Engineered Music

Lesson Focus

Lesson focuses on the engineering behind the design of musical instruments. Teams of students explore the engineering behind recorder manufacturing, and then design, construct, test, and evaluate a working musical instrument using easily found materials.

Lesson Synopsis

The Engineered Music lesson explores how musical instruments are engineered. Students explore how mass manufacturing impacted the recorder, and then work in teams to design their own musical instrument using easy to find materials. Student teams first design their instrument on paper, then build their instrument, and evaluate the strategies employed all student teams.

Age Levels

8-18.

Objectives

- Learn about engineering design.
- Learn about planning and construction.
- Learn about teamwork and working in groups.

Anticipated Learner Outcomes

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

- structural engineering and design
- problem solving
- teamwork

Lesson Activities

Students learn how musical instrument have been designed throughout history, and then work in teams to develop a design for their own instrument using everyday items. Teams plan their instrument, execute construction, test, troubleshoot, evaluate their own work and that of other students, and present to the class.

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)
- Musical Instruments of the World (www.asza.com/ihm.shtml)
- Museum of Musical Instruments (www.themomi.org)
- How Recorders Work (www.flute-a-bec.com/acoustiquegb.html)

Recommended Reading

- The Physics of Musical Instruments (ISBN: 0387983740)
- Music, Physics and Engineering (ISBN: 0486217698)
- Teaching Kids Recorder (ISBN: 0595367437)

Optional Writing Activity

- Pick a country or culture at a point three hundred years ago and write an essay or a paragraph about the challenges they might face finding materials to make a specific musical instrument (trombone, piano, guitar - for example).

Optional Extension Activity

- Purchase two or three clear plastic recorders for the class and disassemble so students can see the different parts that have been engineered.

For Teachers: Teacher Resource

Lesson Goal

The Engineered Music lesson explores how musical instruments are engineered. Students explore how mass manufacturing impacted the recorder, and then work in teams to design their own musical instrument using easy to find materials. Student teams first design their instrument on paper, then build their instrument, test it, and evaluate the strategies employed all student teams.

Lesson Objectives

- Learn about engineering design.
- Learn about planning and construction.
- Learn about teamwork and working in groups.

Materials

- Student Resource Sheet
- Student Worksheets
- One set of materials for each group of students: Nontoxic glue, string, paperclips, paper, cardboard, cardboard tubes (such as from paper towel or toilet paper rolls), paper, rubber bands, wire, aluminum foil, plastic wrap, tape, juice box, wooden dowels. (the materials list may be adapted to point students toward a specific instrument, such as a drum or a xylophone).

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. Divide students into groups of 2-3 students, providing a set of materials per group.
3. Explain that students will design a working musical instrument from materials.
4. Students meet and develop a plan for their instrument. They agree on materials they will need, write or draw their plan, and then present their plan to the class.
5. Note: The instrument must be able to repeat the same set of three different sounds in sequence three times to be a success.
6. Student teams may request additional quantities of any of the materials provided, up to two sets of materials per team. They may also trade unlimited materials with other teams to develop their ideal parts list.
7. Student groups next execute their plans. They may need to rethink their plan, request other materials, trade with other teams, or start over. This project may require overnight drying of glued segments before the performance phase.
8. Each student group presents and performs their instrument
9. Teams complete an /reflection worksheet, and present their findings to the class.

Tips

For younger students, focus on instruments such as drums, guitars, or xylophones which do not require students to put the instrument in or near their mouth.

Time Needed

Student Resource:
Sample Instrument - The Recorder

◆ Recorder History and Engineering Advances

The recorder is a woodwind musical instrument and is a whistle-like instrument similar to the tin whistle. It has holes for seven fingers and one thumb. The body of the recorder is usually tapered from the mouthpiece end. It was very popular in medieval times but declined in popularity in the 1700's when orchestral woodwind instruments (oboe, flute, and clarinet) came into favor because of their greater range.

While engineers are often involved in adapting new designs to musical instruments, either to improve durability, design, or performance, they also have impacted musical instrument mass production.

In the mid 20th century, engineers were able to design facilities to manufacture recorders out of plastic. This made them very inexpensive as so popularized the instrument in schools. Without the plastic manufacturing process, recorders would likely not be used much today. Now, they are one of the cheapest instruments to buy in bulk, and as they are reasonably easy to learn to play, it is an ideal instrument for teaching basic music performance, especially to young children.

◆ How the Recorder Works

The recorder is held straight out from the player's lips (rather than to the side, as with a flute). The breath of the player is constrained by a block (A) that limits how much air can enter the instrument. The air travels down a channel (B) that is called the "windway."

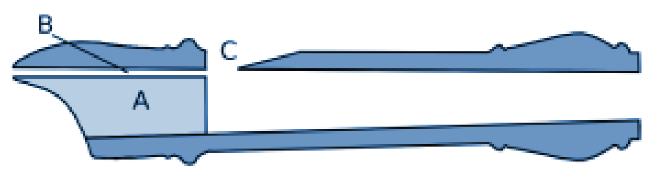

Image Source Public Domain (https://commons.wikimedia.org/wiki/File:Recorder300.svg)

As it leaves the windway, the player's breath hit the "labium" (C) which causes the column of air to oscillate. The length of the column of air is adjusted by finger holes in the front and a thumb hole at the back of the instrument. Adjusting how the fingers cover the holes will adjust the note produced by the air, and adjusting how hard the breath is blown will adjust the pitch. An instrument with fewer holes or a different length, or no block would create different sounds…or perhaps sounds that cannot be reproduced consistently.

Student Worksheet:
Build Your Own Instrument

You are a team of engineers who have been given the challenge of building a new musical instrument that can repeat a pattern of three different sounds three times.

◆ Research/Preparation Phase

1. Review the various Student Reference Sheets.

◆ Planning as a Team

2. Your team has been provided with some "building materials" by your teacher. You may ask for a duplicate set of materials, and may also trade materials with other student teams throughout the project.

3. Start by meeting with your team and devising a design and materials plan to build your structure. You'll need to figure out what building materials you require, and develop a sketch of your plan for review by your teacher. You may need to ask for additional materials or negotiate a trade of materials with other teams in order to plan your instrument.

4. Write or draw your instrument design in the box below or on another sheet. Include a list of materials you plan to use to build the instrument. Present your design to the class. You may choose to revise your teams' plan after you receive feedback from class.

Materials Needed:

Student Worksheet (continued): Build Your Own Instrument

◆ Construction Phase

5. Build your instrument! If you used glue, you may need to let glue dry overnight before testing your instrument.

◆ Performance Phase

6. Each student team will have a chance to perform their instrument for the class.

◆ Evaluation Phase

7. Evaluate your teams' results, complete the evaluation worksheet, and present your findings to the class.

Use this worksheet to evaluate your team's results in the Engineered Music lesson:

1. Did you succeed in creating an instrument that could repeat a pattern of three different sounds three times? If not, why did it fail?

2. Did you need to request additional materials while building your instrument?

3. Did you negotiate any material trades with other teams? How did that process work for you?

4. Do you think that engineers have to adapt their original plans during the manufacturing process of instruments or other products? Why might they?

Student Worksheet (continued):

5. If you had to do it all over again, how would your planned design change? Why?

6. What designs or methods did you see other teams try that you thought worked well?

7. Do you think you would have been able to complete this project easier if you were working alone? Explain…

8. How do you think the engineering designs for musical instruments have changed over time? What impact has the development of new materials had on the engineering plans for musical instruments?

9. What impact has the development of electronics had on the engineering plans for musical instruments?

10. What engineering considerations are needed in musical instrument design to accommodate physically challenged musicians?

For Teachers:
Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆**National Science Education Standards Grades K-4 (ages 4 - 9)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of the activities, all students should develop an understanding of

- Properties of objects and materials

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design

◆**National Science Education Standards Grades 5-8 (ages 10 - 14)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of

- Motions and forces and Transfer of energy

CONTENT STANDARD E: Science and Technology

As a result of activities in grades 5-8, all students should develop

- Abilities of technological design

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in society

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Science as a human endeavor

◆**National Science Education Standards Grades 9-12 (ages 14-18)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop understanding of

- Structure and properties of matter
- Interactions of energy and matter

For Teachers:
Alignment to Curriculum Frameworks

◆**National Science Education Standards Grades 9-12 (ages 14-18)**

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in local, national, and global challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Historical perspectives

◆**Next Generation Science Standards Grades 2-5 (Ages 7-11)**

Matter and its Interactions

Students who demonstrate understanding can:

- 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

Waves and Their Applications in Technologies for Information Transfer

- 4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

Engineering Design

Students who demonstrate understanding can:

- 3-5-ETS1-1.Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2.Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

◆**Next Generation Science Standards Grades 6-8 (Ages 11-14)**

Engineering Design

Students who demonstrate understanding can:

- MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

For Teachers:
Alignment to Curriculum Frameworks

◆**Standards for Technological Literacy - All Ages**

Technology and Society
- Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.
- Standard 7: Students will develop an understanding of the influence of technology on history.

Design
- Standard 8: Students will develop an understanding of the attributes of design.
- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World
- Standard 11: Students will develop abilities to apply the design process.

The Designed World
- Standard 20: Students will develop an understanding of and be able to select and use construction technologies.

The Nature of Technology
- Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.