Natural Science Education in Germany in 2012 after the 1999 European Bologna Reforms

By Eckhard Hitzer – version 4 of 14 March 2012 for Mathematics Education Seminar at Meiji University Tokyo (Ikuta Campus), 18 March 2012, 10:00 - 10:30am. [The quotes of Schleiermacher are from Forschung und Lehre Vol. 10, Oct. 2008, taken from Gelegentliche Gedanken über Universitäten in deutschem Sinn Nebst einem Anhang über eine neu zu errichtende (1808)]

Major drives of reform in German high school education, teacher training and university science education are the *Bologna Process* (1999), and the results of educational surveys like the OECD *Programme for International Student Assessment* (PISA), *Trends in International Mathematics and Science Study* (TIMSS, every 4 years since 1995). Education in Germany is fundamentally a matter of each German *state*, not of the federal government. University budgets are decided by each state, professors are state employees, curricula are decided on a state level, etc.

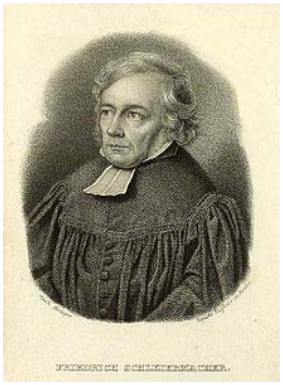
1. High school teacher education

The unexpectedly low German PISA and TIMSS scores were a kind of shock for the German education system and have lead to further reforms, including the university education of science and mathematics teachers. One new educational principle in recent years in Germany is to reduce in high schools the input orientation in favor of more output orientation. Another principle is competence orientation instead of factual knowledge orientation.

Yet overemphasize of competence without a sufficient knowledge base is a dangerous extreme to be avoided.

Critics of mathematics high school curricula in Germany say, that the former strength of didactically well presented mathematics content is nowadays replaced by empirical learning at a rather low level (counting beans). It is said that nowadays there are many vacancies in mathematical didactics at German universities, which is not only a good sign.

The education at German high schools in mathematics is usually insufficient for the needs of a first semester science major in Germany. Therefore, before the first term, the universities nowadays offer 2 weeks of up to eight hours a day introduction courses to mathematics. It is a sore and mysterious question as to why it is not possible at German high schools to remedy this problem. The education of the future mathematics high school teachers also occurs in the universities, partly in special teacher training courses, so this cannot be the reason. The reasons may possibly be found in the study seminars (accompanying teacher training in practice) and in the (Prof. em. H. Dehnen: *criminal*) high school curricula. But the problem is not only with high school math education, the high school physics education is not all that great, though there are some exceptions. Some German states are now said to reduce the number of teacher-in-training years (German: Referendariatsjahre). From within the academic community, e.g., the German Physical Society (DPG) has special programs to give incentives to high school students.



F. Schleiermacher: It is directly detrimental, if universities would only be continued schools. Schools only occupy themselves with knowledge as such, insights into the nature of knowledge in general, the scientific mind, the capacity for innovation and personal combinations are only excited in a preparatory way, but all this is not fully developed in them (schools).

2. Education of University Teachers

So far there is no special education or continuing (on the job) education for university teachers in Germany. There are plans, but not yet realized, to separate the roles of teaching professors and research professors. Even nowadays the main requirement for becoming a professor is to have a *habilitation* (venio docendi). A habilitation is an extended in depth 5 year thesis project, which qualifies to give (private) lectures at a university in

Germany.

During the last 10 years the additional option of 6 year long junior professorships has been created, based on a sufficient number of well-qualified scientific publications. A junior professor can lead his own (junior) research group. But this option is only accepted with a lot of hesitation, because in general there is no guarantee of continuation of employment after the first 6 years. Every junior professor is evaluated twice: after 3 and 6 years, respectively. But there are already some exceptions, where universities have provided a tenured position thereafter.

Yet the introduction of the junior professor ships meant, that for ca. 5 years most positions open for qualified habilitants (Dr. habil.) were given to junior professors instead. That meant that a generation of highly qualified young scientists was either forced to leave Germany or to take up jobs in the industry.

For foreign researchers it is (and always was) possible to become a professor in Germany even without a habilitation. This is also the case for exceptionally high qualified German researchers, based on an exceptional publication record.

A big problem is the new salary system for Germany university professors, who in some cases nowadays earn even *less* than a high school teacher. The basic salary is comparatively low, everything else is based on personal achievements. But the measurement of these achievements is not objective and is a matter of departments and universities. Good teaching is usually not counted as achievement which may earn extra pay. And the achievement bonus completely depends on the individual economic situation of the university, they may be as low as 20 or 30 Euros (2000 to 3000 JPY). Recently the German constitutional high court has ruled that the current salary system is unconstitutional, regarding basic rules of fair payment for this type of highly qualified work. Low university salaries also mean that many of the best researchers choose highly paid industry jobs instead of teaching and research at universities.

There is also stiff resistance at some university departments against reforms of professorial qualifications. For example, the Faculty of Law of the University of Erlangen continues to insist on the habilitation as the sole qualification for university law professors.

F. Schleiermacher: Learning by itself is not the purpose of a university, the purpose is discovery (German: Erkennen). The memory should not be fed, and not only understanding should be enriched. A totally new life, a higher, truly scientific mind should be encouraged. But this does not succeed by force. This experiment can only be tried in the temperature of a total freedom of the mind. … First of all open space is necessary for everything that comes to everybody from inside. The more the mind of science lives, the more the mind of freedom will become active and they will only stand in opposition against imposed servitude.

F. Schleiermacher: If we succeed in illustrating the principle and the fundamental design of all knowledge, the skill will arise, to work out every discipline of science. At the university the aim is to learn how to learn. The aim is the idea of discovery, the highest consciousness of rationality, as guiding principle of mankind.

F. Schleiermacher: The teacher has to let arise everything he says in front of the audience; he shall not tell what he knows, but he shall reproduce his own act of discovery itself, so that the audience will not merely gather knowledge, but can observe the acts of ratio in directly creating discovery and by observing reproduce it.

3. Research at German Universities

There is a growing concentration on special research topics, especially topics, which show some promise for industrial applications. Yet this depends also on politics: When the German Green Party was in the national government coalition, they completely stopped the public funding of nuclear energy research, and rather encouraged research in renewable energies, with the only exception of research into decommissioning of nuclear power stations and the question of safe storage of nuclear waste. Nowadays increasingly research money is invested in large *special research collaborations* (German: Sonderforschungsbereiche) running 5 years (or if renewed for 10 years). A necessary condition for this is a local concentration of researchers of a special research field.

A reaction to the brain drain abroad and into the industry, which accompanied the introduction of junior professorships and the Bologna reforms (next section), were the German *Initiatives of Excellence* university competitions. But even this

initiative has serious serious drawbacks. In the first round only 3 West German universities were awarded with the new excellence status, including huge sums of money: 2 in Munich and 1 in Karlsruhe. It is said, that Leipzig with its 600 year old university (mathematical physics) and the Max Planck Institute (MPI) of Mathematics (with mathematical biology and anthropology) was indeed well qualified for the excellence status it applied for, but was not awarded, only because of political wrangling. As a consequence within 1 year 1 MPI director, 1 MPI research group leader and two more researchers left straight for excellence clusters in West Germany.

Sometimes foreign researchers worry about the situation in Germany as to whether it would still be possible to cooperate with German institutions? Another point of critic is that money was taken from professorial salaries all across Germany and redistributed to excellence clusters, thus eroding the situation at the surrounding universities.

> *F. Schleiermacher:* The state has to leave the sciences undisturbed, all inner (university) institutions should be totally left to the scholars themselves, whereas the state should only take care of economic administration and of observing the direct influence these institutions have on official government services. Schools and universities suffer the longer, the more, under the fact that the state views them as institutions where science is not done for its own (scientific) sake, but for the state's sake. Schools and universities suffer if their natural tendency to form themselves according to requirements of scientific laws, is misunderstood and hindered, and if the state fears that if schools and universities are left to themselves, they would begin to move in a circle of fruitless learning and teaching, remote from life and application. If the state fears that due to the thirst for knowledge the urge for action would die out, and nobody would want to engage in civil business any longer. This seems to be the main reason, why the state takes *too much care* in its way of dealing with these things.

4. The new structure of university degrees in Germany after the Bologna reforms

The so-called European Bologna reforms of 1999 adopted by 29 European countries as part of the Bologna Process (47 member countries) for harmonizing the university degree system across the European Union (EU) and for easing the transfer of credits are nowadays widely implemented in German universities. Part of these reforms are an increasing number of courses taught exclusively in English for attracting international students. Critics say, that in practice it has not become easier for students to transfer to universities in other countries, and that the Bologna reforms effectively only serve to create jobs for bureaucrats. Empirical statistical long term data on the effects of the Bologna reforms in Germany are not yet available.

4.1 The new Bachelor degree

For obtaining a bachelor degree a student has to study for 6 semesters (3 years) and to complete a 6 months final research project. As for physics, during the first 4 semesters (2 years) generally no distinction is made between theoretical and experimental physics. Both is offered in so-called *integrated courses 1 to 4*. Credits are generally awarded after written end of term examinations, more than in previous years. Prior to the Bologna reforms, there were written end of term examinations, but the professors could also opt for oral examinations.

In physics it is nearly mandatory to do a 6 months industrial research internship in an industrial company or in a large research facility, like a national laboratory, etc. This has to result in a final thesis, which is not graded. It is only declared to be acceptable or rejected by a university professor. If a student does not succeed in securing an internship, he can instead attend additional optional university lectures. In principle the student has to find the internship place by himself, but is usually strongly supported in his search by university professors. Though there is no guarantee, that every student can successfully secure an internship placement.

The possibilities of combining a science major with additional secondary subjects have been expanded. Traditionally there were combinations of physics with chemistry and mathematics, but nowadays this may also be economics, law, computer science, etc. Mathematics classes are mandatory for physicists in the form of special lectures for physicists or the same main lectures (analysis, linear algebra and calculus) like for

mathematicians. The main mathematics major lectures are usually offered by the department of mathematics (for example at the TU Munich, of the University of Konstanz), but at some universities they are also offered by the physics department.

On the other hand, the reduced time (3 years for a bachelor instead of 4 or 5 years for a diploma) lead also to a great reduction of undergraduate subjects of choice or of mandatory choice. Either students choose a singe main subject like physics or mathematics, etc. or they choose a combination of two subjects: 1 main subject and 1 subsidiary subject, with a ratio of 90 to 60 lectures. Combined degrees allow also the combination of science or mathematics with philosophy or other humanities and arts. Bachelor students in general are offered across all disciplines something called *Studium Plus* under the principle of *competence education*, this effectively is a new label for the *studium generale* subjects of the former German diploma degrees.

German university professors can try to offer interdisciplinary lectures within this framework, e.g. *natural philosophy* (Naturphilosophie) or *man and cosmos*, etc., which are even open for mathematics majors to attend. Interdisciplinary lectures combining several disciplines (German: Ringvorlesung) may combine subjects like mathematics with psychology, science, history, cultural sciences and humanities.

On the other hand the interest of students from non-mathematical majors in mathematics seems relatively low, even under titles like mathematics for scientists or foundations of logic, etc.

In general, across all disciplines, studying at German universities after the Bologna reform is perhaps better structured, but with less individual academic freedom, it becomes more *like in high school*, where everything is already decided.

4.2 The new Master degree

Prior to the Bologna reforms, Germany universities had no bachelor degrees, only diplomas, magisters, and national examinations for teachers – fully corresponding to the master degrees in the Anglo-Saxon system. Nowadays the master degree follows the bachelor degree and is to be completed (including the 3 bachelor years) after no more than 10 semesters (5 years). The last year of the master degree is a one year research project. Critics say that in Germany the introduction of the Bologna reforms has watered down the very high level of the German engineering diploma degrees.

Acknowledgments

Dr. habil. Bertfried Fauser (University of Konstanz, University of Birmingham). Prof. Dr. em. Heinz Dehnen (University of Konstanz). Prof. Dr. Wolfgang Sproessig (University of Freiberg), Prof. Dr. Hans Juergen Petsche (University of Potsdam), Prof. Dr. Ulrich Kortenkamp (Paedagogical University of Karlsruhe = Paedagogische Hochschule Karlsruhe), Prof. Dr. Martin Eriko Horn (University of Frankfurt), and Prof. Dr. Johannes Balve (University of Kanazawa), Prof. Dr. -Ing. Dr. h.c. Hartmut Fuess (Darmstadt University of Technology).

Further literature:

- Journal *Forschung und Lehre*, http://www.forschung-und-lehre.de/
- *Unabhaengige Deutsche Universitaetszeitung* http://www.duz.de/
- Journal *Freiheit der Wissenschaft*, http://bund-freiheit-der-wissenschaft.de/
- Friedrich Daniel Ernst Schleiermacher, *Gelegentliche Gedanken über Universitäten in deutschem Sinn Nebst einem Anhang über eine neu zu errichtende (1808)*, scan of original available at Google books.

Images:

http://mapsof.net/uploads/static-maps/
http://www.guardian.co.uk/books/2009/oct/11/fairytales-cinderella-perrault
http://www.mm-gi.de/htdocs/mathematikum/
https://en.wikipedia.org/wiki/Friedrich_Schleiermacher
http://arrobo.com/photogallery/photo13213/Antinuclear1.jpg
http://www.hotelitaliani.it/Regioni/EmiliaRomagna/Hotel-Bologna.htm
www.sciencephoto.com/media/223489/