

**CHEMISTRY TEACHING
AND SCIENCE OF EDUCATION IN GERMANY
PART 1: ASPECTS OF CHEMICAL EDUCATION IN GERMANY**

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ABSTRACT

This article summarizes the main ideas of our lectures at the Ho Chi Minh City University of Education in March 2013. It is about aspects of chemical education, goals and problems of chemistry teaching in Germany and the importance of a sustainable and meaningful chemical education.

Keywords: chemical education, legitimation of chemistry teaching, Germany, didactics of chemistry

TÓM TẮT

***Giảng dạy Hóa học và Khoa học giáo dục
Phần 1: Các đặc điểm của Giáo dục Hóa học ở Đức***

Bài viết này trình bày tóm tắt các nội dung chính trong các bài giảng của chúng tôi tại Trường Đại học Sư phạm Thành phố Hồ Chí Minh vào tháng 3 năm 2013. Những nội dung này nói về các đặc điểm của nền Giáo dục Hóa học, cũng như những mục tiêu và các khó khăn của việc dạy học Hóa học ở Đức. Đồng thời bài báo cũng đề cập đến tầm quan trọng của một nền Giáo dục Hóa học bền vững và có ý nghĩa.

Từ khóa: giáo dục Hóa học, ý nghĩa của dạy học Hóa học, nước Đức, phương pháp dạy học Hóa học

1. Introduction

Chemistry teaching seems to be similar all over the world. Although the teaching content consists of neutral, universal perceptions of chemistry, the comparison between Vietnam and Germany shows that there are distinct differences in chemistry teaching in both countries. These differences obviously have traditional, cultural reasons and are matters of education policy. In the cooperation with the Department of Chemistry, Professor Hans-Jürgen Becker from University of Paderborn in Germany was invited to lecture about “Chemistry teaching and Science of education in Germany” at the Ho Chi Minh City University of Pedagogy, HCMC. The lectures were organized by the Department of Chemistry. We would like to thank Vice-Director Huynh Thanh Trieu and Dean Duong Ba Vu for support.

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This article is the first part of three articles. In this article we will describe the didactics of chemistry in Germany and discuss about its meaning concerning a chemical education from a cultural view. The second article will deal with the significance of pupil-orientation compared with subject-orientation, while the last one will focus on our experiences from the lectures at the HCMC University of Pedagogy in March 2013.

2. Chemistry teaching in German school system

Each of the 16 states of Germany has its own education policy and therefore there are different school systems in the country. For the last years education policy has been centralized so the different school systems have been getting more alike over the years. The following information, which is very simplified and without specifications, shows the school system in Nordrhein-Westfalen:

Tab. 1. Chemistry teaching in German school system in NRW

3. Legitimation of chemistry teaching

3.1 "Why?"

The "Why?"-question is a very meaningful question to legitimate chemistry teaching and learning. In Germany it has been a long tradition to think about that. It is necessary to reflect on the meaning, task and responsibility of chemistry teaching (Fig.1). This question is a base to define reasonable aims for education in general and for scientific literacy in particular (especially chemical education) and to pursue these aims effectively. Science and government need to cooperate in order to find an answer. Empirical researches (evaluations, long scale assessments) measure cognitive effects of actions implemented by education policy.

Today the philosophy is that chemistry teaching needs to help explaining the world's phenomena and to show a chemical view of the world. Chemistry teaching should form intellectual and individual abilities of the pupils and give an orientation for

their daily lives after school. Furthermore it is necessary to teach chemistry in order to understand and protect the environment and to secure welfare of the society and human being.



Fig. 1. Concerning the Why? -question: "Just learn it like that. I also don't understand everything I know!"

3.2. "What For?"

3.2.1. Head, Hand and Heart

The "What for?"-question means the defined aims of chemistry teaching according to a chemical education (scientific literacy). A traditional "What for?"-answer can be confined to learning psychology, also known as the 3 H: Head, Hand, Heart.

Head: Chemistry teaching should form cognitive thinking. The lowest level is to know; the highest levels are problem-solving skills, which mean to analyze and evaluate special situations, questions, tasks and problems.

Hand: Chemistry teaching should form experimental skills or psychomotor skills. It ranges from an imitated behavior to an automated activity. Generally, it is the task to connect the head with hand, meaning "handling-orientation".

Heart: Chemistry teaching should make pupils internalize values, attitudes and positions - in their head and in their heart. The easiest degree is to attend. The most difficult degree is to determine a value or a system of value for a student to be active.

Changes in behaviors of pupils are the basis for testing learning effects of chemistry teaching. But in the past this principle was only reduced to cognitive aspects worldwide. "Bildung" in Germany, which means general education, is more than knowledge (Fig.1). Knowledge alone is not enough if pupil's interests or wishes are neglected.

3.2.2. Relevance aspect

Another answer to this "What For?"-question is the consideration on relevance of chemical teaching according to its legitimation. Chemistry teaching has the duty to make pupils familiarize with chemistry and chemistry in the cultural context (relevance).

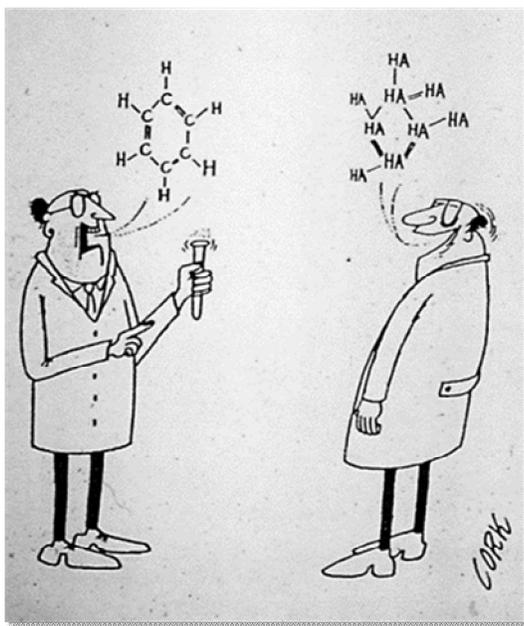


Fig. 2. Subject-relevance

Subject-relevance

- Pupils should have a scientific view of the world and they must have the right imagination about chemistry (Fig.2.). Chemistry teaching needs to lead pupils to acquire chemistry knowledge about phenomena and properties of substances.

Pupils-relevance

- Chemistry teaching has a great influence on the behavior of students and their development. It forms "abstract thinking" or special comprehensive effects, which mean the abilities to recognize and solve problems, to generalize, to describe indifference, to interpret and to explain.

Social-relevance

- This aim is really important and has a long history in Germany. Chemistry teaching should indicate that the scientific discipline “Chemistry” plays an important role in daily life; therefore chemistry lessons should reflect the applications of chemistry in society and should help to understand the world, including the society, the economy, the industrial productions, the political decisions, the daily life and communication processes in public media, etc.

Environment-relevance

- Today Chemistry teaching must form ideas, knowledge and responsibility about ecology and especially environment. This also includes right behavior, for example the attitude towards the waste problem and recycling process. Today this is called sustainability.

These aims are not so concrete but can be more flexible; therefore teachers have more freedom to decide which content to teach and how to organize chemistry teaching.

3.2.3. Competence

In Germany the new answer to the "*What-for?*"-question is the orientation to so-called "competences". The competences characterize standard requirements in 4 following areas:

- **Knowledge and its handling**
- **Extraction of cognition**
- **Communication**
- **Evaluation**

Today, the competence-categories just have been modelled. In the next step the validity and reliability of these models must be tested. So-called "standard requirements" will be used to characterize the behavior of pupils, therefore special exercises/tasks are needed to evaluate these standards. The final step is to plan lessons in order to implement the competences in chemistry class. The new curricula are already competence-orientated and the content has been redesigned based on that model.

3.3. "What?"

"*What?*", that means the content of chemistry teaching, involving the themes or the knowledge of chemistry, that should be learnt in order to reach the aims of chemical education. The content of chemistry has changed for the the last 50 years as it has altered the teaching from “substances and materials and phenomena” to a very abstract structure (“basic concepts”). In the past few years, the so-called "structure of discipline" was the main content of the German chemical education and today it is

usual to teach the chemical sight of discontinuum, which means the imagination of small particles that exist in every substance. This might explain that gap of non-understanding, because pupils usually think in a continuum sphere. They can't see the particles. But this content has never been in doubts for years.

But concerning the aims and goals of chemistry teaching, the content is the greatest problem needed to solve for chemical education worldwide in order to teach meaningfully. For all types of school in the German education system (including the kindergarten), most of chemistry themes are not so compatible with the abilities of learners. Therefore it is necessary to teach different structures of disciplines depending on pupil's age, their mental skills and their relevance of chemistry to their daily life. All of them are the main tasks of didactics of chemistry.

The methodological question ("**How?**"-question) is also an important aspect of chemistry didactics that should also be mentioned here. The consideration on the legitimation, aims, conditions and the orientation is not enough. The reflection on these matters should be included as it is essential to choose suitable methods and media for chemistry lessons (compare part3). There are various methods, but they are just useful in the context of suitable teaching situations or conditions, and meet the aims of teaching.

For that reason requests for a variety of methods have always been didactically orientated.

4. Conceptions: unify "Why?", "What for?", "What?" and "How?"

Researchers in Germany hope that learning problems can be solved by different teaching conceptions.

Conceptions reflect chemistry teaching as a system that brings all the aspects together. They conclude the "**Why?**", "**What for?**", "**What?**"- and of course the "**How?**"-questions. They are programs, no theories, so they are practical tools to create an interaction between the subject (chemistry) and pupils, while methods should be conformed to the guidelines. They help to plan chemistry lessons over a long period, not just one or two lessons. The philosophy of the conception is to form the long lasting chemistry teaching. In the last 25 years a lot of different kinds of conceptions have been developed. The most important and most applied ones are everyday life conceptions. They might provide great potentials and great chances for differentiated learning and more understanding concerning a chemical education.

Tab. 2. Overview of conception

<ul style="list-style-type: none"> • "Open-matter" chemical education (<i>Woest</i>): regarding to contents and design • "Daily-life" oriented chemical education (<i>Pfeifer, Lutz</i>): materials and processes • "Reflected daily life" approach (<i>Becker</i>): communication processes about chemistry • "Integrating scientific disciplines" approach (<i>Freise, Stäudel</i>): a holistic view • "History and philosophy of science" approach (<i>Henseling, Ewers</i>): History, technology and society • "Historical problem-solving-teaching" approach (<i>Jansen, Ralle</i>): Understanding chemistry in a historic way • "Historical genetic" approach (<i>Pukies</i>): Understanding the methodology of chemistry • "Researching-developing" approach (<i>Schmidkunz, Lindemann</i>): The scientific style • "Structure of matter" approach (<i>Grosser, Barke</i>): Understanding through working with models • "Methodological-critical" approach (<i>Reiners</i>): Systemic thinking • "PIN" approach (<i>Harsch, Heimann</i>): Connecting phenomena with theory • "Chemistry in context" approach (<i>Parchmann, Demuth, Ralle</i>): Reality as a background of chemistry • "Learning process" approach (<i>Sumfleth</i>): Students' thinking
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Many conceptions use details or single chemical aspects out from the daily life as stimulus for learning, for example substances, activities out of everyday life, the usual imagination and thinking of people about chemistry, and daily application of chemistry.

Everyday life conceptions are context-orientated. Many researchers have worked together and formed conceptual courses as a program for teaching chemistry, calling "connection between daily life details and chemical theory". The above-mentioned approaches sometimes overlap with or complement each other. Therefore different programs can be combined. In practice, the objective context is the most used one, while the others haven't been developed so much.

- The objective context (*Parchmann, Ralle, Demuth*) tries to illustrate chemistry knowledge. Objective everyday life phenomena are used to motivate pupils for chemistry and to show the role of chemical theory in order to understand those phenomena (For example "textiles").

- The individual context (*Lindemann, Scheuer*) forms right behavior in daily life. This approach focuses on everyday life chemical substances, especially daily chemistry-related activities in order to train the behaviors for students. (For example "teeth brushing")

- The complete context (*Pfeifer, Lutz, Becker*) brings the thinking of people about the substances and experimental activities in the daily life together. It is dependent on communication about chemical issues and it has a communicative evaluating perspective ("Commercial about detergents").

- The open context (*Woest*) is a methodological view to form "open" lessons to consider all individualities, all different levels and skills of the pupils. Although this approach is very popular, it is in fact hardly to adapt because of strict regulations and curricula.

5. Chemistry didactics as interplay of reconstruction and construction

The traditional prospects of didactics of chemistry was the reconstruction of chemistry teaching with the aim to systemize conditions, principles and prospects of chemistry teaching. Today, researchers have a constructing and modeling view of learning with focus on cognition. However both prospects aim at a science that balances between subject, pupils and society. It is a question of how to systematically apply this into practice.

The following highlights focus on different points of views in the epistemic discussion in (West-) Germany (from 1967 till today). Didactics of chemistry has also different legitimations:

Tab. 3. Overview of the historical development of chemistry didactics

<ul style="list-style-type: none"> • Didactics of chemistry as a theory of chemical literacy • Didactics of chemistry as an own aspect of chemistry • First didactics, then the subject • The teaching subject is "didactics of chemistry", not chemistry • Translating findings of general didactics into concrete forms with different teaching methods <ul style="list-style-type: none"> • Optimizing teacher training by thinking about conditions of education • Reflections on "real" chemical education (observing instruction) • Institutionalizing didactics of chemistry as a first step of emancipation • Teaching methods and students' view of importance • Learning-understanding opportunities by a diversity in teaching • Systematic of chemical teaching and learning processes
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- Didactics of chemistry as an agent for judging relevant problems in society
- Didactics of science as a story of difficulties in communication between the researchers
- Chemistry and didactics: Different tasks and goals – still waiting for emancipation
- Didactics of chemistry: science with or without evidence?
- Here are the results! Who cares for implementation?
- Competence-orientated and constructive "phase"

Such general views have formed the chemistry didactical progress of knowledge. The hope was to change directly or indirectly chemistry teaching in a positive way.

Researches of chemistry didactics are versatile in terms of methodical form and content. They are also complex just like its object "chemical teaching and learning processes". The knowledge achievements generate a differentiated and complete image of realities. The urgent task for the future is to connect this knowledge and to condense it to a theory. Integration creates a base for chemistry didactical theories. The aim must be to use this declarative character of chemistry didactical theories also concerning to its prospects. But this seems to be the main difficulty.

This article shows the variety of teaching and learning chemistry. Every chemistry didactical effort tries to achieve improvement considering a sustainable and meaningful chemical education.

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