Design Project Challenge 1: Remove silt (Hydroelectric Power)

PURPOSE
Students will be introduced to hydroelectricity and sedimentation problems along dams.

TIMEFRAME: 15-30 DAYS

OBJECTIVES
Science Activity: Students will -
- investigate the effects of dams on the ecosystem of a region
- use knowledge gained from case studies to take a position on the construction of dams in a region
- identify the role governments and industry play in the construction of dams

GEAR Robotic Activity: Students will -
- investigate programming skills for basic movements, turns, loops, random blocks, and create your own block
- use basic programming skills to complete GEAR design challenge
- use a design journal or notebook to document engineering design process and to maintain a budget for the design project
- create a presentation to showcase robotic solution to design challenge
- discuss ethical considerations for robotic design

BACKGROUND INFORMATION
Hydroelectric Power
http://ga.water.usgs.gov/edu/wuhy.html

Hydroelectric power must be one of the oldest methods of producing power. No doubt, Jack the Caveman stuck some sturdy leaves on a pole and put it in a moving stream. People have used moving water to help them in their work throughout history, and modern people make great use of moving water to produce electricity.

Although most energy in the United States is produced by fossil-fuel and nuclear power plants, hydroelectricity is still important to the nation, as about 7 percent of total power is produced by hydroelectric plants. Nowadays, huge power generators are placed inside dams. Water, flowing through the dams, spin turbine blades which are connected to generators. Power is produced and is sent to homes and businesses.

- Hydropower is the most important and widely-used renewable source of energy.
- Hydropower represents 19% of total electricity production.
- China is the largest producer of hydroelectricity, followed by Canada, Brazil, and the United States (Source: Energy Information Administration).
- Approximately two-thirds of the economically feasible potential remains to be developed. Untapped hydro resources are still abundant in Latin America, Central Africa, India and China.
Advantages to hydroelectric power:

- Fuel is not burned so there is minimal pollution
- Water to run the power plant is provided free by nature
- Hydropower plays a major role in reducing greenhouse gas emissions
- Relatively low operations and maintenance costs
- The technology is reliable and proven over time
- It's renewable - rainfall renews the water in the reservoir, so the fuel is almost always there

Hydroelectric power is not perfect, though, and does have some disadvantages:

- High investment costs
- Hydrology dependent (precipitation)
- In some cases, inundation of land and wildlife habitat
- In some cases, loss or modification of fish habitat
- Fish entrainment or passage restriction
- In some cases, changes in reservoir and stream water quality
- In some cases, displacement of local populations

Hydropower does not pollute the water or the air. However, hydropower facilities can have large environmental impacts by changing the environment and affecting land use, homes, and natural habitats in the dam area.

Most hydroelectric power plants have a dam and a reservoir. These structures may obstruct fish migration and affect their populations. Operating a hydroelectric power plant may also change the water temperature and the river’s flow. These changes may harm native plants and animals in the river and on land. Reservoirs may cover people’s homes, important natural areas, agricultural land, and archeological sites. So building dams can require relocating people. Methane, a strong greenhouse gas, may also form in some reservoirs and be emitted to the atmosphere. (EPA Energy Kids)

Sedimentation Problems with Dams
http://www.internationalrivers.org/sedimentation-problems-with-dams

All rivers contain sediments: a river, in effect, can be considered a body of flowing sediments as much as one of flowing water. When a river is stilled behind a dam, the sediments it contains sink to the bottom of the reservoir. The proportion of a river’s total sediment load captured by a dam – known as its "trap efficiency" – approaches 100 per cent for many projects, especially those with large reservoirs. As the sediments accumulate in the reservoir, so the dam gradually loses its ability to store water for the purposes for which it was built. Every reservoir loses storage to sedimentation although the rate at which this happens varies widely. Despite more than six decades of research, sedimentation is still probably the most serious technical problem faced by the dam industry.
Apart from rapidly filling their reservoirs, sediment–filled rivers also cause headaches for dam operators due to the abrasion of turbines and other dam components. The efficiency of a turbine is largely dependent upon the hydraulic properties of its blades, just as an airplane depends on the aerodynamic properties of its wings. The erosion and cracking of the tips of turbine blades by water–borne sand and silt considerably reduces their generating efficiency and can require expensive repairs.

The amount of sediment carried into a reservoir is at its highest during floods: in the US, for example, commonly half of a river’s annual sediment load may be transported during only 5 to 10 days flow. During and after a particularly violent storm a river may carry as much sediment as it would in several "normal" years. Mudslides caused by earthquakes and volcanoes can also have a dramatic and unpredictable effect on reservoir sedimentation. Global warming, which is predicted to cause more intense storms, will likely increase both the unpredictability and rate of reservoir sedimentation.

ENGAGE – Time: 1 day
2. Discuss and/or research background knowledge on hydroelectricity and sedimentation problems with dams.

EXPLORE (This section will be a non-LEGO activity to reinforce the science behind each GEAR challenge.) – Time: 1 day
1. Students complete the lesson “What Have We Done” (Source http://learningtogive.org/lessons/unit124/lesson2.html%20?print=yes#lesson
During this lesson, students will use case studies to investigate the effect of dams on the ecosystem of a region. The information students can gather from the background knowledge, this lesson, their robotic experience and any other additional research will be used later for a presentation.

EXPLAIN – Time: Construction 3-5 days, Programming 5-10 days
1. Students will be instructed on how to use the NXT Mindstorm –
   a. kit – to build the basic taskbot design from the LEGO NXT Constructopedia (included with the kit) along with sound construction techniques.
   b. software- to program forward/backwards movements, measuring distances, turns, loops, random blocks, and creating your own block
2. Before completing the design challenge, students will need to show mastery of programming basic movements. Any of the following mini-lessons may be used as stand-alone lessons or completed sequentially to develop mastery.
   a. Simple Programming Challenges – students work through a series of written instructions to demonstrate basic programming skills
b. Obstacle Course – using basic movements students build and manipulate a robot through a slalom type obstacle course

c. Robo Racer – students use basic programming to be the fastest robot around a race course

d. Parking Space Challenge – using measurement skills, students park their robot in a specific location

e. Stop for Pedestrians – using measurement skills, students will play “chicken” with their robot and another object

f. Dino-bot – using the random block and loops, try to be the first player to knock down all the obstacles

g. Shape Factory – using the Taskbot, pen attachment, and basic programming students create a variety of two-dimensional shapes

h. Random or Not – program robot to play a sound at random intervals and investigate true randomness of sounds

ELABORATE – Time: 5-10 days

DESIGN CHALLENGE

1. Introduce the design challenge “Remove Silt”.
   a. Scenario – Silt is building up along the Boulder Dam and is causing structural damage to the dam as well as ecological damage to the area. This silt must be removed immediately. Our board of directors is concerned about the continuation of this dam if this problem should persist. However, due to cutbacks we are short of manpower to complete this task. Your company has been requested to develop robotic technology to solve this problem. You will need to design, build, test and modify a robot to complete this challenge. You will also be required to submit a proposal to our company detailing the following: information you learned about dams and sedimentation problems, details regarding your engineering design process, a budget for the cost of your project, ethical considerations for robotic design and a position to our board on whether to continue with the dam project. The winning design will be granted a contract and the ability to earn extra incentives.

2. Introduce the design challenge rules.
   a. The silt (bolts) needs to be completely removed from the enclosed area. Silt may be moved into the player zone or any area in the robot zone.
   b. The enclosed area is defined by boundaries created by the black lines and the field border.
   c. Silt is considered removed when no part of the game element is touching any of the inside white space created by the boundaries as defined by rule 2.
   d. Teams will receive 5 points for every piece that resides outside the boundaries at the end of the match.
   e. While the silt is to be randomly scattered in the area, the silt should not be closer than 2 inches from the boundaries defined in rule 2.
3. Students design, build, test and modify a robot to successfully complete the programming challenge. All work must be documented in student’s notebooks or design journals.

4. Research, document, and discuss the ethical considerations for your robot design. Use the following questions to guide your presentation.
   a. What materials and resources will be needed to construct, operate, and maintain robots?
      (Modification K-8: Have students use LEGO parts and budget sheets. 8-12: Have students research real life applications and materials.)
   b. Who would use this technology and how?
   c. Besides the people using the technology, who else might be affected by it?
   d. What else might be affected? (inanimate world, animals, etc)
   e. What will we do with the robots once they are outdated or otherwise not being used anymore?

EVALUATE – Time 3-5 days

1. Students create presentation for proposal. It must include:
   a. information learned about dams and sedimentation problems
   b. detailed information documented in notebooks on engineering design process
   c. a budget for the project
   d. ethical considerations for robotic design
   e. statement of position – Should the Boulder Dam continue to operate?

2. Allow students to create their own final project for the presentation...PowerPoint, Prezi, poster projects, Pecha Kucha, video, etc. Creativity is a must.

3. Students will be graded using a rubric for presentation, documentation, robotic design and programming challenge, and any mini-lessons used throughout the project.
EXTENSIONS
1. Students can design, build, and test a robotic model of a turbine.
2. Students can research and compare dams around the world – Aswan Dam, Hoover Dam, Three Gorges Dam
3. Students can create a political campaign – pro or con – for a dam to be built in their area.

RESOURCES
Learning to Give
http://learningtogive.org/lessons/unit124/lesson2.html%20?print=yes#lesson

USGS – Water Science for Schools
http://ga.water.usgs.gov/edu/wuhy.html

International Rivers
http://www.internationalrivers.org/sedimentation-problems-with-dams

Discovery Education
http://streaming.discoveryeducation.com/

GEAR robotics
http://www.gearrobotics.org/jm/

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