International Conference on Innovative Learning in Chemistry

Belgian experts' Synthesis on Students' Motivation

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1. European observations

The youths' disaffection for science in general and for chemistry in particular is widespread in Europe.
The situation is worrying: at the University of Louvain, 120 students graduated in chemistry in 1972 while there are only a dozen of them now.
The causes evoked can be divided in two categories :

➡ **Society-related causes.**

Up to the years 70, science and chemistry were considered as **factors of progress** (remember for instance the space missions). The opinion turned after a period of disillusion, science was no longer considered as a source of progress. Environmental concerns (which are legitimate) have taken precedence and the image of chemistry was **tarnished.** It must be pointed out that sustainable development and chemistry are not mutually exclusive, but this idea is not easily accepted by the public. There is much **disinformation** such as the opposition between "chemical" and "natural" product.
It seems that society shows more consideration for a doctor, an economist or a manager, than for a researcher in chemistry or for a science teacher.

➡ **Subject-related causes.**

Studying chemistry is considered as **difficult**.
In secondary schools, chemistry teaching is **too theoretical**, little space and time is dedicated to experiments. Yet chemistry is before anything an **experimental science**.
This is partly related to the **lack of laboratory sessions and equipment** in many schools.
The **methods** used are little appealing: the nomenclature is often learned "by heart", teaching **lacks of context**. Unlike physics or biology, chemistry does not seem to involve a **great challenge**.

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2. Experts' observations

- Despite all the promotion initiatives (from university, the industry, …), the number of chemistry students in higher education is not increasing.

- In secondary education, many teachers are often helpless :
  - There is a same teacher for biology, physics and chemistry
  - Security-related worries
  - Class-groups of 28 students

- Few experiments

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So, what should be done ?

Teaching chemistry poses problems, one has to be "**imbued with chemistry**" to understand them. Only those who have really assimilated the sense of chemistry will be able to validly learn it.
Those who have renounced, thinking that they would not understand anything about chemistry cannot and will not be interested.
According to Bernard Tinant, chemistry, the science of matter transformations, raises two great questions :

With what (which reagents) and in which conditions can I make the product X?

If teachers do not pay attention to the problems of jargon, of symbolism and of **chemists' language** in general, they will answer this question by writing an equation with formulas without explaining why this symbolism is used. The student will very soon be led to **chemistry "on paper".** Chemistry will seem harder than Chinese and meaningless. It must be noted that many students who start the first year at university **mix up reality and formulas…** The remedy is clear we must go back to **experimentations** !

Being aware of the recipe, how much A and B should I use to make 10 Kg of X?

The problem here is human, we have always liked seeing what we play with, yet atoms and molecules are too tiny to do so. We have to **imagine** the microscopic world, we cannot **comprehend** it, "**grab** it". The change of scale that appears when introducing the concept of mole as a unit of quantity of matter is not clearly explained, and the comings and goings between **the microscopic and macroscopic worlds** are not numerous enough.

Beside the complexity of the language, teachers are confronted with those two difficulties when the fundamental bases of chemistry are addressed (in second grade in Belgium). It is probably too early, at least the modelling aspect, when one consider the cognitive and psychological development of 16 year old students. This results in a reaction of reject.

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3. New ideas for remediation

More experiments in the class, specific preparation for studies, ICT associated with systemic approaches…

- To integrate more **experiments in the class,** greater means are necessary, in terms of **equipment**, and **infrastructure** and in terms of **training** of the teachers. In this regard, some initiatives are taken (such as continuing training, new frame of reference for skill).

- **Specific preparations for higher studies in chemistry should be created.** In Belgium, there is no prerequisite to study chemistry at university (unlike, for instance, medicine).

- **To associate the use of ICT, experiments and a systemic approach…** These are realistic ways to "**see**" and "**make**" or, even better, to "**build**" experiments.

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Analysis of the sources of (de)motivation in the school context

The educationalist Rolland Viau proposes a list of practical advice to motivate students.
They can be put in the context of chemistry course :

1. Not to harm students' motivation.

It is in the teacher's best interest to be aware of personal features that might harm students' motivation and to try to counteract the negative effects.

- Master one's subject
  In science education in Belgium, there is often a same teacher for biology, physics and chemistry, and they are not all trained as chemists.
- Adapt the subject to the students
  The gap between the academic knowledge taught in universities and school subjects can be huge.
- Define the contents
  In the laboratory, the substances used are foreign to the student. Chemical phenomena known to the students (meat cooking) are often too complex to be accessible.
- Provide examples and analogies
  Chemistry uses real objects that cannot be perceived by senses (such as atoms, molecules and ions). Moreover, those objects are more numerous than anything the student could comprehend.
- Be willing to teach chemistry
  The work of teacher nowadays is particularly focused on learning and requires a people-oriented profile. Being interested in inert matter is not enough.

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2. To improve one or several aspects of teaching to increase students' motivation.

The teacher should bring students to :

- Make connections between what they know and the new subject.
- Solve problems that will help them better understand the reality around them.
- Play an active and dynamic role.
  The danger of some experiments can be an obstacle on students' initiative.
- Propose activities for assimilation:
- Propose activities for integration. An integration activity requires from the students that they use on their own initiative the knowledge and skills acquired in the learning.
  Chemistry is a particularly complex science, in which beginners need support from an expert.
- Assessments influence motivation

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ICT and systemic approach to chemistry

It emerges that chemistry is an unusual subject, delicate to learn.
Given the evolution of knowledge societies and of the school public (including its motivation sources), teachers find themselves with new constraints that require a change of professional attitude.

The analytical process needs to be completed with a **systemic approach** to learning. By making it possible to dynamically model the microscopic universe, **ICT** participate in this transformation.

Therefore teaching sequences on chemical concepts that are particularly difficult to teach and learn, associating ICT and systemic approach, will be proposed and tested in Belgian secondary school classes that are partner to the European project. Their impact on motivation, and thence on students' learning, will be assessed.

This European project "**Chemistry is all around**" aims at optimising the learning of chemistry, making available to teachers existing ICT resources and newly created learning sequences on the project portal.

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Conclusion :

Chemistry is a particularly complex science, in which beginners need support from an expert in order to :

1. Master the scientific jargon
2. Master it through experiments
3. Master it through the use of ICT

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