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Ethical Issues in Chemical Education Evaluating Daily Life Products

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Abstract
The Italian school curriculum includes topics related to chemical safety, human or animal health, environment respect, emerging technologies and also ethical issues. However teaching practice does not focus enough on the interplay of science, technology and society with regard to local issues, public policy-making and global problems. A modified version of the "socio-critical and problem-oriented approach" can help to overcome the unpopularity of chemistry among students and promote the achievement of high-order cognitive skills, when discussing and evaluating controversial issues taken from their everyday lives and society. The perception of the relevance of chemistry in everyday applications raises awareness of the value of science and enables students to go beyond the surface features of phenomena, understanding key chemistry ideas. In Italian technical schools, chemistry teaching is usually provided just during the first couple of years. The proposed approach can be of use in contrasting the typical lack of attention of this age and the parental background - usually more of help in case of students attending non-technical schools. The experience-based work described is related to the study of a well-known product: the cat litter. This material offers different starting points for a critical examination, highlighting ethical issues involved: is the quality/price ratio justified? Is the composition clearly described? Is it environmental friendly? Is it injurious for the health? First year secondary school students answered these questions by problem solving based laboratory experiments, analysis of various documents and cooperative learning activities planned by the teacher during all the school year. The learning assessment of the considered core chemistry concepts has been compared with the assessment related to the students not involved in the project. Different learning outcomes show that educating future scientists and citizens is more effective if the students are helped by their teachers in relating correctly what they learn in school to their daily lives and global issues.

1. Introduction
Many studies at international level demonstrate that chemistry is unpopular among students [1]. A reason for this unpopularity is believed to be in the use of a content-driven approach in the chemistry lessons. In particular, Italian chemistry teaching is not oriented towards problem-solving and practical applications. Besides, chemistry teaching does not focus enough on the interplay of science, technology and society with regard to local issues, public policy-making and global problems, whereas a wide-ranging science teaching has been really effective in education researches carried out in Italy [2] and abroad [3]. Questions raised by chemical safety, human or animal health, environment respect, emerging technologies, also contain ethical issues. The Italian school curriculum includes these topics explicitly [4], but teaching practice is lacking in them. This modified version of the "socio-critical and problem-oriented approach" [3] (fitting the specific Italian school context) can promote the essential skills of well-developed scientific literacy among students, when discussing and evaluating controversial issues taken from their everyday lives and society.

2. The cat litter
The experience-based work described is related to the study of a well-known product, not only by pets' owners: the cat litter, a cheap, safe, largely available material existing in a wide variety of types (Table 1, Figure 1).

SAMPLES	PACKAGES INFORMATION	
1	"Composition: Natural clay Humidity: max 11% Density: max 1 g/cm^3 Granulometry: 0.5 – 500 mm Water absorption: min 90%"	
2	"Composition: Sepiolite (60 ± 10) % Dolomite (30 ± 10)% Other minerals (10 ± 10) % Granulometry (g): g > 5 mm (5 ± 10) % 0,5 < g < 5 (93 ± 10) % g < 0,5 (2 ± 10) % "	
3	"Cat litter perfumed with lavender". No further information is provided.	
4	VERSION I	VERSION II
	"Vegetal clamping litter made from plant fibers. Clumps form upon contact with liquids and bond liquids and unpleasant odors. Antibacterial."	"Vegetable cat litter made from pure cellulose with natural active yeasts 100% biodegradable. Harmless and non-toxic. Made from untreated silver fir trees, contains an exclusive mix of natural active yeast which offers maximum odor control. Without chemical or artificial additives, it can be disposed of as wet waste in differentiated waste collection or flushed down the toilet."
5	"Silica gel litter. The silica gel is able to perform a sudden adsorption of urine and smells; the water evaporates immediately, thus leaving the cat box completely dry. This super absorbing litter has been studied in order to immediately absorb the cat urine without letting the cat litter get clumped, as such no additional product should be required. Do not worry if the granules change color, as this in not affecting the cat litter absorbing power. Blue crystals have antibacterial action. 100% natural, it can be disposed of as wet waste in differentiated waste collection or flushed down the toilet." Colored crystals composition is not specified. After information request, the company producing the litter replied that crystals are blue because of "red cabbage juice" (anthocyanins). No information has been provided about the pink color (see Figure 1).	

Table 1. Information provided by different cat litter brands.

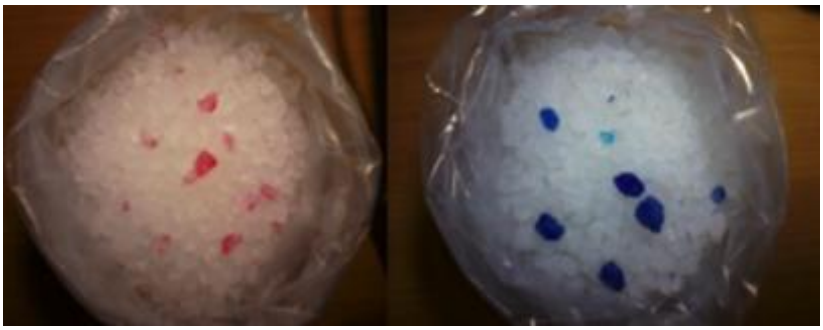

Figure 1. Silica gel litters samples.

The environmental impact of commercial cat litter has become a matter of concern: clay litter is commonly produced in an environmentally degrading process, using strip mining, a very destructive process which involves the removal of a thin layer of material known as an "overburden" to access buried deposits of useful mineral. The unwanted overburden often consists of nutrient rich topsoil,

which may have been built up over centuries; when the overburden is carelessly disposed of, this constitutes an enormous waste. Even when the overburden is replaced, it can take decades or longer for plant and animal life in the area to recover [5]. On the contrary, biodegradable litters are environmental friendly for many reasons, for example the used litter can be completely eliminated by composting. Biodegradable cat litter packages tends to be more expensive than traditional clay litters, so cost is often not a positive factor in their selection; but most biodegradable litters last longer than the equivalent size of clay (or clumping clay) litters. The material required using environmentally friendly cat litter is often lighter than the clay, so less energy is used to transport it. Besides, using eco-friendly litter reduces waste produced.
Samples of dust particles of silica material from a variety of popular clumping and non-clumping clay litters were submitted for analysis because suspected as cause of lung cancer and other respiratory diseases in humans and several animal species [6,7]. The most conservative conclusion is that silica may act as an airway irritant in those cats with airway disease and is not the initiator of a primary disorder [6]. Many conventional and clumping pet litters originating from clay deposits from different geographic areas was tested in order to evaluate silica dust concentrations associated with excess of cancer risk in humans. The key data consisted of laboratory measurements over time of respirable dust generated from activities related to the use of pet litter including initial pouring, clump removal (in the case of clumping pet litter) and replenishment. This exposure level is approximately nine-fold lower than the lowest concentration (0.54 µg/m3) associated with one in 100.000 persons exposed derived from occupational epidemiological studies [7]. Nevertheless, only biodegradable litters are absolutely safe, because they don't contain carcinogenic silica dust. At last, synthetic silica gel litter (a.k.a. "crystal litter") is a porous granular form of silicon dioxide. Silica gel crystals are chemically similar to those used in desiccants. The silica gel crystals in such litters are dotted with tiny pores, allowing the crystals to absorb cat urine, and then slowly allow the water to evaporate off. So, this litter has the highest absorbency of any litter, excellent moisture control and complete odor elimination for an extended period of time compared to other litters. When silica gel litter is saturated, it begins to smell and the white crystals turned slightly yellow.

3. The chemical education project

The cat litter offers different starting points for a critical examination, highlighting ethical issues involved, e.g.: A. is the quality/price ratio justified? B. Is the composition clearly described? C. Is it environmental friendly? D. Is it injurious for the health? To answer these questions, well-timed and simplified materials were given to the students. The teacher guided students in analysing various product aspects reading the documents proposed and dealing with the related issues. Questions about unclear points - related to the product use and its consequences at social, environmental or economic level – are posed. In succession, the teacher planned information research and laboratory activities in order to answer the questions emerged. The one school year project was structured in four stages, corresponding to the four questions listed above; each stage was organized in three phases, according with the sequence shown in the Figure 2. A definite answer is not possible using a school laboratory; anyway, by this method students formulate a more complex vision of chemistry and its relationship with the everyday life, global problems, ethical issues.

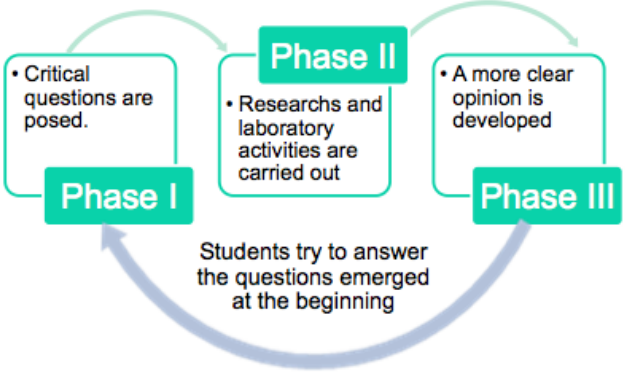

Figure 2. The working sequence of the teaching/learning process.

3.1 Educational context

Four classes of the first year technical school students 14-15 years old constituted the cohort involved in this education research. All the 74 students are boys. Students' families come from working/middle classes. The students have generally a low-level of written and oral language skills, a low attitude in carrying out homework, a medium/high level of interest toward class lessons. At the beginning of the school year, 20 closed questions are posed (0,5 points every right mark, score range from 0 to 10) related to logic (3 questions), arithmetic (7), algebra (3), experimental data comprehension (4), graphs interpretation (3). Education research has been carried out on the classes 1D and 1F. The classes 1B and 1E has been excluded from the education research. This choice is based on the following coupling class criteria: classes' composition balancing factors; students' number of each class; entrance test results.

3.2 Tests on chemical composition

The Figure 3 shows the experimental sequence carried out in order to verify the colored silica gel grains chemical composition, the most important part of the project (related to the question B: is the composition clearly described?). The coloring agent nature of the blue/pink silica gel grains occurring in two different cat litters brands is not specified on the packages. According to the company producing silica gel cat litter with blue grains inside, natural occurring substances called anthocyanins make coloring agent (only one of the two involved companies replied by e-mail to the students' inquiry during the phase I). The laboratory tests on both colored crystals samples constituted the phase II; assuming their correct execution, a false information was provided by the cat litter producing company (phase III): neither the blue color nor the pink color are originated by anthocyanins. So, students used chemistry tools in order to develop a critical thinking about market information lacking in full and correct notes in presenting the product to the consumers. At the same time, they learn chemistry core concepts involved.

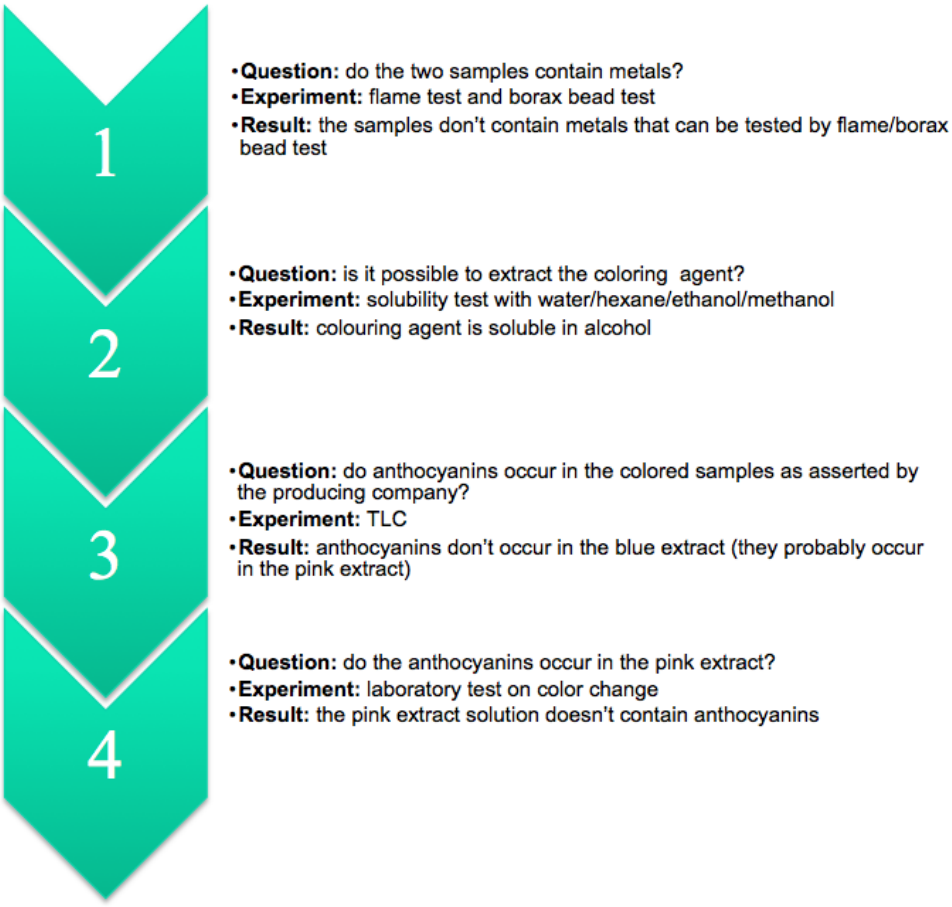

Figure 3. The chemical tests sequence of the question B/phase II

5. Conclusions

In conclusion, the results of this experimentation indicate the teaching method effectiveness in comparison with the traditional way. These results further confirm the importance of a stimulating educational context, in which students are strongly encouraged to think and learn actively. Such a context can be realized by a constant attention to the role of chemistry in a larger context, to encourage students' interest and involvement. Therefore, to achieve good results, a successful strategy is starting from everyday life products in order to learn chemistry concepts and laboratory practices.

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