Chemistry Networking Science and Technology (C#NaT)

PATHWAY

Summary:

Six researchers developed a case each, close to both, their research field and the chemistry and/ or technology curriculum in secondary education. Hands-on experiments in small groups, assisted by research personnel, usually located in research labs are the centre of activity. Besides, introduction to related research fields and everyday implications are given. Usually a product is produced, which may be carried home by the students.

Aims:

Cognitive: to get to know examples of chemistry affecting everyday life. Motoric: carrying out experiments on secondary school level with research equipment schools often cannot afford. Affective: to experience how important chemical research is for the needs of modern technology and to develop an attitude towards probable working as a chemist.

Main activities:

Example case no. 4: Modern Polymers: A. writing with light B. power from light. A. Pupils manufacture a copper copy of a black and white graphic (a logo or comic character) by the aid of a photoresist, transparent master, uv light, developing and etching chemicals. The product may be used as window decoration. B. Pupils manufacture a Grätzel cell from coated window glass, white wall paint and mallow tea (amongst others). Three in a serial circuit may power up an electronic device.

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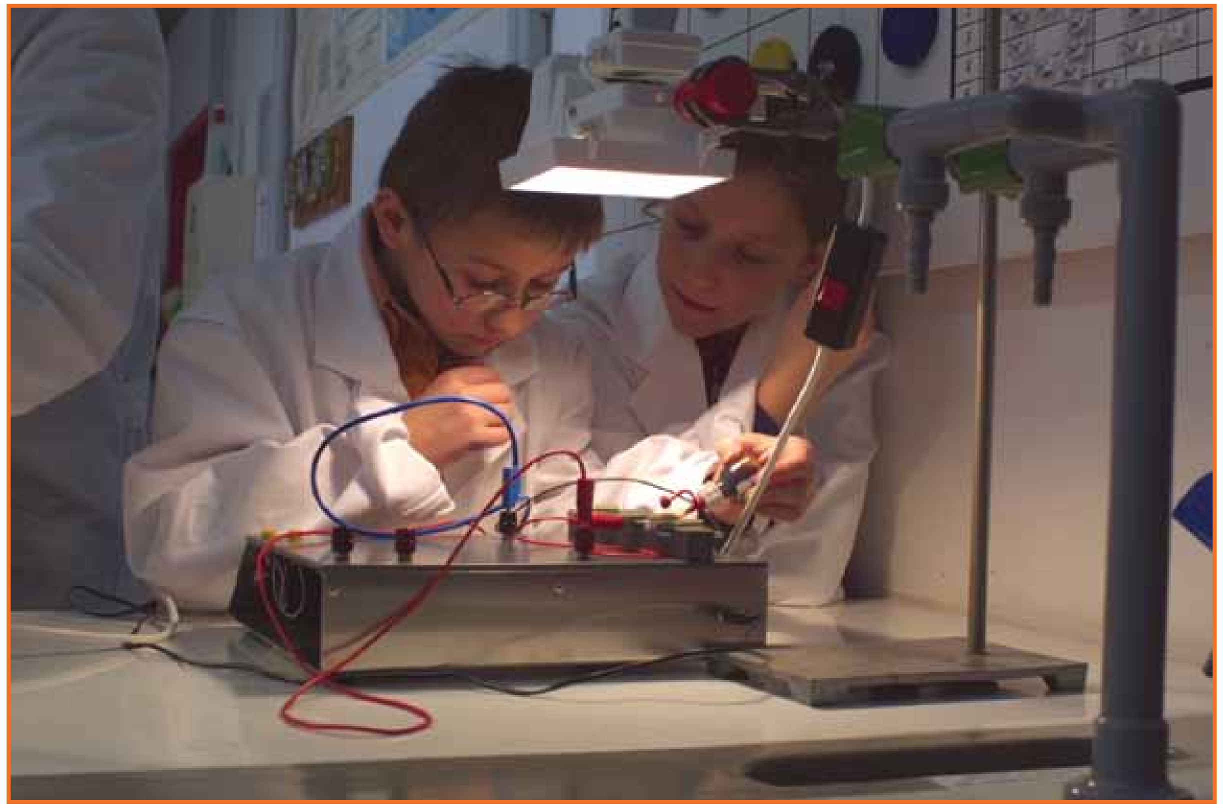
Narrative:

The activity is designed for an average form size of 30-34 pupils. On arrival the form is divided into two groups of equal size. Group 1 is performing activity A only, group 2 activity B.

A. Pupils work in pairs. They prepared in school a transparent master copy of e.g. their school logo or a comic character, place it on top of a photoresist coated copper plate (usually used for manufacturing circuit boards), expose it to uv light, develop in sodium hydroxide solution, wash and etch with a peroxide solution, wash again. The copper layer had been etched away at places exposed to the uv light. The positive image is from copper, adjacent areas show the supporting substrate (glass fiber reinforced plastic or pertinax). The product may be used as a window decoration (substrate being transparent), keyring or neck pendant, and so on. The technical process is a model for the manufacturing of integrated circuits from monocrystalline silicon, where photoresists, uv light exposure and chemical etching is also used at a scale some 100 times smaller.

B. Pupils work in pairs. They learned previously in school about the principles of photosynthesis. In the university lab they manufacture a dye cell of the Grätzel type from TCO coated insulation window glass, white wall paint (containing titanium(IV)-oxide), mallow tea (red sensibilization dye), iodine electrolyte solution and carbon black from a candle. This cell provides a voltage of about 400mV and some 100 microamperes per square centimeter. Working requires concentration and exact following of the experiment guidance. The low level experiment stops here after measuring the voltage as a dimension of quality. At the higher level for grade 10-12 pupils perform serial and parallel circuits of 2-4 cells and determine (at constant light) the characteristics of voltage and current. They may also use a serial circuit for powering up an electronic device. Everybody may carry his cell home. The basic principle of a dye cell is about the same like photosynthesis. Pupils may discover similarities on the macroscopic (grade 5-9) or submicroscopic (from grade 10-12) level.



End user
Children grade 5 to 12 (two different levels available: 5-9 and 10-12)

Involved actors
Researchers, teachers, chemistry education developed the case. During activity researchers and teachers are doing the coaching

Location:
At university lab or very well equipped secondary school labs

Languages available:
German only

Where to find the application or case:
http://daten.didaktikchemie.uni-bayreuth.de/cnat/kunststoffe/kunststoffe.htm

Duration:
2-3 hours net, excluded getting to the university and leaving

Evaluation parameters:
The C#NaT program is running so well that evaluation would be a beneficial positive extra that would add to the case's positive features, that however have not been conducted to far. The content of C#NaT runs so well since it comes directly from the users – the teachers and the students – and evolves through this direct communication and reviewing already during its creation to its well-designed end state. Compared to other cases, the content is not constructed by a third party but directly by teachers and students.

Connection with the curriculum:
Using modern polymers: A. light induced chemical reactions, oxidation, acids, hydrogen peroxide, noble metals, lithography, manufacturing of integrated circuits. B. light induced redox systems, photosynthesis, electric circuit, photoelectric power generation.

Teachers' Competencies

1	subject matter/content knowledge	x
2	nature of science	x
3	Multidisciplinary	x
4	knowledge of contemporary science	x
5	variety of (especially student-centred) instructional strategies	x
6	lifelong learning	
7	self-reflection	
8	teaching/ learning processes within the domain	x
9	using laboratories, experiments, projects	x
10	common sense knowledge and learning difficulties	
11	use of ICTs	
12	knowledge, planning and use of curricular materials	
13	Information and Communication Technologies with Technological Pedagogical Content Knowledge	

Mapping best practices with main principles

PATHWAY

1. Building interest in natural science phenomena and explanations:

A. Curiosity starts when pupils are presented REM pictures of integrated circuits. Watching the scale: structures have dimensions of 1/1000 of the thickness of one human hair. How is it possible to create such structures?
B. Photosynthesis seems like a wonder. If we could imitate the process for current generation our energy problems would be solved. The Grätzel cell does exactly that.

2. Building up informed citizens: Students understanding the nature of Science & Science in society:

A. Many industrial processes require etching with acids. Some produce oxygen, others more harmful products that need to be kept in a closed circuit.
B. Science will provide solutions for major problems of mankind: what to do as soon as fossil fuels will be exhausted?

3. Develop multiple goals:

- **understanding big ideas in science including ideas of science, and ideas about science**
- **scientific capabilities concerned with gathering and using evidence**
- **scientific attitudes**

A. Ideas about science and technology: as soon as a principle has been discovered by scientists, engineers start to build devices and optimize for everyday use. Pupils may optimize using different organic dyes (from raspberry, cherry, blueberry etc.)
B. Big Idea: solving the energy problem for mankind. How does a scientist approach the solution? Observe and copy nature, even optimize.

4. Understanding students' concepts and learning style about of science phenomena:

The program has not yet been evaluated.
The education path is inductive: first, learners come to the university lab and do the hands on experiments. Some of the chemistry facts are given at the end of the program the same day, but basic work is done by teachers the following days. Thus we expect a higher motivation for theory than doing it the deductive way.

5. Relevance of the content to daily life of students:

A. Integrated circuits work in every electronic device we use in everyday life. They allow miniaturization from several kilos to some dozens of grams in about 20 years time.
B. Prototypes exist for Grätzel cells integrated in school bags to power up cellphone or torch or laptop batteries.

6. Understanding science as a process not as stable facts. Using up to date information of science and education:

Progress in technology provides the same educational profit as "science as a process": integrated circuits get smaller and smaller, transformation of energy gets cleaner and cleaner.

7. Activities for gaining knowledge, not for entertainment, nor for simple imitating of results:

A. What is he use of learning about acids and bases in school? Understanding technological processes that provide us with everyday equipment.
B. It is not enough to know the functioning principle of photosynthesis. Devices built according to natural archetypes need to be optimized for everyday reliable and safe use as well as low price and longevity.

8. Doing science: experimenting, analyzing, interpreting, redefining explanations:

B. Evaluating the quality of their personal Grätzel cell by measuring specific electrical parameters.

10. Cooperation among teachers and with experts:

Cooperation had taken place in the development process of the program, now terminated. Teachers communicated their needs for curriculum application, chemistry experts explained their research field, education experts applied a specific organization form. During a series of three party meetings, some of them with a fourth party, students evaluating the experiments, the program was approximated to completion.