



Adaptive Device Design



Provided by TryEngineering - www.tryengineering.org

Lesson Focus

Lesson focuses on the engineering of adaptive or assistive devices, such as prosthetic devices, wheelchairs, eyeglasses, grab bars, hearing aids, lifts, or braces.

Lesson Synopsis

The Adaptive Device Design activity explores the concept of how engineering has made possible the development of -- and ongoing improvements to -- adaptive devices that serve to help individuals with a wide range of physical challenges adapt to the world and participate fully in society. Students learn about the engineering process to solve problems, and work in teams to improve the design of a current or proposed adaptive device. Students start with eyeglasses, disassembling, examining component design and shape, and reassembling...then re-engineer the product seeking improvements to the current product.

Year Levels

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

Objectives

- ✦ Learn about adaptive devices.
- ✦ Learn about how ongoing changes to adaptive devices have impacted everyday life.
- ✦ Learn about teamwork and the engineering problem solving/design process.

Anticipated Learner Outcomes

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

- ✦ adaptive devices
- ✦ impact of engineering and technology on society
- ✦ engineering problem solving
- ✦ teamwork

Lesson Activities

Students learn about how the engineering behind adaptive devices has impacted everyday life. Topics examined include problem solving, teamwork, and the engineering design process. Students work in teams to disassemble a product, evaluate the component parts, and recommend changes to improve functionality through redesign and material selection.

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www.tryengineering.org

Modified and aligned to
Australian Curriculum by
Queensland Minerals
and Energy Academy

Resources/Materials

- ✦ Teacher Resource Documents (attached)
- ✦ Student Resource Sheet (attached)
- ✦ Student Worksheets (attached)

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- ✦ TryEngineering (www.tryengineering.org)
- ✦ Wheelchair Net (www.wheelchairnet.org)
- ✦ Curriculum links (www.acara.edu.au)

Recommended Reading

- ✦ The Design of Everyday Things by Donald A. Norman (ISBN: 0465067107)
- ✦ Emotional Design: Why We Love (or Hate) Everyday Things by Donald A. Norman (ISBN: 0465051367)

Optional Writing Activities

- ✦ Write an essay or a paragraph describing which adaptive device you think has most dramatically impacted the world. Give supporting details, and offer suggestions for further improvements to this device.

Adaptive Device Design



For Teachers: Teacher Resources

◆ Lesson Goal

Explore how engineers have developed products that help those with physical challenges lead more comfortable and independent lives. Students learn about assistive and adaptive devices, evaluate the design and materials used in sunglasses, and develop or improve an adaptive device working as a team of "engineers."

◆ Lesson Objectives

- ✦ Students learn about adaptive devices.
- ✦ Students learn about how ongoing changes to adaptive devices have impacted everyday life.
- ✦ Students learn about teamwork and the engineering problem solving/design process.

◆ Materials

- Student Resource Sheets
- Student Worksheets
- One set of materials for each group of students:
 - One pair of sunglasses (either old or inexpensive new)
 - Eyeglass Repair Kit (including mini screwdriver, replacement screws, and if possible a magnifying glass)



◆ 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. They may also be directed to bring in a pair of old sunglasses from home.
2. Divide students into groups of 3-4 students; provide one set of materials per group.
3. Ask students to complete the three student worksheets: the first prompts a discussion of what an adaptive device would be; the second requires students to disassemble and reassemble an old pair of sunglasses to evaluate materials and design; the third has students work in teams as "engineers" to design a new or improve an existing adaptive device.
4. Each student group presents the vision for their new or improved adaptive design and their views on societal impact of engineering to the class.

◆ Time Needed

One to two 45 minute sessions.

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Student Resource: Who Needs Adaptive Devices?

Adaptive or assistive devices are developed to assist individuals with a wide range of disabilities to improve their ability to live healthy and independent. It is estimated that over 4 million Australians have some degree of disability.



A disability is defined as 'one or more of 17 limitations, restrictions or impairments which have lasted or are likely to last, for a period of six months or more, and which restrict a person's everyday activities'. They include:

- loss of sight (not corrected by glasses or contact lenses)
- loss of hearing where communication is restricted, or an aid to assist with, or substitute for, hearing is used
- speech difficulties
- chronic or recurrent pain or discomfort causing restriction
- shortness of breath or breathing difficulties causing restriction
- blackout, fits, or loss of consciousness
- difficulty learning or understanding
- incomplete use of arms or fingers
- difficulty learning or understanding
- incomplete use of feet or legs
- nervous or emotional condition causing restriction
- restriction in physical activities or in doing physical work
- disfigurement or deformity
- mental illness or condition requiring help or supervision
- long-term effects of head injury, stroke or other brain damage causing restriction
- receiving treatment or medication for any other long-term condition or ailment, and still restricted
- any other long-term condition resulting in a restriction.



According to the most recent statistics for Australia:

- 3.4 million (15%) Australians have a physical disability
- 1 in 6 Australians are affected by hearing loss. There are approximately 30,000 Deaf Auslan users with total hearing loss
- Around 300,000 Australians have a substantial vision impairment (i.e. not correctable by glasses), with around 20,000 being totally blind
- Over 700,000 Australians have an intellectual impairment
- 10% of the population has dyslexia. That's more than two million Australians.
- More than 90,000 people have a mental health disorder

Source: <http://www.and.org.au/pages/disability-statistics.html>

Adaptive Device Design



Student Resource: Wheelchair Design Considerations

◆ Wheelchair History

Greek vases from 530 BC show wheels incorporated into furniture. And, in 535 AD an engraving shows a wheel chair, and King Phillip II of Spain had a wheelchair in 1595 -- so the need to use wheels to ease motion goes back a long way.



◆ What's New?

More recently, materials such as titanium have been used to improve the weight and manoeuvrability of wheelchairs. And, as wheelchair sports have become popular, engineers had to design additional features and capabilities into sport wheelchairs to meet the need of users who rely on the chair for speed and accurate movements.

◆ Material/Design Tradeoffs

Engineers have to weigh different considerations when designing a wheelchair. For example, they know that titanium is the best material in terms of strength to weight ratios -- but it is an extremely expensive material. On the other hand, carbon fibre is less expensive and durable. Different customers may prefer different materials. Engineers might seek to develop the most lightweight wheelchair -- a lighter chair would potentially reduce the amount of wrist injuries because the customer would have a lighter chair to manoeuvre. And, engineers might have to consider the type of tyres that made the most sense for a wheelchair. Also, the braking system is important -- how easy is it for someone with decreased mobility to use the brakes? What type of motor would work best for a motorised chair -- how fast is too fast? Will a new wheelchair design fit on standard wheelchair ramps? Engineers would have to completely redesign a wheelchair for use by children who may have different needs and braking abilities than adults. And, cost is always a big consideration -- if engineers design the best wheelchair, but it costs more than most people could afford, the product will fail.



◆ Research

In developing new designs, engineers might also conduct user surveys to find out what type of chair is most comfortable, most easy to move, most easy to brake. In addition, studies are done to determine the amount of oxygen a customer uses to move a chair, as an indication of how much energy is expended in making the chair move forward. Some motorised wheelchairs move so fast that crash testing is done to determine how the chair would protect a customer in the event of a crash.



Adaptive Device Design



Student Worksheet: Which Are Adaptive Devices?

As a team, complete the following worksheet, indicating which of the products below would be considered "adaptive devices."

Product	Adaptive? Yes or No	Why or Why Not	What Was the Engineers Goal?
Eyeglasses 			
Platforms 			
Baby Stroller 			
Watch that Speaks the Time 			
Walker 			
Headphones 			
Cast 			

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Student Worksheet: Component Parts

Step One: As a team, disassemble a pair of old, unusable sunglasses or glasses, using an eyeglass repair kit provided to you.

Questions:

1. How many component parts did you find?
2. What different types of materials (plastics, metals, glass) were part of the final pair of glasses?
3. If you were reengineering these glasses to make them safer, would you change the shape of any of the component parts? Why? Why not?
4. If you were reengineering these glasses to make them safer, would you change the materials used to manufacture any of the component parts? Why? Why not?

Step Two: Reassemble the glasses.

Questions:

5. What was the hardest part of the reassembly process? Why?
6. Do you think that assembly would be easier managed by a machine? Why? Why not?
7. How hard do you think it would be for a person with arthritis in their hands to reassemble their glasses?

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Student Worksheet: Your Adaptive Device Design

Throughout history, engineers have solved problems by developing products and systems to help people. In the area of adaptive engineering design, the goal is to create products that make life easier, healthier, and more independent for those who face challenges. The following is just a short list of the many devices that have been designed to help people and animals:

- wheelchairs
- walkers
- eyeglasses
- adaptive gardening tools
- hearing aids
- adaptive canoe seats
- replacement joints
- artificial limbs
- adaptive water-skis
- dressing aids
- safety bars for tubs
- adaptive fitness equipment
- shower chairs
- jar opening tools
- specialty computer mouse
- sleep apnea mask
- adaptive golf clubs
- steering wheels
- adaptive tricycles
- lifts for horses
- crutches
- playing card holders
- bedrails
- illuminated magnifiers
- oversized lamp switches
- adaptive video game joysticks

You are the Engineering Team!

Your challenge is to work as a team to either improve an existing adaptive product or come up with a new one that solves a specific problem faced by individuals (or animals) that face physical challenges.

State the Problems:

1. Identify a physical challenge which your product will help to alleviate (for example, a dog that has undergone back surgery still needs to be able to go for a walk).
2. As a team, develop on paper a new product or develop an improvement to an existing product that meet the need of the person/animal.
3. Present your ideas to the class in three forms:
 - describe how your product works, technically, in words...include the materials you think it would be made from, and what you think the product might cost.
 - draw an illustration of either your final product, or a situation where it is being used.
 - describe how your team believes that engineers have impacted the world.

Adaptive Device Design



For Teachers: Alignment to Curriculum Frameworks

Science Inquiry Skills

Year 5

With guidance, select appropriate investigation methods to answer questions or solve problems **(ACSI S086)**

Use equipment and materials safely, identifying potential risks **(ACSI S088)**

Suggest improvements to the methods used to investigate a question or solve a problem **(ACSI S091)**

Year 6

With guidance, select appropriate investigation methods to answer questions or solve problems. **(ACSI S103)**

Use equipment and materials safely, identifying potential risks **(ACSI S105)**

Suggest improvements to the methods used to investigate a question or solve a problem **(ACSI S108)**

Year 7

Collaboratively and individually plan and conduct a range of investigation types including fieldwork and experiments, ensuring safety and ethical guidelines are followed **(ACSI S125)**

In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task **(ACSI S126)**

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 **(ACSI S131)**

Year 8

Collaboratively and individually plan and conduct a range of investigation types including fieldwork and experiments, ensuring safety and ethical guidelines are followed **(ACSI S140)**

In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task **(ACSI S141)**

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 **(ACSI S146)**

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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 **(ACSI S165)**

Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data **(ACSI S166)**

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data **(ACSI S171)**

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 **(ACSI S199)**

Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data **(ACSI S200)**

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data **(ACSI S205)**

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
<ul style="list-style-type: none">Process data using simple tablesData analysis skills (graphs)Analysis of patterns and trendsUse of metric units	<ul style="list-style-type: none">LiteracyNumeracyCritical and creative thinkingPersonal and social capacityICT capability	<ul style="list-style-type: none">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.