CHEMISTRY TEACHING AND SCIENCE OF EDUCATION IN GERMANY PART 2: PUPIL-ORIENTATION

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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 the significance of pupil-orientation compared with subject-orientation and the necessity of a change of orientation in order to improve the situation for a sustainable and meaningful chemical education.

Keywords: chemical education, pupil-orientation, imagination, Germany.

TÓM TẮT

Giảng dạy Hóa học và Khoa học giáo dục ở Đức
Phần 2: Lấy người học làm trung tâm

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. Trong bài này, chúng tôi trình bày ý nghĩa của việc lấy người học làm trung tâm, cũng như sự cần thiết của việc thay đổi phương pháp giảng dạy, hướng đến giáo dục có tính chất lượng cao và bền vững trong môn Hóa học.

Từ khóa: giáo dục Hóa học, lấy người học làm trung tâm, sự tưởng tượng, nước Đức.

1. Introduction

In the context of a cooperation with the Department of Chemistry Prof. Hans-Jürgen Becker of the University of Paderborn was invited to lecture about “Chemistry teaching and science of education in Germany” at the Ho Chi Minh City University of Pedagogy. The lectures were organized by the Department of Chemistry.

This is the second of three articles, which summarizes the main ideas of the lectures about aspects of chemical education in Germany and problems of chemistry teaching. Formulated aims and goals of chemistry teaching (compare part 1) are indeed necessary and important for life, society and environment. Knowledge about how to handle chemical problems related to society and environment includes great responsibility. But does chemistry teaching really reach these goals? Most of the pupils complain that chemistry class is too difficult and in fact chemistry teaching is unpopular in Germany, which may be an effect of pupils' learning problems in science and especially in chemistry teaching. Results of the large-scale-assessment-studies like

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TIMS (Third International Mathematics and Science Study) and PISA (Programme for International Student Assessment) have shown that science teaching is not very effective and the reality shows that chemistry teaching doesn't cause responsibility towards environment and it doesn't help to clear the phenomena in daily life.

2. Problems with chemistry teaching

"Chemistry teaching wouldn't be so useless, if the things could be adapted in everyday life. Then there would be a relation to practice and chemistry teaching wouldn't be just an abstract complex of formula. Such knowledge relating to everyday life is general education and this could be useful especially for those who are not aiming for a chemical job."

Quotation of a pupil in Niedersachsen (2011)

In Germany many people and pupils deny chemistry teaching, although they like chemistry. There are a lot of researches and studies about popularity of chemistry class, about emotion of pupils and people concerning chemistry teaching. They prove that chemistry loses more and more sympathies (and passion), although it is still respected as an important part of education.

Tab. 1. *Quotes of pupils attending different school subjects at Gymnasium high school in the state Nordrhein-Westfalen (2004)*

Ranking of subjects at Gymnasium higher class in NRW - 2004						
Ran king	**Male**			**Female**		
	Subject	**Quotes**		**Subject**	**Quotes**	
		Intensive	**Basic**		**Intensive**	**Basic**
1	Math	43%	33%	German	44%	28%
2	English	32%	25%	English	40%	16%
3	German	26%	38%	Biology	27%	21%
4	History	20%	22%	Math	23%	43%
5	Biology	20%	13%	Pedagogy	18%	19%
6	Geography	16%	18%	History	11%	15%
7	Physics	15%	5%	Geography	8%	9%
8	Social science	8%	17%	French	6%	2%
9	Chemistry	6%	2%	Arts	6%	6%
10	Pedagogy	4%	4%	Social science	4%	10%

The graphic shows that pupils don't prefer chemistry teaching (science in general) in higher class. It also indicates that especially girls have even less interests in chemistry teaching. In the female ranking chemistry is not even listed.

Why is chemistry teaching so unpopular, although chemical knowledge is so important for life?

Indeed there is a huge difference between practice and theory. In order to teach effectively, determined regarding the aims and goals of chemistry teaching the content

(“**What?**” -question) has been a great problem for chemical education in Germany - and also worldwide. The curriculum consists of too many themes and these chemistry themes are too abstract, difficult and not suitable for most of the pupils (compare Quotation of the pupil). That's why chemistry teaching is unpopular, why so many students deselect chemistry teaching in higher classes and that's why chemistry teaching often misses the aims. Therefore it is necessary to teach a different "Structure of discipline" (content) depending on age, skills and the mental abilities of the pupils and on pupils' relation to chemistry in daily life in order to motivate and activate the pupils.

One possible solution for the problems concerning a meaningful, sustainable chemical education could be a change of orientation, a change towards the pupil and towards a meaningful sustainable chemical education.

3. Pupil-orientation vs. Subject-orientation

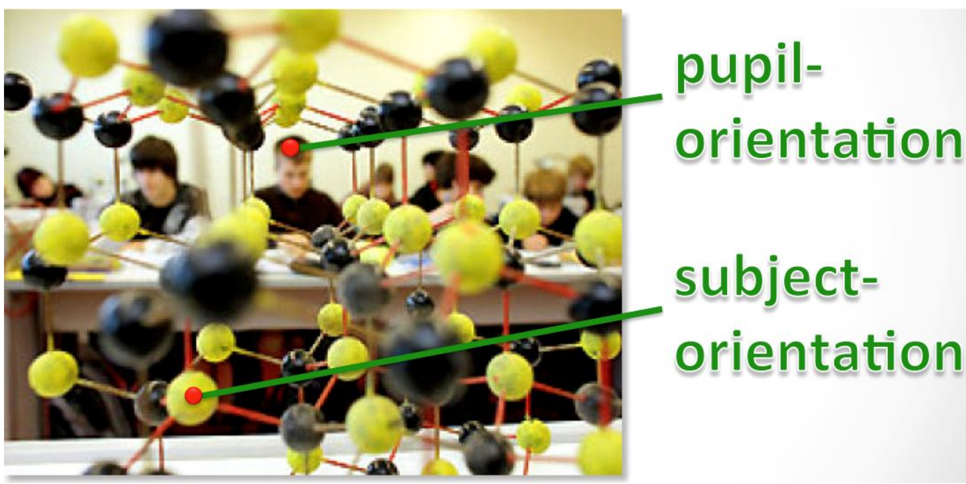

Fig.1. Pupil- or subject-orientation?

3.1. Subject-orientation

The trend in Germany shows that chemistry teaching is mostly subject-orientated and only subject orientated. School teachers and university teacher tend to those conceptions. Of course this is the easiest and traditionally way to teach the structure of chemistry ("structure of discipline"), but it also causes problems and learning difficulties, because it neglects learning psychological requirements and conditions.

The following list shows pros and cons of pure subject-orientation. Of course it is not complete and it is not objective but there are many indicators in the present situation for these arguments:

Tab.2. *Pros and cons of subject-orientation*

Pros
• The orientation on modern chemical views (discontinuum) represents the effort and results of chemistry science. • The scaffold of chemical terms could be a guideline for life • The linear build up structure of chemistry provides clarity and transparency for everybody • The concentration on structure of discipline is a helpful navigation for teacher and a good preparation for pupils who want to study chemistry at university (special education) • The challenging and abstract themes practice thinking and understanding for "good" pupils.
Cons:
• The subject-orientation neglects imagination, wishes, interests, conditions and abilities of pupils therefore chemistry teaching seems to be useless for the pupils. The learning structures of pupils were ignored therefore subject-orientation is contrary to modern learning theories. • The request on abstract themes, contents with any relevance causes problems of learning and supports non-understanding learning therefore it is just a limited guideline for life. • The orientation on the structure of discipline stands for cumulated knowledge that becomes inert and forgotten knowledge. • The subject orientation also neglects the formation of "chemistry": its meaningful history and its long development, its versatile imaginations and ideas.

3.2. Pupil orientation

Pupil-orientation means to regard the skills, abilities, emotion and wishes of the pupils. Its adaption seems to suit with pupils' conditions (cognitive) and interests (emotional) and aims sustainable knowledge and social, environmental responsibility. Versatile cognitive and psychomotor activities should be considered and be used in order to help pupils learn and develop their knowledge, abilities depending on age and skills.

- Practical activities (doing), e.g.to observe, explore, participate, experience, notice, collectdata,ask, analyze, journalize, regard, film, take a photo, experiment, draw, apply, try, imitate, describe, measure, discussand
- Cognitive activities (thinking), e.g.toevaluate, interpret, summarize, tructure, concentrate, deduce, compare, determine, link, assign, explain, generalize, analyse, detect, abstract.

And there are a lot more activities concerning scientific chemical activities that need to be considered while teaching and assessing pupils in chemistry class. Pupil-orientation means to regard activities more, not only theoretical knowledge.

3.3. Imagination

Besides the activities, the imagination is also an important factor of pupil orientation. Its consideration is therefore meaningful for a sustainable chemical education. The imaginations have a great influence on learning effects and they are a fundament of learning. In order to teach thoughts and ideas of chemistry it is important to know about the naive imaginations of the pupils (everyday life imaginations) and to work on these views. Teaching without this will isolate chemical knowledge from reference to life and fails the aims and meaning (compare Interviews).

Various terms of imagination are used in daily life, for example naive theory, life world interpretation, misconceptions, and individual imagination. There are also versatile meanings and imaginations of imaginations. The following definition makes clear what we mean with this.

"Pupil imaginations are mental models of phenomena and terms. They are mentally connected and they are stored in the pupils consciousness." (Ehlert)

"Pupil's imaginations influence the learning process. Such previous knowledge determines which information the pupil should use and how to connect new and old knowledge." (Sumfleth)

The development of mental thinking operations reffering to pupils'ages can be divided into three different types of imaginations. Children in pre-operational phase (4-8years) have physical imaginations while children in concrete-operational phase (6-12 years) orformal-operational phase (11-15) they have realistic or causal imaginations.

Some of these imaginations become apparent in the following twointer views with an 42-year old adult and 16-year old pupil about the term "salt". These interviews were conducted with Vietnamese people, but the results are the same as in Germany.

Tab.3. *Interviews about "Salt"*

1. Interview with an 42-yearsold adult (had learnt Chemistry at school in former days)
Question: What is salt? Answer: Salt is a flavoring to add some seasoning to the food, right?! Q: Where do you find salt in everyday life? A: Salt is ... - as I know – salt is.. is taken from the salty ocean.
2. Interview with a 16-years old pupil (10th class chemistry)
Q: What is salt? A: Salt is a compound between metal sand acid radicals. Q: Ok. Where do you find salt in everyday life?

A: In ... the kitchen.
Q: In the kitchen?
A: Yes.
Q: Where else?
A: (He is thinking about it and then signalising that he has no idea?)
Q: You don't know?
A: Yes.

The term of substance is predominant "material"-orientatedor operational defined. Both examples of imaginationare "concret-, realistic", which accord to childish thinkings chemata (function-orientated, "in orderto") and they are totallly different to the abstract chemical term of salt.

The functionality –usage of salt – was emphasized in the first interview. The adult has a material-orientated and functional "substance" imagination. The person doesn't recognize that "salt" is a abstract term for a chemical family. For him salt seems to be only cooking salt that "is taken from the salty ocean", althoughth is "salt" is a mixture of different types of salt from a chemical perspective. This imagination is the most common one with no chemical, but functional reference.

The interview with the pupil shows, that chemistry teaching had an effect on the pupils knowledge. At least he could remember the definition of the inorganic salt term. In this definition he used the plural that indicates "salt" consists of or can be produced by different metal sand different acid radicals. This operational term of salt looks to be learnt by rote and this knowledge seems to be just formal and without relevance for consequences:

- which individual substances could exist, after this definition?
- Where can we find salt in everyday life, outside of the kitchen?

In Germany such situation was called "träges Wissen" (inert knowledge) that means it has no value for a chemical education for the pupil. It's just a pure accumulation of knowledge that needs to be learnt in order to pass the examination and that has no obvious relation to real life. Pupils don't profit by this kind of chemistry teaching except for those who want to study chemistry.

In order to extract imaginations diverse tools and techniques are useful. In daily life imaginations are expressed by communication, for example in a dialogue, interview oron printed newspaper, product information or in commercial. They are visual in drawings, analogies, mappings or they also can be seen in experiments and activities. Some popular developed diagnostical teaching methods are talent differentiating experimental tasks, interrogation of symbolic language, diagnostical learning circle, learning street and ritualized feedback method

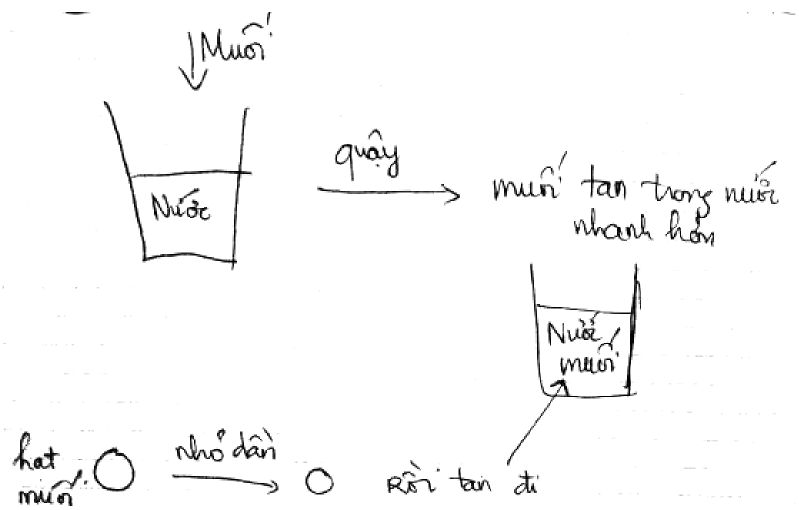

***Fig.2.** Extraction by drawing: imagination about solving "cooking salt" in water*

This extracted imagination of cooking salt was made by a vietnamese student (22 years). The drawing shows substances with changing sizes but still with same properties and form. Solving cooking salt seems to be a mechanical, physical process: Salt is getting smaller by tossing. It is obvious that this student has a realistic but no chemical imagination of that phenomen. This representation doesn't reveal that ionic particles of cooking salt are seperated, hydrated by water and therefore soluted.There are no imaginations of discontinuum, but simple imaginatons of continuum.

Extracting the pupils' imagination is a fundamental effort reffering to the thinking and learning structure. With this finding it is possible to concentrate on connection between knowledge and imaginations. Teacher must tie in with that in order to detect differences between pupils' belief and chemistry structure and in order to uncover learning difficulties. Working on pupils imaginations gain learning effects.

4. Conclusion

Pupil- or on subject-orientation? This is a question of balance: Teaching pupil-orientated means considering pupils conditions, abilities, skills, emotions and wishes while teaching subject-orientated means considering the chemical content and methods.

Teaching pupil-orientated doesn‘t mean to deny chemistry-orientation or chemistry knowledge. It is just an opportunity to make chemistry teaching even more, meaningful, “sensual“ and suitable for pupils. Fortunately both orientations (subject and pupil) have approached in the past years. There are many indicators for this, e.g. several empirical findings about effects of chemistry teaching and many researches about interests and wishes of pupils. Pupils' wishes and interests are getting more attention by researchers. Suitable contents might be the first step forward to pupil-orientation and a way to solve the problem of non-understanding and unpopularity.

Concerning a pupil-orientated and understood learning of chemistry it is necessary to pick the imagination of pupils out as a central theme. The meaning of imaginations should be seen as a requirement of chemistry teaching and there by it is the teachers' duty to diagnose. In Germany the diagnostical approach is currently in the foreground and with that there are versatile, differentiated possibilities for teachers (compare 3.4.).

The teacher training tries to consider these "contents" more in their curricula. It is hoped that students will teach more pupil-orientated as a teacher later on.

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