

The Engineering Doctorate in Change – An Analysis from a German Point of View –

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Abstract

Due to decisions in the Bologna process, the engineering doctorate is in a change in Europe. Since former reforms initiated by the Bologna process did not necessarily improve higher education in Europe, experts in higher education in Germany are concerned about political decisions in that field. Therefore, they have made protection of a qualitatively high doctoral education their business. This paper describes their conclusions.

1. Introduction

The European systems of higher education are in a process of change. This process is known as the "Bologna Process" [1] - [4].

The European ministers responsible for higher education will confer in May 2007 on the process status, and they will make further decisions. It is supposed that after introduction of a system based upon an undergraduate and a graduate cycle, the doctorate will not only be declared to be the third cycle of higher education [4]. It is also expected that the roadmap to achieve the doctoral degree will be subject to new rules in the European Qualification Framework (EQF) [5]. Therefore, analysis and

discussions are necessary to avoid wrong decisions.

2. Engineering Doctorate Is it Different in Germany?

The engineering doctorate in Germany has some particularities that make it different from doctorates in other fields, at least in Germany, and probably also in other European countries. For that reason, it might be useful to shortly analyze it.

For electrical and information engineering this was firstly done by this author in early 2005 for the German council of university departments of Electrical and Information Engineering (FTEI). It was made public in May 2005 [6]. As a result, the following "FTEI-descriptors" were formulated to describe the competencies that doctors of engineering are supposed to exhibit. These are the competencies

to autonomously disclose new sources of knowledge ,

to independently work out that knowledge,

to process this knowledge by applying scientific methods, and to self-containedly increase it

to hand-over to others acquired knowledge in an appropriate way,

thereby guiding less qualified students, and

to contribute for the acquisition of financial and other means

Note that an essential subdescriptor in each of these descriptors is autonomy (or independence or self-containedness).

It turned out that independently and some months earlier another working group had tried to reformulate required competencies for bachelors and masters in general, and to adapt this type of requirements to the doctorate. These requirements are now known as the Dublin descriptors [7]. On a first glance they are sounding quite similar to the FTEI-descriptors:

“Doctoral degrees are awarded to students (!) who

have demonstrated a systematic understanding of a field of study and mastery of the skills and methods of research associated with that field;

have demonstrated the ability to conceive, design, implement and adapt a substantial process of research with scholarly integrity;

have made a contribution through original research that extends the frontier of knowledge by developing a substantial body of work, some of which merits national or international refereed publication;

are capable of critical analysis, evaluation and synthesis of new and complex ideas; can communicate with their peers, the larger scholarly

community and with society in general about their areas of expertise;

can be expected to be able to promote, within academic and professional contexts, technological, social or cultural advancement in a knowledge based society”

What is essentially missing in the Dublin descriptors (as compared to the FTEI-descriptors) is the emphasis on the autonomy of acting, the doctor-engineer is supposed to show. However, autonomy is seen by the FTEI as one of the main criteria to distinguish between masters and doctors.

Indeed, a study [8] of the VDMA (Verband Deutscher Maschinen- und Anlagenbau - German Engineering Federation), a federation of employers whose main business is machine production and plant construction, is supporting this point of view impressively. VDMA is pointing out that the main reason of their members to employ doctors of engineering is their competencies that might be formulated by the FTEI-descriptors, but that might not be brought to the point by the Dublin-descriptors.

As soon as there is agreement upon the idea that the doctoral phase is an individual's development from a master (or someone with equivalent competencies) in an engineering subject to someone having achieved the competencies as described in the FTEI-descriptors, it is evident that this phase cannot possibly be organized as a study course program, where students are guided through all difficult passages: Autonomy cannot be learnt this way.

Consequently, and following a tradition at German universities (including technical universities), candidates of the engineering doctorate are *not* seen as students, rather they are seen as engineers in the first phase

of their professional career. Therefore, they are normally given a work contract. As part of their responsibilities, they often have to take over duties of lecturers, or they are running a research project or a basic development project.

As a particularity, doctoral candidates in such a program – in most cases – are *not* directly aiming at an academic career. It is rather expected that more than 90% of the doctors of engineering are going to have a subsequent contract in industry or administration. Those who would like to start an academic career – in most cases – are supposed to first work in industry. Then, after some years of experience and having written a set of adequate publications, they might apply to be employed as professors.

This illustrates that the engineering doctorate in Germany is different from most other doctorates in Germany and – maybe – in other European countries.

It is German industry that claims that this way of achieving competencies makes these doctors particularly useful for their companies, since from the beginning these doctors might take over the responsibilities of group leaders in labs, virtually right from the first working day in industry.

3. The Influence of Politics and Administration

The influence of politics and of governmental institutions on the development of higher education and thus indirectly on science has always been significant in Europe, and that applies particularly to Germany. The university of Heidelberg, for instance, the oldest university in Germany, needed the permission of the pope for its foundation in 1386.

This influence was not always beneficial, however, universities (and society) benefited always from these influences, when the initiators were highly educated not only in one singular field of interest, but on a more universal basis.

The Prussian reform of higher education in the beginning of the 19th century, initiated by Wilhelm von Humboldt is a wonderful example. It was the basis for the rise of the German system of higher education in the 19th and 20th century. One of Humboldt's main ideas was the belief that *all* talents and potentials of an individual ought to be brought forward.

It characterizes most of today's main players in the Bologna process that they dismiss Humboldt's ideals as not being efficient enough: they are requiring educational programs that are training students in a short time for a highly specialized field.

It does not come as a surprise, therefore, that some of the main German players in the Bologna process do only see their particular field of interest. They do not exhibit a sufficiently broad basis of higher education to recognize that different areas of studies might need different administrative frameworks. Instead, they are looking for an egalitarian solution. It appears, as if for them, it would be more important, that qualifications (in a sense of a paper stating a degree) assign rights to their holders, rather than guaranteeing their equal competencies. It might be feared that this is not only a typical German problem.

4. A coalition of engineering educators

Since educational experts in Germany do not have a powerful political lobby, creation of political awareness in higher education is

characterised by extraordinary reluctance of decision makers to communicate with those concerned, in particular with the experts at universities. It even appears sometimes, as if apolitical experts would be seen as obstacles on the way to a successful reform of the European Higher Educational Area.

Therefore, an association has been founded in 2006 that is the umbrella organisation of the four councils of schools of engineering and of computer technology at German universities. It is called 4ING, and it represents more than 2.000 professors and lecturers, 10.000 scientific members of staff and 120.000 students.

On the initiative of 4ING, a dialogue between representatives of university educators of engineering on the one side and politicians and professional organisations on the other side has started beginning in summer 2006.

The aim of the dialogue is to actively participate as recognized experts in the Bologna process.

Concerning the doctorate, one particular important aim is, based on the FTEI descriptors, to formulate principles describing the requirements and a roadmap for achieving the doctoral degree. It is hoped that these descriptors are supposed to persist after regulation in a European qualification framework, at least in a national qualification framework.

4ING has already published in September 2006 a position paper [9] about the importance of the doctoral phase. This paper received high attention by German industry and governmental organizations. Far-reaching economic consequences and significant effects on higher educational systems have been pointed out in case that larger change in the system should be implemented.

5. Achieving the competencies of a doctor of engineering

These implications have been recognized by industry associations, who feel in line with 4ING on this concern, and who would like to rely on those competencies that they are used to find in a doctor of engineering of German universities nowadays. Therefore, any change of higher educational systems must keep or even improve this high standard.

It is alarming that the latter point does not play a decisive role in the official discussions!

In order to find a sensible solution of these problems, it must be asked what distinguishes the competencies of a doctor of engineering from the competencies of a master of engineering sciences.

A first answer might be found in a working paper on the planned European Qualification Framework (EQF) [5]. The latter was initiated in the Bergen communiqué. The working paper comprises a table with eight reference levels of the European Qualification Framework defined by knowledge, skills, and wider competencies. Levels 6, 7 and 8 correspond to the first, second, and third cycle in the Bologna process.

It is in the nature of the EQF that the EQF descriptors are too general as to describe the engineering doctorate. The most important of them for the doctorate (level 8) are cited subsequently:

Learning situations for level 8 qualification are novel and require solving problems that involve many interacting factors, some of which are changing and are not obvious to the individual and therefore cannot be anticipated making the context

complex and unpredictable. Learning takes place in a highly specialized field.

Study for these qualifications mostly takes place in specialist higher education institutions. Learners achieving a qualification at level 8 have demonstrated a systematic understanding of a field of study and mastery of the skills and methods of research associated with that field.

Learning at this level is mostly independent of formal learning programs and takes place through self-initiated actions guided by other high level experts. Individuals working at this level will often coach others to high levels of expertise.

Level 8 qualifications offer access to employment opportunities in specialized fields and career progression for those involved in jobs requiring research skills, scholarly work and leadership.

In comparison to the FTEI descriptors, the aspect of self-containedness is still not yet emphasized enough.

4ING und their experts paid their attention not only to descriptors like these, but also to the roadmap how the competencies of a doctor of engineering might be achieved.

As a result, they came to the conclusion that there must be necessarily differences between competencies of doctors of different sciences: A doctor of engineering must have acquired competencies that are different from those of a doctor of philosophy or of medicine or others.

This does not only and simply concern their different subjects, since methodologies in these sciences might differ considerably.

Even the definition of what is „science“ or „work using scientific methods“ might be different.

It is not sufficient, therefore, to look at the doctorate from a legislative point of view. Rather a clear profile of competencies must be described.

Competencies are acquired step by step. They are building upon other competencies. Therefore, it is sensible to first describe competencies of bachelors and masters before defining competencies of doctors of engineering.

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 [10][11], they have at the same time prevented the bachelor degree from being a true professional degree. People would laugh at a someone, 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 easier to define, 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 [11]. 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.

Consequently, the doctorate cannot possibly be another part of higher education. It is rather the first part of a professional scientific career, where *autonomy* in any respect is *the essential* difference to competencies of other engineers.

It is for that reason that the FTEI descriptors as defined in section 2 are describing the competencies of a doctor of engineering better than the EQF descriptors or the Dublin descriptors.

From these arguments it is evident that an engineering doctor's competencies cannot be acquired by sitting in a classroom and listening to experienced engineers.

The above mentioned VDMA study [8] underpins impressively that the engineering doctorate as offered in Germany meets most of the industrial requirements. Nevertheless, this system might be improved by adding "structuring elements" to the programs.

The above analysis shows also very clearly that structuring elements in doctoral programs must not impair the existing programs. Therefore, in contrast to doctoral programs found in some other European countries, structuring elements must not consume too much time of the doctoral programs.

Representatives of those German universities who have the right to award the doctoral degree agree with representatives of German industrial organizations that the so-called "professional doctorate" is not leading to the acquirement of the competencies that are expected by a doctor of engineering [12]. They refuse, therefore, to acknowledge this title as a doctoral degree.

6. Conclusion

The Engineering doctorate is in a change, not only in Germany, but also in other countries of Europe. These changes are initiated by those who work in the Bologna Follow-up Groups and their suborganizations.

Since their attention is too much concentrated on legal aspects, they are in danger to lose sight of the real quality of the doctoral education, in particular in engineering.

Leading experts of engineering education in Germany, therefore, request educational politicians to influence the Bologna process such that the quality of the engineering doctorate might be kept.

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