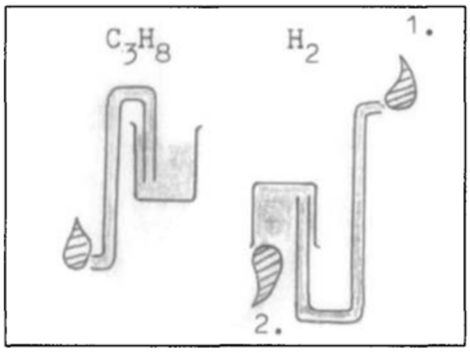

Fig. 4. *Kommunizierende Leitungen*

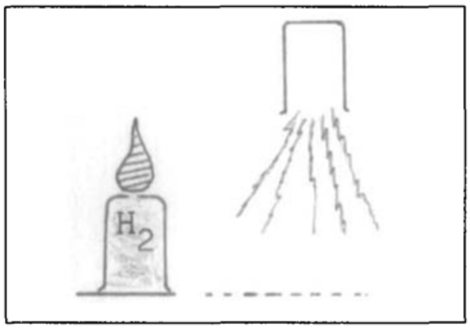

Fig. 5. *Ausströmender Wasserstoff*

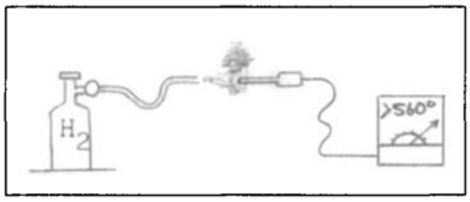

Fig. 6. *Zündtemperatur*

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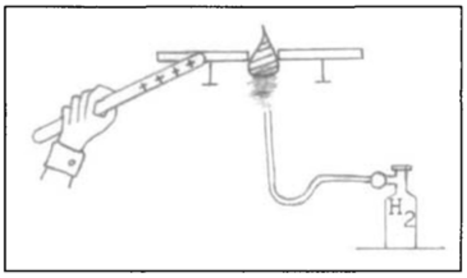

Fig. 7. *Elektrostatische Entladung 1*

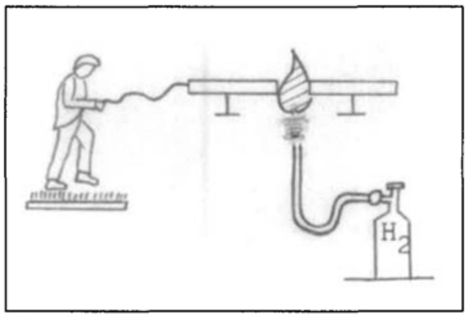

Fig. 8. *Elektrostatische Entladung 2*

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Sogar die blosse elektrische Induktion durch die Ladung eines geriebenen PVC-Stabes kann zur Funkenbildung und Zündung von Wasserstoff führen (*Fig. 9*). Heimtückisch sind diese elektrostatischen Versuche auch für den Experimentator, denn sie gelingen nur bei trockener Luft, z.B. im Winter.

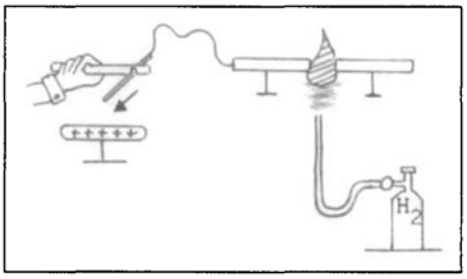

Fig. 9. *Elektrostatische Entladung 3*

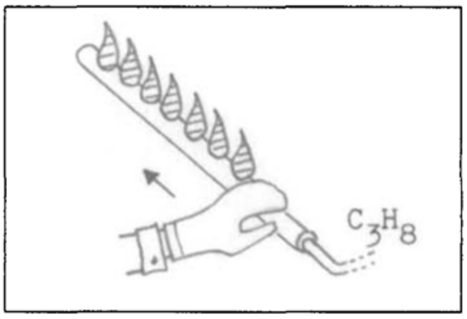

Fig. 10. *Brände löschen*

Brände können gelöscht werden, wenn eine der oben erwähnten drei nötigen Voraussetzungen (Zündquelle, Sauerstoff und Brennstoff) nicht mehr vorhanden ist: Aus einem Metallrohr mit feinen Löchern entweicht Propan, das entzündet wird (*Fig. 10*). Fährt man mit einem Lederhandschuh über das Rohr, so wird kurzzeitig der Kontakt der Flamme mit dem Brennstoff unterbrochen und dadurch der Brand gelöscht. Die Brandgefahr bleibt natürlich bestehen, solange Gas ausströmt.

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Chimia 49 (1995) 340–342

ISSN 0009–4293

A Science Course as an Experience of Scientific Life

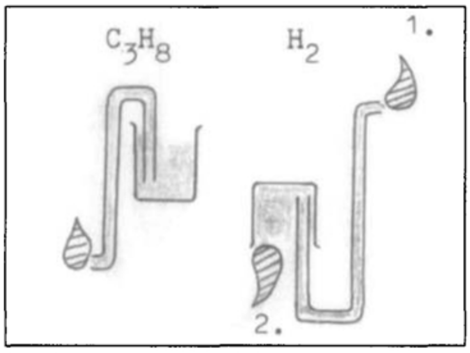
Carlo Devittori*

In teaching scientific subjects such as biology, chemistry, or physics at secondary school level the principal objective of the course should be to give the students a thorough knowledge of scientific methodology [1]. Thus it is not unusual to find in a course an introductory chapter regarding the various types of scientific activity; in other cases a separate chapter is not dedicated to this aspect, but rather it is taught through frequent referral throughout the course to the various topics of classical scientific methodology [2].

In the classroom the objective is pursued, according to traditional teaching methods, by recapitulating the salient moments of scientific investigation:

- qualitative and quantitative observation

**Correspondence*: C. Devittori
Laboratorio di chimica Liceo di Lugano 2
Centro Studi Trevano
CH–6952 Cannobbio



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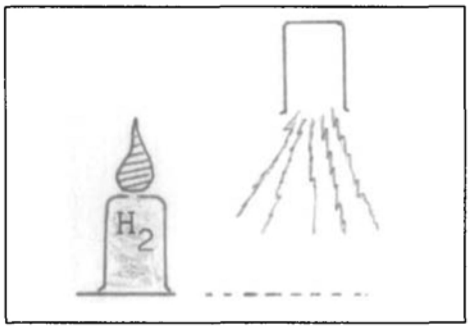

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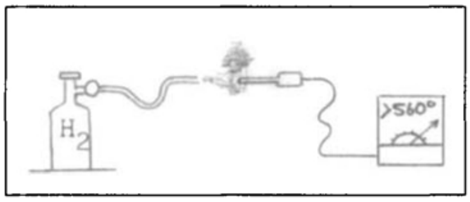

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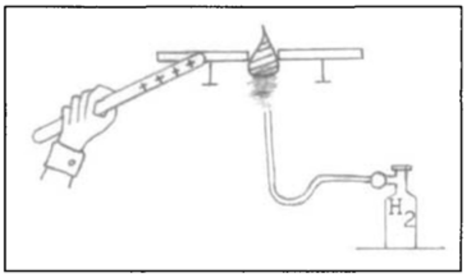

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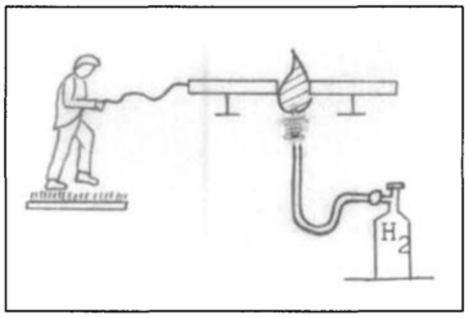

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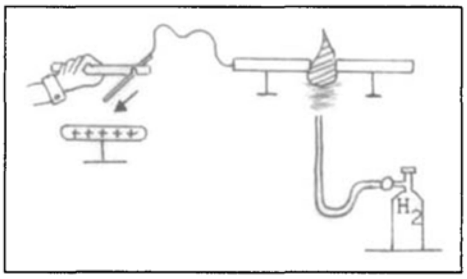

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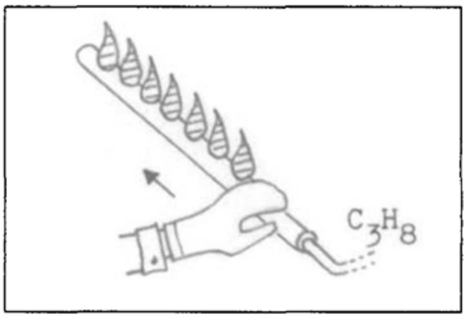

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In the classroom the objective is pursued, according to traditional teaching methods, by recapitulating the salient moments of scientific investigation:
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- analysis and statistical evaluation of the data obtained
- formulation of a hypothesis
- theoretical predictions based upon the hypothesis [3].

When the methodological objective is predominant it is achieved through study of particular phenomena [4] or through the presentation of specific problems [5].

During experimental classes (perhaps better termed 'experimentatory' classes) one tries to instill manual skills as well as rigour in measuring, evaluation of collected data, and verification of a law which is usually already familiar to the student [6]. In more demanding courses only the problem and the objective are presented, whilst knowledge of the law and any theoretical deductions are reached under the guidance of the teacher.

All of these teaching methods present some negative aspects from the point of view of the acquisition of a methodical scientific attitude in students who are normally also obliged to study other nonscientific subjects such as history, philosophy, languages, *etc.*:

- During lectures scientific methodology is often reduced to an argument (one of many) which occupies the attention of the student during a single lesson (usually the introductory one); afterwards the argument tends not to be considered by the student who is busy trying to learn definitions, laws, and quantitative concepts and how to resolve calculations. A more involving way to develop scientific methodology is to conduct investigations on everyday problems. However, practical activity in this direction is not common.
- Traditional laboratory exercises are often viewed by a student as being extraneous to everyday problems and carried out simply to verify some abstract law; experimental activity often arouses the curiosity of students but the procedures used, as well as the reasons for the experiment, often seem strange to the student.

In no case does the student experience the fundamental moments of scientific activity whereby a problem is visualised in a real context, specialist literature is searched, an experiment is designed which can be carried out in the laboratory under controlled and reproducible conditions, and a protocol drawn up.

The student is also denied the satisfaction of dealing first hand with a real problem which his contribution, albeit modest, serves to resolve and thereby add to the pool of knowledge. If the theoretical parts of a course appear to the student to be abstract and only remotely connected to reality, laboratory work of the traditional type often seems to be 'artificial', somewhat like boring 'training' for some future game, or even as an exercise already carried out by generations of former students and not at all original or personal.

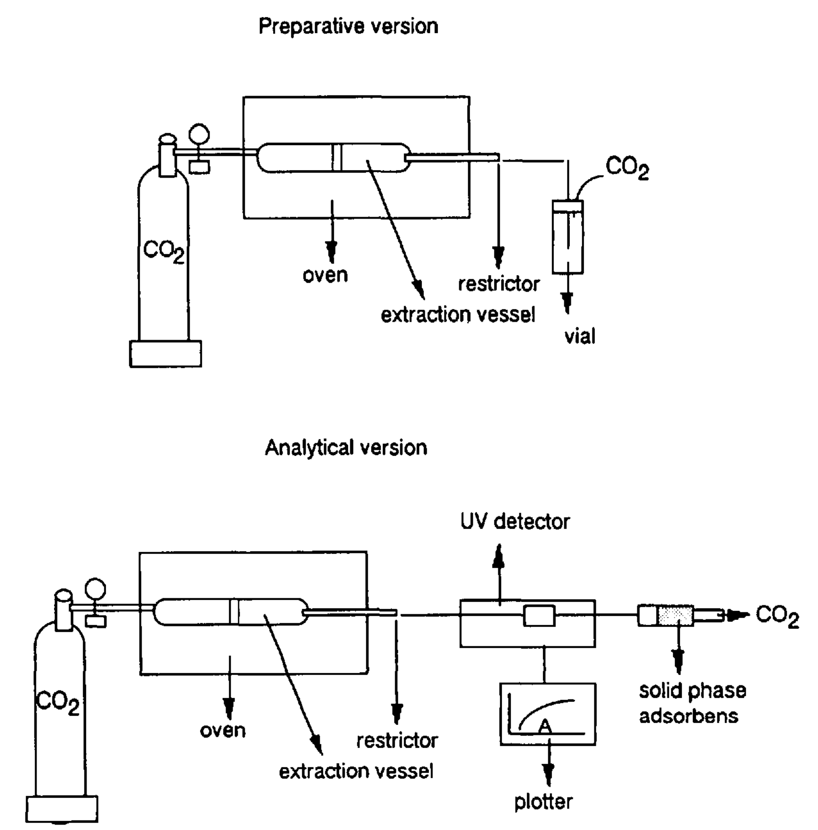

Fig. 1. *Preparative and analytical versions of the home-made supercritical fluid extraction unit*

Is it possible instead to involve students in a true scientific experience? If some old prejudices are demolished, perhaps the answer is affirmative.

First of all it is necessary to remember that students can be presented with relatively complex problems in a scientific form which is simplified but still without distortion or trivialisation. It should be noted that a falling body, an energy flux during a chemical reaction, or photosynthesis, are phenomena of great complexity which nevertheless are commonly presented in a simplified, but still correct, way.

Should it not be possible to make equally accessible research problems regarding pollution of the ambient, preparation of new materials, studies of the behaviour of vegetables, animals, and materials under conditions which are typical of today's reality?

The same goes for many techniques of measurement and observation which have a theoretical basis which can be summarised in simplified, but nevertheless scientifically correct, terms. No one worries too much about understanding the complicated physical principles behind a chronograph, a tachometer, a microscope, or a pH meter – cannot one make use of a spectrometer or particle counter in the same spirit? If one accepts these principles it becomes possible to design countless small but realistic scientific research projects, wherein the main objective remains the acquisition of scientific methodology and perspective; according to this sort of scheme a second, short term objective becomes the acquisition of relatively simple notions, whilst a third, longer term objective is to develop curiosity and a desire to know more about theoretical aspects.

A project of this type has been conducted with final year students at Lugano 2 High School, and consisted in finding replacements for organic solvents in extraction of natural products of interest to the pharmaceutical and food industries.

Thus interest was focused on extraction using supercritical fluids, a field of research in rapid development and likely to see many other development applications in the future, including contributions from non-university students. Moreover, this field of research offers a remarkable number of interdisciplinary aspects (chemistry, physics, biology, and mathematics) *e.g.* in the definition of the biological

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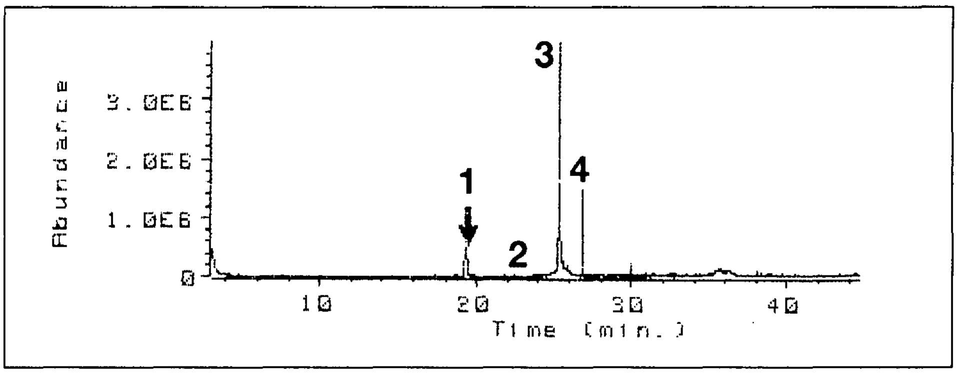

Fig. 2. *Chromatogram of SFE extract of cigarette tobacco.* 1: Unknown; 2: (*E*)-solanare; 3: nicotine; 4: neophytadiene.

material selected for extraction, in the choice of extraction conditions, in the qualitative and quantitative studies of the extractive ability of the fluids, and in the realisation of the instrumentation on a limited budget.

During two years of work, good results have been obtained based upon observations regarding the extractive power of gases such as helium and nitrogen, first under normal conditions [7] and later at increasing densities, and finally using carbon dioxide and an extractive technique based on makeshift equipment [8].

The extracts obtained from natural products such as spices, coffee, tobacco, flowers, and leaves have been analysed using analytical techniques such as GC, GC-MS, SPME-GC-MS and IR.

Construction of the extractor and its validation represented the major part of the work during the first year.

The apparatus which was developed, as well as several extracts (essential oils of pepper, cinnamon, rose, tobacco, and crude caffeine), were given a prize at the National Youth Science Competition and the students were invited to the International Meeting for Young Scientists in Luxembourg. *Fig. 1* shows the preparative and analytical versions of the extractor.

Good results were obtained for extraction of spices such as pepper, cinnamon, cumin, cloves (which showed a high concentration of piperidine, cinnamaldehyde, cuminaldehyde, and eugenol), jasmine flowers and rose petals, pine needles, orange peel, coffee, as well as cigarette tobacco which gave rather selective extraction of nicotine and neophytidine under the conditions used (see *Fig. 2*).

In the next few years, depending on available funds, the intention is to develop a more sophisticated extractor with a pump, solvent recycle, and fraction collector for separation through multi-stage decompression; this extractor will be built or assembled at the school.

An important feature of the new extractor will be an increased operating pressure and a higher flow rate, as well as the possibility to fractionate through progressive reduction of the pressure. Bench scale extraction using volumes of around 500 ml will permit the introduction of mathematical models, and will be integrated with the courses in mathematics and applied mathematics, the latter having recently been introduced in the science curriculum.

From both the scientific and teaching point of view the experience has proved highly successful, as is seen from the number of students who have joined the course and in their dedication to resolving the various problems.

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Chimia 49 (1995) 342–343
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ISSN 0009–4293

Experimental Chemistry Is Fun – But Theoretical Chemistry Tells You what the Fun Is About!

Gustave Naville*

Eine andere didaktische Herausforderung als die im Editorial angesprochene doppelte Zielsetzung des Chemieunterrichtes und gleichzeitig die stille Begeisterung des Chemielehrers ist: Experiment und Theorie.

Schon *Liebig* soll als Vorgeschichte, wenn nicht gar als Grund seines Studiums sich an seinen Chemielehrer erinnert haben, in dessen Unterricht es knallte und stank und farbenprächtig reagierte. Auch ein fachtüchtiger Kollege, unterdessen in aktiver Pension lebend, erzählte mir mit leuchtenden Augen von ähnlichen Jugenderlebnissen. Aber nur an den Experimenten kann es auch seinerzeit nicht gelegen haben.

Andererseits gibt *Wagenschein* mit seinem 'Rettet die Phänomene' jedem naturwissenschaftlich Unterrichtenden und sei-

**Korrespondenz*: Dr. G. Naville
Kantonsschule Oerlikon
CH–8050 Zürich