The doctoral phase of higher engineering education in Germany and in the framework of the Bologna process

M.H.W. Hoffmann
Dept. of Microwave Techniques
University of Ulm, Ulm, Germany
Michael.Hoffmann@uni-ulm.de

***Abstract* — In the framework of the Bologna process, European ministers decided to "reform" the doctoral phase of higher education and to introduce "doctoral-school education". Having learnt from the former consequences of the Bologna-process, German engineering organizations are worried about another debacle concerning higher education. Therefore, the current doctoral education in Germany is compared to the newly suggested scheme that is proposed by some educational politicians. A SWOT analysis of both will be presented. It will be required that any reform must end up in a system that outperforms the old system. It will be shown that the system proposed by the Bologna-follow-up groups does not meet this requirement, at least with respect to engineering education.**

Keywords – Doctoral studies, Bologna process, higher education.

1 Introduction

Engineering education at European universities is in a process of structural changes. This process is known as Bologna-process. European governments initiated this process by agreeing on harmonizing and reforming higher education, which in principle is an excellent idea.

Meanwhile, reforms have been initialized concerning the first two cycles of university education on a bachelor's level and on a master's level (first and second cycle of higher education). Whether these reforms are a success or a failure is disputed between German university faculties of engineering on one side and some companies and politicians on the other side.

In the meantime, European ministers in charge of higher education decided to "reform" the doctoral phase, which they are calling the "third cycle" of higher education [1].

This time, however, university faculties and engineering bodies agree upon their concern about a debacle concerning the doctoral phase of higher education. They have the impression that educational politicians, who are often jurists, are mistaking their own way of higher education for the higher education of engineers – as they already have done it when setting up the legal bases for the bachelor and master degrees for higher education in engineering in Germany.

In order to enlighten the different points of view, the current doctoral education is compared to the newly suggested "doctoral-school education" that is proposed by some educational politicians. A SWOT analysis will be performed in order to assess the competing systems, since it must be required that any reform must end up in a system that outperforms the old system.

2 Qualifications: the degrees of a bachelor, a master, and a doctor

Educational politicians and institutions of higher education agree upon that bachelor-degree, master-degree and doctoral degree are seen as evidence of different professional skills of their holders. They argue on the way how to achieve these skills.

It is not a surprise that there is a debate, since until now the ministers in charge of higher education in the European countries have not yet been able to define what the differences are between these professional skills. In the Bergen communiqué [1], ministers stated "We adopt the overarching framework for qualifications[1] [2] in the European higher Education Area (EHEA), comprising three cycles (…) , generic descriptors for each cycle based on learning outcomes and competences, and credit ranges in the first and second cycles. We commit ourselves to elaborating national frameworks for qualifications compatible with the overarching framework for qualifications in the EHEA by 2010, and to having started work on this by 2007."

In other words: these frameworks are not yet created. Nevertheless, politicians are already discussing the reform of the doctoral qualification.

Universities know quite well about the professional skills and competencies of bachelors, masters and doctors. It is all the more surprising that their advice is not welcomed by German ministers of higher education.

There was a similar situation when the first two cycles of higher education were introduced. As a result, there is less compatibility between bachelor degrees from different European universities than ever.

It might thus be useful for the further debate to clearly define the professional skills and competencies of bachelor-, master-, and doctoral degrees. Indeed, this discussion must start with the competencies and professional skills of a bachelor, since the doctoral phase is building on the skills and competencies of a master, which in turn is building upon those of a bachelor.

According to the Berlin communiqué [3], ministers stated in 2003 "First and second cycle degrees should have different orientations and various profiles in order to accommodate a diversity of individual, academic and labour market needs. First cycle degrees should give access, in the sense of the Lisbon Recognition Convention, to second cycle programmes. Second cycle degrees should give access to doctoral studies."

No clear-cut description is available until now that describes the competencies of a bachelor though there has been a seminar on it [4]. This is also underpinned by another statement of the ministers given in 2005 in the Bergen communiqué [1] where they admit that "there is a need for greater dialogue, involving Governments, institutions and social partners, to increase the employability of graduates with bachelor qualifications." This is obviously a confession that a bachelor degree is not clearly defined by competencies, and that it is not a true professional degree.

[1] Within this context, the term „qualification" must not be confused with the term "professional skill", since in the Lisbon convention [2], "qualification" was defined as "any degree, diploma or other certificate issued by a competent authority attesting the successful completion of a higher education programme."

Similar statements could be found by chief executives of American professional bodies. William A. Wulf, president of the National Academy of Engineering (USA) states [5]: "Unlike engineering, most professions – business, law, medicine – do not consider the baccalaureate is the first professional degree… Trying to squeeze 10 pounds of material (the engineering curriculum) into a five-pound sack (a four-year course of study) just won't work". James M. Tien, Vice President Educational Activities of the IEEE, states [6]: "Even though industry persistently calls for engineers to have … a solid knowledge base, and a practical design approach, universities are still trying to cram all that content into only four years. There wasn't enough time to cover these in the 20th century, and four years certainly won't be enough time in the 21st. I propose restructuring the U.S. undergraduate and graduate degrees into a professionally oriented program based on a five-year European model …".

Top level universities in the United States of America have already drawn their conclusions. MIT, for instance, recommends for majors in the department of electrical engineering and computer science to pursue both a bachelor's and master's degree at the same time [7], while in Europe, politicians are about to give up that standard.

Based on the experience made in America, and meanwhile also in Europe, the following still very general definition of the competencies of a bachelor of engineering might be given:

> A bachelor of engineering must have acquired all the competencies and professional skills that enable him/her to perform simple engineering tasks under the supervision and guidance of an experienced senior engineer. He or she must be able to pursue further studies to achieve a master's degree.

I.e.: a bachelor of engineering is employable, and thus meets some needs of the labor market, but he or she is not having the competencies or skills of a professional engineer.

This is in severe contradiction to political statements. However, since politicians have restricted the duration of bachelor education to 180 to 240 ECTS credit points [4], they have at the same time prevented the bachelor degree from being a true professional degree. People would laugh at a politician, who would demand to reduce schooling from K-12 to K-8. However, politicians, who demand to bring down engineering education from five years to three or four years expect to be taken seriously.

A master's degree in engineering is a bit better defined, since it might be compared to the classical Diplom-degree that was and still is awarded by many European universities. Attempts to define the competencies and professional skills of a master are also found in [8]. Together with agreements from the classical Diplom-degrees, the following definition might be given:

> An engineer holding a master's degree must have acquired all the competencies and professional skills that enable him or her to perform standard engineering tasks in his or her special field without supervision. He or she must be able to communicate technical problems and results of his or her work to other experts and to explain consequences of his or her work to those who are affected by it. He or she must be able to pursue further studies in the process of life-long learning.

A master's degree in engineering attests thus professional qualification.

Under these premises, it is evident that a doctoral degree is much more than just another professional degree: an engineer who is professionally working on a similar subject as in his or her master studies does not achieve professionalism as lately as during preparation of the doctoral thesis; he or she has already achieved it before.

The association of faculties of engineering at German universities (4ing) is in the process of defining the competencies and professional skills of a doctor of engineering [9]. They agree in the essential points with an already published paper that was edited by the German federation of technical and scientific associations (DVT), which include virtually all professional bodies of engineers and of technical scientists [10]. In a draft paper [9], 4ing gives the following descriptors.

> A doctor of engineering must be able
> to autonomously make accessible new sources of knowledge,
> to self-containedly develop that knowledge using a scientific methodology (research),
> to circulate that knowledge in a suitable form to others,
> to supervise less qualified engineers,
> and to acquire financial and ideal means for supporting his or her research.

It is exactly that professional profile that makes a doctor of engineering a valuable staff-member in research institutions as well as in industry.

3 Achieving the qualification of a doctor of engineering

3.1 Prerequisites and formal arguments

It is evident that the professional skills of a doctor of engineering could only be acquired by individuals who have acquired the professional skills of a master's degree of engineering, afore.

It might be disputed whether or not it is necessary to require the *formal* qualification of a master's degree before entering the doctoral phase of studies. Anyway, it must be factually required that a bachelor who is willing to enter the doctoral phase, and who is not yet holding a master's degree, achieve competencies and professional skills of a master (but not necessarily a master's degree) before major parts of a doctoral thesis might be prepared. This is not different at good American or British universities.

Nevertheless, there are good reasons to also consider the formal qualification. If it is agreed upon that the main part of the doctoral phase is done by an individual already being an engineer with professional competencies and skills, then the doctoral phase must no longer be considered to be postgraduate studies. It is rather the first phase of a researcher's professional life, where "evidence is provided on a particular, individual, scientific, and professional performance" [10]!

This is why the association of German university faculties of engineering prefers to talk about the doctoral phase rather than about doctoral studies.

3.2 Research-based doctoral education

In most European universities, doctoral education is mainly research-based, in most German universities it is even purely research-based. This might easily be understood in the light of the above given descriptors of the competencies of a

doctor of engineering, where the autonomous creation and development of scientifically based knowledge is one predominant aim.

Indeed, it is difficult to imagine that the necessary competencies and professional skills to perform research could be learnt by not practicing research. It is a huge difference to absorb knowledge as compared to make accessible new sources of knowledge. It is a large difference to further develop knowledge and to present these new results to others as compared to reproducing and presenting results of a problem that was already solved by others. It is the same type of a difference that distinguishes a producing (creative) artist from a reproducing artist.

Therefore, research-based doctoral education might be seen as self-education, and as a part of life-long learning.

Nevertheless, there must be kind of a guidance of the doctoral candidate by an experienced professor. This "mentor's" tasks are to create a suitable environment for research, to initiate an appropriate subject of research, and to be contact person for scientific discussions. It is not the mentor's task to closely guide the doctoral candidate through the difficulties of the work, nor to prescribe or to teach him or her particular lectures (though there is no reason why a doctoral candidate should not join particular and highly specialized lectures given by this or another professor). The mentor might be seen as a senior scientist and discussion partner for the doctoral student rather than a supervisor.

At German universities, it was always demanded that professors do both, research work and higher educational work, since a good researcher might continuously improve own lectures by including new results and novel methods. Vice versa, a good lecturer could arouse interest in students for research work.

Therefore, it is good tradition at German universities that doctoral candidates are included into the process of teaching. By these actions, they are achieving professional skills in circulating knowledge and in supervising less experienced individuals.

For hedging research funding, doctoral candidates are also required to cooperate in applying of new research projects.

Thus, research-based doctoral education is giving a good opportunity to acquire the necessary competencies and professional skills.

3.3 Classroom-based doctoral education

Recent discussions initiated by the Bologna-follow-up group have brought up the model that doctoral education might also be performed by classroom-education. The idea is to present doctoral candidates a set of specialized lectures and lab-courses that ends with a set of exams and project work of a very limited duration. In other words: this is nothing else than another and more specialized master course program of studies. In this model, doctoral candidates would work like specialized students but not as professional engineers.

3.4 Strengths, weaknesses, opportunities, and threats: a SWOT analysis

Measured at the descriptors of a doctor of engineering, research-based education is the king's way for acquiring doctoral qualification, since it is training by doing. This is clearly the dominating strength of that model. However, the relatively long duration of the research doctoral phase, which is often taking five years, is a weakness of this scheme.

The duration of the classroom-based model is certainly shorter. This is, therefore, a strength of the model. On the other hand, any serious research work consumes a good part of time, which is not available in that scheme. This is clearly a weakness of it.

Now, where the main strengths and weaknesses of the competing models are known, it must be asked for the opportunities and threats, that both models are offering. Since the research-based education is supporting all the competencies and professional skills of a doctor of engineering, research institutions and development labs in industry are highly interested in employing these engineers. But there is also interest of these institutions to cooperate with such doctoral candidates during the doctoral phase. Research-based doctoral education might thus be a motor of research work.

On the other hand, educational politicians complain about a research-based doctoral phase, since in this phase doctoral candidates are not seen as students, but as professional engineers. Therefore, doctoral candidates must be paid a salary, while students would have to pay money. Thus, politicians might withdraw their support for that type of doctoral education.

Looking to the opportunities and threats of the classroom-based doctoral education reveals only few opportunities, since such a doctor would be nothing else than a master with an additional specialized education. However, there is a major threat, too. Since during classroom-based education, doctoral candidates had nearly no opportunity to practice autonomous research-work, there is no guarantee for potential employers that doctors evolving from that model have acquired the according competencies. Indeed, it happens quite often in American companies that a post-doc must supervise a doctor who has achieved his or her degree by classroom-based education.

From the point of view of German economic policy, however, there is a much worse threat that is indirectly evolving from the classroom-based scheme. In Germany, a major part of research is done at universities and at specialized research institutions. Many companies have outsourced their research activities to these labs, since these are able to offer research at a better price. Would a change of systems require German universities to replace research-based doctoral education to classroom-based education, then German industry would face severe problems. German industry has recognized this threat and refuses a change of models, which they have published in [10].

4 Conclusions

Balancing strengths, weaknesses, opportunities, and threats yields a clear advantage in favor of the research-based model of doctoral education. It guarantees a tailor-made support for training the necessary competencies and acquiring the professional skills a doctor of engineering must have. This cannot be said about the classroom-based model. The research-based model offers much better opportunities and it does not provide so sever threats as its competing model. It clearly outperforms the classroom-based model.

In order to acquire many promising doctoral candidates, master education must be optimized for research, i.e. for a thorough education, also with respect to theoretical fundamentals. For that purpose, it should be made possible to again combine

bachelor and master education in a way that used to be given formerly in the classical Diplom-education.

Professors not only at German universities but also at many other European universities have clearly recognized the situation. It is high time that they are recognized by politicians as experts in the field. Their vote must be heard in the Bologna-follow-up process, in particular in the discussions concerning the doctoral phase of education in order to avoid another debacle in higher education.

References

[1] The European Ministers Responsible for Higher Education, "The European Higher Education Area - Achieving the Goals", Bergen, 19.-20.05.2005, [online, retrieved on 12th March 2006]: http://www.bologna-bergen2005.no/Docs/00-Main_doc/050520_Bergen_Communique.pdf

[2] Council of Europe - UNESCO joint Convention, "Convention on the recognition of qualifications concerning higher education in the european region", Lisbon, 11.04.1997, [online, retrieved on 12th March 2006]: http://www.bologna-berlin2003.de/pdf/Lisbon_convention.pdf

[3] The European Ministers Responsible for Higher Education, "Realising the European Higher Education Area", Berlin, 18.-19. 09. 2003. [online, retrieved on 12th March 2006]: http://www.bologna-berlin2003.de/en/main_documents/index.htm

[4] Anonymous, "The Bologna Process – Conference on Master-level Degrees", Helsinki, 14./14.03.2003. [online, retrieved on 12th March 2006]: http://www.uni-leipzig.de/studref/download/Master-level%20degrees.pdf

[5] W. A Wulf: "2003 Annual Meeting – President's Remarks", National Academy of Engineering Annual Meeting, Washington, DC, USA, October 12, 2003. [online, retrieved on 12th March 2006]: http://www.nae.edu/nae/naehome.nsf/Multi+Database+Search/85256DAD003F352385256DF1005CD6F9?OpenDocument

[6] J. M. Tien, "Time to think about a master's of engineering". IEEE, The Institute, June 2003, vol. 27, no.2, p. 15. [online, retrieved on 12th March 2006]: http://www.theinstitute.ieee.org/portal/site/tionline/menuitem.130a3558587d56e8fb2275875bac26c8/index.jsp?&pName=institute_level1_article&TheCat=2023&article=tionline/header_ti_qtrly.xml&

[7] MIT degree programs, "Bachelor's and master's degree". [online, retrieved on 12th March 2006]: http://web.mit.edu/uinfo/academics/programs/reqs/dualdegree.html

[8] Anonymous, "The Bologna Process Seminar on Bachelor-level Degrees", Helsinki, 16./17.02.2001. [online, retrieved on 12th March 2006]: http://www.uni-leipzig.de/studref/download/Bachelor-level%20degrees.pdf

[9] The association of German university faculties of engineering (4ing), "Draft paper on the on the doctoral phase of higher education at German universities", unpublished.

[10] Deutscher Verband Technisch-Wissenschaftlicher Vereine DVT, „Stellungnahme zur geplanten Einführung von 'strukturierten Promotionsstudiengängen' ". Berlin, 11.06.2006, [online, retrieved on 12th March 2006]: http://www.dvt-net.de/fileadmin/downloads/Promotionsstudieng__nge-DVT_Stellungnahme-110606.pdf