Smartphones as didactic tools

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Abstract: How to link Chemistry and Earth Sciences in high schools? Chemistry is considered difficult by teenagers because of its language and themes, far away from reality. Geosciences are often left in the corners and in particular the teaching/learning of minerals and rocks is particularly boring! It is important to find new ways to ensure that students fall in love with these disciplines and acquire their fundamental concepts starting from their interests and linking teaching to everyday life. In our project we adopt an inquiry- based methodology: students pose and answer questions in different steps. Starting from students' answers different activities were carried out in groups to discover the proprieties and the role of the elements contained in the mobile phone.

Keywords: periodic table, smartphone, Chemistry, Earth Sciences

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1 Introduction

We realized our project in two secondary schools (a Scientific Lyceum and a technical school) with the aim to link chemistry with geoscience. Teaching Science in high school allows to get in touch with students difficulties and misconceptions. We tried to overcome them linking together different topics and disciplines and stimulating student interests.

In Italy the ministerial indications for Chemistry for the first two years of secondary school refer to the "observation and description of phenomena and simple reactions (their recognition and their representation) with reference also to examples taken from everyday life" and "**classification of elements**"(MIUR, 2010).

2 Theoretical background

The Chemistry of touchscreen technology is very wide and vast. Our project starts from common devices as smart phones, because they are very familiar to students and offer the opportunity to know not only common chemical elements but also the new economically strategic elements as well as the link with their geological contest. Of the 83 stable (non-radioactive) elements, at least 70 are found in smartphones.

Moreover in smartphones rare earth elements with atomic number from 57 to 71 (15 elements called lanthanides, those ending with the orbital 4f) are present in small quantities and allow the display of colours. Smartphones also contain scandium and yttrium that have similar properties. Only promethium (Pm) is not present because radioactive. In addition to allow the display of colours, rare earth metals, named by the U.S. Department of Energy "technological metals", are used in circuits and acoustic devices: the smartphone would not be able to vibrate if there were no neodymium (Nd) and dysprosium (Dy).

3 The methodology

We adopted an Inquiry based Learning Methodology an approach to teaching and learning science that comes from an understanding of how students learn, the nature of science inquiry, and a focus on basic content to be learned. It also is based on the belief that it is important to ensure that students truly understand what they are learning, and not simply learn to repeat content and information. 5the different phases of IBSE are: Engage, Explore, Explain, Elaborate, Evaluate.

4 Engage

At first we submitted to the students an initial questionnaire to analyse their misconceptions about the topic. We built the questionnaire with open questions to discover their knowledge about the periodic table and the implication of different elements in the objects that they use in everyday life.

Table 1. Questionnaire to be answered.

1	How many chemical elements can we find in a mobile phone?
2	Which metals, which non-metals, which semi-metals?
3	Do you think the mobile phone is like a mine for elements?
4	Where these elements are coming from in nature? Which minerals are used to extract them?
5	Advertising urges us to buy more smart and powerful mobiles, what do you do with your old cell phone?

48 students aged fifteen responded to the questionnaire. The maximum number of elements known to students was 8 (8 students), the exact elements named were: Lithium, Carbon, Aluminum, Silicon, Gold, Copper. The non exact elements named were: Calcium and Iron. As regards the classification of elements students know

metals and non-metals but 98% of them doesn't know the semimetals. Into metals they inserted Lithium Aluminum, Iron, Calcium, Gold, Copper. Into non metals they inserted: Carbon, Silicon.

For all of them the smartphone isn't a mine. Lithium, Calcium , Carbon, Aluminum, Iron, Silicon, Gold, Copper came from in **mines** nature for 95% of students. Only 10% of the students know the minerals used to extract the elements of the smartphone and the most know is chalcopyrite. The most common use of smartphone recycling is to give it to grandparents and parents.

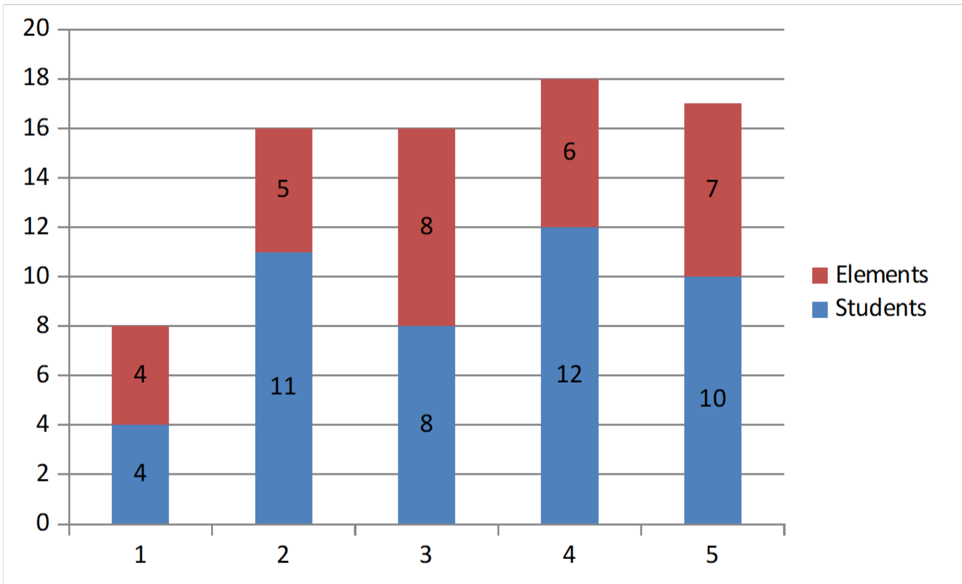

Figure 1. How many chemical elements can we find in a mobile phone? Answers to the initial questionnaire

5 Explore - Explain

We discussed with students about their answers inviting them to ask new questions. Using an interactive periodic table we discussed about the importance of the periodic table and its history. To overcome students' misconceptions we organized a game in groups: a "treasure hunt". It was realized in class and outdoor. The teacher drew a diagram of the different parts of the mobile phone on a large sheet and prepared cards with all the elements of the periodic table present in the mobile.

The class was organized in groups: each group received the scheme of a cell phone with the boxes in white and a Qr code with clues. Cards with the elements of the mobile phone were hidden by the teacher in the classroom and outdoor. All groups must complete the scheme by finding the cards in the time decided by the teacher (*e.g.*

half an hour) and posing them in the correct place of the scheme (e. g. Indium on the screen).The winner is the group who who finds the most cards and puts them in the right place of he scheme. The solution in discussed together and a complete scheme is built.

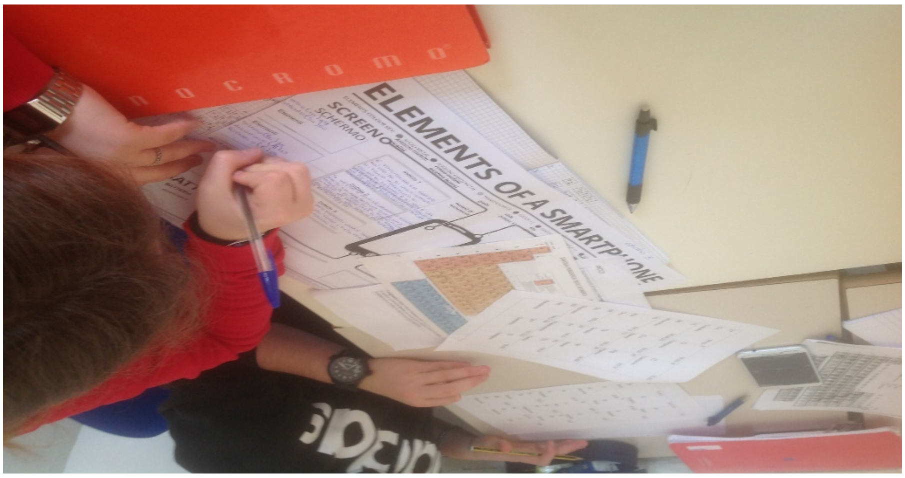

Figure 2. Students are posing cards in the correct place of a scheme of the smartphone.

6 Elaborate

Our smartphone: a mine? Each group of students is given a sheet with the name of some elements (the number depends on the number of students), every student is responsible for at least one element.

Students have to answer questions, on the basis of the information read on Qr code or on clue sheets and to find information to prepare cards for every elements of the smartphone. Students search information on the web: they use Europeanaa https://www.europeana.eu/portal/en# or other web resources.

They can also pose new questions, improving the cards. (for example a students of “terza A” posed the question: *who earns from the mines? why are many countries rich in mines poor?*

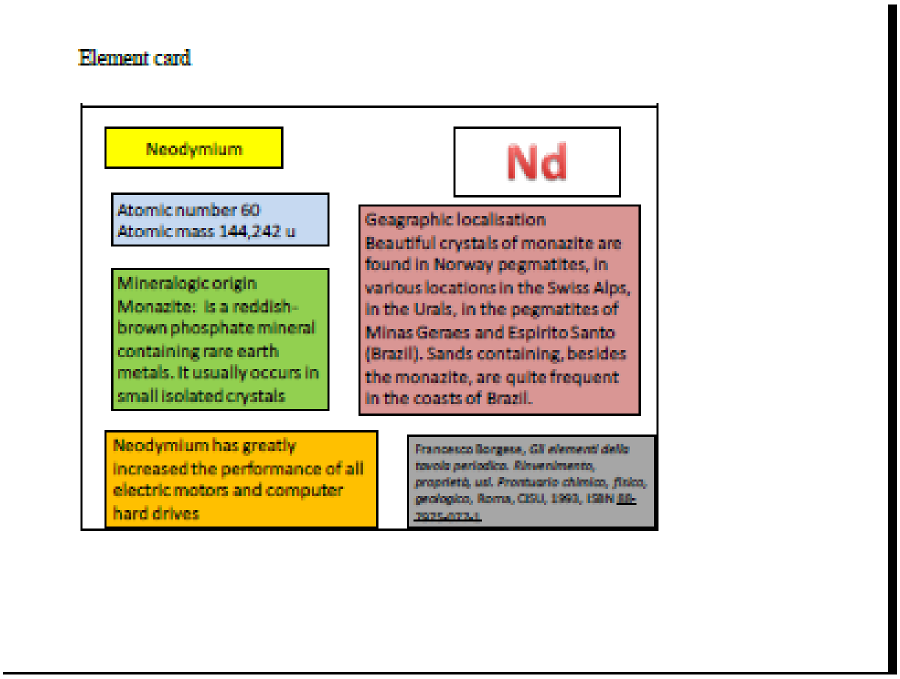

Figure 3. A card of an element of the mobile phone

Is our smartphone a mine? In class students present their cards and locate the elements of the smartphone on a planisphere where they think there was a mine where that element is extracted from rocks.

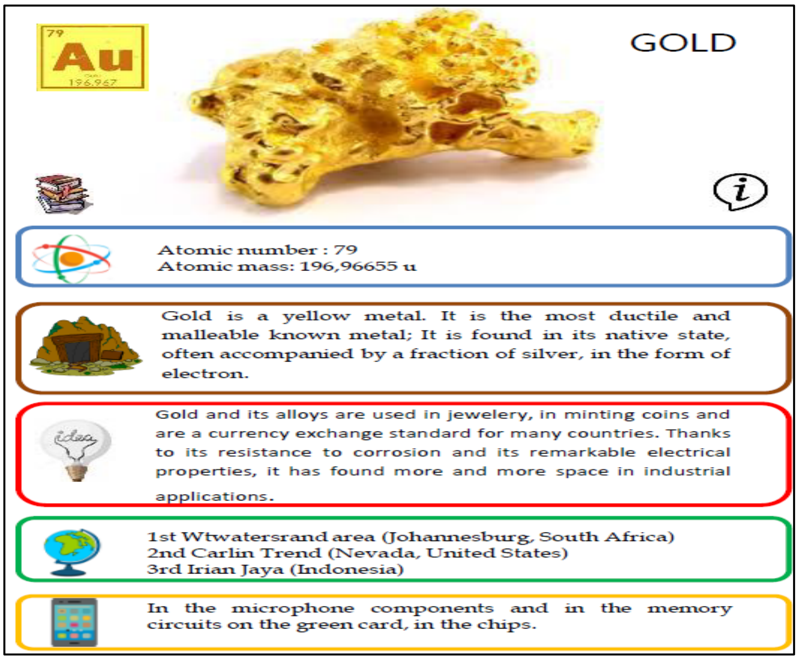

Figure 4. A card of an element made by students.

This activity was implemented through personal researches conducted by students using websites and scientific resources to locate past and recent mines, linking them to the history and to the environmental impact on the territory where they are located.

What about your old phone? Students in group looked for Italian and European law about waste electrical and electronic equipment (WEEE). In class they discussed together and with the teacher about the possibility to recycle elements of the smartphone. They produced billboards to be exhibited in the school corridors.

Students of ITE A.Bassi, Lodi decided to organize in their school a collection and disposal centre for mobile phones. They took part in a scientific fair, they displayed their posters and had them explained to other students justifying their choices.

Figure 5. Students of ITE A.Bassi, Lodi in the scientific fair ”Scienza under 18”-May 2019.

Cell phones and wars: *who earns from the mines? why are many countries rich in mines poor? The rush to raw materials has caused conflicts in the past?* Students discussed together and with the teacher about Coltan, a dull black metallic ore, from which the elements niobium and tantalum are extracted. Tantalum is used in a lot of electronic products. It comes from the Democratic Republic of Congo one of the poorest nations pervaded by conflict, poverty and corruption. The country’s economy is completely dependent on mining. Many poor families are completely dependent on their children working the mines. Now Venezuela emerges as new source of ‘conflict’ minerals”. Students searched on the web about “mines and poverty- smartphone and war". They discussed their conclusions. At home they wrote an article about this items for the school magazine

Evaluate

Students documented all activities in their work book and produced materials: carts, billboards, articles and a padlet to illustrate their conclusions.
An assessment rubric was used to evaluate the process and the product of the activity. In addition, the questions in the initial questionnaire were re-proposed.

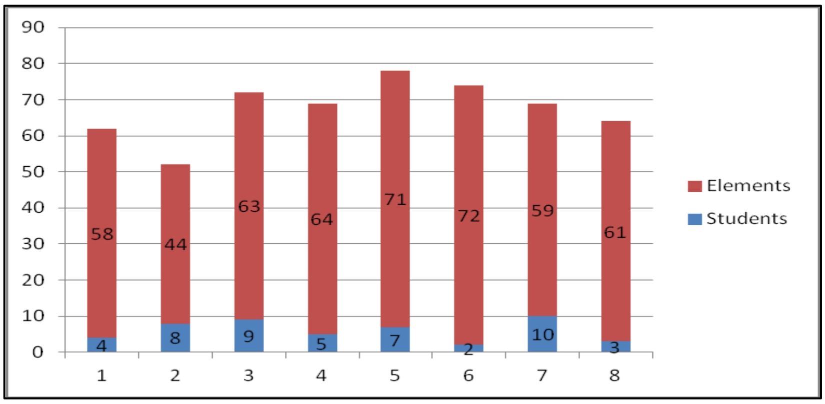

Figure 6. How many chemical elements can we find in a mobile phone? Answers to the final questionnaire

The maximum number of elements known to students is 72. All students have improved their knowledge on the properties of the elements and on the minerals from which they are extracted. The students demonstrated the capacity to separate metals, non-metals and semimetals. They proved to know the name of the most important minerals (*calcite, barite, ematite, cromite*).

Implementation

Among the great number of chemical elements contained in a smartphone manganese was evidenced as common in phone batteries. In order to get in touch with the territory and allow students to contextualize their chemical knowledge, teachers of Liceo Scientifico A. Banfi, Vimercate organized a visit to a still active mine, the mine of Valgraveglia, near Chiavari (Liguria, Italy).

The mine is called "Gambatesa", it was discovered by Augusto Fages in 1876. Now the mine can be visited thanks to the refurbishment of the equipment which was once used for the extraction of the manganese and for the miners' safety.

The visit to this mine was useful for a story telling approach: the students observed the complete cycle of formation of an element of the periodic table form stars, its arrival on the earth, its concentration in a particular place, its exploitation until its exhaustion. The visit to the mine allowed to consolidate the local culture, the knowledge of the territory and to mature those values of preservation and protection of environment that are fundamental for a rational use of resources with a view to sustainable progress.

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