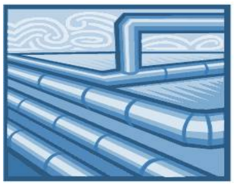
Pipeline Challenge



Provided by TryEngineering - www.tryengineering.org

Lesson Focus

Lesson focuses on how engineers develop pipeline systems to transport oil, water, gas, and other materials over very long distances. Lesson provides background about three major pipeline systems worldwide. Students work in teams of "engineers" to develop a pipeline system to transport both a golf ball and ping pong ball across the classroom terrain. Teams develop a plan, draw their pipe plan, anticipate part requirements, build their pipeline, evaluate other plans, and reflect on the activity.

Lesson Synopsis

The Pipeline Challenge activity explores how engineers work in a team to solve problems, such as planning a pipeline to deliver water, oil, or gas to a community. Students learn how land and weather, distance, and materials to be transported impact engineering plans. Students work in teams to design a pipeline to transport both a golf ball and ping pong ball from one end of the classroom to another with obstacles and turns. Students develop a plan/drawing, execute their pipeline plan, and evaluate the strategies employed by other student teams.

Year Levels

5 – 10 Science Inquiry Skills and Science as a Human Endeavour

Objectives

- Learn how civil engineers approach large scale problem solving.
- Learn how engineering teams address problem solving.
- Learn about teamwork and working in groups.

Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- engineering design
- problem solving
- teamwork

Students learn how land and weather, distance, and materials to be transported impact engineering plans. Students work in teams of "engineers" to design a pipeline to transport both a golf ball and ping pong ball from one end of the classroom to another with obstacles and turns. Students develop a plan/drawing, execute their pipeline plan, and evaluate the strategies employed by other student teams.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Worksheets (attached)
- Student Resource Sheets (attached)

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- TryEngineering (www.tryengineering.org)
- American Experience: Alaska Pipeline (www.pbs.org/wgbh/amex/pipeline/sfeature)
- CSG to LNG Pipeline (http://www.aplng.com.au/); (http://www.qgc.com.au/qclng-project/along-the-main-pipeline/export-route/pipeline-construction.aspx)
- Curriculum links (www.acara.edu.au)

Recommended Reading

- Oil & Gas Pipelines in Nontechnical Language (ISBN: 159370058X)
- Piping and Pipeline Engineering: Design, Construction, Maintenance, Integrity, and Repair (ISBN: 0824709640)

Optional Writing Activity

- Write an essay or a paragraph describing how the impact on the environment must be considered when developing a new pipeline system. Give examples of a pipeline in your country that had environmental implications.

Pipeline Challenge

For Teachers:
Teacher Resources

◆ **Lesson Goal**

Explore engineering problem solving by working in teams to determine a plan for a classroom pipeline. Lesson focuses on how engineers develop pipeline systems to transport oil, water, gas, and other materials over very long distances. Students work in teams of "engineers" to develop a pipeline system to transport both a golf ball and ping pong ball across the classroom terrain. Teams develop a plan, draw their pipe plan, anticipate part requirements, build their pipeline, evaluate other plans, and reflect on the activity.

◆ **Lesson Objectives**

- Learn how civil engineers approach large scale problem solving.
- Learn how engineering teams address problem solving.
- Learn about teamwork and working in groups.

◆ **Materials**

- Student Resource Sheets and Worksheet
- One set of materials for each group of students:
  - Golf ball (or similarly sized rubber ball), ping pong ball
  - Piping set up (assuming a 40cm x 40cm room, allow for about 6 metres of cardboard or PVC tubing. Angled pieces can be cut for the required turns.)

◆ **Procedure**

1. Show students the various Student Reference Sheets. These may be read in class, or provided as reading material for the prior night's homework.
2. Consider having students visit the American Experience: Alaska Pipeline website and explore how different types of pipe plans are suited for different environmental challenges (www.pbs.org/wgbh/amex/pipeline/sfeature).
3. Divide students into groups of 2-3 students, providing a set of materials per group.
4. Explain that they are engineering teams that have been hired to design and test a pipeline to carry a golf ball and a ping pong ball across your classroom. The successful design will include four angles including one right angle (90 degrees), and a height difference of no more than 18 inches from the beginning to the end of the pipeline. Be sure to identify environmentally protected areas, water, or other hazards in your classroom that the students will have to consider in their plan.
5. Student teams develop the shape of their pipeline on paper, then build their pipeline with materials provided.
6. Each student group evaluates the pipelines developed by other teams, and completes an evaluation/reflection worksheet.

◆ **Time Needed**

Two to four 45 minute sessions

Student Resource
Pipeline Projects and Facts

Pipeline transport is a transportation of goods through a pipe. Most commonly, liquid and gases are sent, but pneumatic tubes that transport solid capsules using compressed air have also been used. As for gases and liquids, any chemically stable substance can be sent through a pipeline. Therefore sewage, slurry, and water pipelines exist; but arguably the most important are those transporting oil and natural gas.

◆ Baku-Tbilisi-Ceyhan Pipeline

The Baku-Tbilisi-Ceyhan pipeline (sometimes abbreviated as BTC pipeline) transports crude petroleum 1,776 km from the Azeri-Chirag-Guneshli oil field in the Caspian Sea to the Mediterranean Sea. The total length of the pipeline in Azerbaijan is 440 km long, in Georgia it is 260 km long and in Turkey is 1076 km long. There are 8 pump stations through the pipeline route. The construction of the BTC pipeline was one of the biggest engineering projects of the last decade. It was constructed from 150,000 individual joints of line pipe, each measuring 12 m (39 ft) in length. It has a projected lifespan of 40 years, and when working at normal capacity, beginning in 2009, will transport 1 million barrels (160 000 m^3) of oil per day. It has a capacity of 10 million barrels (1.6 million m^3) of oil, which will flow through the pipeline at 2 m (6 ft) per second. The pipeline will supply approximately 1% of global demand.

◆ Trans-Alaska Pipeline System

The Trans-Alaska Pipeline System is a major U.S. oil pipeline connecting oil fields in northern Alaska to a sea port where the oil can be shipped to the Lower 48 states for refining. The main Trans-Alaska Pipeline runs north to south, almost 800 miles (1,300 km), from the Arctic Ocean at Prudhoe Bay, Alaska to the Gulf of Alaska at Valdez, Alaska, passing near several Alaskan towns. Construction of the pipeline presented significant challenges due to the remoteness of the terrain and the harshness of the environment it had to pass through. Between Arctic Alaska and Valdez, there were three mountain ranges, active fault lines, miles of unstable, boggy ground underlain with frost, and migration paths of caribou and moose. Since its completion in 1977, the pipeline has transported over 15 billion barrels (2.4 km3) of oil.

◆ CSG-LNG Pipeline Project

Gas will be transported from QGC's processing facilities in southern Queensland to a liquefaction plant on Curtis Island, near Gladstone, via a one metre (42 inch) diameter steel pipeline. The northern arm of the pipeline links well sites near Woleebee Creek. The southern arm links wells south-west of Dalby. In total, this 540km journey is roughly equivalent to the distance from Brisbane to Port Macquarie - or from London to Glasgow in the UK. The pipeline - consisting of 46,200 individual sections - is designed and constructed in accordance with Australian Standard 2885 (AS2885), which applies to high-pressure hydrocarbon pipe.

Student Worksheet: You are the Engineer!

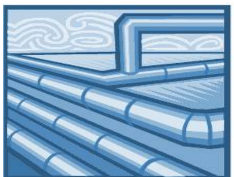
◆ You are a team of engineers which has to tackle the challenge of developing a pipeline system to transport a golf ball and a ping pong ball from one side of your classroom to the other. But, it's not as simple as it sounds! You need to incorporate four angles in your design, one of which is a right angle (90 degrees) and the difference in height from one end of your pipe to the other can be no more than 45cm. Your teacher may identify environmentally protected areas, water, or other hazards in your classroom that you'll have to consider in your plan.

◆ Planning Steps
1. Review the various Student Reference Sheets.
2. As a team, develop a plan for your pipeline. Draw it in the box below, and include other identifying features of your classroom such as doors, desks, or other areas:

◆ Construction Stage
1. Build and test your pipeline using both a golf ball and a ping pong ball.
2. Observe the pipelines constructed by other teams in your classroom

◆ Evaluation and Reflection
1. Complete the evaluation sheet and present the work of your team to the class.

Pipeline Challenge



Student Worksheet: Evaluation/Reflection

◆ Use this worksheet to evaluate the different pipelines developed by the "engineer" teams in your class.

1. What challenges did you face in executing your pipeline?

2. Did you find you needed to rework your original plan when you began building the real pipeline in the classroom? If so, how did your pipeline change?

3. Did you find your pipeline was more effective using the ping pong ball or the golf ball? Why do you think this was true?

4. Which pipeline developed by another "engineering" team did you think worked best? Why?

5. If your design were scaled up to a real pipeline, do you think you would need pumps to keep the materials flowing through your system? Why or why not? And, if so, how many pumps would you add, and where would you put them?

Student Worksheet: Evaluation/Reflection (continued)

6. Do you think your pipeline design would work if you used it to transport water? Feathers? Butter? Why or why not?

7. Did you find that there were many ways to solve this challenge? If so, what does that tell you about the engineering designs of real pipelines?

8. Do you think you would have been able to create a successful pipeline as easily if you had not been working in a team? What are the advantages of teamwork vs. working alone?

9. How do you think engineers on the Baku-Tbilisi-Ceyhan Pipeline determined that they needed eight pumps to run the length of the project?

10. How do you think engineers working on the Alaskan Pipeline attempted to avoid negative environmental impact in Alaska? Did they succeed?

For Teachers:
Alignment to Curriculum Frameworks

Science Inquiry Skills

Year 5

With guidance, select appropriate investigation methods to answer questions or solve problems (**ACSIS086**)

Use equipment and materials safely, identifying potential risks (**ACSIS088**)

Suggest improvements to the methods used to investigate a question or solve a problem (**ACSIS091**)

Year 6

With guidance, select appropriate investigation methods to answer questions or solve problems. (**ACSIS103**)

Use equipment and materials safely, identifying potential risks (**ACSIS105**)

Suggest improvements to the methods used to investigate a question or solve a problem (**ACSIS108**)

Year 7

Collaboratively and individually plan and conduct a range of investigation types including fieldwork and experiments, ensuring safety and ethical guidelines are followed (**ACSIS125**)

In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task **(ACSIS126)**

Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of data collected, and identify improvements to the method **(ACSIS131)**

Year 8

Collaboratively and individually plan and conduct a range of investigation types including fieldwork and experiments, ensuring safety and ethical guidelines are followed (**ACSIS140**)

In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task **(ACSIS141)**

Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of data collected, and identify improvements to the method **(ACSIS146)**

Year 9

Plan, select and use appropriate investigation methods, including fieldwork and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods **(ACSIS165)**

Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data **(ACSIS166)**

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data **(ACSIS171)**

Year 10
Plan, select and use appropriate investigation methods, including fieldwork and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods **(ACSIS199)**

Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data **(ACSIS200)**

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data **(ACSIS205)**

Science as a Human Endeavour

Year 5
Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena **(ACSHE081)**

Scientific understandings, discoveries and inventions are used to solve problems and directly affect people's lives **(ACSHE083)**

Year 6
Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena **(ACSHE098)**

Scientific understandings, discoveries and inventions are used to solve problems and directly affect people's lives **(ACSHE100)**

Year 7
Science knowledge can develop through collaboration and connecting ideas across the disciplines of science **(ACSHE223)**

People use understanding and skills from across the disciplines of science in their occupations **(ACSHE224)**

Year 8
Science knowledge can develop through collaboration and connecting ideas across the disciplines of science **(ACSHE226)**

People use understanding and skills from across the disciplines of science in their occupations **(ACSHE227)**

Year 9

Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries **(ACSHE158)**

Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities **(ACSHE161)**

Year 10

Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries **(ACSHE192)**

Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities **(ACSHE195)**

Mathematics Links with Science Curriculum (Skills used in this activity)	General Capabilities	Cross-Curriculum Priorities
• Process data using simple tables • Data analysis skills (graphs) • Analysis of patterns and trends • Use of metric units	• Literacy • Numeracy • Critical and creative thinking • Personal and social capacity • ICT capability	• Sustainability

Science Achievement Standards

Year 5

By the end of Year 5, students classify substances according to their observable properties and behaviours. They explain everyday phenomena associated with the transfer of light. They describe the key features of our solar system. They analyse how the form of living things enables them to function in their environments. Students discuss how scientific developments have affected people's lives and how science knowledge develops from many people's contributions.

Students follow instructions to pose questions for investigation, predict what might happen when variables are changed, and plan investigation methods. They use equipment in ways that are safe and improve the accuracy of their observations. Students construct tables and graphs to organise and identify patterns. They use patterns in their data to suggest explanations and refer to data when they report their findings. They describe ways to improve the fairness of their methods and communicate their ideas, methods and findings using a range of texts.

Year 6

By the end of Year 6, students compare and classify different types of observable changes in materials. They analyse requirements for the transfer of electricity and describe how energy can be transformed from one form to another to generate electricity. They explain how natural events cause rapid changes to the Earth's surface. They decide and predict the effect of environmental changes on individual living things. Students explain how scientific knowledge is used in decision making and identify contributions to the development of science by people from a range of cultures.

Students follow procedures to develop investigable questions and design investigations into simple cause-and-effect relationships. They identify variables to be changed and measured and describe potential safety risks when planning methods. They collect, organise and interpret their data, identifying where improvements to their methods or research could improve the data. They describe and analyse relationships in data using graphic representations and construct multi-modal texts to communicate ideas, methods and findings.

Year 7

By the end of Year 7, students describe techniques to separate pure substances from mixtures. They represent and predict the effects of unbalanced forces, including Earth's gravity, on motion. They explain how the relative positions of the Earth, sun and moon affect phenomena on Earth. They analyse how the sustainable use of resources depends on the way they are formed and cycled through Earth systems. They predict the effect of environmental changes on feeding relationships and classify and organise diverse organisms based on observable differences. Students describe situations where scientific knowledge from different science disciplines has been used to solve a real-world problem. They explain how the solution was viewed by, and impacted on, different groups in society.

Students identify questions that can be investigated scientifically. ***They plan fair experimental methods, identify variables to be changed and measured. They select equipment that improves fairness and accuracy and describe how they considered safety. Students draw on evidence to support their conclusions***. They summarise data from different sources, describe trends and refer to the quality of their data when suggesting improvements to their methods. They communicate their ideas, methods and findings using scientific language and appropriate representations.

Year 8

By the end of Year 8, students compare physical and chemical changes and use the particle model to explain and predict the properties and behaviours of substances. They identify different forms of energy and describe how energy transfers and transformations cause change in simple systems. They compare processes of rock formation, including the time scales involved. They analyse the relationship between structure and function at cell, organ and body system levels. Students examine the different science knowledge used in occupations. They explain how evidence has led to an improved understanding of a scientific idea and describe situations in which scientists collaborate to generate solutions to contemporary problems.

Students identify and construct questions and problems that they can investigate scientifically. ***They consider safety and ethics when planning investigations,***

including designing field or experimental methods. They identify variables to be changed, measured and controlled. Students construct representations of their data to reveal and analyse patterns and trends, and use these when justifying their conclusions. ***They explain how modifications to methods could improve the quality of their data and apply their own scientific knowledge and investigation findings to evaluate claims made by others***. They use appropriate language and representations to communicate science ideas, methods and findings in a range of texts types.

Year 9

By the end of Year 9, students explain chemical processes and natural radioactivity in terms of atoms and energy transfers and describe examples of important chemical reactions. They describe models of energy transfer and apply these to explain phenomena. They explain global features and events in terms of geological processes and timescales. They analyse how biological systems function and respond to external changes with reference to interdependencies, energy transfers and flows of matter. They describe social and technological factors that have influenced scientific developments and predict how future applications of science and technology may affect people's lives.

Students design questions that can be investigated using a range of inquiry skills. ***They design methods that include the control and accurate measurement of variables and systematic collection of data and describe how they considered ethics and safety. They analyse trend in data, identify relationships between variables and reveal inconsistencies in results. They analyse their methods and the quality of their data, and explain specific actions to improve the quality of their evidence***. They evaluate others 'methods and explanations from a scientific perspective and use appropriate language and representations when communicating their findings and ideas to specific audiences.

Year 10

By the end of Year 10, students analyse how the periodic table organises elements and use it to make predictions about the properties of elements. They explain how chemical reactions are used to produce particular products and how different factors influence the rate of reactions. They explain the concept of energy conservation and represent energy transfer and transformation within systems. They apply relationships between force, mass and acceleration to predict changes in the motions of objects. Students describe and analyse interactions and cycles within and between Earth's spheres. They evaluate the evidence for scientific theories that explain the origin of the universe and the diversity of life on Earth. They explain the processes that underpin heredity and evolution. Students analyse how the models and theories they use have developed over time and discuss the factors that prompted their view.

Students develop questions and hypotheses and independently design and improve appropriate methods of investigation, including field work and laboratory experimentation. They explain how they have considered reliability, safety, fairness and ethical actions in their methods and identify where digital technologies can be used to enhance the quality of their data. When analysing data, selecting evidence and developing and justifying conclusions, they identify alternative explanations for findings and explain any sources of uncertainty. Students evaluate the validity and reliability of claims made in secondary sources with reference to currently held scientific views, the quality of methodology and the evidence cited. They construct evidence-based arguments and select appropriate representations and text types to communicate science ideas for specific purposes.