CHEMISTRY EDUCATION:
RESEARCH AND PRACTICE IN EUROPE
2000, Vol. 1, No. 3, pp. 365-374

Claus HILBING and Hans-Dieter BARKE
University of Münster, Institute for Didactics of Chemistry

AN IDEA OF SCIENCE: ATTITUDES TOWARDS CHEMISTRY AND CHEMICAL EDUCATION EXPRESSED BY ARTISTIC PAINTINGS

Received: 9 February 2000; first revision: 4 May 2000;
second revision: 18 July 2000; accepted: 30 July 2000

ABSTRACT: The present study deals with attitudes towards chemistry and chemical education of pupils with and without experience in chemical lessons. The pupils were asked to draw paintings to reflect their point of view of chemistry. Attitudes were investigated by a common questionnaire. In comparison with a study conducted 15 years ago, it became obvious that today's pupils are better informed. The pupils evaluate chemistry by considering disadvantages and advantages of science, medicine, chemical industry, environmental pollution and nuclear power! Pupils without experience in chemistry lessons show a broadly varied conception of chemistry and evaluate chemical education convincingly. Furthermore, the attitudes towards chemistry and towards chemical education of experienced pupils interact slightly with each other. For this reason we support the initiatives that introduce children to chemical phenomena and to scientific thinking in kindergartens and primary schools to avoid emotional and cognitive misconceptions. [*Chem. Educ. Res. Pract. Eur.*: 2000, *1*, 365-374]

KEY WORDS: *attitudes to chemistry; attitudes to chemistry lessons; idea of science; pupils with and without experience in chemistry lessons; artistic paintings*

INTRODUCTION

"Mrs. B. asks : As you have now acquired some elementary notions of Natural Philosophy, I am going to propose to you another brand of science ... Chemistry.
Caroline answers : To confess the truth, Mrs. B., I am not disposed to form a very favorable idea of chemistry, nor do I expect to derive much entertainment from it." (Marcet, 1806)

Over the past 30 years, chemistry has lost much esteem in German society. In the sixties, chemistry was described as "a girl who is able to do nearly everything" (Zahn, 1979, translated by Hilbing). Later in the seventies and strengthened in the eighties (especially following the disasters of Seveso in 1976, Bhopal in 1984 etc.), the image of chemistry deteriorated. From this historical point of view, one can assume that the attitude of young persons towards chemistry - depending on the idea of chemistry in a society - has deteriorated as well. This hypothesis is supported by an investigation done by two Swiss scientists, who examined the idea of science in 1983 (Heilbronner & Wyss, 1983).

Investigation in 1983

Heilbronner and Wyss asked Swiss pupils (11 to 15 years) to paint their images of chemistry. After collecting 151 paintings, the researchers were surprised at the artistic merit of the paintings, but at the same time they were deeply affected by the choice of motifs. Critical and disapproving attitudes towards chemistry were shown in 66% of the paintings. The paintings dealt with environmental pollution, threats to the individual by chemical industry and with animal experiments. Fantastic laboratories as "Frankenstein" and similar science-fiction scenes were shown by 33% of the paintings.

If pupils have in fact a poor attitude towards chemistry and chemistry lessons like Caroline (the quotation at the beginning of this section), we can assume that chemistry lessons may have limited value. For this reason *Society of German Chemists* (GDCh) initiatives to influence in a positive way the attitude towards chemistry and chemical education of young children in the kindergarten (3-6 years old) and primary schools (6-11 years old).

THE PRESENT INVESTIGATION: HYPOTHESES AND METHOD

The aim of this investigation was to examine the attitude of young pupils towards chemistry and chemical education at German grammar schools. It was carried out in 1998. We were interested not only in the attitudes built up during chemistry lessons, but also in the attitudes of pupils before they start with chemical education. Therefore, we investigated pupils with experiences in chemistry lessons and young persons without any such experiences. Impressed by the creative and profound paintings obtained by Heilbronner and Wyss, we decided to base our study upon their experiences. In view of the bad image of chemistry in the 1980s and the predominantly negative attitude seen in the paintings, we assumed a correlation to exist between the pupils' attitude and the bad image of chemistry in the society. Moreover, since the image of chemistry lessons in the 1980s was also poor, we were able to assume a correlation there, as well. These thoughts led us to the hypotheses of the investigation:

Hypothesis I: ”An interrelation occurs between the attitudes towards chemistry and the attitudes towards chemical education in 1998.”
Hypothesis II: ”Pupils without experience in chemical education also develop an attitude towards chemical education.”

The theoretical foundation for these hypotheses was the attitude-concept by Hovland and Rosenberg (1960). They understand attitude in two dimensions: a cognitive on the one hand and an affective-emotional dimension on the other. Both dimensions can be investigated separately but affect each other. Upon this foundation we developed a questionnaire consisting of items which display both dimensions of attitude. We used open-ended and close-ended questions to evaluate the attitudes. The open-ended questions served to inform us about the attitude in general and the close-ended questions were used for the attitude measurement as described in the following.

Referring to Mikelski (1979), we have developed questions to evaluate the attitudes towards chemistry of the pupils. After a pre-test, it had become obvious that eleven items are relevant to measure the attitude to chemistry of a pupil. The difficulty index ranged between 0.2 and 0.8 . The discrimination index was larger than 0.3. The coefficient *alpha* of reliability for this sub-group of items was found to be equal to 0.70. A high value on this

attitude-scale referred to a positive attitude towards chemistry. We subdivided this scale in three parts: positive, indifferent and negative attitude towards chemistry.

In the same way we have developed a scale which displays the attitude towards chemical education. The questions were based on the experiences of Klamke (1992). In this case we have considered 23 items as relevant for the attitude-scale. The coefficient *alpha* for this sub-group of items was found to be equal to 0.90 . The subdivision of this scale produced the same classification as above.

The hypotheses proposed above influenced our selection of test-persons. We had to consider (a) pupils without experience in chemistry lessons: 12 years old, 6th grade: N = 265; and (b) pupils with some experience (half a year) in chemistry lessons: 13 years old, beginners, 7th grade: N = 89. In addition, we considered pupils with a longer experience (one and a half years) in chemistry lessons: 15 years old, 9th grade: N = 126. Pupils in the federal state Brandenburg start with chemical education in 8th grade; in the federal state North Rhine-Westphalia in 7th grade; so we grouped pupils of 7th grade in Brandenburg with pupils of 6th grade in North Rhine-Westphalia. This situation has led to the greater number of pupils without experience in chemistry.

Course of investigation-sequences

The investigation started with a brainstorming question: What is chemistry? The pupils collected many words and associations. This collection was the foundation for the decision about which motifs had been chosen by the pupils for their drawings or pictures. These were painted in the course of six lessons which formed part of the pupils' art lessons. The teachers guided the pupils in relation to technical and artistic questions. Hints of guidance concerning the content of the pictures were not allowed to be given to ensure that the pictures reflected the pupils' own ideas. After completing the pictures, the pupils were asked to fill in a questionnaire that included questions on the motifs of paintings, on the attitudes towards chemistry and on attitudes towards chemistry lessons. It was recognised that the brainstorming itself and the open investigation situation did not prevent that pupils formed their attitude during discussion in art lessons. This potential disadvantage was consciously tolerated in favour of a higher motivation of the pupils.

Analysing the paintings

The methodology adopted for the investigation was based on the approach of Heilbronner and Wyss in 1983. In this, Heilbronner and Wyss assigned each painting to only one of their three categories. The first category dealt with *environmental pollution* and the threat to the individual by chemical industry. The second category consisted of paintings with motifs in relation to *animal experiments*. The third category covered paintings depicting *laboratory situations*, featuring, for example, scientists, laboratory settings or research institutes. In addition to these three categories, we added two further categories, the following: *specialised knowledge* and *everyday life*.

Heilbronner and Wyss's method of categorising the paintings was modified in 1998. During the art lessons, it became obvious to us that, if we simply assigned each painting to only one category, we would have reduced the information and the message of the painting in an unacceptable way. Therefore, we decided to consider not only the main message emerging from a picture, but also additional motifs appearing in it. Consequently, one painting could be assigned to two or more different categories, according to the motifs.

RESULTS

Comparison of the 1983 and the 1998 studies

Heilbronner and Wyss calculated the share of paintings assigned to one category in relation to all paintings. To facilitate a comparison of the results of these two investigations, we too looked initially at the percentage of paintings with motifs of one category in relation to all paintings. For example, all paintings featuring animal experiments were related to all paintings.

The percentage of paintings with motifs of the category *environmental pollution* (see Appendix, case 1) and *animal experiments* (Appendix, case 2) in 1998 was less than in 1983. If one considers that every painting includes more than three motifs and that these arrangements include not only negative motifs, the decrease of negative motifs will be strengthened. This tendency for change was emphasised by the paintings in the subject area of *laboratory*. Whereas laboratories were painted threateningly and bizarrely in 1983, the laboratories in 1998 were presented in a more realistically and friendly fashion (Appendix, cases 3 and 4). In addition to this, we found that the motifs relating to categories: *everyday life* (Appendix, case 5) and *specialised knowledge* (Appendix, case 6) reflected predominantly positive attitudes of the pupils.

To sum it up, there has been a pleasant change over the last 15 years. Our results showed that, nowadays (1998), pupils are better informed about chemistry than they were in the 1980s. Particularly, the balance of knowledge about chemistry is more extensive than it was in 1983. This means that the pupils more often considered risks as well as advantages of chemistry (Appendix, case 7).

Comparison of 6^{th}, 7^{th} and 9^{th} grades

First of all, we have to point out that the choice of motifs depends on grade-level. It became clear that half the pupils in 6^{th} and 9^{th} grade painted motifs that can be categorised under *laboratory* and *specialised knowledge*. However, pupils in 7^{th} grade predominantly chose motifs relating to the categories *environmental pollution* and *everyday life*. Unexpectedly, the proportion of motifs categorised under *laboratory* was very small in 7^{th} grade. Similarly, the percentage of motifs categorised under *specialised knowledge* in grade 7 was smaller than in the 6^{th} and the 9^{th} grades. In both cases the differences were statistically significant (p=0.00, Mann-Whitney U-Test). However, the proportion of these motifs was largest for the 9^{th}-grade pupils, which is probably due to the fact that they had had the longest experience in chemistry lessons. The polarisation into positive and negative motifs, *everyday life*, *specialised knowledge* on the one hand, *environmental pollution* and *animal experiments* on the other, showed that in all grades a large proportion of the pupils viewed chemistry from a positive (regarding the categories *everyday life* and *specialised knowledge*) and negative stands (regarding the categories *environmental pollution* and *animal experiments*): 6^{th} grade, 33%; 7^{th} grade, 36%; 9^{th} grade, 38%.

Comparison of girls with boys

We did not find many strong differences between the girls and boys in the different grades. Girls painted fewer pictures with negative motifs than boys did. Approximately 70% of the paintings of the boys whereas 53% of the paintings of the girls included at least one negative motif. This difference was significant (p=0.001). Pictures showing only negative motifs had been painted by 36% of the boys, but only by 17% of the girls (p=0.00). These

significant differences were caused by the following choice of motifs: boys prefered motifs from the category *environmental pollution* (p=0.001), whereas girls prefered motifs from the category *laboratory* (p=0.001).

DISCUSSION AND CHECK-UP OF HYPOTHESES

Attitudes towards chemistry

The polarisation into positive and negative motifs, *everyday life, specialised knowledge* on the one hand, *environmental pollution* and *animal experiments* on the other, shows that in all grades a large share of the pupils regarded chemistry from both a positive and a negative point of view. Moreover, using the three categories for the attitude scale, roughly 30% of all pupils expressed a positive attitude in the questionnaires regarding the subdivision of the attitude-scale. Pupils with two years of experience in chemistry lessons expressed significantly more often a positive attitude in questionnaires (p=0.011). In view of this, we can assume that the 9^{th}-grade pupils acquired a first scientific knowledge, which affected their attitudes.

Attitudes towards chemistry lessons

The extent of positive attitudes towards chemistry lessons shown by 6^{th} grade pupils amounted to only 17%. This unexpectedly low figure set us thinking. We can assume that the attitudes of pupils with little or no experience in chemical education are affected by their parents (52% of the pupils stated that they are informed by their parents), friends and siblings (56%) and by the media (67%). The proportion of positive attitudes towards chemistry teaching grew up to 37% in 7^{th} grade, non-significantly (p=0.326), although it decreased significantly to 20% in 9^{th} grade (p=0.025).

Check-up of hypothesis I

According to this hypothesis, an interrelation exists between the attitudes towards chemistry and the attitudes towards chemical education in 1998. To check this, we calculated the Spearman correlation coefficient, which showed that both attitudes interact slightly with each other: $\rho = 0.238$ at the 0.01 significance level. Although this hypothesis cannot then completely be sustained, the work of Wenck, Müller-Harbich, & Bader (1990) supports our hypothesis. In our opinion a sound chemical education, with good chemistry lessons is accepted by young people and contributes towards the elimination of prejudices against chemistry. On the other hand, a smaller distance from chemistry may cause a better attitude towards chemistry lessons and motivate reserved pupils to deal with and solve chemical problems.

Check-up of hypothesis II

This hypothesis stipulated that even without an actual experience of chemical education, pupils develop an attitude towards chemistry and chemical education. Our findings indicated clearly that pupils without experience in chemistry lessons posses a basic knowledge of chemistry. Particularly, the pupils of 6^{th} grade dealt very creatively, artistically and factually with the task. They displayed a broadly varied conception of chemistry comparing the pros and cons of chemistry. Looking at their attitudes towards chemical education we can observe that they seemed to evaluate chemistry lessons very

convincing. Their ideas of chemistry lessons and notions about the learning of chemistry concepts and doing experiments were just as good as those of the pupils in 7th and 9th grade. Our results show the importance of giving young children some background in chemistry, so that they can develop informed attitutdes towards both the subject and its teaching.

Concluding remarks

Our results lead us to an well-known thesis proposed by Dewey in the early 20th century: "all instruction has to begin with the experience of the children". As we were able to establish, preconceptions about chemistry are naturally brought by pupils into their introductory chemistry lessons. Emotionally burdened prejudice against chemistry can cause pupils to show a degree of apathy towards chemical education in its early stages. Additionally, a lot of pupils without experience in chemistry lessons hold concrete - predominantly negative - ideas of chemistry lessons possibly imparted by parents, friends and media.

For these reasons, we suggest that pupils' emotional attitudes towards chemistry and chemical education need to be addressed while they are taking part in chemistry lessons and – more important – before pupils have built up a concrete and prejudice-laden view of chemistry and chemistry lessons. Initiatives designed to introduce children to chemical phenomena and to scientific thinking at an early stage in their schooling may contribute to this end.

ADDRESS FOR CORRESPONDENCE: *Claus Hilbing, University of Münster, Department of Chemistry and Pharmacy, Institute for Didactics of Chemistry, Fliednerstrasse 21, D-48149 Muenster, Germany, Fax: ++49 251 83 383 13, e-mail: hilbinc@uni-muenster.de*

APPENDIX: ILLUSTRATION OF CATEGORIES

1. Category: *Environmental pollution*

"Acid rain" painted by a girl without experience in chemistry lessons.

2. Category: *Animal experiments*

"Animal experiments" painted by a girl being taught in chemistry lessons for $^{1}/_{2}$ a year.

3. Category: *Laboratory*

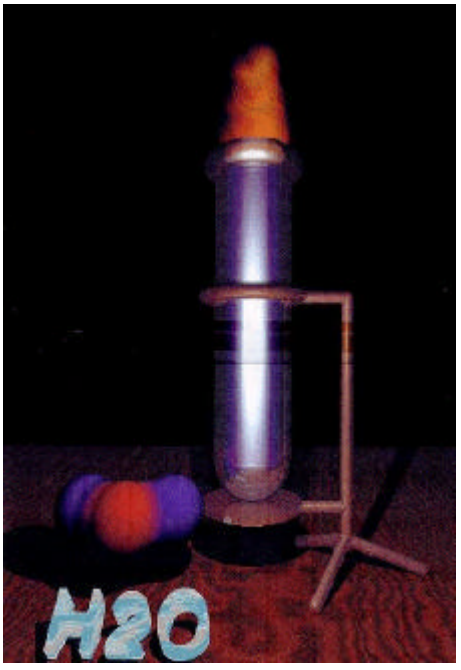
"Lab 1998" painted by a girl without experience in chemistry lessons.

4: *"Lab 1983" painted in 1983.*

5: Category: *Everyday life*

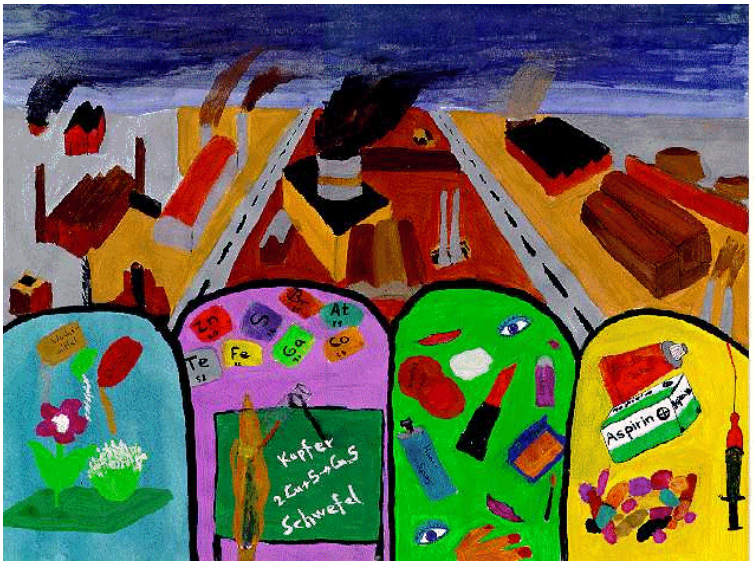
"Medicament" painted by a girl being taught in chemistry lessons for 2 years.

6. Category: Specialised knowledge



"Detonating gas experiment" painted by a boy being taught in chemistry lessons for 2 years.

7. "pros and cons" painted by a girl being taught in chemistry lessons for 2 years.



REFERENCES

Heilbronner, E., Wyss, E. (1983). Bild einer Wissenschaft: Chemie. *Chemie in unserer Zeit, 17*(3), 69-76.

Klamke, H. (1992). *Chemieunterricht. Analyse eines unbeliebten Faches in der Hauptschule.* Frankfurt am Main: Europäische Hochschulschrift.

Marcet, J. (1806). *Conversations on chymistry, in which the elements of that science are familiarly explained and illustrated by experiments and plates.* London: Longman, Hurst, Rees & Orme.

Mikelskis, H. (1979). *Zum Verhältnis von Wissenschaft und Lebenswelt im Physikunterricht Dargestellt am Thema Kernkraftwerke.* Bremen: Diss.

Rosenberg, M. J., Hovland, C. I. (1960). *Attitude organization and change*. New Haven: Yale Universtity Press.

Wenck, H., Müller-Harbich, G., Bader, H. (1990). Die Einstellung von Realschülern zum Chemieunterricht, zu Umweltproblemen und zur Chemie. *chimica didactica*, *16*, 233-253.

Zahn, Peter von (1979). Begegnung mit der Chemie. *Gießener Universitätsblätter*, 12(2), 7-16.