ENGINEERing challenge workshop for science museums in the field of sound & acoustics

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Workshop ID card

Name of the workshop: Let's hear!

The Challenge: Build a simple string instrument

The Engineering field: acoustics

The science field: sound

Target audience: Families with children from the age of 8 and / or pupils grade 3-5

Type of activity: workshop

Duration of activity: 45 minutes

Specific notes: the workshop can best be held in a classroom-like room, which can be closed off from surrounding noise

Context

This workshop teaches what sound is, what the difference is between a high pitched a low pitched sound and how this knowledge can be used to create a simple musical string instrument.

Maximum number of participants: 30
Number of facilitators (intern): 1
Location: classroom-like room, which can be closed off from surrounding noise
Set up time needed: 15 minutes

General objectives

The Engineer Museum Activities:

- ✓ Offer the participants to find and experiment different solutions to solve a "real" engineer problem
- ✓ Give a new perspective on Engineering as a field, a process, a way of thinking and working
- ✓ Introduce and exemplify the EDP (Engineer Design Process: Ask, Imagine, Plan, Create, Improve), or part of it
- ✓ Give the participants the possibility to reflect on what they have done and how the Engineers work.
- ✓ Are based on IBSE - Inquiry Based Science Education and are not gender oriented.

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Specific unit objectives

Participants of the Engineer Museum Activities Let's hear:

- ✓ Learn to look at sound in a scientific way;
- ✓ Learn that sound is a vibration;
- ✓ Learn that sound needs a medium to travel;
- ✓ Experience that a tight string produces a high pitched tone;
- ✓ Experience that a more loose string produces a low pitched tone;

Contact Person

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Resources

Material	Total amount	Expendable	Non- expendable
Tuning fork	10		✓
Ping pong ball on a string	10		✓
Slinky	1		✓
Wooden blocks (+/- 25x 2x5 cm)	20	✓	
Fishing thread (0,3 mm)	5 spools	✓ (1 meter per participant)	
Eye lag	80	✓	
Paper cups	20	✓	
Tape	5 rols	✓	
Dental floss	5 boxes	✓	
Hand drill	10		✓
Scissor	10		✓
Blunt embroider needle or perforating tool	10		✓
Large illustration of the EDP	1		✓
Computer with internet access, beamer, screen	1		✓
Tables	4 (5 participants per table)		✓
Chairs	20		✓

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The workshop

1. Introduction

Welcome the participants and tell who you are.

1.1 Sound in science

- Ask the participants how to describe sound.
- Tell them that they will do some short experiments to investigate sound.
  Show them a tuning fork.
  Show them how to use a tuning fork: let it bounce gently on the edge of the table with one of the tines of the fork and hold it next to your ear.
  Who knows how it works and what it is used for?
- Tell that they are going to do two experiments, they work in pairs.
  1. Every couple gets a tuning fork and a ping-pong ball on a string. Work together! Take the ping-pong ball and hold it vertically by the string. The partner can strike the tuning fork, hold it very gently against the ball. What happens?
  2. You can also strike the tuning fork and hold it against the different materials on your table, or against the table itself! Try out whether it makes any difference if you hold the tines or the handle against different materials. Try to make the sound as loud as possible <u>without striking it harder</u>. Go ahead and try it out!
- Ask for the attention of the audience, so you can talk about the conclusions of the experiments.
  1. What happens when you hold the tuning fork against the ping-pong ball?
     Answer: the ball is set in motion. You can see for yourselves that the tuning fork vibrates; this causes the sound it makes. The vibrations are transferred to the air and travel through the air to your ears. <u>Conclusion: Sound is a vibration.</u>
  2. What happens when you hold the tuning fork against something else?
     Answer: You hear a sound and sometimes the sound becomes louder! This is because the material helps the tuning fork to transfer the vibrations to the air. It vibrates along with the tuning fork. You also hear a slightly different sound because the material is not a tuning fork.
- How is it possible that the vibration of the tuning forks gets into your ears?
  How does sound travel?

1.2 Sound needs a medium to travel

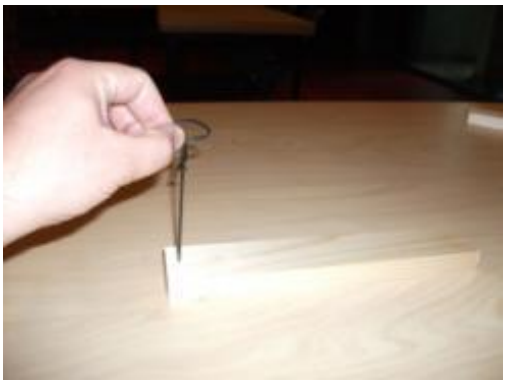
- Tell the pupils we already discovered that sound is a vibration. Moving sound is called a sound wave.
  Who knows what a wave is? *The pupils may come with waves in the sea.*
  What is a wave in the sea? *In the sea a wave is water that is travelling.*
  Is this the same for sound in the air? *No it is not. In air the sound is passed by air, the air is not 'blown' by the sound.*
- Demonstrate this with a slinky. Put the ends of slinky about 80 centimetres apart and push a wave in motion. Let the participants observe.

- Do they see the wave (area of compression) go from one side to the other? *Yes.* Slinky moves from side to side and then it returns to its original position. Sound travels the same way. The air moves a little, but it doesn't blow the sound in your ear. The air particles are set in motion, the vibration travels through the air.
- Show short movie of wave in stadium. Make the comparison with a wave in a stadium, not the people are moving from one end of the stadium to the other, the wave is. Links: http://youtu.be/6SGeUVOP3GE (2012-05-26 Denmark - Brasil | Wave going through the stadium)
- So sound needs a medium to travel, air for example. Do you think sound moves only by air? Could it also move through this table? Let everybody lay an ear against the table and tap with their hand on the table. What do you hear? Sound is passed through by the wood of the table.

2 The main activity

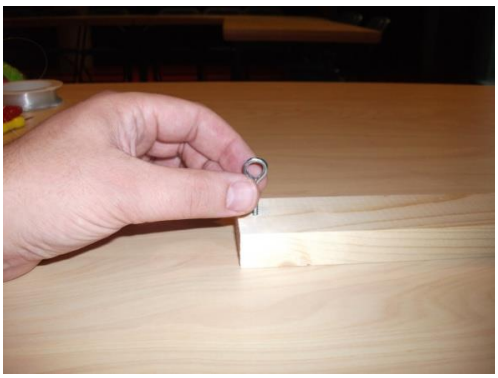
The participants are building there instrument here. Guide them through the process. Safety is important here, because they will be working with tools.

2.1 Instruction



Use an example instrument if necessary. The participants can build their instrument themselves after the instruction.

1. Drill a small hole on each end along the length of the wooden block (it doesn't matter so much whether they do this on the broad or on the narrow side). The hole doesn't need to be deep, it is just to prepare a small hole to screw the screw eye more easy in!
2. Screw two eye lags in the holes.
3. Choose a type of string, using the scissors, cut of a length twice as long as your wooden block and attach it to the eye of the screw eye. Put the string through the eye of the screw, pull it tight and wind it once around the bottom.



4. Make a resonance box for from a paper cup. Make a hole in the middle of the bottom of a paper cup, use the perforating pen. Pull the string through the hole and attach the string at the other screw eye.
5. Now carefully try to tighten the screws so the string winds around it at each turn and is pulled tighter. Try to pull the string so tight you can pluck it and it makes sound.

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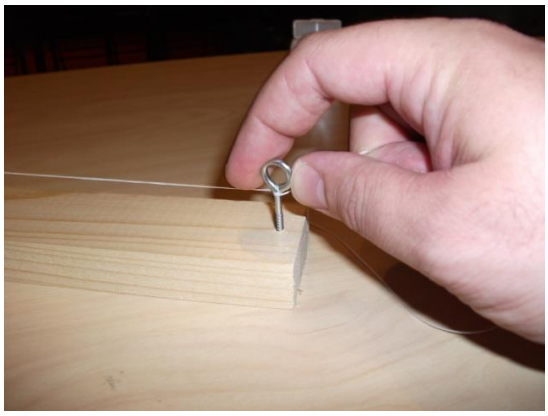
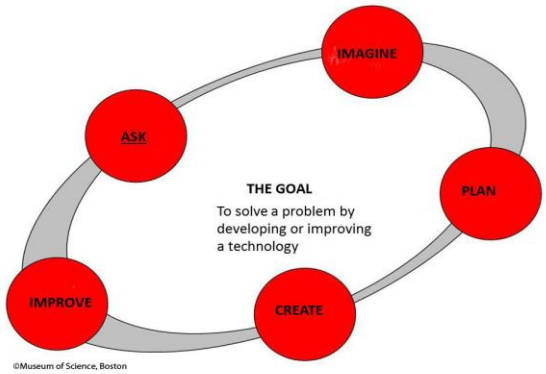
6. Add another string of a different material. The best they can make this on another side of the wooden block.



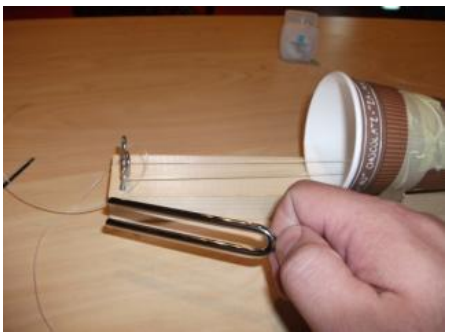
7. The simple string instrument is done! Test it out!

2.2 Possible improvements



- Ask attention from the pupils. Introduce the EDP.
- When you want to solve a problem by developing or improving a technology you can use the EDP.
- Show the EDP and name the steps. Then go through the steps with examples.
- **ASK -** In this step you think of things you need to know. For example: how can I influence the sound of a string? What is sound? How do I make a high/low pitched sound?
- **IMAGINE -** what are possible solutions? What am I going to make? We didn't do this step.
- **PLAN -** what are the materials I am going to use. I gave you the materials and said how to build it.
- **CREATE -** after planning it's time to start building, following your plan. You did this!
- I**MPROVE -** is there something you want to improve? Let the pupils answer. And tell them they can take their instrument with them and improve it at home or at school.

Tip: if some participants are fast: let them try to tune the instrument using the tuning fork. Strike the tuning fork and listen to the sound. Now pluck the string of yo ur instrument and listen to the sound. Is the sound higher or lower than the tuning fork? Try to make the sound the same. Remember that a tighter, shorter string vibrates faster and creates a higher sound. So if you want a higher sound you have to make the string tighter (shorter).



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3.0 Conclusion

What did we find out during this workshop?

- Sound is a vibration.
- Sound needs a medium to travel
- The tighter the string the faster the vibration.
- The faster the vibration, the higher the sound.
- Using a resonance box will help you to amplify sound.

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Information for the facilitator

Background information

- Sound is a pressure wave travelling through a medium (often air or water). Without a medium (for example in vacuum)it is impossible to hear sound. Your ear contains the eardrum which vibrates along with differences in pressure in the surrounding medium. The vibrations are passed through to your inner ear where it is transformed into electrical signals that travel through nerves to your brain where the sound is interpreted.
- A sound has two parameters: frequency (pitch of the sound) and amplitude (loudness of the sound) The frequency means the speed of the vibrations. If the vibrations follow each other very fast, you get a high sound. Frequency is measured in vibrations per second (Hertz). The amplitude means the relative difference between the highest and the lowest pressure in the wave. If the sound causes very large differences in pressure in the medium, it is very loud. Amplitude is measured in Decibel.
- A musical instrument is essentially a device to create vibrations of different frequencies and transfer those vibrations to the air as sound. The way the sound is created and how it is transferred to the surrounding air determines what the instrument sounds like. An instrument usually makes a range of different frequencies: a ground note and several overtones. What those are and how loud they are relative to each other determine the timbre of the instrument.
- A tuning fork is an instrument that creates a very pure note, without any overtones. The characteristic shape of the fork causes this. This makes a tuning fork ideal for tuning other instruments.
- The size of an instrument determines for a large part how high or low a sound is, not how loud it is. A long string or pipe creates a slower vibration, therefore a lower frequency and a lower sound. Tuning means making a pipe (in case of a flute) or string (in case of a violin or guitar) longer to create a lower sound or shorter to create a higher sound. String instruments have to be tuned regularly because the strings are flexible. They stretch over time. They become less tight and produce a lower sound. When tuning, you have to tighten them to make them as short as they used to be.
- A resonance box is a hollow part of a musical instrument that vibrates along with the vibration that is created. We call this resonance. A sound box resonates along with the ground note but also to a greater or lesser extent with the overtones. It transfers these vibrations to the surrounding air. In this way a sound box amplifies the sound of a musical instrument, but also determines what it sounds like, it's timbre.

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FAQ participants can ask

- Q: Does a larger instrument make a louder sound?
  A: No, a larger instrument makes a lower sound than a small instrument. It becomes louder if you play it harder
- Q: Why does making a string tighter make the sound higher?
  A: This is because when you make a string tighter, you make it shorter and it vibrates more quickly, a faster vibration makes a higher sound
- Q: Why does a tuning fork have such a peculiar shape?
  A: Because it makes a purer note than a string or a bar. This makes it more suitable to tune other instruments, also, because of the shape; you can hold it at the handle without dampening the vibration of the tines.
- Q: How does a sound box work?
  A: It vibrates along with a string or a tuning fork and increases the amount of air that starts vibrating, so you can hear the note better. Also it changes the sound because it is made from a different material that vibrates in a different way.
- Q: How does an electric guitar work?
  A: An electric guitar doesn't have a sound box. It has a magnetic element. An element transforms the vibrations of the strings into electric currents. These have to go through a wire to an amplifier that transforms them back into a (louder) sound.

Problems you can encounter

- The workshop is designed for children of 8-12 years of age. The children have to have some fine motor skills as well as strength in their hands to tighten the strings, get the screws in etc.
- Children generally have no experience with how a tuning fork works. You have to show them exactly how to use it, or they won't understand and won't get any sound out of it. For example, they will hold it at the wrong end, bang it flat on the table or hit the table and don't pull back so the sound is dampened.
- Because this is an interactive workshop about sound, where possibly 30 participants start experimenting, you may get a lot of noise in your workshop room. It can be useful to agree upon a non-verbal sign that the children have to copy when the facilitator shows it, in order to quiet the group down.

Tips & tricks regarding the materials

- Use pinewood or another soft kind of wood for the workshop.
- Most materials are available from the DIY shop. Fishing threat and ping-pong balls are available at the toy store. You can get tuning forks either from a store that sells musical instruments or educational materials. The most readily available kind of tuning fork is an A (440Hz) they cost between €5,- and €8,- a piece. Other kinds of tuning forks may have to be bought in a set for educational purposes.
- Dental floss works very well as a string, it is cheap and not hard to make knots in.

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