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STEM
E-CONTENT
3D VIRTUAL REALTY

The Key To Global Life,
Digital Change Of Nature

Total Duration: 1 week

Student's Age: 12-18 Years

Application Area:
- Electronic Recycling,
- Design, Technology,
- CAD Design,
- Materials Science,
- Maths.

Keywords: Recycling, electronics, Reuse, Design, Recycling, Conversion Economy, Life Cycle Assessment

E5 - Do It Yoursel Fog machine

Module
- Environmental pollution
- Global Warming

E5 - English Version

Materials:
- (Broken) electronic household items
- Handheld tools (claps , pliers , screwdriver,...)
- Soldering station
- 2D design software (e.g. inkscape)
- 3D CAD software (e.g fusion360, tinkercad , siemens nx , onshape,...)
- A working fog machine
- Optional: digital machines to make parts for the now item or machine

Notes:
- Electronic waste contains many components that are usable after the device has broken down. Due to ignorance, we often throw away the entire device while it can be a source of usable parts.
- Many electrical appliances contain precious metals and other precious raw materials.
- Always work safely when opening a device, wear safety goggles and use the right tools correctly.

Introduction

Electronic waste. Many electronics go to waste due to the rapid expansion of technology and the consumption driven society. For example, a Dutch household consisting of two parents and two teenagers has an average of four smartphones, a computer, a tablet, two laptops, two TVs and gadgets as connections to a printer at home, household appliances not included. Where do all these equipment go when at the end of their life cycle?

When we throw away electronic devices we are creating e-waste!

E-waste is the term used to describe any discarded electronic device or a product that contains electronic components. That includes anything that uses electricity, either from a power outlet or a battery.

Improper e-waste disposal in landfills or other non-dumping sites pose serious threats to current public health and can pollute ecosystems for generations to come. When electronics are improperly disposed of and end up in landfills, toxic chemicals are released, impacting the earth's air, soil, water and ultimately, human health.

E-waste contains a wide variety of materials that affect the environmental impact of e-waste, including:

- Metals
- Plastics
- Hydrocarbons
- Other toxins

You may use the following table as a reference of terms you want the pupils to learn and understand.

Accumulate	Build up over time
Consumer demand	The amount of a product that people want to buy
Decompose	Go rotten and break down
Electronic	An electrical item than includes computer chips, like a mobile phone, tablet, laptop or TV
E-waste	Old electronic items that are thrown away
Landfill	Waste that is buries in the ground
Metal	A solid, conducting material like copper, steel or gold
Natural resource	Materials found in nature that are used for energy or to make things
Plastic	An insulating material, made from oil, that can be molded into different shapes
Pollution	A harmful or poisonous substance in our environment
Recycle	Collect waste and turn it into new things
Re-use	Use an old item again
Toxin	A poisonous substance

Considerations

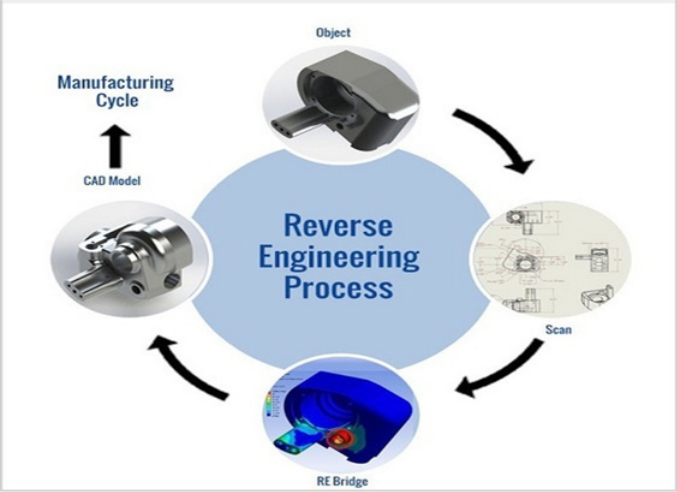
- Electronic waste contains many components that are usable after the device has broken down. Due to ignorance, we often throw away the entire device while it can be a source of usable parts.
- Many electrical appliances contain precious metals and other precious raw materials.
- Always work safely when opening a device, wear safety goggles and use the right tools correctly.

Aim of the Activity

- To learn about the problem of electronic waste
- To understand the meaning of e-waste
- To know how e-waste can pollute the environment and cause a problem
- To know that unwanted electronic goods can instead be re-used or recycled
- To be motivated to take practical steps to reuse or recycle unwanted electronic goods and play a personal part in preventing e-waste
- To engage in the creative challenge to create a working device by hacking and/or combining discarded machines.
- To learn about reverse engineering and learn to apply the reverse engineering design process
- To reconstruct the working of devices through reverse engineering.
- To work iteratively following the design cycle.
- To define environmental protection
- To explain the importance of reuse and recycling and their environmental protection.
- To engage in design processes where one make or use 2D or 3D digital drawings
- To learn about product design

Activity Process

Before Activity



Picture 1. Reverse Engennering Process

Discussion:

Discuss with the students different ways to minimize e-waste and consider “art from trash” as a possibility to prolong the life of devices and give parts a different function as well as a way to raise awareness about the problem of e-waste.

Introducing the principles of reverse engineering the teacher can let the students discover how to combine reusable parts to make new things and new working devices.

The teacher can start by letting the students collect and dismantle discarded devices and let them sort the parts by type. Then the students are asked to design a concept they want to make with these objects.

Before starting making, the teacher introduces the principles of reverse engineering (Picture 1).

What is reverse engineering (RE) ?

Reverse engineering (RE) is the process that identifies a physical object's properties by performing a comprehensive analysis of its structure, functions and operations. Measurements of the object's full surface geometry are taken, either manually or with various 3D measurement technologies, to create a 3D digital representation of the object.

RE is a systematic procedure to analyze consumer goods or systems in a destructive way. It allows manufacturers to understand how a part was designed in order to either replicate it, or make modifications or enhancements.

Reverse engineering is also known as back engineering. Because reverse engineering teams work "backwards" from the original design process; they start with the end result, deconstruct the product, and carry out assessments and measurements in order to obtain the physical design information.

Explore with the students different aspects of reverse engineering. Below we give some pointers you can discuss.

Applications of reverse engineering. RE is distinguished in 2 big groups.

- In the abstract world of coding and algorithms (software)
- Objects and products.

Designing countermeasures:

Like a lot of things RE is first used in the army for the purpose of designing countermeasures, like a gasmask or a bulletproof vest. Luckily, this was not always for cruel intentions but also for saving lifes.

Improving existing products:

The R & D department in a company does 2 things : inventing new objects or products and optimize the performance of existing objects. When a team of designers wants to improve their vision of an object they take it apart and analyze every step and part of the product. By this way, a team of engineers gathers new insights. This is mostly done by a new team of designers who didn't develop the first object.

Creating add-ons:

If a manufacturer wants to produce new tools or add-ons for existing products (water hose on a tap, expresso pads for expresso machine). It is crucial that every product fits perfectly and not all made by the same manufacturer. The designers of the new product will RE the object where the add-on should fit on. It is not just only important in an industrial context but also in the maker community. For example, if a maker is making an aid for somebody with a disability, it is important to measure the dimension of the tools and person. By this way, the add-on will fit perfectly.

Determine market position:

It is important for a company to define his market position and to analyze the products of their competitors carefully because it is a gray area that can be seen as plagiarism.

Recycling:

In the current situation, it is very important to recycle products and components. If you want to recycle or reuse parts or products, it is very important that it is known from which materials it is made. Not only for recycling purposes but also for reusing specific components. The only way to discover this is to RE the objects or code.

Modeling a freeform object:

Everything that is made is first designed on the computer. This is called a CAD (computer aided design) model. For an engineer, it is his daily day work. But if it is an organic product, it is very difficult to draw it on the computer. Then the common method is making the model by hand (clay , wood , foam ,..) and take a 3D scan which delivers the designers an editable CAD file. The car industry uses this method quite frequently.

Reverse engineering for makers:

It's not always possible for a maker to fabricate or design a complete product. Sometimes it is necessary to use parts of other objects. As a maker, it is not always funny and educational to analyze every part of a system or object, hacking objects and breaking them but it is basically what a maker does. In the wide interpretation of the word, this is reverse engineering.

Let's Start

The students will create a working machine using parts from discarded electronic devices. As an example, they can either read or try the tutorial From hairdryer to smoke machine

Please check the document:
Hairdryer to smoke machine

1 Preparation Phase:

The preparation phase consists in two parts. In the first one, the teacher introduces the e-waste problem to the students through discussions and easy research assignments. The aim is to let them develop a personal response to the e-waste challenge. In the second part, they prepare and make the creative design (engineering). Making a device or a art piece from discarded electronics is the challenge.

Start discussions and let the students do some research using the leading question: "Which electronic items do we own?"

1. Let students survey their peers or family and quantify which items they all have, and optionally how they feel about recycling. Let them present their findings in a bar chart or as tallies. To help students to identify what their surveys could include suggest:
   - List or count how many electronic goods they own (e.g. by each person ticking or circling items on a list)
   - What are the most common popular items?
   - Which of these items might get replaced most often?
   - Explore attitudes and understanding (e.g. through yes/no questions or ' scale' questions where each person circles a number to show how strongly they agree or disagree with a statement)
   - What are students' families' attitudes towards recycling e-waste?
   - Which items do students think their families need most encouragement to reuse or recycle?

2. Discuss with the students different ways to minimize e-waste and consider "art from trash" as a possibility to prolong the life of devices and give parts a different function as well as a way to raise awareness about the problem of e-waste.

3. Collect discarded electronic devices and set up one island in your classroom to test and to analyze an existing (fog) machine. Execute this part as a group.
   - Collect discarded electronic devices, in particular some hair dryers.
   - Divide students into groups by their interests.
   - Set up a workshop to take apart discarded electronic devices.
   - Investigate the working of one machine in detail.

4. When dissecting a (fog) machine keep the following in mind.
   - Take apart the machine while trying not to break (too many) pieces. You will need the pieces!
   - Investigate. Once the device is open, examine and discuss each component. What material is the component made out of ? How is that component connected to other components? What purpose does it serve?
   - Draw. Sketch the inside of the machine and write down what you think a part's function is.

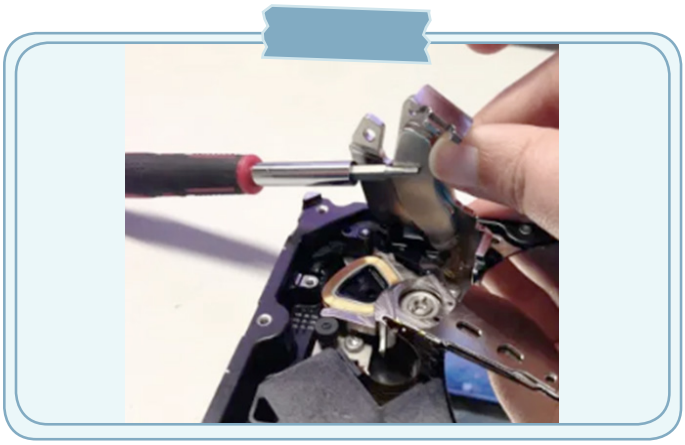
5. Review with the entire group how you can hack the components and transform them into new machines. Use the tutorial Hacking the hairdryer.
6. Make sure you have access to a laser cutter to cut MDF and a 3D printer to make other components you need to finalize your new machine.

2 Design Steps:

The challenge is to create a machine from discarded electronic devices.

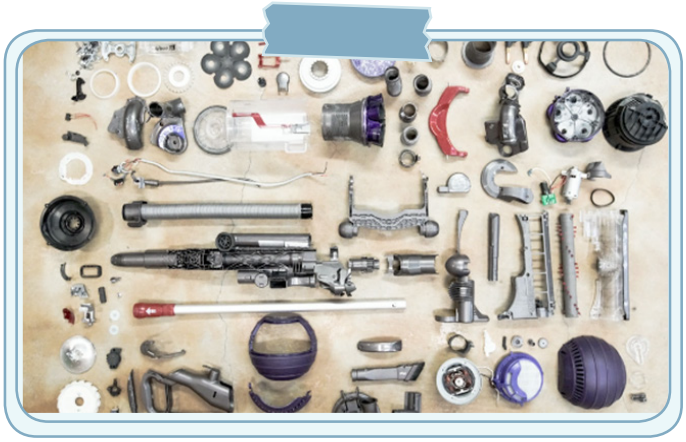
1. Understanding how a machine work:

Take a working machine apart. Identify and classify parts (Picture 2).



Picture 2. *Parts of working machine*

Picture 2. *Understanding how a machine work*



Picture 3. *Electronic devices*

When identifying parts, note in a table the following information: what do they do, what is their relation to the other parts, and keep track of the process in a table as for example the one given below:

no.	***part***	***description***	***function***
0	push button	(.....)	turning the machine on and off.
1	(.....)	(.....)	(.....)
2	(.....)	(.....)	(.....)
3	(.....)	(.....)	(.....)
4	(.....)	(.....)	(.....)
.....	(.....)	(.....)	(.....)

2. Reflect:

Write down in your own words how the machine works.

- Take care to answer this question: What are the essential parts needed to make it work?
- Search in internet to find if you can have extra information.
- Make a schematic presentation of the workflow of the machine.

3. Get inspired and get insights:

The challenge by reading the tutorial From hairdryer to smoke machine. Search internet information for inspiration and examples (Picture 4).

Please check the document:
Hairdryer to smoke machine

- Brainstorm with the members of your group and design what you are are going to build.
- As a group, make a sketch/mindmap of/ for the chosen design. Choose parts of the dismantled electronics and build your own machine.
- Remember that the chosen design doesn't have to be useful, it can also be a decorative piece. But it should do something, eg. make light or sound.

Picture 4. *Examples of Design pieces*

Closure

- Design the case for the machine and make it either via laser cutting or 3D printing. If these tools are not available, use common hand tools or make cardboard prototypes (Picture 5).
- Wrap up and showcase the creations in the school.

Picture 5. *Examples of prototypes*

Assesment

Evaluation

- This activity is expected to improve students'ability to conduct a work group and to use the engineering design cycle steps and becoming confident with the reverse engineering process. Students are evaluated by the teacher and other students. The evaluation concerns the following main objectives:

Goals	Must be Improved (1)	Medium (2)	Good (3)	Very Good (4)
Understanding the impact of e-waste on environment	(.....)	(.....)	(.....)	(.....)
Explaining some risks and problems when e-waste is sent to landfill and identifying steps to prevent e-waste.	(.....)	(.....)	(.....)	(.....)
Understanding the many ways in which e-waste can be re-used or recycled	(.....)	(.....)	(.....)	(.....)
Listing some ways that a whole item, its parts or materials could be (re-) used	(.....)	(.....)	(.....)	(.....)
Self expression	(.....)	(.....)	(.....)	(.....)
Join discussion	(.....)	(.....)	(.....)	(.....)
Appropriate reporting of collected data (survey of families attitude about e-waste)	(.....)	(.....)	(.....)	(.....)
Development of the design project	(.....)	(.....)	(.....)	(.....)
Appropriate design to the function	(.....)	(.....)	(.....)	(.....)
Effectiveness of the presentation	(.....)	(.....)	(.....)	(.....)
Total				

Links

- Wikipedia – electronic waste https://en.wikipedia.org/wiki/Electronic_waste
- European Recycling Platform e-waste http://www.erp-ewaste.co.uk/
- e-waste's 'toxic mine' (Independent article - consulted december 2022): https://www.independent.co.uk/news/world/politics/electronic-waste-worth-ps34bn-piling-up-in-toxic-mine-warns-un-report-10187364.html
- E-waste article from Ethical Consumer - consulted december 2022: https://www.ethicalconsumer.org/technology/e-waste-toxic-techno-trash
- E-WASTE QUADCOPTER LIFTS YOUR SPIRITS WHILE KEEPING COSTS DOWN: hackaday.com/2014/04/01/e-waste-quadcopter-lifts-your-spirits-while-keeping-costs-down/
- Smoke machine: https://bit.ly/mistmachineDIY
- Hack-A-Lantern: Recycled Computer Power Supply Flashlight: https://www.instructables.com/Hack-A-Lantern-Recycled-Computer-Power-Supply-Fla/