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Liberato CARDELLINI
University of Ancona, Department of Material Science and Earth

AN INTERVIEW WITH HANS–JÜRGEN SCHMIDT

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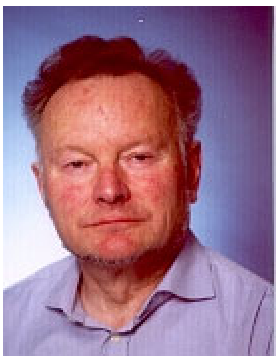
ABSTRACT: In this interview Schmidt provides some glimpses of his private life, from the time he decided to study chemistry until his career at the University of Dortmund and then, after retirement, at the University of Karlstad, Sweden, as guest professor. As an undergraduate in Heidelberg he worked under the supervision of the Nobel Laureate Georg Wittig in organometallic chemistry (he gives some personal memories about this outstanding man). After graduating he continued his research work in the field of rubber synthesis in industry. Prof. Schmidt also discusses the importance of the results of educational research for teaching; he explains the success of the *Dortmund Summer Symposia* and suggests some relevant qualities for being good teachers. He provides a personal perspective on the impact of new technologies in education and discusses the results of his research work on stoichiometric calculations. He sheds some light on some of the results of his many studies on students' misconceptions and explains why students develop some misconceptions in chemistry. [*Chem. Educ. Res. Pract.*: 2003, *4*, 11-17]

KEYWORDS: *Hans-Jürgen Schmidt; educational research; misconceptions; multiple choice questions; stoichiometric problem solving; Georg Wittig*

EDITOR'S NOTE: This is the fifth in a series of interviews that Liberato Cardellini has taken with leading chemistry education researchers/chemical educators. References to the previous interviews are provided at the end of this interview.

INTRODUCTION

Hans-Jürgen Schmidt studied chemistry at the *Universities of Kiel* and *Heidelberg* 1952-1960, and got his PhD in chemistry from the *University of Heidelberg* 1960, with supervisor *Georg Wittig,* the Nobel Laureate. After working for one year (1960-61) as Research Fellow at the *Max Planck Institute for Medical Research Heidelberg*, he took up a position as Assistant at the *University of Braunschweig* (1961-64). Following that, he worked as researcher in chemical industry (*Chemische Werke Hüls*) until 1971.



Professor Hans-Jürgen Schmidt

He served as Professor for Chemical Education first at the *Teacher Training College (Pädagogische Hochschule*) in Dortmund (1971-1980) and, until retirement, at *Dortmund University* (1980-1998). Since 1999, he is Guest Professor for Chemical Education at the *University of Karlstad* in Sweden.

He was "Minister for Foreign Affairs" of the *German Association for Mathematics and Science Education* (MNU) (1973-1999) and Delegate of the *German Chemical Society* at the *Education Division of the Federation of European Chemical Societies* (FECS) (1993-99). He has been the initiator and organizer of the *Dortmund Summer Symposia* from 1981 until 1996. Also, he was Chair of the *First Scandinavian Symposium on Research Methods in Science Education*, University of Karlstad, 2000. He served/serves as Member of the Editorial Boards of the following journals: *Journal of Research in Science Teaching* (1992-1996); *International Journal of Science Education* (since 1994); *Chemistry Education: Research and Practice in Europe (*since 2000).

Awards received: Aulis Award 1972/73, *International Council of Associations for Science Education* (ICASE) Distinguished Service Award 1994, Prize for Excellency in Teaching of the *University of Dortmund* 1998. Honorary Member of the *German Association for Mathematics and Science Education* (MNU) 1999.

THE INTERVIEW

Working with Georg Wittig and in industry

1. Has education always been your main interest?

After I had finished grammar school, I was unsure whether I should study chemistry to become a teacher or a chemist. My father was a teacher. I decided to study chemistry, took my thesis in organometallic chemistry with Georg Wittig, the Nobel Laureate, in Heidelberg. When I worked in industry, I was asked to give chemistry courses at the local grammar school in my free time. In those days we had a shortage of chemistry teachers. This reactivated my interest in teaching chemistry. When chemical education became a subject in several teacher training institutions (Pädagogische Hochschule) in Germany I was offered such a position in Dortmund. There is no doubt, I have a strong background in chemistry. This is reflected in my research: it is strongly connected to chemistry.

2. What was the most important thing you learned from Georg Wittig? Is there something you remember about this outstanding man?

Wittig highly esteemed research. He was a good supervisor. Every day he visited every member of his team to discuss the results of experiments or the planning of new ones. After we had decided on what to do in my master's thesis he said: When you have finished your first experiment, please call me. I will show you how to do first tests with the reaction mixture (organometallic compounds). Good service guaranteed.

It was an absolute must to do the experiments accurately. The main and all important side reactions had to be studied before the next experiment was started. Wittig asked us to expecially look for the unexpected.

Wittig was a quiet, unassuming person. This may be the reason that he received the Nobel Price very late at the age of 82. He convinced me that hight quality research always pays.

Stories? When I worked in Wittig's team we had a senior who had suffered a lot in World War II. He was always about to take his final exam, but withdrew in the last minute. This happened for quite a long time. One day, when our colleague had cancelled the PhD exam again, Wittig sent two of his assistants to bring the reluctant examinee by all means to his office. They had to follow him everywhere. The exam was taken, the man's career as a chemist secured.

3. In which field have you worked in chemical industries?

When I was a young chemist some chemical companies in Germany did research in the field of rubber synthesis using organometallic activators ("catalysts"). However, in those days few chemists were trained at universities as polymer chemists. Ziegler himself, who had invented the Ziegler-Natta polymerization a few years before, was originally not an expert in this field. He was a organometallic chemist like me. So I thought, I could accept a position in industry as a researcher for synthetic rubber. I had an interesting time.

Educational research: Concepts and misconceptions

4. What are the greatest ideas that have been made available to teachers by educational research?

Doing empirical studies in chemistry education I analyzed students' answers to written tests and students' comments in interviews. I was deeply impressed seeing how students tried to make sense of chemistry. It became clear, too, that many students were driven to the same incorrect answer using the same strategy. These observations formed the basis to study students' conceptions (and alternative conceptions) in a systematic way. It was also to be seen that students had difficulties in understanding even the basic principles of chemistry. What I learned from educational research is: many students are really interested to understand chemistry in a reasonable way. In chemistry lessons we should, therefore, give them a hand and teach chemistry in an intellectually more challenging, i.e. more reflective, way. We should also accept our students as they are and concentrate in our teaching more on the basic principles.

5. You have done extensive research on misconceptions. How did you identify them?

We always used quantitative and qualitative methods to identify students' concepts and misconcept(ion)s. As a quantitative method we used paper–and–pencil tests and counted the number of answers. The reason was: we wanted to differentiate between common – frequent – misconceptions and singular cases. Therefore, we asked several thousand students to take part in a written test. As a qualitative method we used the interview technique. However, the written tests also had a qualitative component in that we analyzed students' comments in detail. This combination of methods was used for triangulation purposes: the results of the interviews supplement the results of the written tests and the other way round. In students' comments and in interviews it became clear that many misconceptions had a logical basis. I, therefore, prefer the term *alternative concept* instead of *misconcept*.

6. Why do students develop misconceptions?

In some cases it is easy to understand why students propose alternatives to scientific concepts. Difficulties are, for example, looming if students reason about concepts that have changed with time. In the course of the history of chemistry new theories are often connected to old terms. A shift of meaning took place. As a result terms become ambiguous since they now contain an old and a new aspect.

The term neutralization is an example. It originally referred to acids and bases being substances that consume each other. The Brønsted theory, however, describes a neutralization as a proton-transfer reaction between particles, one acid-base pair disappears, another pair is formed. Research (Schmidt, 1991) has shown that students mix up the original and the modern interpretation of the term.

Another example: The term chemical reaction originally referred to a one-way process in which reactants disappear because they are transformed into products. At a more advanced level (in history as well as in chemistry teaching) a chemical reaction is seen as an equilibrium in which a forward and a reverse reaction compete with each other. Both, reactants and products, are present. Students have difficulties to understand the new concept, because they still have the original concept in mind (van Driel et al., 1998).

7. What is wrong with having misconceptions?

Terms are labels for concepts. Chemists' conceptual framework is not consistent in every respect. We often use, for example, an old and a new version of a term, although being incompatible, side by side. However, in our courses we may not discuss these inconsistencies, because we are not aware of them. This means that on one side teachers may learn from students' misconceptions to become better teachers. On the other side, it may well happen that a student develops an interpretation of a term that deviates from the generally accepted one. This often shows that he or she is a good thinker. We, therefore, have to be fair in judging our students. Therefore, my answer to your question is: nothing is wrong with having misconceptions. I am in favour of a chemistry course in which every student has ample opportunity to explain his or her understanding of chemistry to others (Schmidt, 2000).

Research on stoichiometry

8. You have also done extensive research on stoichiometry. What lesson did you learn from it? Could you suggest a logical approach to stoichiometric calculations?

Our research concentrated on problems in which students had to use three variables, the mass, the molar mass, and the amount of substance. Research showed that students often tried to solve our items by using two variables only. This method is – of course – incorrect. However, these students may be seen as on their way to the correct answer. From the strategies students used to solve the problems correctly we were able to construct easy-to-solve test items. In our empirical studies (Schmidt, 1994; 1997a) several students said that they had solved these items by 'pure logic' and 'without maths'. I suggest teachers should use simple problems of that kind to introduce stoichiometric calculations and to discuss the principles before mathematical strategies are used. This approach could easily be implemented into a unit of Nuffield chemistry – for example.

Research methodology

9. In your written tests you asked several thousand students to cooperate. Why did you need so many?

We work with large populations to ensure that in each class only one student (two on average at most) receives a certain item. Statisticians tell you that it is more reasonable to investigate 10 students from different classes than 10 students from one class. We also need large populations to get a sufficient number of comments for each misconception. Example: let us assume 150 to 200 students completed a test item. 20% made an interesting mistake, 50% of these gave a detailed explanation of their answer. We end up with 15 to 20 comments we can analyze. In a written test we work with 150 to 200 classes in one go, i.e. 3000 to 4000 students (Schmidt, 1997b). However, one test consists of six or more projects. The individual items are distributed to the students at random.

10. Do you see problems using multiple choice questions in research?

A student trying to find an answer to a multiple choice item is given the opportunity to compare a correct with several incorrect answers. The text of an item, therefore, hints to both a correct and an incorrect statement. Nevertheless, incorrect statements may mislead students. Here the triangulation comes in: approach the problem under investigation by using different methods, written tests and interviews as discussed under 5. I don't think, this is a real problem for research.

The Dortmund Symposia

11. You organized the Dortmund Summer Symposia. How was the idea born? Why did so many scholars attend the symposia?

Proper research in chemistry education is not easy to do. When I became interested in empirical studies, I started with the Dortmund Summer Symposia as a forum to present and discuss studies in science education with special emphasis on the methods used. The first symposia were held every year between 1981 and 1987 with German as the conference language. From then on every second year English was used as the conference language. This lasted until 1996. It was a tradition for every speaker to have the same amount of time to present his or her paper as well as for the discussion afterwards, namely 40 to 45 minutes. As we had no extra money, everybody – even the speakers – had to pay for their own expenses. However, the conference was very well accepted and became an international event. In the beginning we met for two days, in the end for four days. Participants liked the exchange of ideas. For me, there was no symposium as enjoyable as the Dortmund Summer Symposium. I learned a lot from the papers presented, especially from the discussions, and made new friends.

Chemistry education in a chemistry department

12. Do your colleagues appreciate your work in education? How are you seen by the academic body?

I belong to the chemistry department of my university. A few years ago all the chemistry departments of the Federal State where I work were evaluated by the government. We had to report on what we had done. Later a group of professors came and interviewed the staff, the other personnel of the department and the students. We got top marks, better than some other groups in the department. The evaluators especially appreciated our international activities (i.e. the Dortmund Summer Symposia) and the publications in international journals.

From 1999 I started as a guest professor for education in chemistry at the University of Karlstad/Sweden. These and other facts are very much appreciated by the members of the department /university. My status as a (full) professor for education in chemistry is the same as that of a (full) professor for inorganic, organic, physical etc. chemistry.

Lessons for teachers

13. What qualities do you think are relevant for teachers?

I consider three characteristics to be very important for teachers:
(a) Students need time to come to understand scientific concepts. *Teachers, therefore, need to be patient.*
(b) When students learn chemistry, they may develop their own ideas (see 6). *Teachers*, therefore, *have to be good listeners*.
(c) *Teachers should know their subject very well*. This is meant in two ways. Good knowledge of chemistry is a good basis for teachers to make explicit to students why they like chemistry and teach it. Knowledge of some results of science education research will help teachers to improve their teaching.

14. The rise of instructional technology can deeply modify higher education. Will teachers be replaced by computers?

Modern technology will influence teaching in the future as it has happened in the past. When I began to study chemistry at the university the professors had no overheads. Later learning programmes (*Lernprogramme*) were developed. In those days teachers were scarce in Germany. Therefore, these programmes were seen as a possibility to substitute teachers, but that did not work. I personally feel that we will need teachers in the future because learning is at least partly a social process.

CORRESPONDENCE*: Hans-Jürgen SCHMIDT, Universität Dortmund, Fachbereich Chemie, Otto-Hahn-Straße 6, 44227 Dortmund, Germany. Fax: +49 231 7552932; e-mail: dc2@pop.uni-dortmund.de.*
Liberato CARDELLINI, Dipartimento di Scienze dei Materiali e della Terra, Via Brecce Bianche, 60131 Ancona, Italy. Fax: +39 071 220 4414; e-mail: libero@unian.it

NOTE: Previous interviews of Liberato Cardellini with leading chemistry education researchers/chemical educators:

- An Interview with Alex H. Johnstone. *Journal of Chemical Education*, 2000, *77*, 1571-1573.
- An Interview with J. Dudley Herron. *Journal of Chemical Education*, 2002, *79*, 53-59.
- An Interview with Richard M. Felder. *Journal of Science Education*, 2002, *3*, 62-65.
- An Interview with Dorothy L. Gabel (in Italian). *La Chimica nella Scuola*, 2001, *XXIII*, 165-168.

Note also that the present interview has previously been published in Italian: *La Chimica nella Scuola*, 2002, XXIV, 134-137. Permission for the translation into English was granted.

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