs and Advocates Network
www.wepan.org