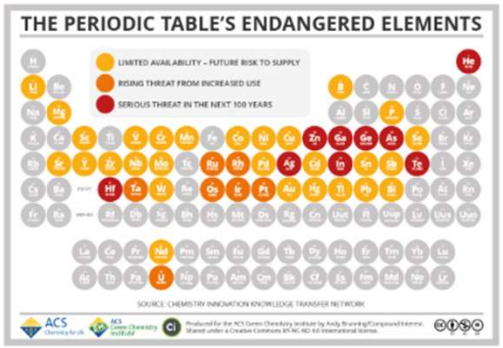
“Don’t Throw Away your Mobile!” Pupils’ Perception of Raw Materials in Electronics



Marica Canino

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What is a raw material?

The basic material from which a product is made

Al

glass

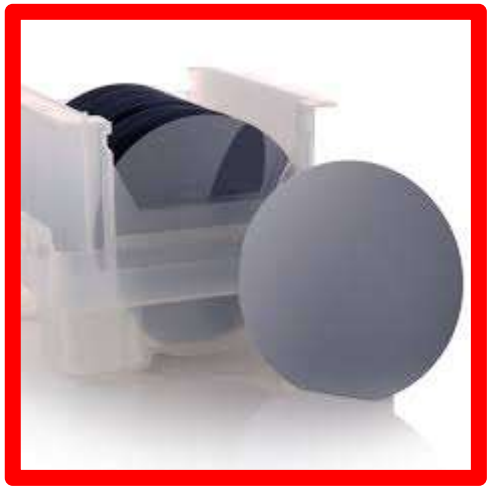
Raw materials in electronics

The most important is Silicon

It is extracted from sand (SiO_2)…

…then purified (Si)…

… takes a crystalline form and …
eventually it is cut in slices



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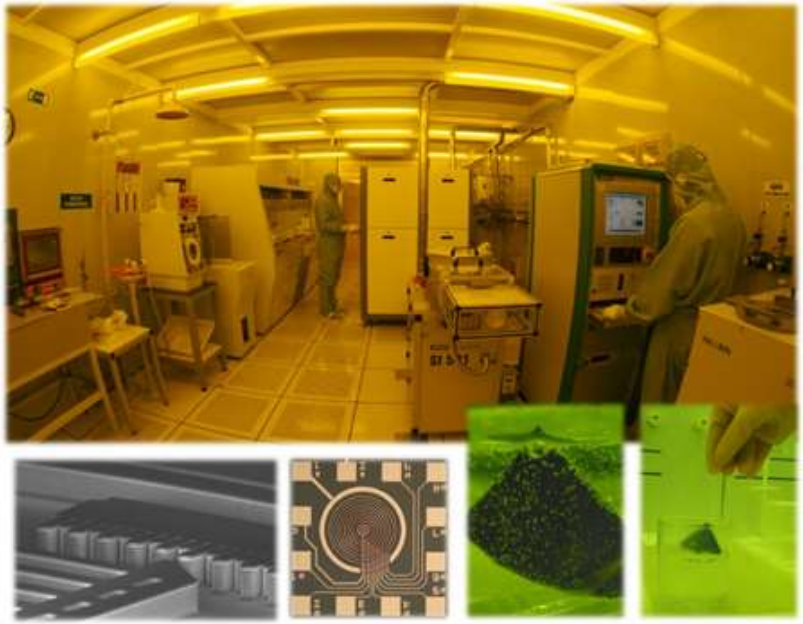
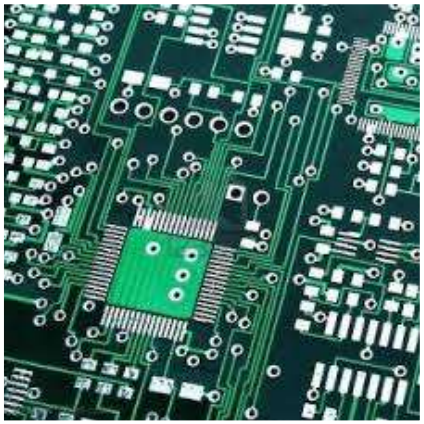
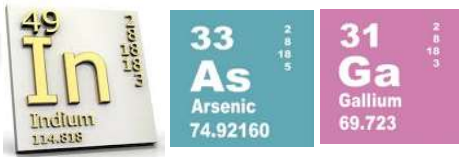
Silicon slice (wafer) micromachining to produce devices





Emerging electronic technologies

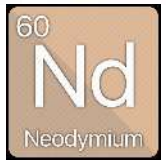
SOLAR PANELS



LIGHT EMITTING DIODES (LED)

FIBER OPTICS

ELECTRIC CARS



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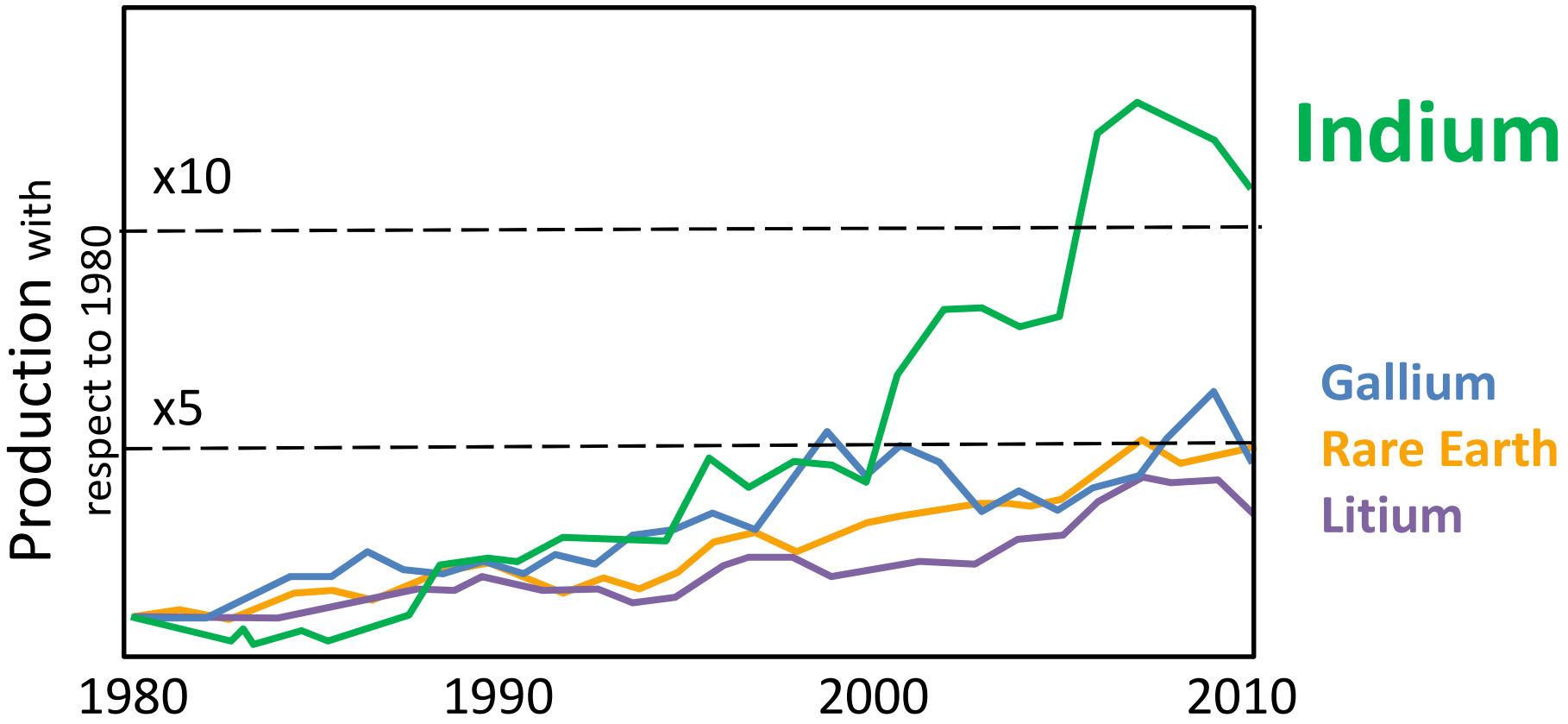
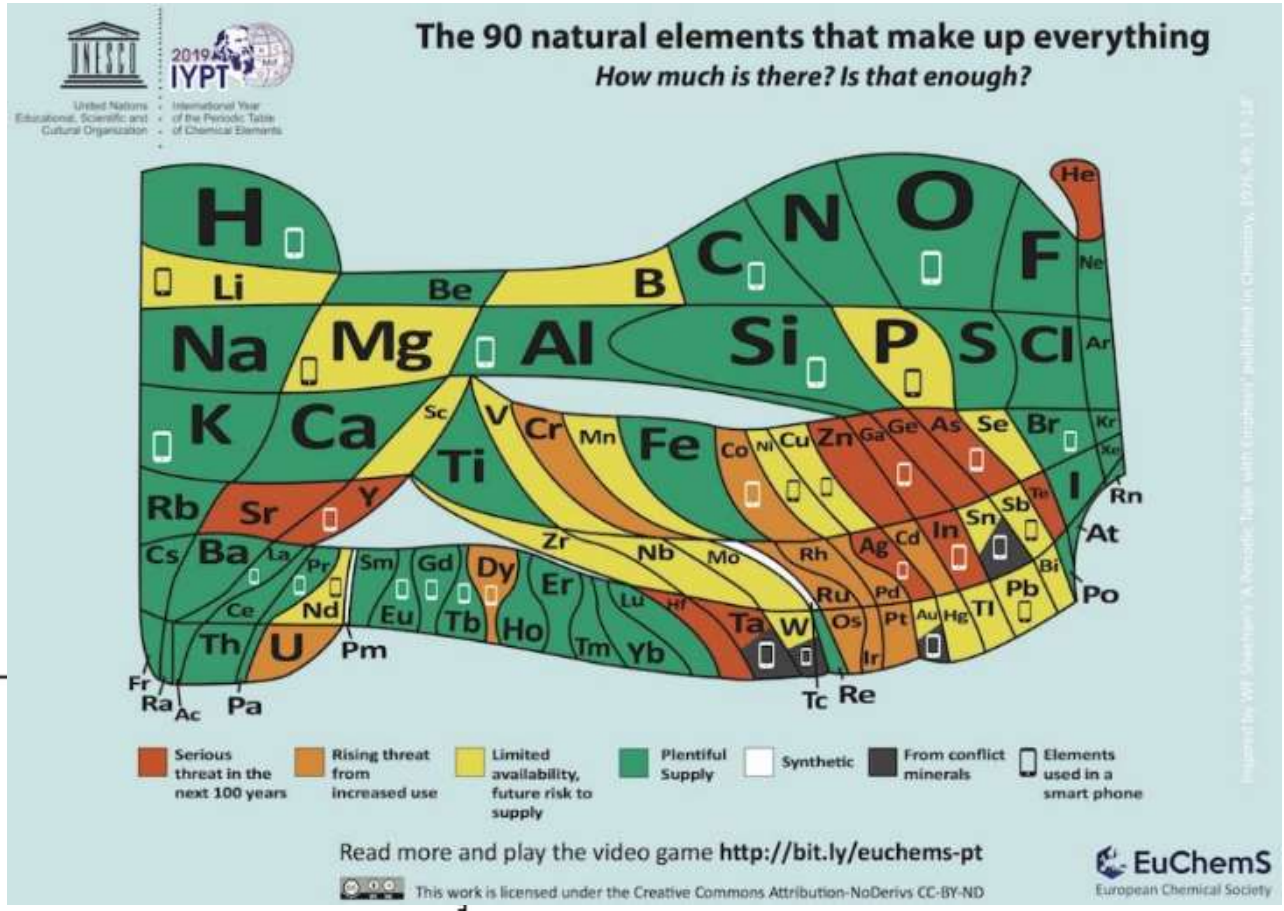
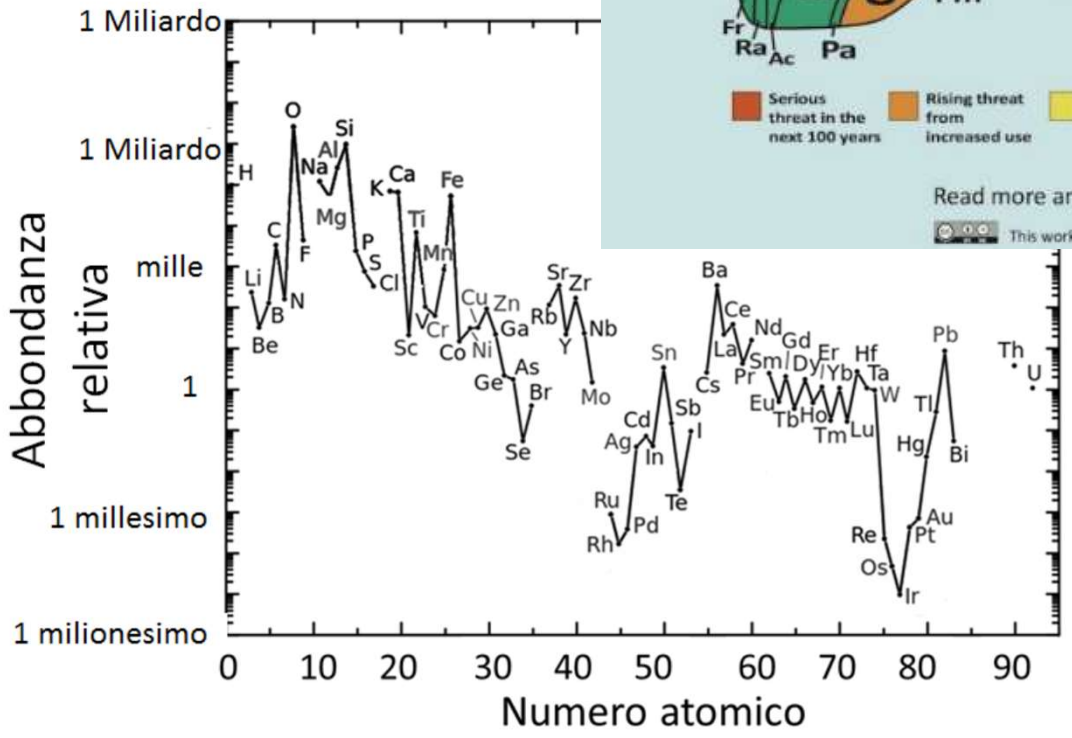
Growing use

Rapidly growing consumption in the last decades



Abundance





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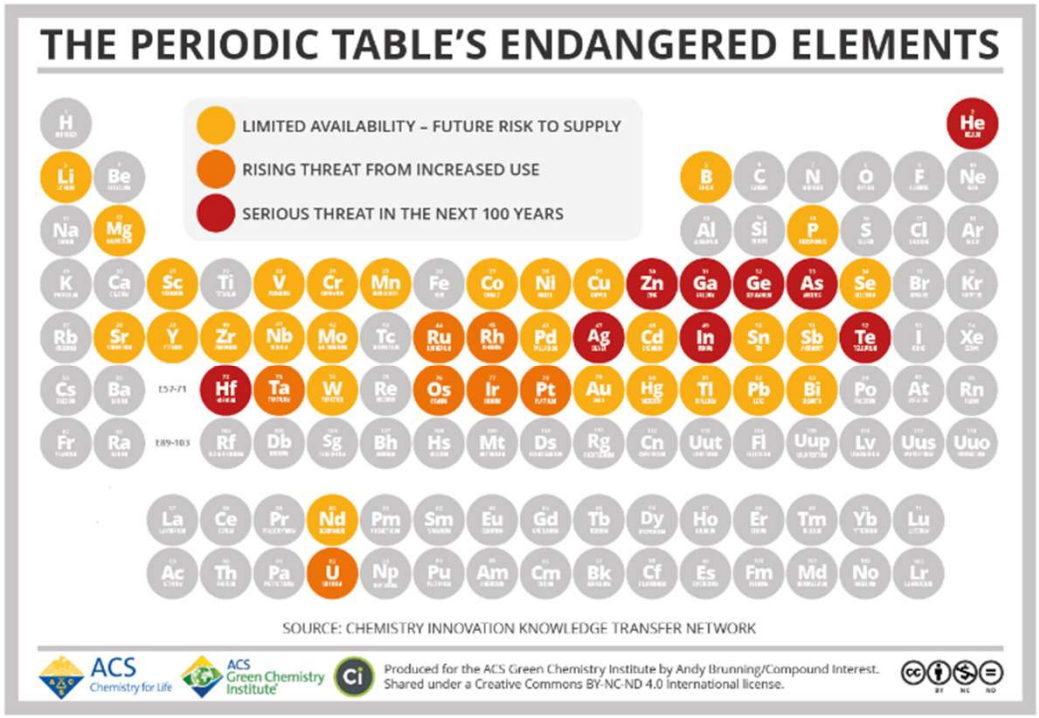
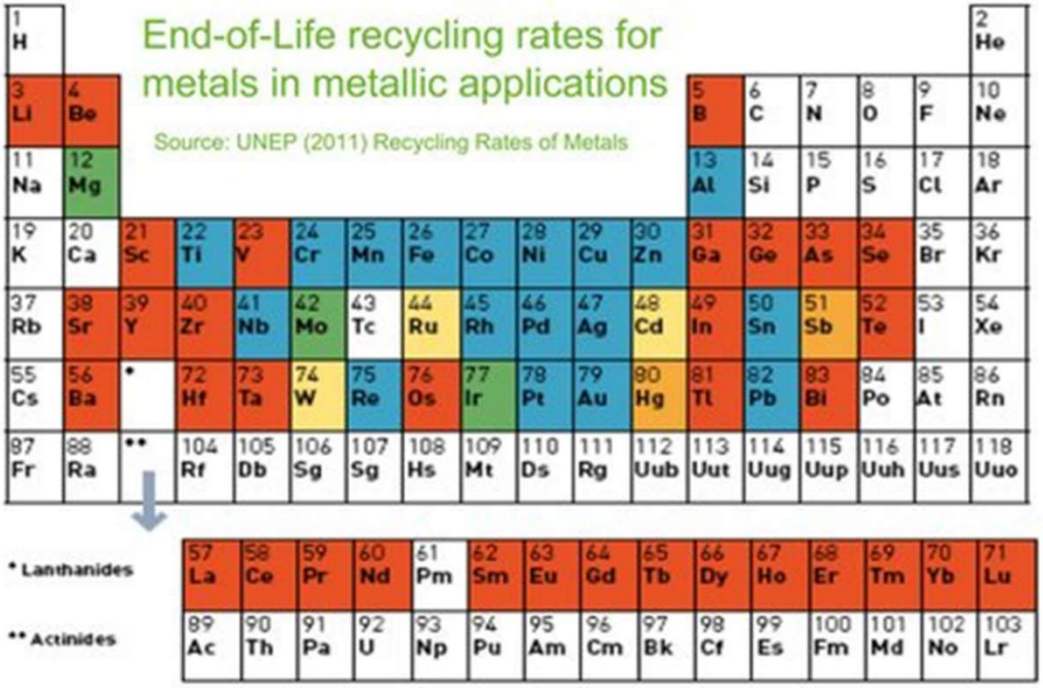
Supply



Recycling



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EIT Raw Materials

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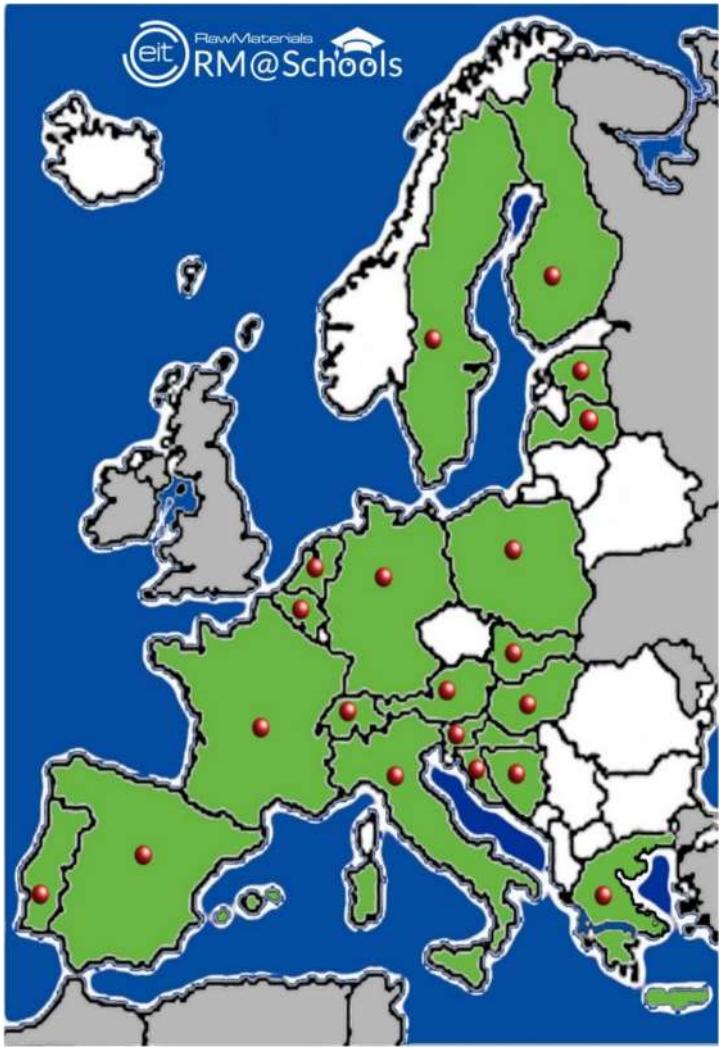
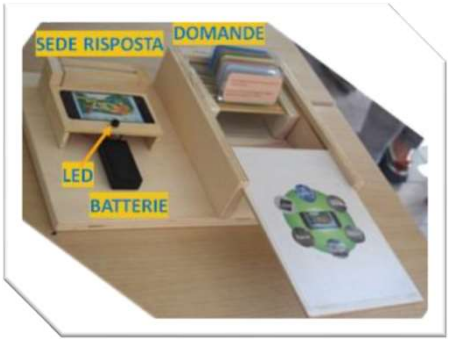


HANDS-ON TOOLKIT

COMPANY VISITS

DISSEMINATION TOOLS



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ELEMENTS OF A SMARTPHONE

ELEMENTS COLOUR KEY: ALKALI METAL | ALKALINE EARTH METAL | TRANSITION METAL | GROUP 13 | GROUP 14 | GROUP 15 | GROUP 16 | HALOGEN | LANTHANIDE

SCREEN

49 In Indium, 50 Sn Tin, 8 O Oxygen

Indium tin oxide is a mixture of indium oxide and tin oxide, used in a transparent film in the screen that conducts electricity. This allows the screen to function as a touch screen.

13 Al Aluminium, 14 Si Silicon, 8 O Oxygen, 19 K Potassium

The glass used on the majority of smartphones is an aluminosilicate glass, composed of a mix of alumina (Al_2O_3) and silica (SiO_2). This glass also contains potassium ions, which help to strengthen it.

39 Y Yttrium, 57 La Lanthanum, 65 Tb Terbium, 59 Pr Praseodymium, 63 Eu Europium, 66 Dy Dysprosium, 64 Gd Gadolinium

A variety of Rare Earth Element compounds are used in small quantities to produce the colours in the smartphone's screen. Some compounds are also used to reduce UV light penetration into the phone.

ELECTRONICS

Copper is used for wiring in the phone, whilst copper, gold and silver are the major metals from which microelectrical components are fashioned. Tantalum is the major component of micro-capacitors.

29 Cu Copper, 47 Ag Silver, 79 Au Gold, 73 Ta Tantalum

Nickel is used in the microphone as well as for other electrical connections. Alloys including the elements praseodymium, gadolinium and neodymium are used in the magnets in the speaker and microphone. Neodymium, terbium and dysprosium are used in the vibration unit.

28 Ni Nickel, 66 Dy Dysprosium, 59 Pr Praseodymium, 65 Tb Terbium, 60 Nd Neodymium, 64 Gd Gadolinium

Pure silicon is used to manufacture the chip in the phone. It is oxidised to produce non-conducting regions, then other elements are added in order to allow the chip to conduct electricity.

14 Si Silicon, 8 O Oxygen, 51 Sb Antimony, 33 As Arsenic, 15 P Phosphorus, 31 Ga Gallium

Tin & lead are used to solder electronics in the phone. Newer lead-free solders use a mix of tin, copper and silver.

50 Sn Tin, 82 Pb Lead

BATTERY

3 Li Lithium, 27 Co Cobalt, 8 O Oxygen, 6 C Carbon, 13 Al Aluminium

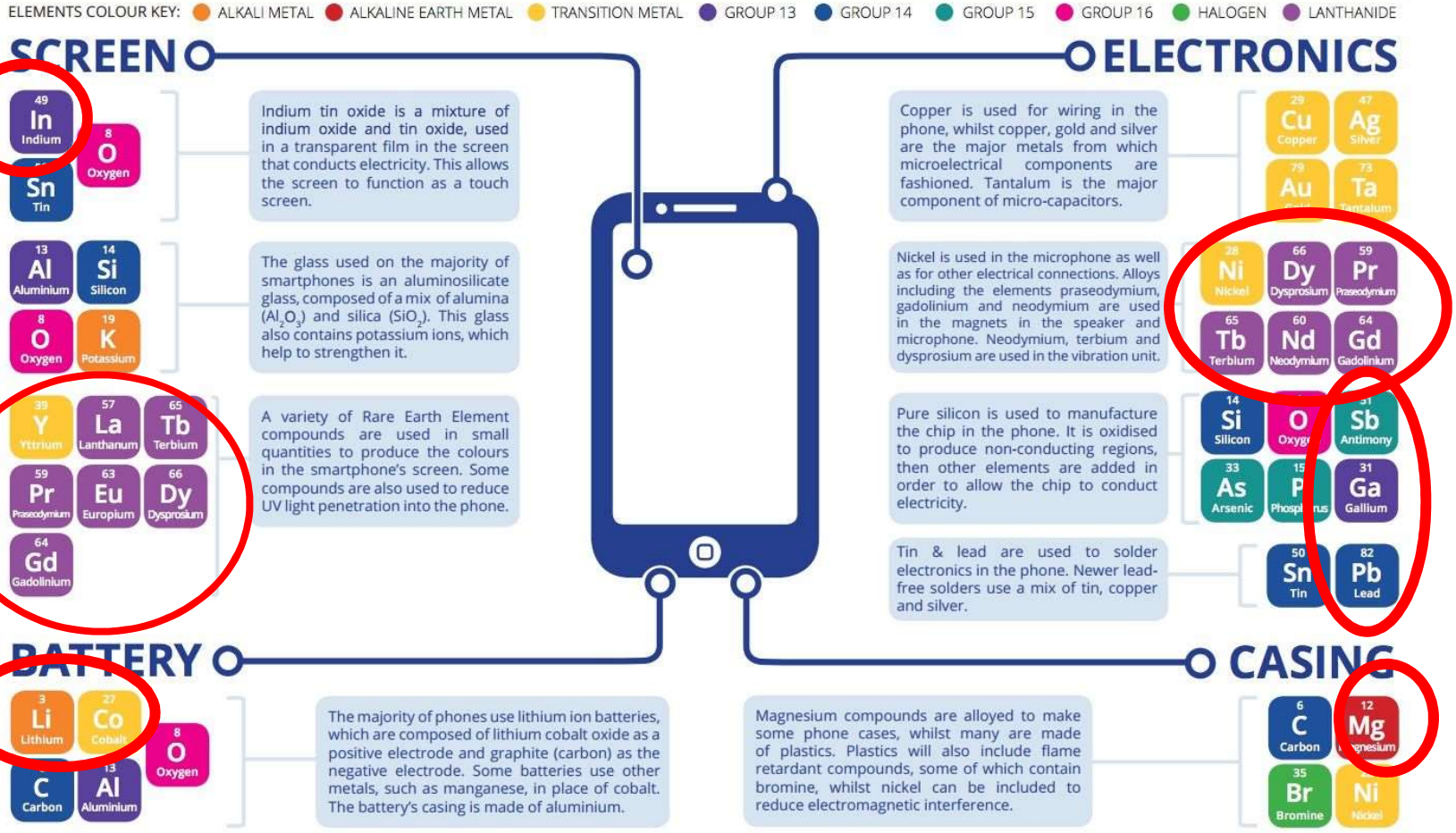
The majority of phones use lithium ion batteries, which are composed of lithium cobalt oxide as a positive electrode and graphite (carbon) as the negative electrode. Some batteries use other metals, such as manganese, in place of cobalt. The battery's casing is made of aluminium.

CASING

Magnesium compounds are alloyed to make some phone cases, whilst many are made of plastics. Plastics will also include flame retardant compounds, some of which contain bromine, whilst nickel can be included to reduce electromagnetic interference.

6 C Carbon, 12 Mg Magnesium, 35 Br Bromine, 28 Ni Nickel

ELEMENTS OF A SMARTPHONE



Pathway on materials in electronic devices

RM@Schools methodology

Presentation of the scientific topic → Widening/ Strenghtening of knowledge → Creation ITA/ENG → Dissemination

Don't throw away your mobile

Seminar
Circular economy

Dissemination products

Live event

Visit to CNR

Seminar
Organic Photovoltaics

Experiment
Material substitution
in transparent electrodes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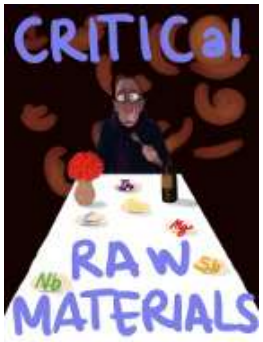
Raw Materials in PS4:

Where are they and how to recycle them.

PS4 is one of the most famous consoles in the world, over 80 million PS4s have been sold around the world



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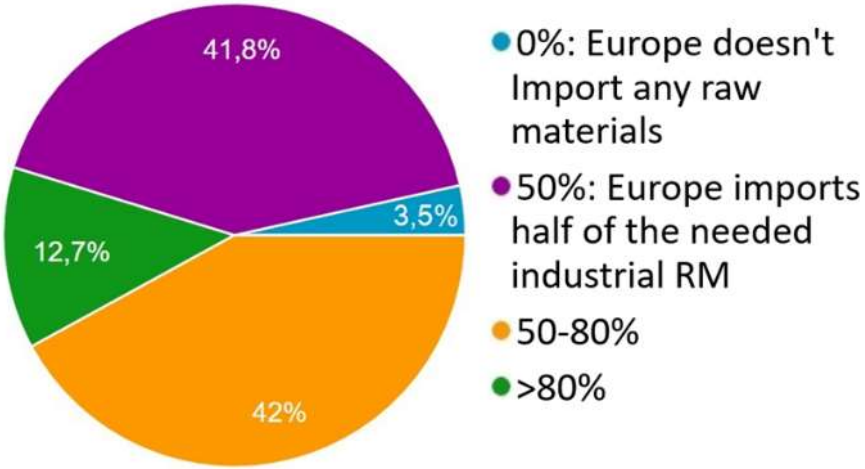
Research questions

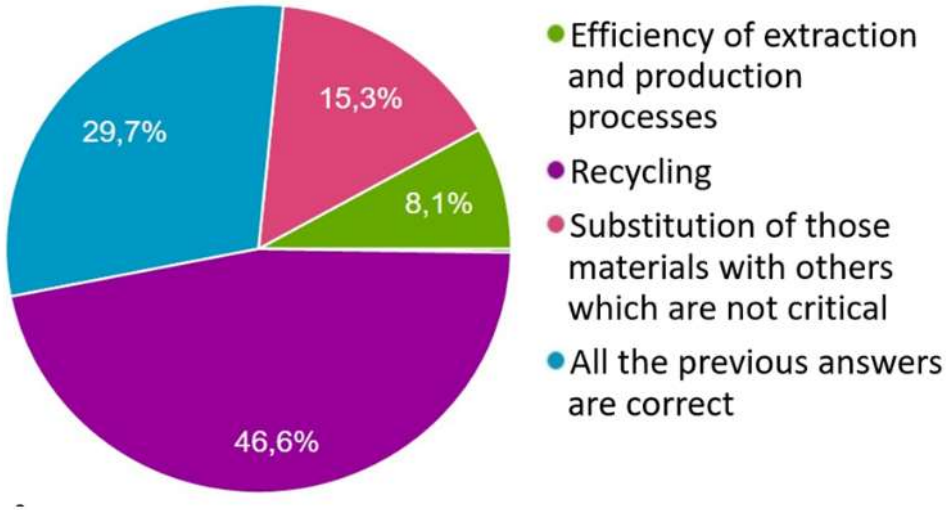
- What average Italian pupils knew about raw materials before taking part in the project?
- What are their perceptions of the topic after making their research?
- Is the topic suitable for 11-17 year old pupils?

State of the art before the project

What is the percentage of raw materials imported by Europe ?



Which is the best option to invest in?

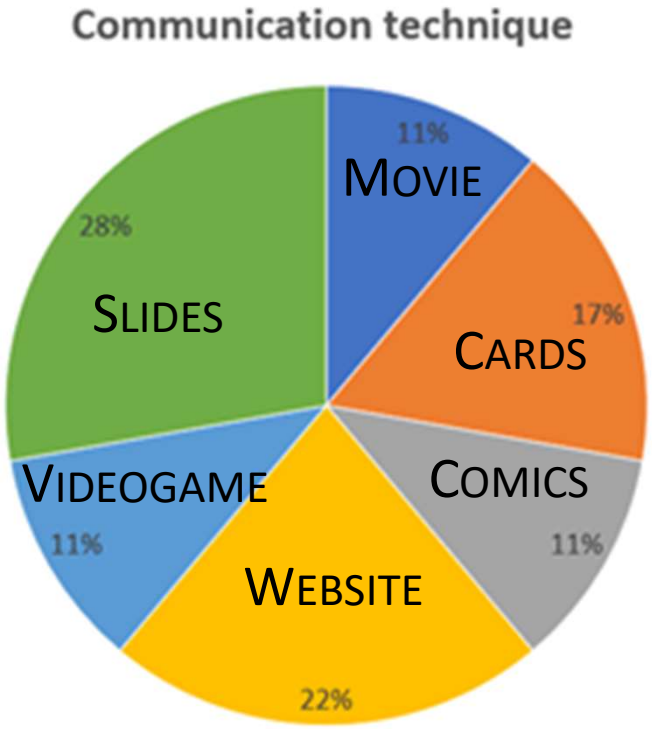


> 400 ANSWERS IN 3 DAYS !

Survey spread through social networks

Results: dissemination tools realized by the students

> 20 works collected along 3 years



Slides useful in class
Websites, apps, fb pages: interest in modern communication technologies

Mobile = interesting topic!

Reverse engineering website

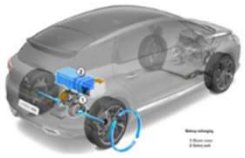
https://rmschools.isof.cnr.it/schools/2016/3-E/HybridCars/English/HomeEnglish.html 80%

Hybrid Cars

HOME | ANALYSIS | COBALT | LITHIUM | MANGANESE | NICKEL

Home

Read this page in Italian!



Nowadays green technologies have become very popular thanks to the production of wind and solar energy ,of energy-saving lighting systems and hybrid cars. The great results we have achieved, however, pose numerous problems concerning the disposal and availability of raw materials to create our own devices, whatever they are. Researchers and industries in Europe and elsewhere are working to find solutions in order to ensure the development of low carbon energy technologies.

Specifically, we will analyze the critical materials contained in hybrid cars: in these vehicles rare materials are mainly located in the batteries that power them.

Inside the battery cells there are some critical materials which depend on the type of the battery used. Some of the most used are:

- cobalt
- nickel
- manganese
- lithium.

At present the preferred material for Li-ion batteries is $LiCoO_2$. Since Cobalt is considered critical, alternative solutions are represented by $LiNIO_2$ and $LiMn_2O_4$. Together with the substitution of Co, Li recycling is mandatory to meet the increasing needs of portable Li-ion batteries.

Clic on the page with the name of the critical material if you want to know more about it.

Sources: wikipedia.org

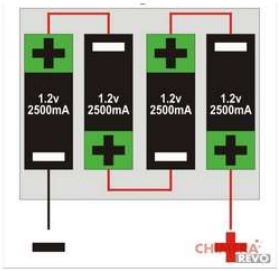
RM@Schools RawMaterials

Reverse engineering website

HOME	ANALYSIS	COBALT	LITHIUM	MANGANESE	NICKEL

Analysis

Read this page in Italian!



A hybrid vehicle (car, bus, moped) is provided with a propulsion system with two or more engines (electric and thermal), which work together accumulating energy.
This energy accumulates in the battery, which can be charged also from the outside and it provides energy motor power to make the vehicle move.
The battery of a hybrid vehicle is formed by multiple cells which work together.
These cells have two electrodes (a positive one and a negative one) which accumulate and emit negative charges (electrons).
The electrodes are separated by a polymer film (such as the one that covers pharmaceutical products) which prevents them from touching, which would create a short circuit.
By doing so, only when we start the vehicle there will be a flow of electrons.
The electrodes are immersed in an electrolytic solution (a solution which conducts electricity).
When the electrons move from the negative electrode (anode) to the positive one (cathode) they make the vehicle work.
During the recharge process the reverse process occurs, so the reaction can start again.
The acceleration of the vehicle is determined by the power of the battery.

Sources: wikipedia.org

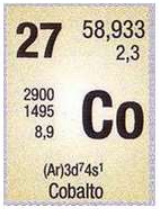
RM@Schools RawMaterials

Reverse engineering website

HOME	ANALYSIS	COBALT	LITHIUM	MANGANESE	NICKEL

COBALT Co

Read this page in Italian!



Cobalt (Z=27) is a transition, white silver, ferromagnetic metal and it is very tough.
In nature we can find it in sundry minerals, often with Nickel (which with Cobalt forms a characteristic component of meteorites) and copper.
The main world producers of cobalt are: Congo, Zambia, Russia and Australia. We can also find it in Finland, Azerbaijan and Kazakhstan.
The total world production amounts to 17,000 tons per year.

Some of its applications are:

- METAL ALLOYS (for the construction of turbines, for aircraft engines, jewellery ... ..)
- MAGNETS
- CATALYST (for petrochemical and chemical industries)
- DEHYDRATING COMPOUNDS FOR PAINTS, LACQUERS AND INKS
- IN BATTERIES ELECTRODES (in particular in batteries CELL of hybrid cars, with nickel and manganese)
- OTHER USES

In battery cells of hybid cars, cobalt is in the form of Cobalt Dioxide, or in NCM (nickel-cobalt-manganese) and in NCA (nickel-cobalt-aluminum).
Cobalt Dioxide was used for a long time, despite its high cost (110 dollars\kg), because it is more reactive than Nickel and Manganese and it can store more energy.
However, Cobalt Dioxide stores less and less energy with the passing of time.
Cobalt is a critic metal because the demand of this material is constantly growing (only in 2015 by 6%) because it is one of the most used material for batteries construction, especially for electric vehicles.
The main producer of cobalt is the Democratic Republic of Congo, which produces 600.000 tons per year and considering the country's political instability, threats of supply disruption could be a

Reverse engineering website

HOME	ANALYSIS	COBALT	LITHIUM	MANGANESE	NICKEL

LITHIUM Li

Read this page in Italian!

Lithium (z=3) is one of the main elements of the periodic table and it belongs to the alkaline metal group. In its pure form there is a soft silver white metallic element that oxidizes quickly in contact with air or water.

Lithium can't be found in nature in the metallic state (because of its very high reactivity), but we always find it associated with other elements or compounds. In almost all igneous rocks we find a minimum amount of lithium. But the sea water contains the major amount of lithium (approximately 230 billion tons) but this lithium isn't extractable; or in any case, we don't own the technology to start a process of extraction from the sea that could be economically sustainable.

The major manufactures of lithium in the world are, in descending order: Chile,Australia,China,Argentine,Zimbabwe,Portugal,Brazil,USA. The total production of the major manufactures (excluding the USA, which didn't want to divulge the digits of its production) is 35320 tons per year (source: year 2014).

Lithium is used :

- in the production of ceramic and glass
- in electronics
- for batteries (for hybrids cars,smart phones, starter batteries,for electric cars)
- in the production of lubricating greases

Please check

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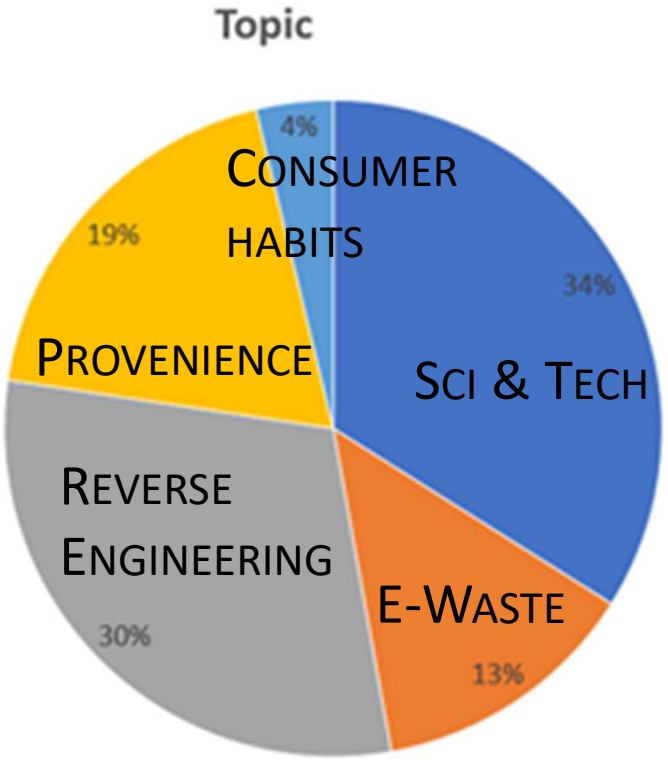
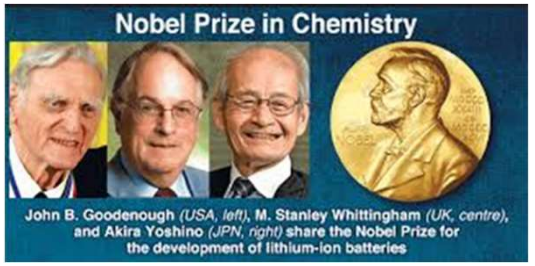
Results: dissemination tools realized by the students



Interest in applications
Attracted by science
Surprised about provenience
Worried about E-waste

Lithium battery and grpahene: material available also because Nobel Prizes awarded



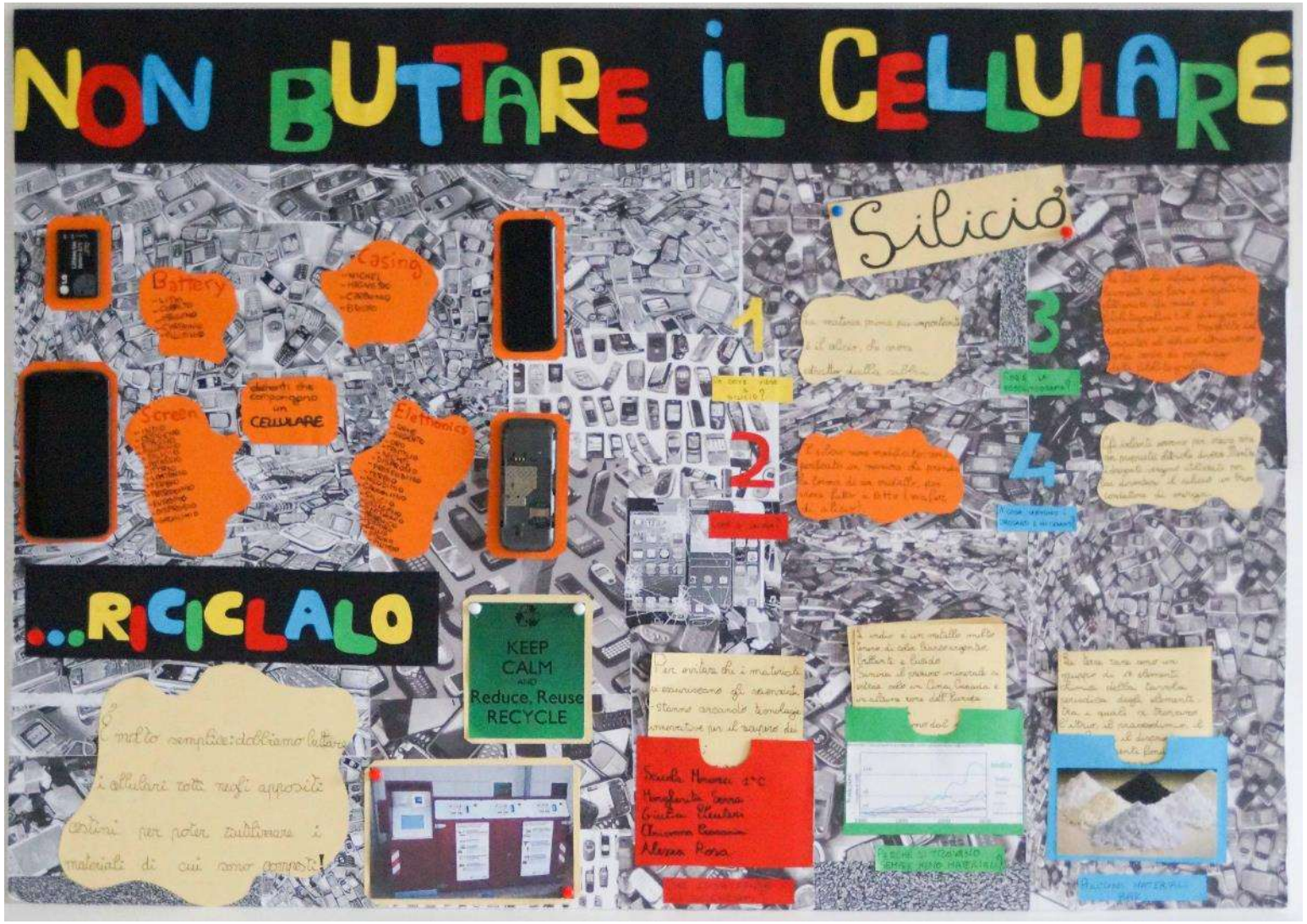
E-waste recycling

width 6 cm x height 8 cm x 1.5 billion sold in a year = 7.2 km^2

Twice the surface of Bologna old town

11 year old

E-waste recycling



Conclusions

Interesting topic for 11-19 year old pupils

At the forefront of innovation

International

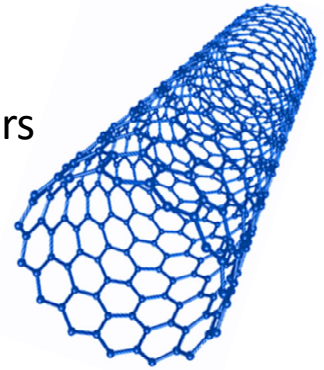
Suitable for citizenship education (compulsory in Italy since 2020-21)

Versatile methodology applied in different Countries

Different levels of insight:

Young / Single lesson
Mobile phone
Provenience
E-waste recycling

>16 year old / combined pathway
Several applications, e.g. electric cars
Research to substitute critical RMs
Provenience



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Thank you!

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