Science Education on the Secondary School Level in Germany

with special emphasis on chemistry as an example

Heindirk tom Dieck[i]
Gesellschaft Deutscher Chemiker e.V.

The following report is prepared for a hearing in the Spanish Senate about the situation of the scientific education on the secondary school level in Spain. During the overall report the comparative situation in other European countries will also be discussed. In this paper a number of qualitative and quantitative aspects of science education in Germany are presented which might be helpful for decisions to be taken in Spain.

The Standard School Curriculum

Children enter primary school at the age of six. Their ability is, nevertheless, matter of a test. Children might be sent back for one further year if considered not yet mature. Although the percentage of children visiting a kinder garden (3 – 6 years of age) is steadily increasing as the Federal Government has imposed on the community (Towns, villages) by law that parents shall have the right to find a place in the kinder garden for their child/children, the kinder garden does not act as a pre-school system. There are exceptions to this general statement. In some communities preparatory classes (age of 5 years) are compulsory. Statistically the enrolment in primary schools saw an increase versus the age of 7 years , there are recent political counteractions to reduce enrolment age.
Primary school is for four years (age 6 – 10, classes 1 – 4). During this period there is teaching in a subject (”Sachkunde-Unterricht”), in which very elementary science is presented.
Following are two years (orientation phase, ”Orientierungsstufe”, starting age 10, classes 5 and 6), which are quite differently organized in different states. The purpose of the orientation phase is to give parents/children the possibility to find the adequate type of subsequent education for further four following years of compulsory school. For the purpose of this report those pupils are considered who continue in the Secondary I school system (”Sekundarstufe I, starting age 12, ending after 4 years at the age of 16, classes 7 – 10). During this period science education is important and will be specified later.
After compulsory 10 school years pupils receive a first ”maturation” document, an intermediate high school certificate (coll.: ”Mittlere Reife”). They may leave school and continue with an apprenticeship (including parallel specific school for vocational training).
In the school type ”Gesamtschule” (comprehensive school) and Gymnasium (the traditional high school leading to a degree which allows to pass on to a university) pupils or students continue for another three years in the Secondary II. (”Sekundarstufe II”; age 16 – 18, finishing at the age of 19!, classes 11, 12 and 13) This is different from most other European countries. There is a tendency to reduce Sec. II to only two years. Experimental curricula are now introduced. While class 11 is still traditional with many different compulsory teaching subjects and only a small portion of optional subjects ”classes” 12 and 13 (”Reformierte Oberstufe”, reformed upper phase) are more or less age-classes (of school life) with individually composed curricula, of course according to a minimum scheme. Maths and science cannot be ”avoided”; on the other hand may be selected as priority field with special courses.

Pupils/students normally enter high schools (”Gesamtschule or Gymnasium”) after the primary school (plus observation phase) and stay there for Sec. I and Sec. II until the final examination at the age of 19+.

Private schools and boarding schools have statistically negligible importance in Germany.

Whole-day school is very uncommon; meals at school are also uncommon. Teaching is concentrated from 8:00 to 14:00, or from 8:00 to 13:00 plus some lessons in the afternoon. This has an obvious influence on the professional occupancy and time management for parents.

The Federal School System

The Federal Republic of Germany comprises 16 states (”Länder”). Educational and cultural matters are the most important political fields in which the State Governments (”Länderregierungen”) are the decisive authorities, and this part of states´ competence is jealously protected.
To secure important elements of homogeneity in the German educational system the ministers for culture and educational matters together form the Cultural Ministers´ Conference (”Kultusministerkonferenz” KMK). Nevertheless there is substantial variation in particular teaching aspects, this also holds for science teaching.
The State Governments are, of course, of different political ”colour”, which has an impact on the educational systems, on the (political) preference of certain school types and on the sociological educational structures.
The States show further very important differences with relevance to school matters: Some of the States such as Berlin, Hamburg and Bremen are more or less big cities with extremely dense population, dense infrastructure and hence many schools of different types and of the same type within reach of one living area. Other states with a large surface, more rural character, less producing industry, and/or less service industries, have a different repartition of parents´ professions and longer distances to one or a selection of secondary schools.
The States are of different economic strength. A horizontal financial equalization reduces the disadvantages for poorer areas

Political and Societal Influences

School politics are always a matter of debate prior to State elections and have shown substantial polarization between conservatives and social democrats. In the past social democrats had a tendency to support comprehensive high schools and under-privileged families from less educated groups of the population. This ”equal chances” politics gave rise to a higher percentage of students per age group to acquire the final high school grade (”Abitur”). More conservatives states stressed the terms of quality and performance and showed a more rigid selection to allow students to continue beyond Secundary I. Twenty years ago the difference between the States of Berlin, Hamburg, Bremen (> 30% of the age group with final exam ”Abitur”; less than 15% in the State of Bavaria) was typical for such conditions. The average (1999) is now >25% successful final exams from general public schools, 11% from vocational schools. Thus 36% of the corresponding age group are permitted to continue in universities (27,3 %) or polytechnics (9,2%). Girls are slightly (53%) ahead of boys.

The increasing importance of leisure and holidays for the parents´ generation had its influence on school life. In most states teaching is from Monday thru Friday, only occasionally on Saturdays, or a maximum of 50% of the Saturdays.

University Studies in the Sciences and the Engineering disciplines have always been considered as difficult. On the other hand the reputation of the profession of an engineer, a chemists, or a physicist was very high in the past. Some of the reputation of these professions with an academic educational basis – and this is especially true for the engineers and the chemists – stemmed from the high positions and also the high salaries which could typically be reached in industry. The very general attitude to earn ones living with less stress and work and also the intermediate difficult years of globalisation a heavily competitive labour market had a marked effect. The number of pupils choosing the science-profile school curricula in Sec. I and of the students in Sec. II declined strongly. Later on, starting in the early 90ies, the number of university students in science and engineering science dropped sharply in many highly industrialized countries, very typically in D, NL, CH, Scandinavia. Parts of Europe will face a sharp shortage of young human capital in science prior to learn to hire new staff outside traditional areas.

Teacher Resources

The severest political and/or societal influence on the science teaching is directly and indirectly linked to the German demographic development and may serve as a bad example for other countries. The birth rate in West Germany was at maximum between 1960 and 1967. From 1968 – 1974 the rate fell 45% and remained quite low. The States authorities reduced the number of newly employed teachers so drastically that the age of the teaching staff grew accordingly. Further, young persons were totally discouraged to study for high school teachers as there were almost no new openings and this continued for such a long (too long!!) period that we face a relatively over-aged staff and a lack of resources to be employed.
Different from many other countries, the university curricula and the final exams for students to become teachers are controlled by the States, they are different from diploma studies, and they are also differing for teacher students for primary school, for Secondary I and for Secondary II.
To become a science teacher in the Sec. II level teacher students have to choose two science subjects (e.g. biology and chemistry) and have to go through an important theoretical pedagogic education; after the 1st state exam they will continue a practical stage at the high school plus a 2nd state exam.
There is almost no exception from the rule that teachers have to be educated according to this specific and well-defined scheme, which separates science curricula in universities with repect to the choice of the later profession. Diploma physicists, chemists or biologists even with a PhD grade are not admitted to become teachers.

Quantitative and Qualitative Aspects of Science Teaching

There is a relatively early decision in an individual pupil´s school curriculum whether to prefer a language or science orientation (”Sprachlicher Zweig” or ”Mathematisch-naturwissenschaftlicher Zweig”).
Traditionally the sciences are taught separately, i.e. there are lessons in physics, in chemistry and in biology. There is no subject geology, but geography. Geography is not assigned to the science sector. The teachers associations and the learned societies (such as the German

Chemical Society GDCh) are successful to explain to the political authorities that the methods and contents of these three sciences are so different that each of them fulfils a specific pedagogic goal, how observe and to document an experiment or an event, to reach conclusion, how to think in terms of strictness and logic, and how to reach levels of abstractness and general insight.

Recent proposals to introduce a subject ”science education” instead of the three different sciences as subjects have low probability of realization. They stand against German tradition; the teachers´ education does not qualify for this broad subject in view of the strict university curricula described above. One origin of such proposals might be the philologists´ side, as the continuous request from all teaching areas (foreign languages, social subjects, maths and sciences) to increase their portion of teaching hours and reduce the others accordingly might find a good solution in decreasing science by introducing this comprehensive subject.

Hours of Chemistry Teaching:

Orientation Phase: (classes 5 and 6):	1 – 2 h/week in 3 states
Secondary I	
class 7:	1 – 2 h/week in 3 states
class 8:	2 h/week in 8 states
class 9:	2 h/week in 15 states; (3 h*)
class 10:	2 h/week in 15 states, (3 h*)
Secondary II	
class 11:	2 h/w Standard
	3 - 4 h/w science Profile (depending on state)
	up to 5 h/week special profile (”)
”class 12 and 13”	dep. individual choice and state(0 – 6 h/w)

Example of a German State with language or science profile (Baden Württemberg)

Language Profile (lessons of 45 min per week)

Class =>	5	6	7	8	9	10	11
maths	4	5	3	5	4	4	4
Physics	(1)	(1)		2	2	1	2
Chemistry	(1)	(1)			2	2	2
Biology	2	2	2	1			1

Science Profile

Class	5	6	7	8	9	10	11
Maths	4	5	3	5	4	4	4
Physics	(1)	(1)		2	2	2	3
Chemistry	(1)	(1)			3	2	2
Biology	2	2	2	1	1	2	2

Chemistry like physics and biology is an experimental science. Group work and laboratory work was and is considered to be very important for the pedagogic goals of these subjects. Chemistry is struck harder than the other two areas by the steady development of ever higher standards in safety, health and environmental impact. Schools were left alone for many years with the correlated problems in performing experimental work and also with the increasing costs beyond the needed materials. Chemical industry and university laboratories have made

great efforts to help schools, teachers and students. Partnerships have been built up, but the support from the ministries and further public authorities is still considered insufficient to guarantee solid laboratory conditions for experimental work of teachers and of students themselves.

Further information on Educational Matters in Germany

Very extensive information on all school matters (and further education matters) can be found on the following internet addresses, which also give information on print products, many of which are free

Http://www.bmbf.de Server of the Federal Ministry of Education and Research; This ministry publishes every year a very informative 500 pp guide entitled “Grund- und Strukturdaten” (free from the Publisher: BMBF, Post Box 300235, D-53182 Bonn or by Fax (0049) 1805 262 303)

http://www.bildungsserver.de From this education server you are linked to all corresponding servers of the different States, and thus to specific State information; most of the materials can be downloaded, including complete education plans with the whole content description.

http://www.kmk.org is the server of the States´ cultural ministers conference, with many links to all school matters. On this server under www.kmk.org/schulk/home1.htm there is a links to a very recent 24 pp report on “Activities of the states to develop the education in science and mathematics”, taking into account the results of the TIMS and the PISA 1 study.

http://www.mpib-berlin.mpg.de is the server address of the Max-Planck-Institute for Education Research, which was the national institution responsible for the German part of the PISA 1 study.

http://www.eurydice.org is the server for the Eurydice database on Educational systems in Europe.
http://www.eun.org is the corresponding server on the European Schoolnet

Some Activities of the German Chemical Society GDCh
on Educational Matters and public understanding of science

http://www.gdch.de is the server of the German chemical society, Gesellschaft Deutscher Chemiker GDCh. GDCh has a division on Chemistry Teaching with approximately 2000 members. GDCh publishes regularly recommendations on Educational Matters in chemistry; GDCh has its own Chemistry Teaching Journal “ChemKon”. GDCh has a special continuous education programme for chemistry teachers and a regional programme for continuous education, teachers and students´ experimental days in universities.
GDCh has also decided in 2001 to create and co-finance Teachers´ Continuous Education Centers in Germany and has started a competition to allocate the financial resources.

Together with the Chemical Producers´ Association VCI, the Chemistry Trade Unions IGBCE, the Chemical Employers Association BAVC the GDCh is running a political initiative during 2001, 2002 and 2003 throughout Germany

Education Initiative in Chemistry

The purpose is to enhance the political and public understanding that good science education in schools is the foundation for an encouragement of youngsters to decide for scientific and technical studies and professions, a prerequisite for the needed human capital in a leading technological nation.

The year 2003 will be celebrated as the "Year of Chemistry" with the purpose to enhance the visibility and the public understanding of this science. The "year of Chemistry" is performed and sponsored by all chemistry organisation, the federal ministry and is directed and coordinated by the German Chemical Society GDCh. Schools, teachers and student groups will be in the focus of the 2003 activities. Public awareness for chemistry will be enhanced by a new 2003 post-stamp and a 10€ coin with the portrait of Justus Liebig, one of the world´s best known chemists, born 1803. Details can be taken from www.jahr-der-chemie.de.

A "Year of Physics 2001" was the starting point in the Public Understanding of Science programme, followed by a "Year of the Life Sciences 2002".

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[i] Prof. Dr. Heindirk tom Dieck.
Managing Director of
Gesellschaft Deutscher Chemiker e.V.
Varrentrappstr. 40-42
60486 Frankfurt (Main)
Tel (0049) 69 79 17-320 Fax –307
email: htd@gdch.de