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German High School Students' Interest in Chemistry – A Comparison between 1990 and 2008

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Piaget (1974, p. 131) considers interest a decisive factor in the learning process, he defines interest as the dynamic aspect of assimilation, every process of equilibration is based on an interest. Together with many other authors we also believe that developing interest in a topic is one important pre-condition for self-directed learning as well as an important goal for school learning with regard to life-long learning, out-of-school behavior and choice of profession. These were reasons which have led us to do intense research into students' interest in physics and chemistry as well as in regard to variables influencing that interest. This article focuses on the definition of interest, the quantitative description of students' interest referring to chemistry lessons, and the relationship between factors like achievement, gender, relevance, curriculum, teacher and classroom climate and students' interest. Based on these results we will develop curricula and methodical recommendations. Questionnaire data from 1990 and 2008 of German high school students (grades 8 to 10) are analyzed with SPSS and Lisrel and descriptive results as well as those from factor-, item-, and path analysis will be presented. The calculated model (path analysis) shows the significant interrelationship of cognitive, emotional and value related factors with interest. The descriptive data show interesting gender related differences and development during the past 20 years.

KEYWORDS: chemistry education, interest in chemistry, self-concept

Introduction

When you ask adults what their favorite subject was in school, they almost never answer "chemistry". Most of them will only remember formulas and equations which they never really understood as well as calculations and reports which ruined even that little fun they had doing the few experiments they were to do. Another thing most adults have in common is the feeling that what they learned in chemistry class was not important for later life, unless they ended up working in a chemistry-related profession.

When such statements are compared with those from students who have not had any chemistry lessons yet, a deep chism between the two becomes obvious. Ten to twelve year-old pupils generally look forward to having chemistry lessons and expect a lot from them. They hardly can await the first chemistry period. But pupils' originally positive attitude towards science subjects changes significantly in the upper grades (Schibeci, 1984, p. 46). Such a negative attitude towards a subject leads to a lack of interest and, when the subjects can be selected as in the course system of the upper secondary level of German schools they are likely to drop the subject or course (Schmied, 1982).

The task of compulsory schools is to educate students to be mature responsible citizens. Science education contributes to fulfill this task by imparting knowledge and skills as well as fostering the development of attitudes, interests, and values. Interest, therefore, has a double function: On the one hand, interest is a pre-requisite for meaningful learning (see also Rennie & Punch, 1991; Nenniger, 1992; Schiefele U. et al. 1992; Voss & Schauble, 1992). On the other hand interest represents the goal of teaching to guarantee a life-long openmindedness (see Schiefele, H., et al. 1979).

Because of this double function, importance should be attached to the construction of interest within research of science education.

The IPN (Institute for Science and Mathematics Education) has a long tradition in this field of research. Already in the 1970ies they started studying "interest" or "subject-related motivation" especially in physics (see Lehrke et al. 1985). Between 1984 and 1989 a comprehensive longitudinal study (Haeussler, 1987; Hoffmann & Haeussler, 1995) was carried out in connection with a cross-sectional one. In 1988 we began planning a study to research interest in chemistry similar to that in physics so that the knowledge and experiences gained from the given long-standing research could be referred to. We collected data of more than 3000 German students in 1990 and again of 1222 in 2008. This paper will de-

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scribe parts of the results and compare those from 1990 with the recent ones. I will focus on the following questions:

- What is meant by interest? How can interest be defined?
- What kind of interest is shown by our students? Are there differences between boys and girls?
- Which variables influence the students' interest? Which personal and environmental characteristics have to be considered?

Our overall goal was to find criteria to develop methods which could help to promote students' interest and motivate them to engage more deeply in science issues.

The concept "interest"

When students are asked what conditions or circumstances affect the success of their learning most, they usually answer "the interest in what is being taught". If we look at the learning process from a constructivist's point of view, it is easy to agree with this statement. Piaget, for example, describes the learning process as a process of an individual's adaptation to the environment — defined as equilibration —, the components of which are assimilation and accommodation. Piaget (1974, p. 131) has defined interest as the dynamic aspect of assimilation, every process of equilibration is based on an interest. By the means of this mechanism, the individual constructs his/her environment. When he/she learns something new, he/she tries to assimilate this new information to existing schemes. In case there is no adequate scheme available, then an accommodation process takes place, i. e. a new scheme has to be constructed. One can assume that the more interesting the object is to the individual the more serious will be the attempt to find creative solutions of the problem. Empirical findings underscore this assumption by recognizing that learning guided by interest leads to a more complex and flexible structure of knowledge than extrinsically motivated learning processes (Biggs, 1987). Prenzel, et al. (1986) define a person-object relation which is expressed by the person's active manipulation of the object as interest. This manipulation explores the object and brings about pleasant feelings to occur (emotional component). The object has a high rank in the person's value hierarchy (value oriented component). This interest-guided action is in itself sufficient, it needs not be motivated by external stimulation (self-intentionality). The observed interest is always by parts the actualized individual interest (a personal trait) and a situational interest (a state) which is depending on the more or less stimulating environment. A repeatedly experienced situational interest can lead to a persistent individual interest (Krapp et al., 1992).

Many studies have shown that students' interest obviously does not receive the necessary attention in science lessons: The popularity of the physical sciences is on the decrease; the attitudes towards lessons, especially physics and chemistry lessons and science itself, are negative; science courses (except biology) are dropped at upper secondary level (Schmied, 1982), and students' interest in science topics decreases grade by grade (cf. Schibeci, 1984; Schibeci & Riley, 1986).

Variables with potential influence on interest in chemistry

The poor image of the chemical industry could influence students' attitudes and their interest in a decicive way. Heilbronner and Wyss (1983) studied 11 to 15-year old students' attitudes in Switzerland. They were asked to portray their imagination of chemistry in a drawing. Two thirds of the drawings predominantly displayed negative aspects such as the pollution and destruction of the environment or animal experiments.

Besides this **poor image of science and technology**, I would like to point out some common associations with chemistry lessons:

- One reason for the unpopularity of chemistry lessons has to do with the **subjects' difficulty**. Most of the topics in chemistry are abstract in nature, meaning working with theories and models. Such work requires thinking at a formal-operational level. However, various studies show that most of the students at the age level in question have not reached this level of thinking (Gräber & Stork, 1984; Lawson, 1978).
- Many male and even more female students complain that chemistry is **too abstract, thus cannot be related to their environment**, and quote this as reason for dropping chemistry. With regard to this deficiency, Stork (1984) says: "Chemistry lessons mainly focus on problems which are related to the interconnection of chemistry-specific concepts. As students see it, chemistry is limited to the proceedings only within the lesson, while the knowledge gained from it cannot be used for mastering off-school life situations."
- The **teacher's personality** is another important variable. In this context, Mead's and Métraux's (1973) respective observations can be summarized as follows: "Scientists tend to transfer their discipline's abstracting methods to everyday life and the classroom instead of enlivening the material with their personality."

Followingly, I would like to present data about the realization of our empirical study and its results.

Sample

The investigation in 1990 included a total of 42 schools in the former Federal Republic of Germany. One chemistry class per grade and per school was polled in addition to another class that would start with chemistry lessons the following year in order to study the situation before having had chemistry lessons. We polled a total of 3,203 pupils. The male/female ratio was about 1:1. This paper refers to a subsample (737 females, 594 males) which only considers the students who learned chemistry in grades 8 to 10. In 2008 we asked 1222 students (622 girls, 599 boys) from the same age group and school types with a shortened version of the original questionnaire.

The questionnaire (plan of variables)

Our questionnaire is structured according to the following variable plan. We distinguish between three types of interest: interest in chemistry, interest in chemistry lessons, and leisure interest in chemistry. These three types could be influenced by a complex combination of out-of-school and in-school condition variables just as various teachers' and students' personality characteristics. (Figure 1)

Operationalization of Variables

The original questionnaire includes 400 items. Except for chemistry marks all variables are scales composed of several items which have been tested by means of principal component and item analysis. The following is to give a brief impression of the items.

Interest in chemistry lessons:

Exemplary item: "How much are you interested in chemistry lessons?" Very interested … hardly interested, (5-point Likert scale). — Two item scale (α = .84). This important variable does not really describe interest in a narrower sense of person-object relation. The interest in lessons is often put on a level with enjoyment or popularity by the students. It is connected with feeling good, a willingness to cooperate, curiousity and being excited.

Interest in chemistry:

Exemplary item: "How interested are you in learning more about how to make plastic from petroleum?" (5-point Likert scale). — 29 item scale (α = .95). This construct achieved our special attention because we assumed that the contents covered determine the students' interest in the lessons most. The construct "interest in chemistry" is based on the theoretical assumption of a multidimensional object structure subdivided into the categories "topics", "contexts" and "activities". Accordingly, students were not simply asked about their interest in the different chemical topics but the topics were deliberately presented in different contexts and linked to different activities.

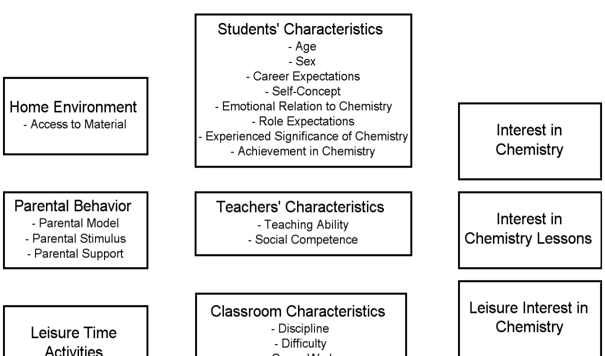


Figure 1.

Leisure interest in chemistry:

Exemplary item: "When I find something in the newspaper about something we have heard about in chemistry class I read it …" (5-point Likert scale). — Five item scale (α = .82).

This variable describes the interest in chemistry-related issues that were stimulated by the lessons. It is the basis for personally initiated discussions with chemistry questions in the everyday life and should lead to lifelong open-mindedness.

Self-concept:

Exemplary item: "I understand the taught material in chemistry …" (5-point Likert scale). — Seven item scale (α = .88).

The self-concept scale represents the students' self-perceptions of their ability of learning chemistry. "In very broad terms, self-concept is a person's perception of himself. These perceptions are formed through his experience with his environment, …, and are influenced especially by environmental reinforcement and significant others." (Shavelson et al. 1976).

Experiencing chemical-technical phenomena:

Exemplary item: "It fascinates me to see how a blast flame or an explosion can be caused by a simple chemical experiment." (5-point Likert scale). — Three item scale (α = .62).

According to Prenzel et al. (1986), the emotional bonding to an object and the value that is attached to it are the two components which determine interest towards an object. Concerning the emotional component, we confronted the students with several items focussing on their inclination for chemical phenomena within nature or technical fields. Using the PCA, the two factors "chemical-technical phenomena" and "chemical phenomena in nature" could be confirmed, as expected. For the question treated here only the "chemical-technical phenomena" scale had a significant impact on the students' interest, therefore we will not go into the "chemical phenomena in nature" scale in any detail.

Significance of chemistry:

Exemplary item: "Chemistry is a field that will become more and more important in the future." (5-point Likert scale.) — Five item scale (α = .65).

The question complex shows the significance or value the students personally place on chemistry in nature, technology, and the environment. We asserted that the higher the value of chemistry is placed, the higher will be the interest to deal with it.

Subject-competent teacher:

Exemplary item: "Our teacher gives good examples which make learning easier." Usually true … not usually true, (3-point Likert scale). — 15 item scale (α = .88).

This variable as well as the next one are drawn from our special classroom climate study based on a 54 item questionnaire developed and tested by ourselves. Using a PCA we identified 5 factors which can be interpreted. Regarding our objective only two factors showed significant influence, so that the others will not be looked at any further.

Social-competent teacher:

Exemplary item: "Our teacher helps us outside the class." Usually true…not usually true, (3-point Likert scale). — 12 item scale ($\alpha = .84$).

Further variables:

The variables concerning home environment, parental behavior, and leisure time actitivies, i.e. the out-of-school variables, have also been taken into consideration but did not exert any significant influence on the interest within our model and will not be discussed here.

Path analysis

The path model calculated by means of Lisrel 8 shows the interest variables' interconnection of school variables and the students' and teachers' personal characteristics. 68% of the variance of interest in chemistry lessons, 47% of the interest in chemistry, and 40% of the leisure interest in chemistry are explained. Looking only at the interest variables first, it becomes obvious that interest in chemistry lessons and leisure interest are both directly and indirectly (through interest in chemistry) interlinked. One can conclude that the leisure interest can be braced and fostered by positively manipulating either the interest in chemistry or the interest in chemistry lessons. This deduction is explained by the independent variables shown on the left of the path model. (Figure 2)

All of the variables have a significant impact on the interest in chemistry lessons. The enormous influence of the achievement variables can be drawn from the high path coefficients: The grade as the external measurement of the student's achievement is at 0.3, and the chemistry-related self-concept of the own ability as the internal perception even at 0.45. The significance of the competent teacher (0.13) who knows her or his trade and is able to impart it in a profitable way points into the same direction. Obviously, students expect to gain competence from their lessons; they want to learn something and hope to receive adequate assistance at it.

Strongly differing from the conditions of the interest in chemistry lessons are the conditions of the interest in chemistry. While grades still have some significance in this context, the emotional as well as the value component play the more important role: The "emotional bonding to chemical-technical phenomena" is at path coefficient 0.22 and the "significance of chemistry" that is traced to it at 0.13.

The model calculated on the base of the new data from 2008 looks very similar, with the exception of the variable "chemistry marks", this variable showed no significant influence and thus was not considered in the new model.

In the following chapters we will focus on the single variables and will compare the data from 1990 and 2008 on a single item base.

Interest in Different School Subjects

We asked the students as how interesting they perceive their different subjects.

Graphic 1 shows the percentage of students who have shown "great" or "very great" (marking "4" or "5" on a 5-point Likert scale) interest in any of the subjects, differentiated by gender and date of study (1990 res. 2008). The subjects Chemistry and Physics show the low interest of girls. The male students are more likely to place chemistry education at a medium level, whereas Physics and Mathematics are top-rated. Language arts (German) is less interesting to the boys. These results confirm a wide-spread opinion: Boys prefer the so-called hard sciences with a mathematics-technology orientation. The girls prefer the humanitarian, veterinarian, and environmental Biology, Fine Arts and languages. Comparing the two points of data gathering, one can see the increase of voting to each of the subjects (particularly for Chemistry) with the exception of Biology. This could perhaps be explained with new approaches in German chemistry classes, which focus more on project oriented lessons and the inclusion of everyday life issues.

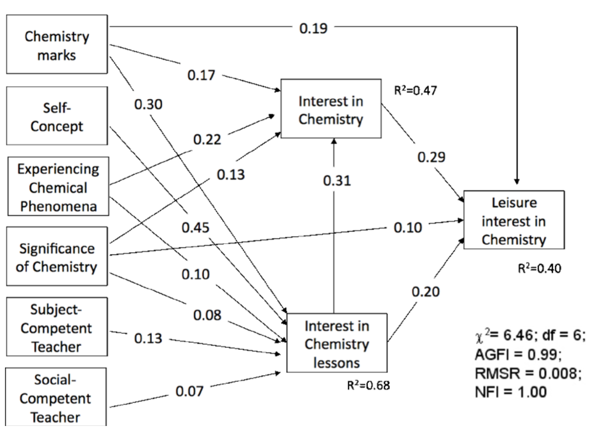
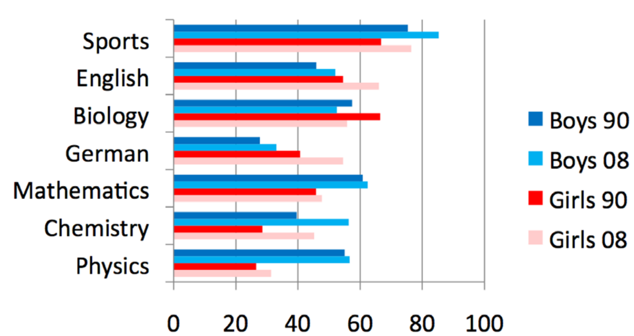


Figure 2.



Graphic 1.

Interest in Chemistry

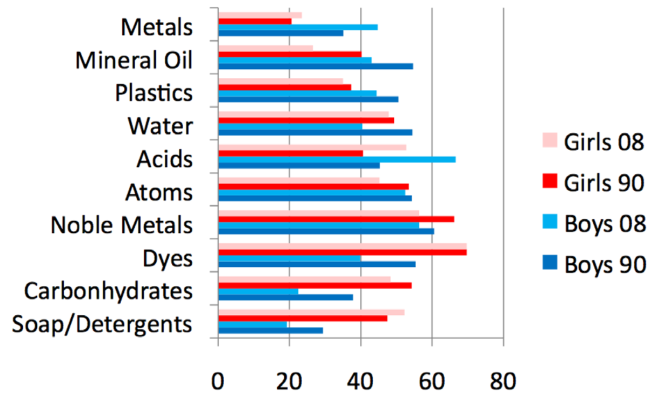
Students' interest in chemistry as such called our main attention, and we thought interest in chemistry as being the most important variable to explain interest in chemistry lessons. The following will mainly present the results that describe interest in chemistry according to topics, contexts, and activities.

The pupils were asked to indicate their degree of interest in various chemistry topics. Of course, when you ask about topic as a general, as is often the case, the questions can be understood differently. Everyone certainly has own associations when asked e. g. about interest in the topic soap/detergents. When I consider soap in a chemical context I think of its chemical composition, of analysis and synthesis, of its chemical formula, or of how it reacts with other materials. The same question may lead to other answers if you associate it with everyday life. Advertisements show us the effects of soap and detergents. Another aspect is water pollution due to detergents which refers to ecological or socio-political problems. Also, soap can be looked at from a historical perspective: How and when was it discovered? How has it influenced the human kind? Furthermore, certain professions are connected with its production or use. We call all these associations contexts and ask about interest in those as well. Moreover, a content in a certain context can be treated in multivarious ways. For example, I can carry out an experiment by myself, only watch the students carrying it out, describe it, explain or record it. Probably we will receive very different reactions to the chemical experiment depending on how it was tied into the lesson.

The answers related to questions about topics show that modifications of the curriculum are often required. An unpopular topic could be enriched by giving it an interesting context or by connecting attractive activities to it. Partially, the questionnaire employs items which combine all three aspects in one while in another section different questions asked about contents, contexts, and activities as isolated aspects. Regarding the latter, some of the results will be presented as follows.

Interest in Chemical Topics

Graphic 2 reflects students' interest in various chemical topics, it shows the percentage of students who indicated to be "very interested" or "interested". They are listed according to the extent of difference between the statements made by girls or by boys. The first topic, soap, shows the highest difference and was chosen mainly by girls; 47.4% of the girls and 29.4% of the boys showed interest or even high interest in 1990. The girls prefer more than boys topics they can personally relate to, such as hygiene, nutrition, and decoration. The boys are more likely to be interested in the topics within the field of technology, such as commercial metal, mineral oil, plastics. Remarkable is that the girls choose topics having to do with organic chemistry, an area hardly treated in introductory chemistry lessons in Germany. The two topics that interested both girls and boys equally, like dyes and precious metals, are nearly not covered at all by the lower secondary syllabi.

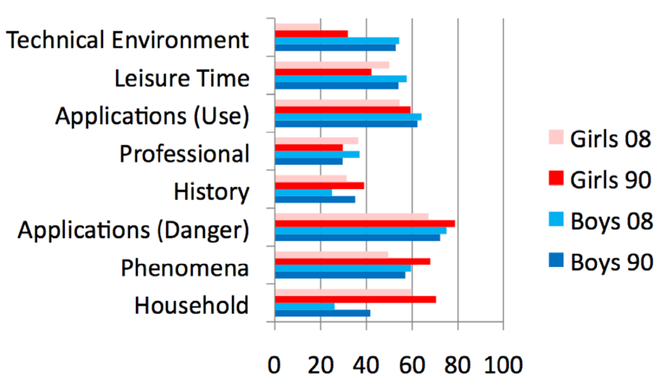


Graphic 2.

Comparing the data from 1990 with those from 2008, it is to be seen, that there are only little changes with the girls interest, while the boys interest has decreased in nearly all topics. There is a remarkable increase of interest in acids and bases for all students, perhaps a reaction to our new curricula with more attractive issues related to this topic.

Contexts

Referring to contexts we find the results mentioned above confirmed (Graphic 3). The number of girls who find "chemistry in the household" "interesting" or "very interesting" exceeds significantly the number of boys. Chemistry within a technical environment ranks at the lower end of the scale for girls and at the upper end for boys. If you take a look at the absolute data, you will find that two items, "chemical applications that can be of great use to us now and in future" and "chemical applications that can endanger us and the environment", were marked by most of the girls and the boys. These items go beyond a personal interest, they also illustrate a socio-political dimension. This indicates that the students are interested in chemistry lessons that serve to show the personal and social importance of chemistry. At the same time it



Graphic 3.

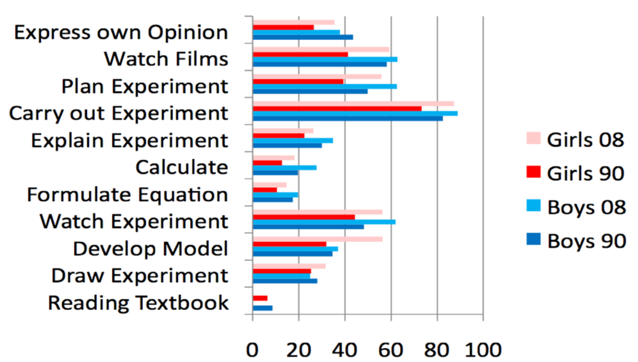
implies that the poor image chemistry has does not lead to students turning their backs on it. If you wish to be able to develop an own opinion and be able to make critical remarks about the danger of new chemical and technical developments you have to learn chemistry: this is most students' view. In contrast to our expectations, only about one third of the girls and boys judge the historical or the professional aspects to be "interesting" or "very interesting". Further detailed studies on this are thus required.

Many votings are higher in the 2008 study, with the signicant exceptions of the decreasing interest of boys in "chemistry in the household" and girls' interest in "technical environment" and phenomena.

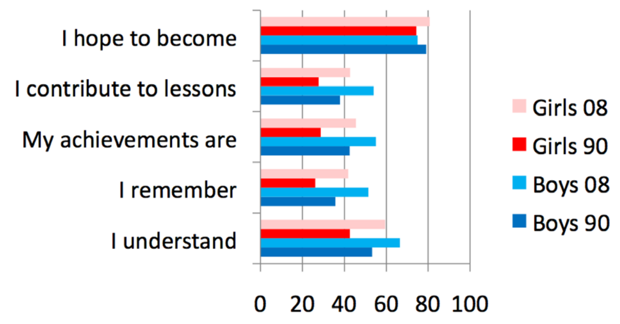
Activities

Concerning the section "activities", an enormous interest in making chemistry experiments is evident. 73.2% (87.2% new) of the girls and 82.4% (88.8% new) of the boys are "interested" or "very interested". There is little interest in reading chemistry textbooks, calculating or setting up equations. However, considering the different activities that are connected to carrying out experiments, it is obvious that it is not sufficient to include experiments in the lessons, since the activities involved are evaluated very differently by the pupils (Graphic 4).

Boys and girls prefer carrying out experiments by themselves. This is not enough, though; experiments have to be explained which is perceived to be not interesting to most pupils. It seems that teachers often do not take their time to solve the problem together with the pupils, but rather just wait for the right answer. Often teachers are likely to classify the observations made by students as "not relevant", and students' clumsy attempts to explain things based on their personal experience are taken neither seriously nor are they discussed. A student who repeatedly experiences such will not seriously try to solve the problem, but try to guess the right answer. This is not an appropriate way to create an interest in the subject. In addition, lessons usually draw the line too quickly from observation of a phenomenon or its description to symbolic equations. In sum, too much is demanded from the majority of students who learn below the formal-operational development level and they easily lose interest when they are not successful.



Graphic 4



Graphic 5.

There are no really remarkable differences between the old and the recent data. One exception is the enormous increase of girls' interest in developing models. Concerning "express own opinion" girls and boys' interest are the same in the new study. Girls seem to have gained a higher self-concept and contribute more self-confidently to chemistry class discussions.

Self-concept

The most important variable to influence the interest was the chemistry related self concept of own ability. Students answered to several items on a 5-point Likert scale, and Graphic 5 sums up the percentage of students who answered with "good" or "very good" and "often" or "very often" (4 or 5). Looking for differences we find for each of the items a higher voting in 2008 compared to 1990, but still lower quotes of girls than of boys. But both boys and girls look very optimistic into future: around 80% say in future their achievements will be "good" or "very good"! Looking at the marks boys and girls really get, there are no differences, they have both become much better during the past 20 years. In 1990 there were around 20% who received a "very good" or "good" and in 2008 about 35%. So, no differences in their achievements, why then do the girls underestimate their performance and achievement, or are they over estimated by the teachers who give the marks? More research needs to be done.

Conclusions

The interpretation of the study results indicates possibilities to intervene predominantly in two areas: first, with regard to the contents, and, second, in a didactic-methodical way.

The analysis of the interest in chemistry made obvious that it was indeed necessary to apply such a differentiated model since it brought us into the position to show the gender-specific differences. While female students revealed primary interest in topics with reference to hygiene, nutrition, and health, male students showed higher interest in industrial and technical matters. Both female and male students indicated to be strongly interested in socially relevant topics like pollution or power supply. Moreover, the study gives information about how less attractive topics can be upvalued when imbedded into contexts that are found to be interesting or linked to activities which are done with pleasure.

The path analysis even underlines the results by drawing attention to the emotional and value components. The topics should be personally relevant to the student, stem from their living environment, and gain transparence through explaining them by scientific concepts. In addition, phenomena occurring in and outside the classroom should be part of the topics to be taught in order to create an emotional bonding between student and topic.

The most important aspect, however, seems to be to foster the student's self-concept. The data show that the subjective perception towards the own achievement is highly significant for explaining motivated activity during lessons. The fact that behavior is more a function of perceived than of objectively existing origins has already been recognized by Bernard Weiner. Accordingly, following measures should be taken into consideration when teaching chemistry:

- imparting positive learning experiences
- giving individual-oriented feedback
- changing reference groups
- supporting cooperative learning.

There are several new chemistry teaching approaches in Germany which include these recommendations, perhaps these can contribute explanations to the slightly improved results about students' interest in chemistry during the past 20 years. More longitudinal intervention studies are needed to answer these questions.

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