Philosophical aspects of analytical chemistry III *
On education and definitions**

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1 Introduction

FECHEM-Conferences provide opportunities for truly collaborative international efforts to replace the symbolic and sometimes paternalistic arrangements of the past. The 2nd FECHEM-Conference on Education in Analytical Chemistry is to be considered from this point of view. The Working Party's concern about this subject may be traced back to EuroAnalysis II (Budapest, 1975) and to the 1st FECHEM Conference held in Vienna in 1980 and has since been a permanent topic of its activities. Since R. Kellner became the chairman of the special Study Group on Education, many issues have been released to the analytical community. One of the major events in the activities was the well attended special session on Education with many contributions, held at EuroAnalysis VII in Vienna, 1990. This event clearly showed that the time was ripe for a re-evaluation of the curriculae for Analytical Chemistry to produce better ones than those currently existing throughout Europe (and USA). Gradually as the problem becomes more urgent, the wish (and the need) for a drastic change cannot be overlooked. The best proof for this are the "Declarations of Vienna"[1]. This aim of such Declarations is to strengthen efforts for the creation of new curricular which can and should come about in response to the expanding capabilities and aspirations of many more people than just those involved in WPAC/FECS.

However wishes and realities are two different pairs of shoes and in order to specify the wishes pair, the 2nd Conference has been arranged here in this wonderful city of Prague.

2 On education

Education always starts with the demarcation and alignment of the theme to be taught. This paper is the last of a series of papers aiming at a basic discussion on the subject and especially its definition.

2.1 General

Education in its broadest sense can be viewed as transmission of the values and accumulated knowledge of a society to its children to guide them in learning a culture, molding their behaviour into the way of adulthood, and guiding them towards their role in society.

In the most primitive cultures, there is often very little formal learning; little of what we would call school and teacher. In more developed cultures, experiences become less direct, less a matter of showing and learning in the context of the workaday world, and more abstract. This concentration of learning in a formal atmosphere allows children to learn far more of their culture than by merely observing and imitating. As societies attach more and more importance to education they try to formulate overall objectives, content, organization and strategies of education. They develop philosophies and theories of education which are often very different from each other (East-West, Liberal-Centralised, etc.).

If we want to understand "Education" better, than it is wise to read B. Russel's book "Education and the Social Order" [2] and the last chapter of "Problems in Philosophy" [3].

One of the most important men in the field of education at the time of Rudolf II was the Moravian, Jan Amos Komensky (called Comenius). We are celebrating his 400th birthday this year.

His most famous books have been translated into 16 languages and the "Orbis Sensualium Pictus" (1658) has remained popular in Europe for two centuries, attempting to dramatize Latin through pictures illustrating Latin sentences, accompanied by one or two vernacular translations.

Following the Encyclopedia Britannica (18, 44ff.), he was the humanist who claimed [4] "...understanding and cooperation can best be achieved through "pansophia" (universal knowledge among all men and all nations), achieved by means of widespread educational reforms in the methods and principles of teaching, including a universal language and universal co-education ... With regard to methodology ... education must take care to get the timing right and in the right sequence. The lesson must begin with clear, practical facts, enable pupils to engage in independent and self-regulated activity and have time for revision and practice.

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Most important, everything should be presented to the senses — and to as many senses as possible simultaneously, using pictures, models, workshops”.

It is really naive to believe in our life as a whole that a strict separation is possible of politics and science or politics and culture. All we do and everything in our behaviour is (or should be) conducted under well understood Platonisms, sometimes political but at all times based on belief in the unchanged and eternal truth of reality, independent of the changing aspects of the things of our world as perceived by our senses. This is based on the “Politeia” and leads us — in the interpretation given by C. F. v. Weizsäcker (in his book “Garten des Menschlichen” [5]) — to the theory of “Idealization” (Ideenlehre) of Plato and shows, by the end, the four part pattern of the general aspect of anything as shown above. As for Higher Education, the essential characteristics for education at University level were firmly established during the 11th and 16th centuries (at least in Europe). Since that time a bigger change took place during the Age of Enlightenment with Humboldt particularly important for western universities; today there is again an educational revolution throughout Europe.

If it is still agreed that the “Universitas litterarum” should remain the place for “higher education through philosophy and science” and that scientific truth should never be a ball in the game of “democratic football”, then it is time to define the aim of modern education as follows: “To create critical graduates who not only have the required knowledge and skill to enable them to compete on an international level but, above all, are aware of their responsibility toward society and nature”.

This is exactly our point — we are looking for a picture of Analytical Chemistry which is not only adequate to the facts but also to philosophical and linguistic needs.

2.2 The motivation for a change in education of Analytical Chemistry

What are the motives for seeking educational change in Analytical Chemistry?

Without going to a profound depth into the ways of gaining, accumulating and transmitting knowledge in our modern world of enlargements in space and time as well as in the change in the ways of production-consumption policy (going from chemurgy to ecochemistry) and above all in recalling the old philosophical aspects in the good conduct of life, an essential consideration of the four basic pillars of any science, namely:

Analysis, Synthesis, Theory and Practice  
or in terms of Plato  
Image, Construction, Idea and Use

needs to be brought into all our teaching systems.

To make it more clear, let us point to some new aspects. First let us call on I. Newton [6] who said

“Quamadmodum in mathematica, ita etiam in physica, investigatio rerum difficilium ea methodo, quae vocatur analytica, semper antecedente debat em quam appellatur synthetica. Methodus analytica est, experimenta capare, phénomena observare; indeque conclusiones generales inducitio in ferre, nec ex adverso ullas objectiones admittere, nisi quae vel ab experimentis vel ab aliis certis veritatis desumantur.”

“As in mathematics also in physics the exploration of difficult matters must be preceded by that method which is called the analytical one and applied before that which is called the synthetic method. The analytical method is to comprehend experiments, to observe phenomena — and from this to develop general conclusions through induction and not to allow any speculations, except those drawn from experiments or other true events.”

This statement still fully holds in principle. Even if there are so many new basic philosophical treatises in knowledge theory, it is obvious that natural sciences are basically empirical with some feedback to rationalism. Such considerations finally lead to the question: “Is Analytical Chemistry a deductive or an inductive science, or in other words, is it philosophy, philosophy of analysis” or “analytical philosophy”.

Second and very close to current concerns, is the definition of an Analytical Chemist given in 1991 by the RSC [7].

“An analytical chemist is one who applies knowledge of the principles of the physical, life and engineering sciences to provide and utilise the means whereby the constitution of substances is established and who exercises professional judgement on the interpretation and use of the information obtained”.

In this definition, an initial move towards establishment of an international standard for competence, the analytical chemist seems to be well described — but not analytical chemistry. And what about if the “one who applies” comes from another scientific discipline?

Moreover, looking more closely at the word and meaning of “judgement” we are immediately led to I. Kant’s three books on “Critiques” and far away simply from “number production” leaving the judgement of the primary results of work to others! Here lies the big social challenge, not only in view of the work of the analyst for society but particularly of his position in the society of being a scientist, artist or craftsman. To what goal is education directed?


This argument says in the last instance: Analysis is (as “Analitike” in the sense of Aristotles or as Analytics in modern science theories) the sole tool for:

1. clarification of fact — causality relationships;
2. any assertion (conclusion, judgement) and the verification of its truthfulness;
3. any prognosis or retrognosis in natural science. This is demonstrated in Fig. 1.