

Empowering the Next Generation: Cross-disciplinary Learning Pathways in Electronics and Sustainability for High School Students

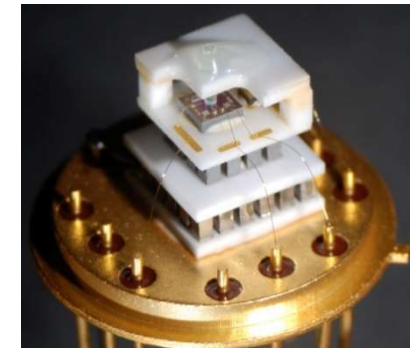
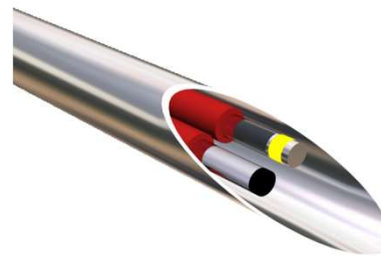
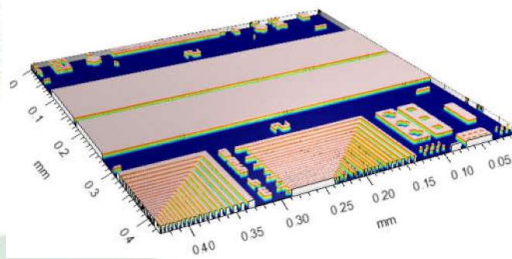
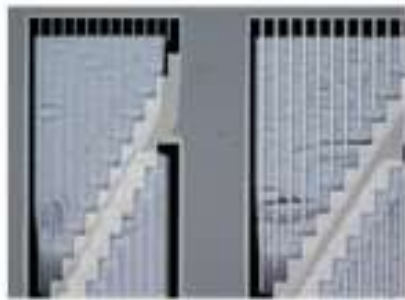
Marica Canino CNR (Italy)

F. Suriano, A. Torreggiani, E. Cozzani, F. Marucci, A. Zanelli,
V. Boldrini, G. Carrara, S. Marzocchi, S. Zampolli

Background

FABRICATION OF NOVEL ELECTRONIC DEVICES

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Scientific research for schools

Bologna CNR Research Area



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800 people

Materials, Electronics, Climate,
Geology, Atmosphere, Sea,
Astrophysics, Technopole



Raw Matters Ambassadors@Schools



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CO₂ Monitoring

in scHools for digitAl aNd Green compEtences



Co-funded by the
Erasmus+ Programme
of the European Union

CHANGE aims at developing a STEM pathway centered on Indoor Air Quality (IAQ) in schools of Bulgaria, Italy, Romania and Spain. The didactic material consists of a theoretical section on IAQ and climate changes, a practical section on the assembly of open-source CO₂ monitoring stations and their usage for experiments and continuous monitoring.

Why electronic materials in high schools

blockchain-Internet artificial-
intelligence electronics-
vehicles intelligence-
electronics of-things data-
artificial vehicles-domotics
things-big Internet-of big-data
domotics-undefined



SUSTAINABILITY



EMPLOYMENT



CITIZENSHIP

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Skills



Knowledge

- Current and future trends in electronic devices
- Sustainability & performance (design, raw material production processes, low energy consumption during operation, end of life)
- Use
- Open source

Soft skills

- Citizenship
- Networking and cooperation
- International dimension of learning
- Creativity
- Analytical skills

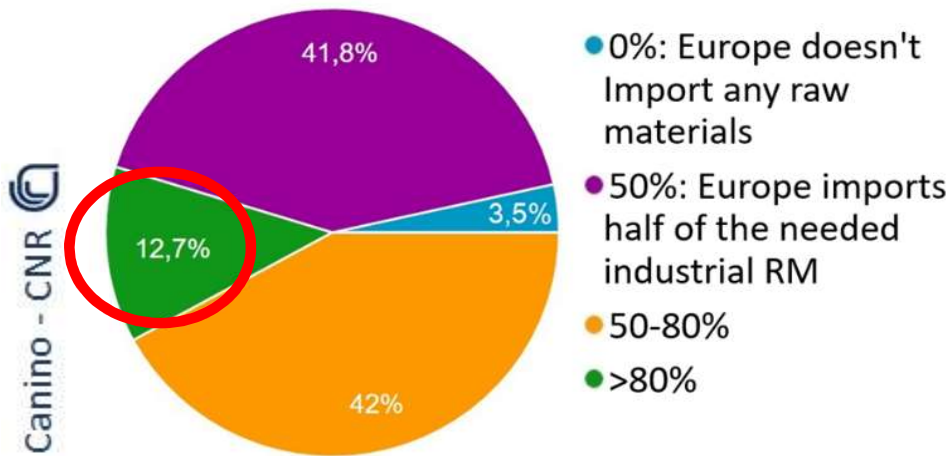
Research questions

- Previous knowledge of Italian students
- Favouring students' interest
- Learning assessment
- Empowering students
- Conclusions

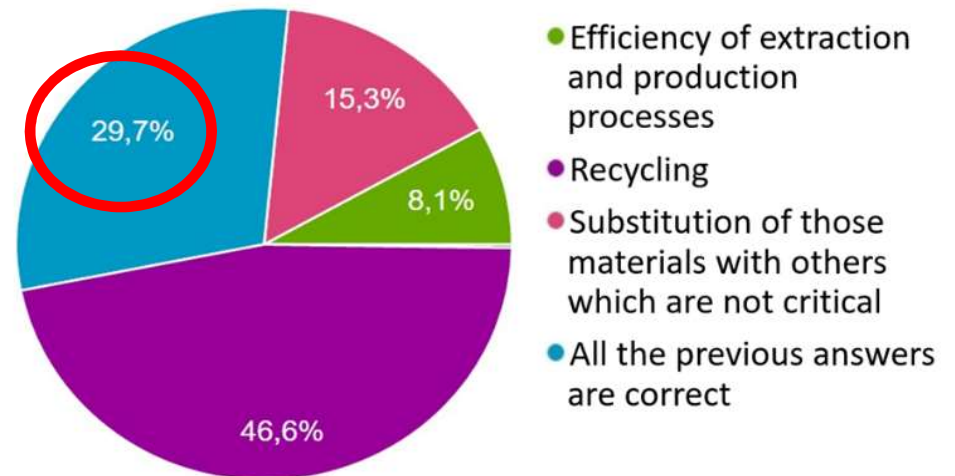
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Knowledge before the project - 2016

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

Link to everyday life

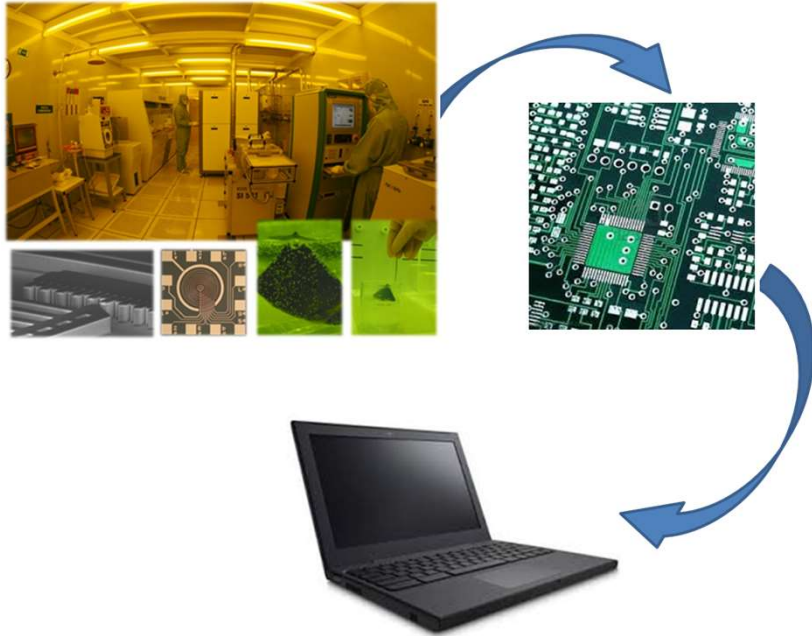
Link with society and policy

Use of smartphone

FAVOURING STUDENTS' INTEREST

Smartphone storytelling

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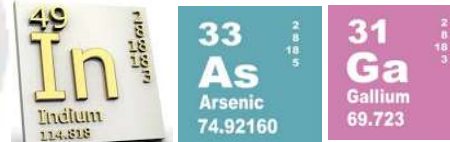
Devices/Technologies



Emerging electronic technologies



SOLAR PANELS



LIGHT EMITTING DIODES (LED)



ELECTRIC CARS

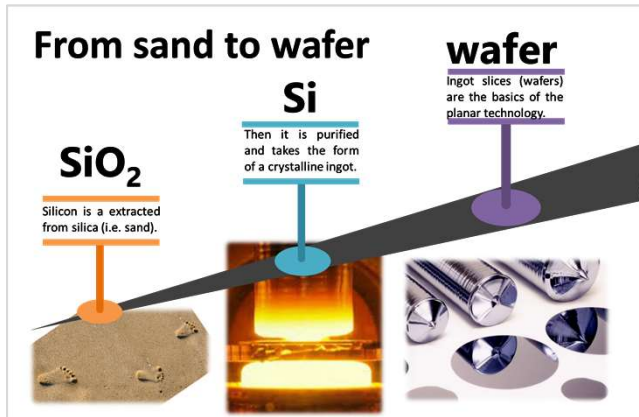


FIBER OPTICS



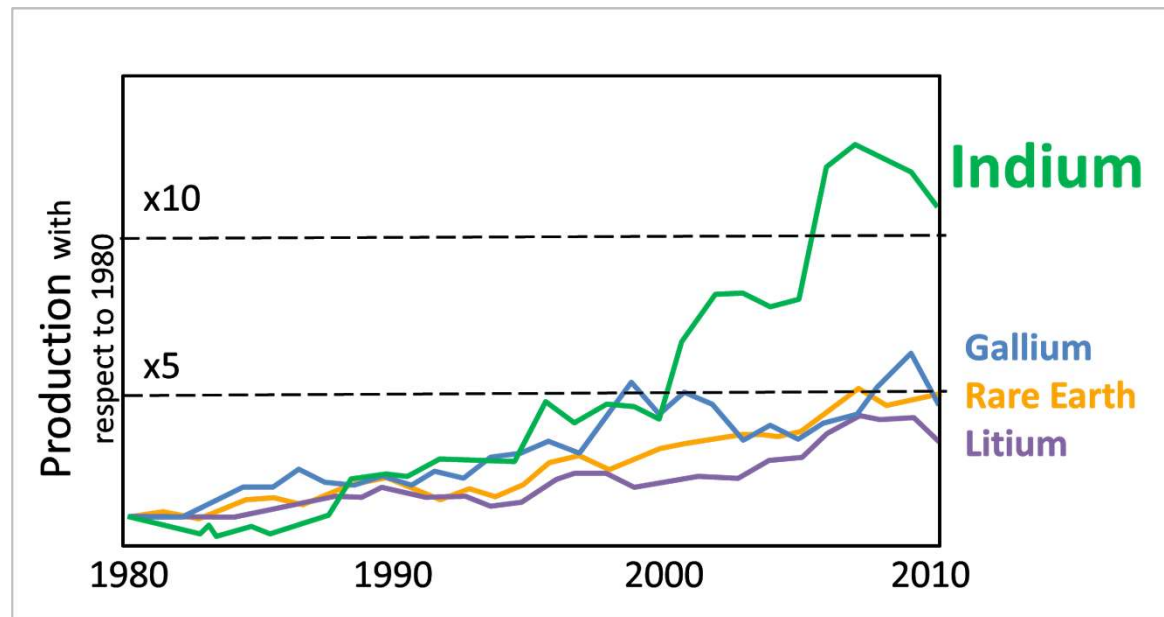
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Smartphone storytelling



- Devices/Technologies
- Materials/elements

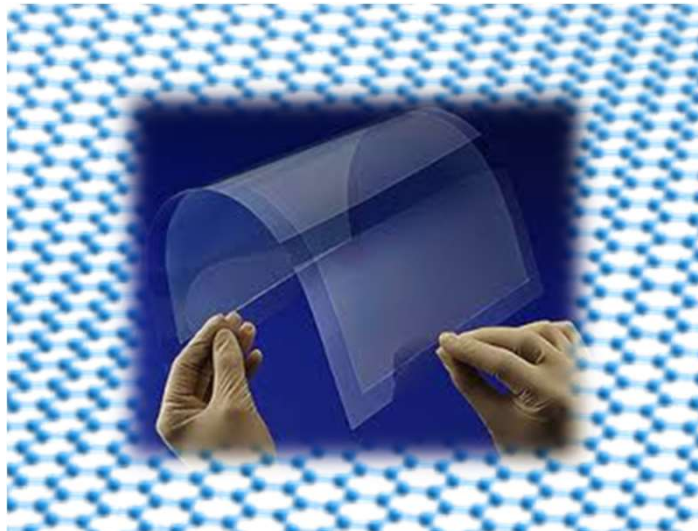
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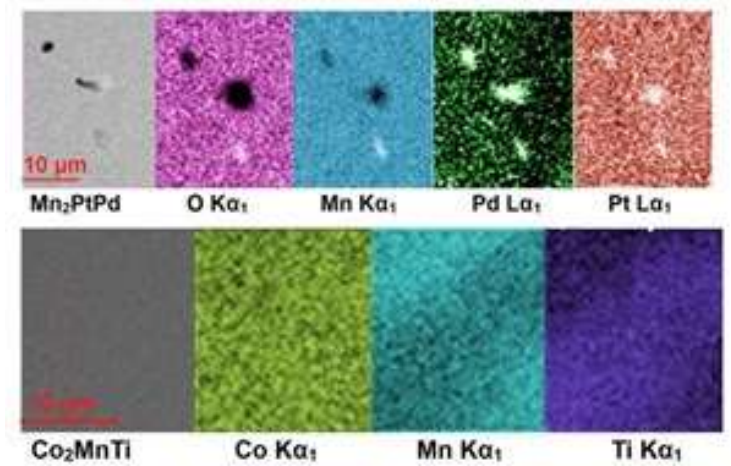
Novel materials

Substitution of CRMs in strategic applications

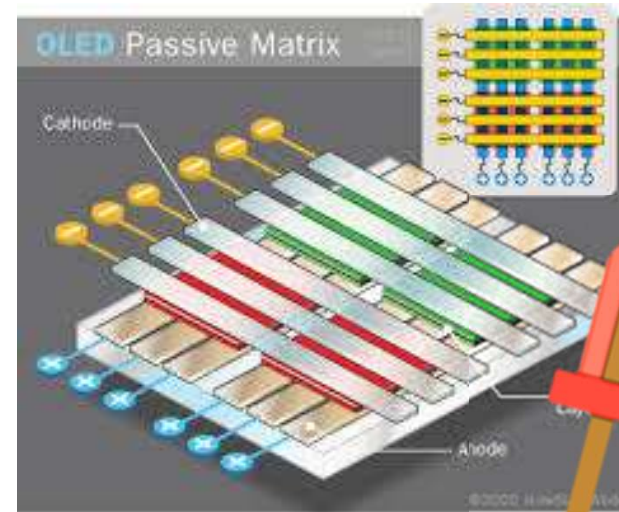
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TRANSPARENT ELECTRODES



MAGNETIC MATERIALS

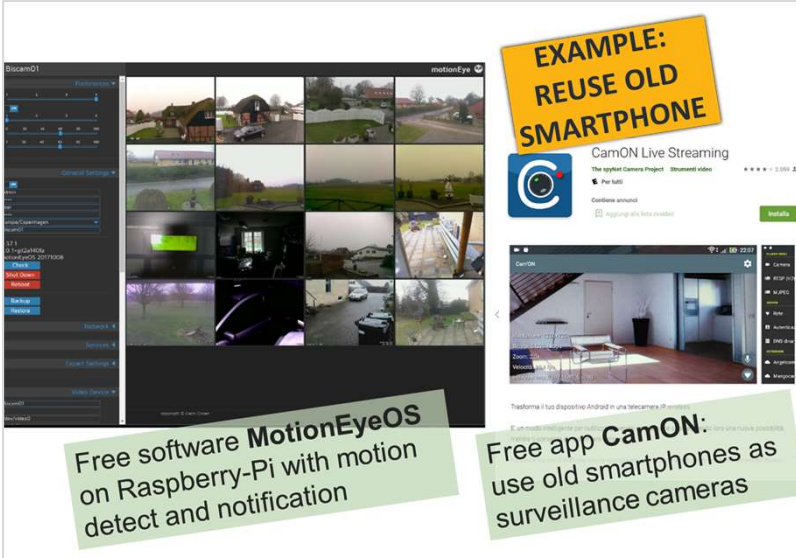


OLED



Smartphone storytelling

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**EXAMPLE:
REUSE OLD
SMARTPHONE**

Free software **MotionEyeOS** on Raspberry-Pi with motion detect and notification

Free app **CamON**: use old smartphones as surveillance cameras

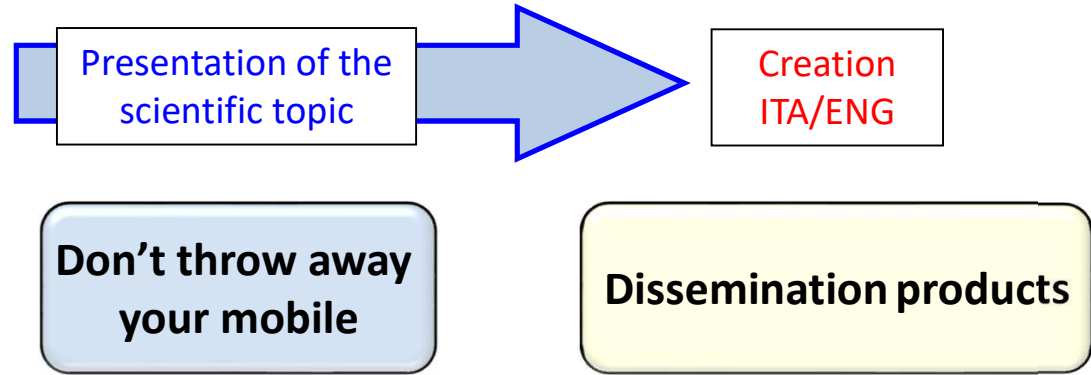
- Devices/Technologies
- Materials/elements
- Lifecycle/circular economy



Analysis of dissemination products realized by students
Use of digital communication techniques
Recycling and reverse engineering

LEARNING ASSESSMENT

Dissemination products



Comics
Poster
VIDEO
PRESENTATION
 Social network

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RM@Schools

Raw Materials in PS4:

Where are they and how to recycle them.

PS4 is one of the most famous consoles in the world, over 50 million PS4s have been sold around the world from January 2013. It contains a lot of raw materials, most of which are in the magnet of the hard disk, in the PCBs, printed circuit boards and in the screen that most of the people use to play.

Gallium

The most common use of gallium are led diodes

Led diodes

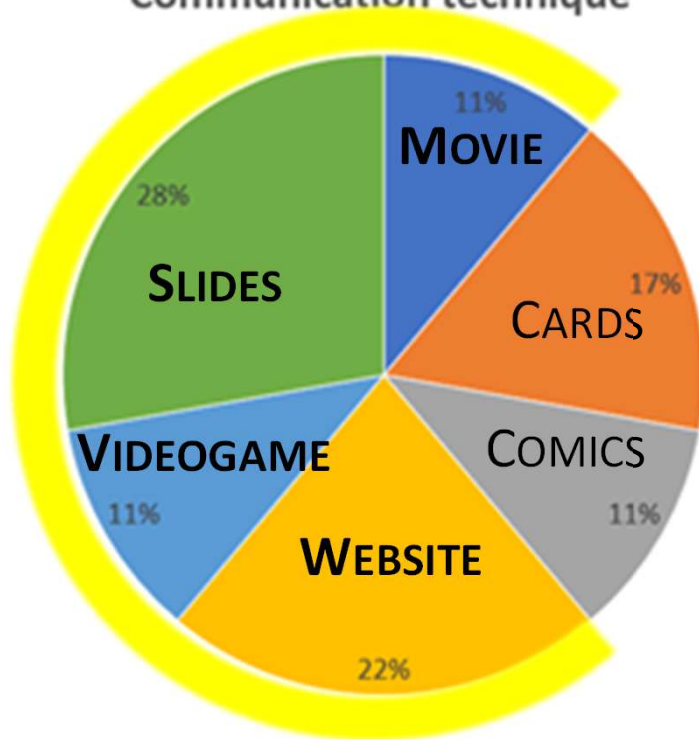


<http://www.rmschools.eu>

Techniques

> 20 works collected along 3 years (2016-2019)

Communication technique



72% digital techniques

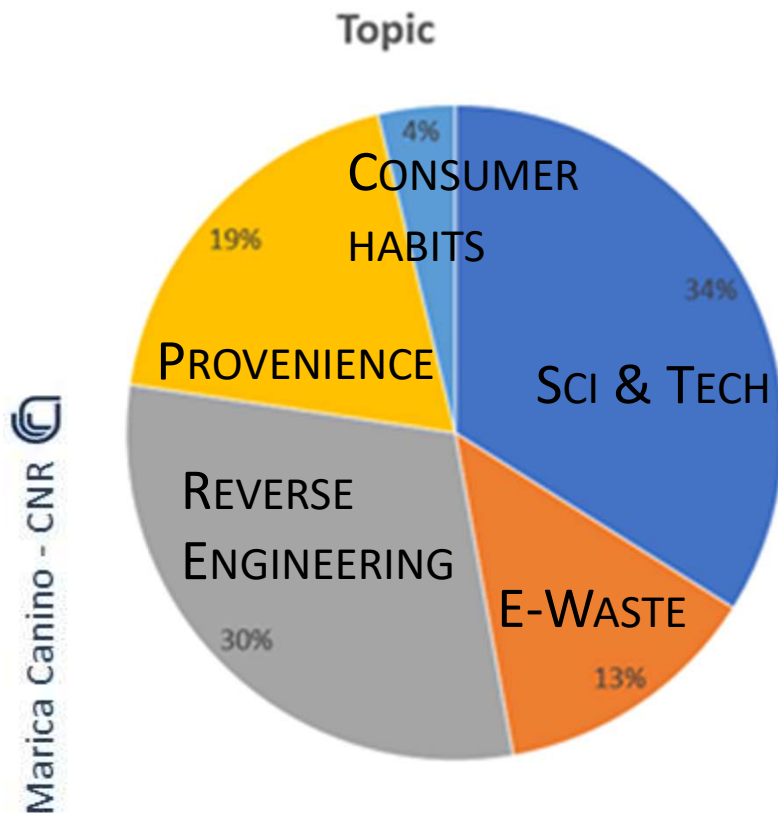
Slides useful in class

Websites, apps, fb pages: →



Interest in the use of digital communication technologies

Topics



- Attraction for science
- Interest in applications
- Surprise about provenience
- Concern about E-waste

Teacher training
Increase the insight
Hands-on solutions
Spread the word

EMPOWERING THE NEXT GENERATION

Teacher active participation

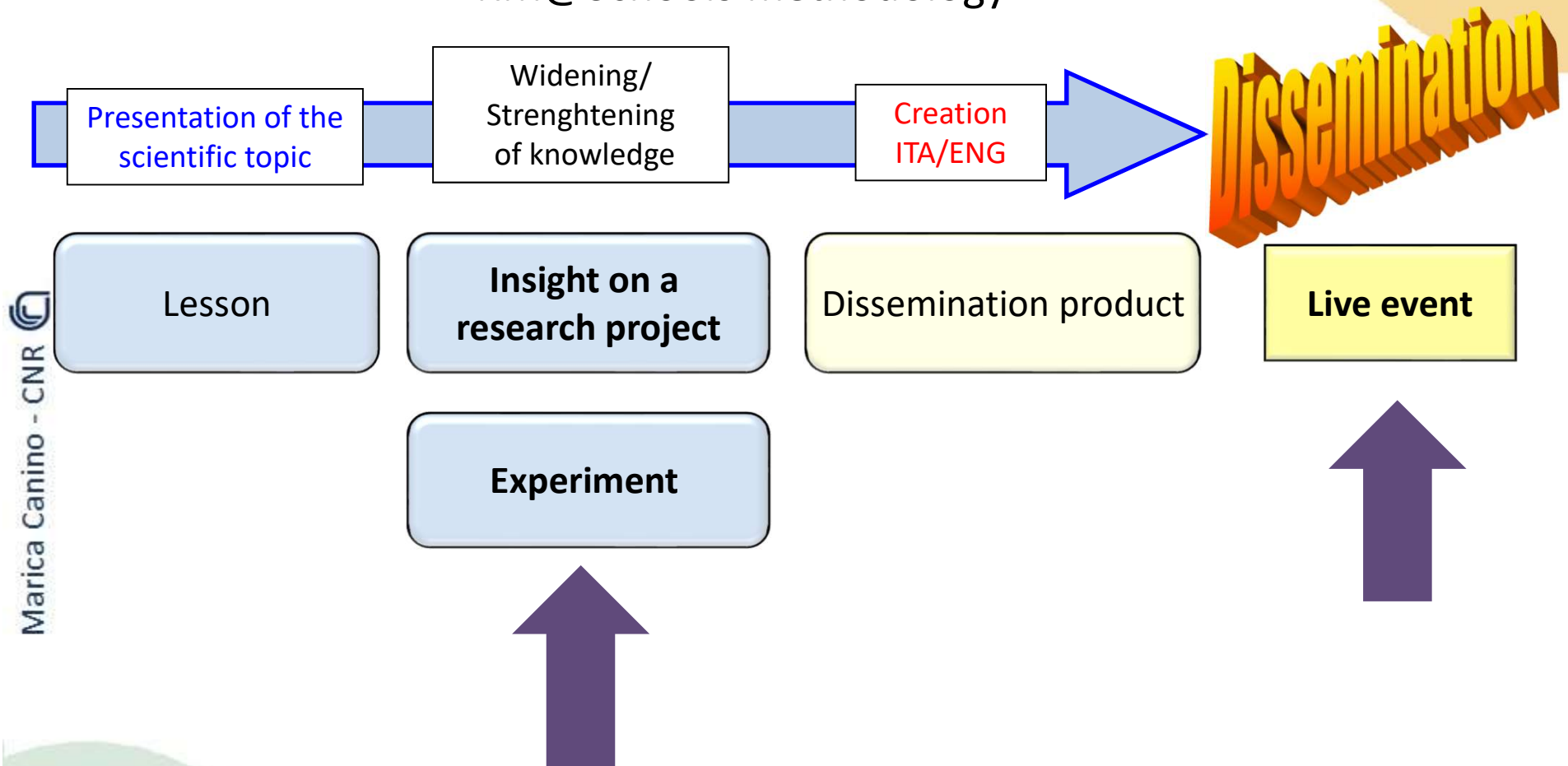
- Accredited training courses for teachers
- Mandatory to foster student involvement

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Pathway on materials in electronic devices

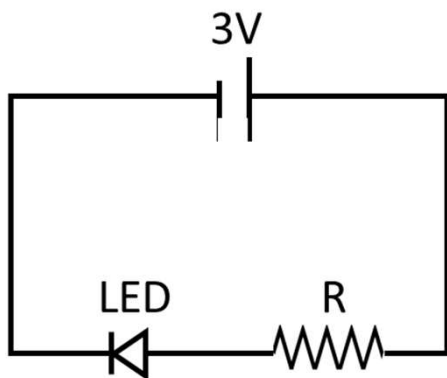
RM@Schools methodology



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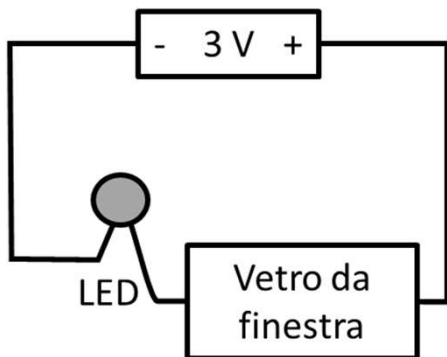
Experiment 1: transparent electrodes

CIRCUIT SCHEME

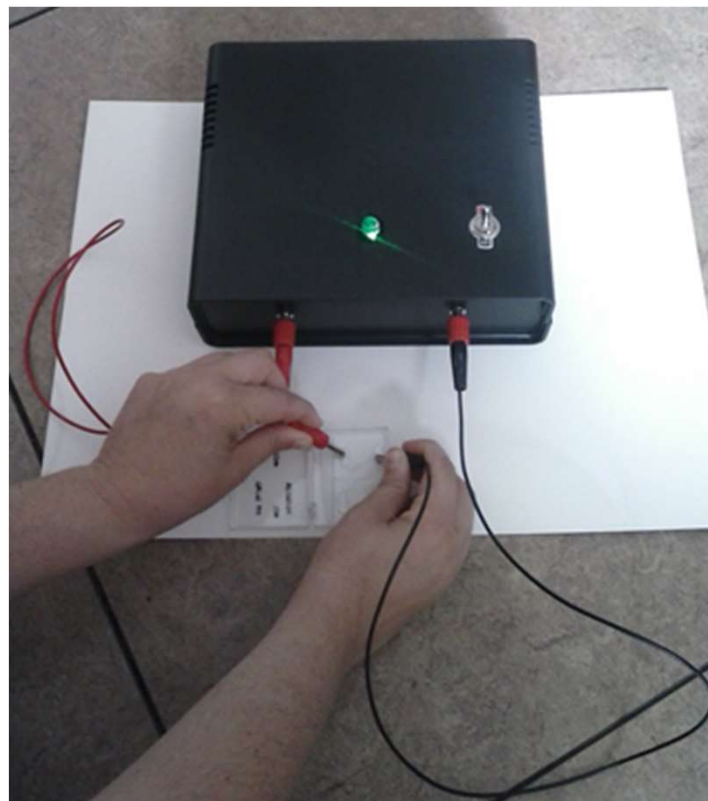
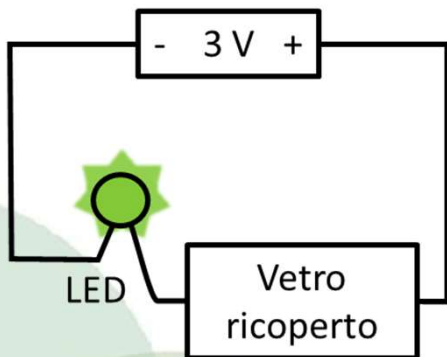


Comparison between commercial electrodes with rare indium tin oxide vs novel graphene-based electrodes

WINDOW GLASS
LED OFF

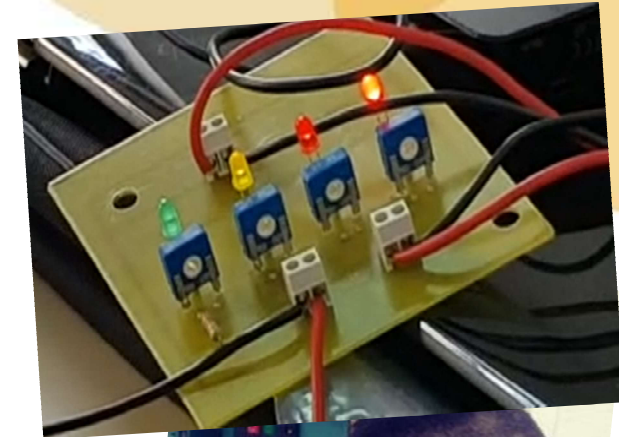


COATED GLASS
LED ON

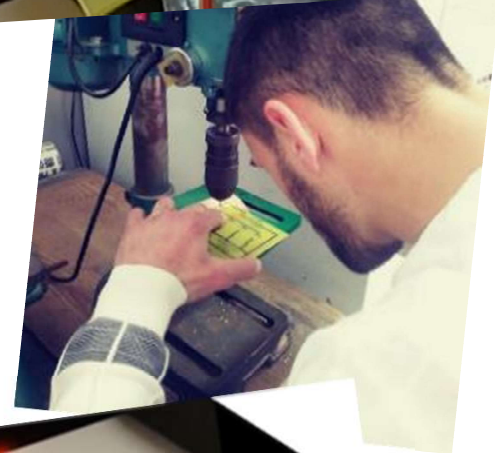
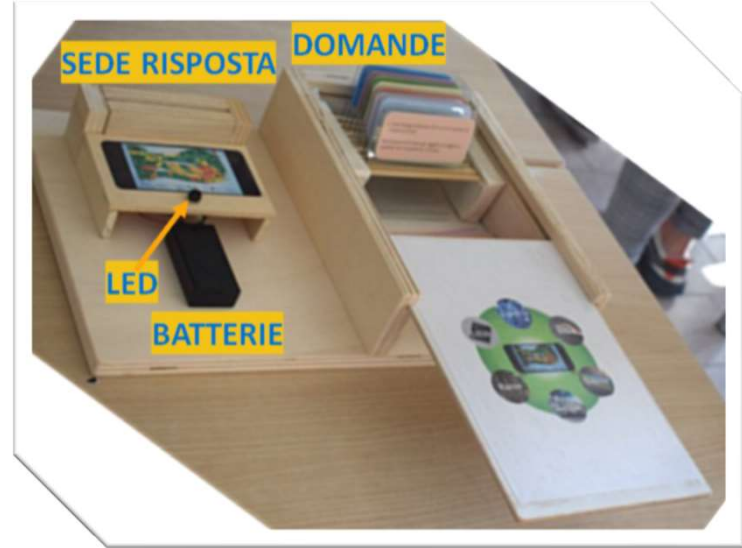


Students' re-elaboration

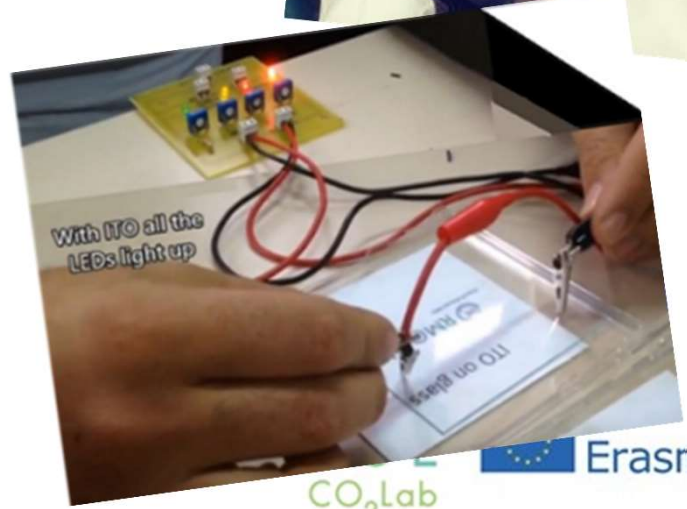
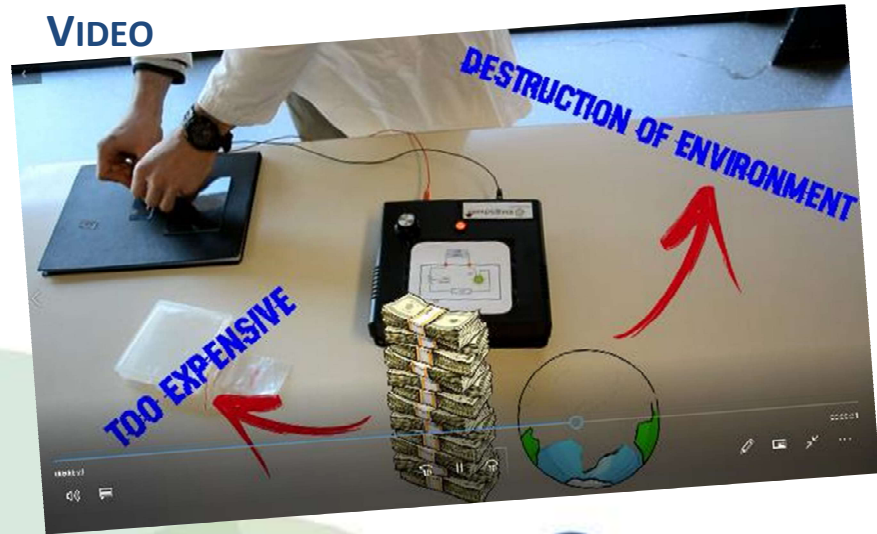
CIRCUIT



GAME



VIDEO



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Experiment 2: CO₂ monitoring

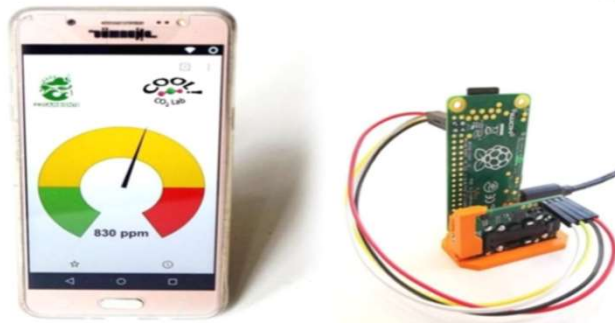
Old smartphone used as screen for CO₂ monitoring station

- Based on **open source** material and software
- Station assembly by **pin connection**
- **CO₂ monitoring** in classroom
- Raspberry PI **Python** coding
- WebApp development (**Javascript**)

2 sustainability issues
Indoor air quality &
Circular economy

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DIAMO UNA SECONDA VITA AI NOSTRI CELLULARI



Evitando di lasciarli chiusi in un cassetto...



Spread the word

- Science exhibitions
- Open seminars
- Open days in Schools
- Peer education

RUN EXPERIMENTS



PRESENTATION



SHOW THEIR OWN PRODUCTS



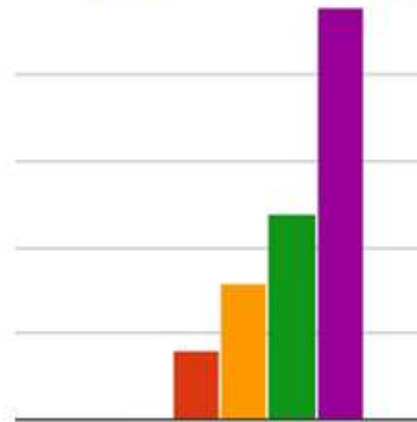
ENGAGE IN DISCUSSION

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Spread the word

insight + fun

■ Poor ■ Fair ■ Average ■ Good ■ Excellent



Participation to international events

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- ✓ Internationalization
- ✓ Networking
- ✓ Communication skills
- ✓ English

Conclusions

- ❑ Scarce awareness of materials issues in electronics
- ❑ Catch interest through link to everyday life
- ❑ Electronic devices interesting for 11-19 year old pupils
- ❑ Need for taking actions by recycling
- ❑ Higher levels of insight achieved through student and teacher active involvement

Thank you!

mariaconcetta.canino@cnr.it

Online seminar hosted by
the CHANGE project!

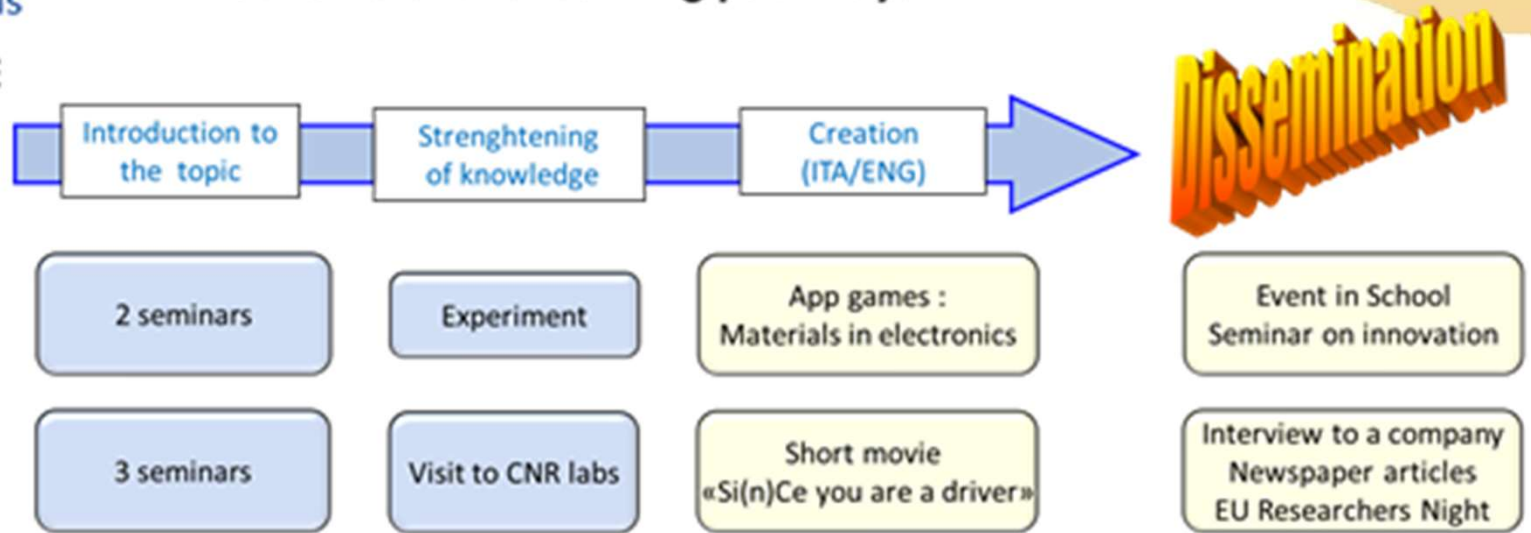


Twining with H2020 project Challenge



Scheme of the learning pathways

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Spread the word

Open day @ school

Experiment demonstrator

Apps

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






Alternanza Scuola Lavoro

Elettronica di Potenza e optoelettronica

Classe 4A IPSIA "G. Ferraris" Catanzaro- CNR Bologna

OUR APP....

<p>semiconductor or insulator?</p>  <p>semiconductor or insulator ? assign each material to its category learningapps.org</p>	<p>https://learningapps.org/watch?v=pkzi8kgzi19</p> 
<p>Where are the materials (in the world)?</p>  <p>Where are the materials (in the world) ? After having visited the continent, click on the Answer! learningapps.org</p>	<p>https://learningapps.org/view6559214</p> 
<p>Hangman game</p>  <p>Hangman game !!!!! learningapps.org</p>	<p>https://learningapps.org/view6557343</p> 
<p>Puzzle: Materials for Electronics</p>  <p>Materials for Electronics Associate each material with its corresponding learningapps.org</p>	<p>https://learningapps.org/watch?v=p3hw3141c18</p> 

Scan the Qr Code and play with us !!!!!

Dissemination products

Video



Students of 16 yrs become aware of raw materials used in mobiles and relate them to resources coming from around the world, thanks to their involvement in a popularization work.

Class 3B (2016) - teachers: Silvana Bertuzzi and Fabiano De Luca Picione - Liceo Scientifico "N. Copernico", Bologna (Italy).

[Show less](#)

M

<http://www.rmschools.eu>



Facebook Page

"Graphene project" on Facebook

"Graphene Project is part of RM@School European project in collaboration with C.N.R. . We are students involved in science and in safeguarding the planet, our objective is to create a disclosed product to explain everybody the brilliant properties of graphene, in a simple and efficient way, using videos and interactive posts."

Class 3 C Liceo Scientifico "N. Copernico", Bologna (Italy)

Teachers: Patrizia Zambonelli and Annachiara Tognetti

RM Ambassadors: Simone Dell'Elce and Alberto Zanelli

SCIENCE AND TECHNOLOGY OF GRAPHENE

Graphene, you may have heard of it, the new wonder material or something like that. But what exactly graphene is, I mean what is scientifically?

Before examining graphene, we need to talk about carbon, one of the most abundant elements in the universe, we extract it from the bottom of known life.

One of the most interesting properties of carbon is its capacity to form allotropes (from Greek allos, other and tropos, way) that are different forms of the same substance.

In regard to carbon we recognize two different allotropes: diamond and graphite.

Even if the diamond looks more precious and we see graphite only when we write, they are both important and interesting, as a matter of fact is from graphite that graphene comes.

To understand better how graphene is composed you can imagine it as a book, imagine that the book is composed of a lot of pages. Every page is what we call graphene.

A process called hexital irradiation gives it the classic hexagonal form.

A sheet of infinite hexagons with very strong bonds between the atoms and very weak bonds between every sheet.

The thing that seems really incredible is that the thickness of the lattice is only one atom so we can talk about a monatomic sheet.

If we think to the way that the book is organized the first page is the introduction, the second like an index and so on.

The two pages of the book are made of carbon atoms, the atoms who are bonded to the lattice.

Graphene is a very thin layer of carbon atoms, it consists of a single layer of graphite with a piece of search and teaching a single monatomic sheet.

Its special properties derive from bonds between the atoms, very strong, the versatility is one of its qualities. It's extremely resistant, 100 times more than steel, but flexible and transparent. The electric and thermal conductivity is higher in graphene than in any other material (for example in copper). The applications are really infinite, but we will see them in the next articles. There is still a lot to do, and I hope we won't see some important applications in 5 or more years. But if we think that in 1950 graphene was considered a theoretical material and not really achievable, reaching just for last years would be nothing.

In the end, about the applications, I'd like to mention Arvid Capri, who said that the frontier of the future applications is only the human imagination.

Arvid Capri answering at the question what graphene is good for: "I don't even know, in fact in present a piece of plastic is considered a material and not really achievable, reaching just for last years would be nothing."

History of Graphene
p. 3
Applications p. 6-7
And there is a lot more!

Comics



Super Cell

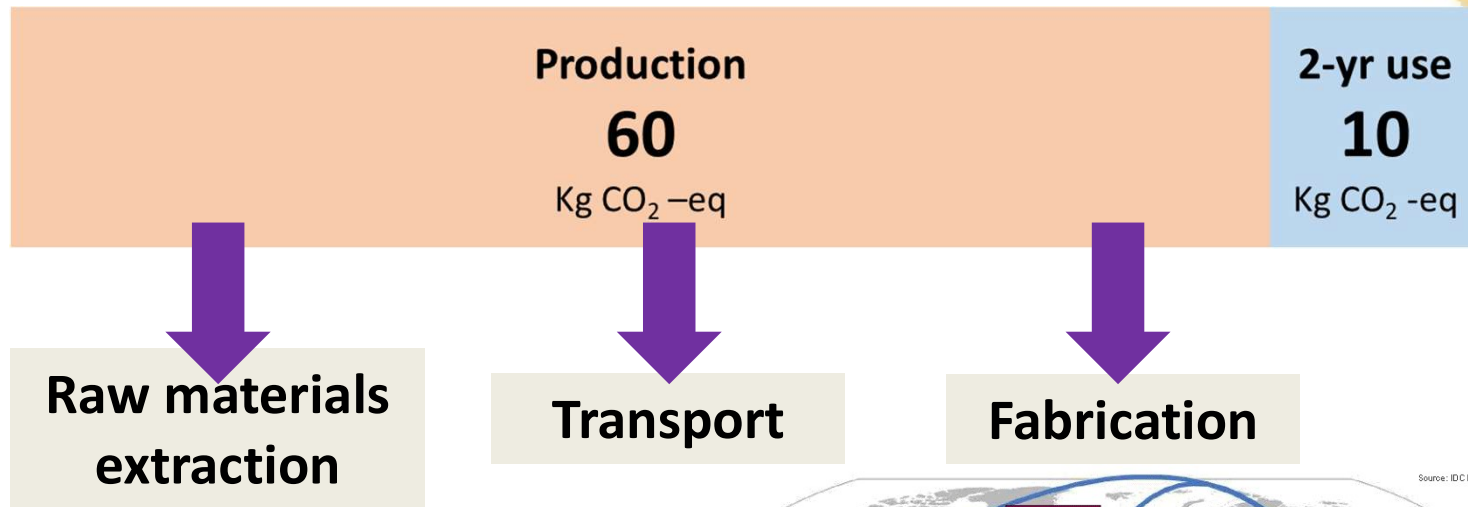
Young students of 11-12 yrs convince people not to through their cells away by means of a nice cartoon. Their superhero "Super Cell" helps the young Marco to convince his grandmother of the importance of the recycling action, besides pushing him to become a Raw Materials Ambassador!

Class I C Scuola Media Zanotti, Bologna (Italy)

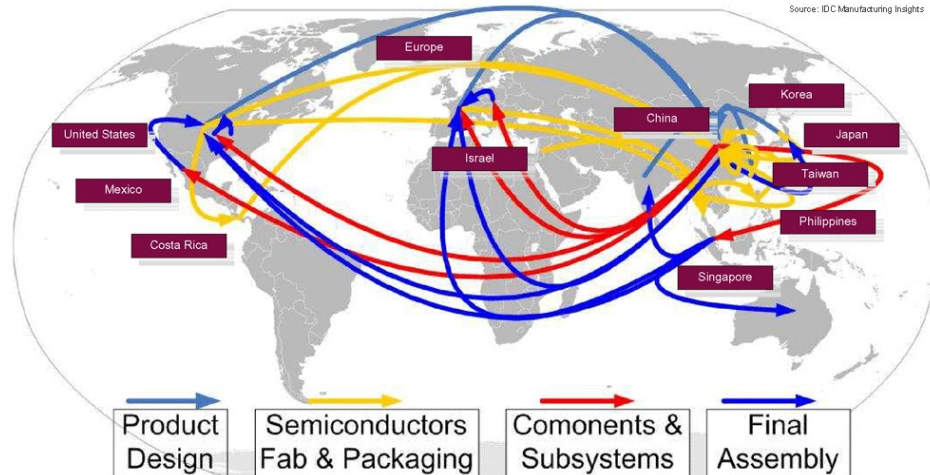
Teacher: Lioiola and Lippi

RM Ambassadors: Marica Canino

Policy contextualization



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Ref.

L. Belkhir, A. Elmeligi, (2017). Assessing ICT global emissions footprint: Trends to 2040 & recommendations. <https://doi.org/10.1016/j.jclepro.2017.12.239>

Smartphone

- Students' interest
- Availability
- Platform for experiments

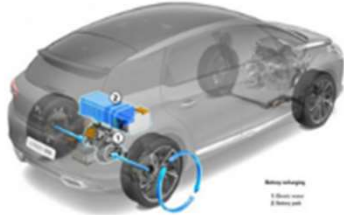

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Reverse engineering website

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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

E-waste recycling

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