The need for professional skills training in Engineering programs

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ABSTRACT: This paper makes the claim that the present and future Engineering workplace requires skills of graduates which go beyond those taught in traditionally designed university programs. Many of these professional skills fall under the general categories of communication and teamworking. In the paper, we discuss why such skills must be considered to be key qualifications. Using examples from the author's previous and current affiliations, the goals of traditional Engineering programs are contrasted with these key qualifications. It is argued that these additional, non-technical qualifications must be considered to be of strategic importance for national economies such as that of Germany and many other European countries. Suggestions are made for the inclusion of this type of training in current programs, and some attention is given to the particular needs of the new international programs which have recently been introduced in Germany.

1. INTRODUCTION

The beginning Engineering graduate's workplace has seen many changes in the past few years. These include not only the obvious technical advances such as the use of computers and microelectronic devices, but also changing organisational forms, increasingly international and interdisciplinary workgroups, a higher degree of self-responsibility, and more frequent and more varied interactions with a wider range of people, including no longer just close colleagues, but also specialists from other departments and organisations, senior management and customers. It is now widely accepted that the ability to communicate effectively is one of the key factors for success in almost any environment. The need for these and other non-technical qualifications is strongly emphasised by employers and is well documented by their hiring and promotion policies.

Qualifications of this kind, which go beyond merely technical knowledge, are known as "professional skills", "soft skills" or (in German) as "key qualifications" (*Schlüsselqualifikationen*). Many of the most important of these qualifications can be integrated under the two general headings of 1) communication and 2) teamworking.

Unfortunately, it has to be said that traditional academic Engineering programs do not adequately prepare their students for these challenges. Even when new programs are created which are not limited by historical constrictions (Mechatronics and the new international Masters programs are currently good examples), the opportunity is often not taken to modernise the curriculum in this respect and thus the deficit is perpetuated for new generations of students.

The author has taught courses at the Universities of Erlangen and Magdeburg to students from a variety of programs, including both traditional degree (*Diplom*) programs and also international English-language Masters programs with students from Europe, Asia, Africa, Latin America and the Middle East. These courses include creativity techniques, presentation skills, inter-cultural communication and supervised project work in teams which were both international and interdisciplinary.

In the next section, the academic nature of traditional Engineering degree programs is described and a partial explanation for the German case is offered. In Section 3, the case is argued for considering key qualifications as being of strategic economic importance. Section 4 gives a partial list of key qualifications as published by one large German employer. In Section 5, attention is given to the special case of international postgraduate programs. In Section 6, some of the common objections to key qualifications training are stated and the author's strategy for their introduction is presented. Section 7 briefly summarises the paper.

2. THE NATURE OF TECHNICAL EDUCATION

"Culture" has been defined as the set of unconscious beliefs, assumptions and behaviours that a well-defined group of people have in common [7]. In this paper, we are touching on one of the basic axioms of (at least) German academic culture – namely that technical knowledge as it is currently taught in our universities is (and should be) solely rational-analytic and objective in nature. To take one example: the Computer Science program at the University of Magdeburg consists of courses in the following subject areas [3]:

- Computer Science
- Mathematics
- Subsidiary subject (such as Electrical Engineering or Economics)

Neither emotional, cultural and psychological topics nor communication and interaction issues are included in this curriculum. This is not surprising, since – being a cultural axiom – the same is basically true for all Engineering programs in Germany. The axiom is demonstrated by the following two quotes from the study regulations (*Studienordnung*) for the Computer Science program at the University of Erlangen ([1], Paragraph 5, Numbers 1 & 2):

> *Das Studium soll die Fähigkeit vermitteln, die auf Informatiker zukommenden Probleme mit wissenschaftlichen Methoden zu bearbeiten und zu lösen, [...].*
> *(The program should confer the ability to work on and solve the problems faced by Computer Scientists using scientific methods [...]).*
>
> *Das Studium bereitet auf die Tätigkeit des Diplom-Informatikers in anwendungs-, herstellungs-, forschungs- und lehrbezogenen Tätigkeitsfeldern vor.*
> *(The program prepares [students] for the profession of Computer Scientist in the areas of application, production, research and teaching)*.

Since this is the expression of an axiomatic belief, as with the Emperor's new clothes, it would hardly be challenged (or even commented on) by most academics in the field. Nevertheless, the implication of the first sentence quoted above is absurd, namely that (all) the problems to be faced by Computer Science graduates will be scientific in nature and can thus be solved using (solely) scientific methods.

Most programs in Germany define themselves as being *berufsqualifizierend*, i.e. as qualifying their graduates for their future profession (see, for example, the general regulations for all programs at the School of Engineering at the University of Erlangen [2]). This goal is reflected directly by the second quote.

By contrast, in a 1998 study, Engineering graduates were asked two to three years after beginning professional practice which skills they most miss not having studied at university. Of the 15 or so answers given, "presentation" and "teamwork" tied for 1st place with about 66% each, while "more academic courses" scored only 6% and ranked close to last.

That good academic grades alone are not sufficient for professional success is, of course, no secret outside the university walls. Promotions and the assignment of more interesting tasks with increased responsibilities after the first few years depend almost entirely on non-technical skills and qualifications. In many cases, these skills are now required even for entry-level positions, as is documented by the extensive interviewing process often employed and the use of assessment centres for judging graduate applicants. It is now common for job interviews to last one or two days. This "interview" may include tests of

- teamworking abilities,
- presentation and communication skills,
- leadership skills,
- self-confidence and
- goal orientation,

in addition to the more usual criteria. In one case known to the author, a well-known international company based close to the University of Erlangen recently did not take on four Computer Science graduates after their three-month trial period (*Probezeit*), because despite their good academic records and technical competence, they were not able to communicate effectively with other members of the company whom they were supposed to be supporting.

3. KEY QUALIFICATIONS AS A STRATEGIC COMMODITY

Many countries in Western Europe are characterised economically as highly industrialised but poor in natural resources. Under such conditions, the health of the national economy depends heavily on a high level of general education and a high degree of specialisation in Science and Engineering. In Germany, this is reflected by widely accepted political and financial support for education and training, and, more recently, for novel degree programs at the Universities.

It is now possible to obtain a good technical education at the undergraduate level in most countries in the world. In the coming years, it is to be expected that their availability at the post-graduate level will increase. The reason for this is clear: by its very nature as a purely rational-analytical object, academic technical knowledge is easily communicable and teachable. With the arrival of the Internet, photocopiers, video and other replication and communication technologies, up-to-the-minute information becomes instantly available around the globe. Already one can purchase complete university courses on video given by leading experts in their various fields. Computer-based learning and virtual universities (for example the African Virtual University [8]) also provide ubiquitous international-standard technical education.

Since it is virtually free of subjective content (i.e. it is free from personal involvement, individual interpretation and cultural assumptions) technical knowledge can be taught and learned equally easily anywhere. The work of Newton, Pythagoras, Ohm and Turing is accessible and acceptable to rational minds at any location.

Thus, in the forseeable future, Engineering knowledge and production capabilities will be available around the globe, and will cease to be an advantage held by Western nations only. The past decades have been characterised by ever-increasing numbers of suppliers of technology entering the market. We can now purchase integrated circuits from Korea, have our software written in India and launch our satellites into space by Chinese rockets. Under these circumstances, countries such as Germany will have to look for new areas of expertise in which to excel and thus retain a competitive advantage.

If a significant economic advantage can no longer be maintained on a purely technological basis, from where could it then come? One possibility lies in managerial and organisational capability – the ability to structure, plan, organise and successfully carry out large and complex projects. Another lies in the sphere of personal economic competence – for example the ability to conceive and develop new ideas (innovation and creativity), transport these ideas accurately and convincingly (presentation and communication), and to work together effectively with others to put them into practice (teamwork). To the authors knowledge, none of these is taught systematically in Engineering programs anywhere in Germany.

One good example for this thesis is Project Management. Large-scale international projects such as building industrial plants, power stations and transportation systems have been for many years a speciality of European companies and consortia. Nowadays, the purely technical expertise necessary (to manufacture turbines, pour concrete and so on) is often available in the client's own country. However such projects are still awarded to European contractors because these have the additional capability to plan, finance, organise and carry out projects on such a large and complex scale. Thus project management (and, by implication, the ability to work in teams, assume responsibility, co-ordinate and plan efficiently, communicate effectively and a host of other non-Engineering abilities) advance from merely ancillary factors to key commodities which can be marketed and sold for a high price as specialised services.

We thus see that in order to ensure continued economic prosperity, future Engineering graduates will have to be proficient in more than just their technical academic disciplines. Both managerial and personal qualifications will be increasingly necessary to retain competitiveness in a world in which the technical ability has become commonplace. By contrast to technical knowledge, these additional qualifications are all of a highly personal and subjective nature. They cannot be taught impersonally over the Internet or by a computer program; they require the presence and individual attention of a highly qualified human instructor.

4. KEY QUALIFICATIONS

What, then, are these additional, non-technical qualifications that are in such demand? A comprehensive answer to this question can be obtained simply by examining advertisements for positions for Engineering graduates. One leading employer of engineers in Germany publishes on its Internet webpages many open positions for technical staff [4]. In addition to the usual information, each advertisement contains a section *"The following abilities are essential for success in this position:"*. Browsing through the entry-level positions for Engineering graduates yields the following selection of abilities mentioned in this section:

- Teamwork
- Communication
- Presentation
- Initiative
- Strategic thinking
- Assertiveness
- Responsibility
- Creativity
- Pragmatic, goal-oriented thinking
- Confidence in negotiation and presentation
- Networking skills
- Flexibility

Note how all of these properties are of a subjective, personal nature; in this they contrast to the objective, impersonal content of technical courses. This explains the some of the resistance to the introduction of these themes into Engineering curricula – they require new and unfamiliar approaches to teaching, training and assessment. In addition, to be trained effectively, they require charismatic and empathic teachers, who are able to motivate students to take risks and thus enable them to grow.

5. SPECIAL NEEDS IN INTERNATIONAL PROGRAMS

In the last few years, many international English-language and bi-lingual Masters programs have been created in Germany. This was due to a large extent to encouragement from federal and state governments who wanted to increase Germany's attractiveness for international students. More recently, the motivation has been to support the job market for technical specialists at a time when the demand is high and is predicted to continue growing while at the same time the number of nationals entering the market is expected to decrease. Examples of such programs are Computational Engineering at the University of Erlangen [5] and Computational Visualistics at the University of Magdeburg [6].

Students in these programs come from all over the world; however almost all are from non-Western cultural backgrounds - in many cases, the large majority are from Asia, in particular from China, India and Pakistan. Compared to the local students, these international students are faced with significant additional challenges, including acclimatisation and language difficulties, and differing cultural norms and assumptions.

Experience with such programs sheds a new light on the topic of this paper. As long as the degree requirements are limited to traditional performance criteria (i.e. passing academic exams), students can be graduated who have serious deficiencies in their soft skills. This has, of course, always been the case. Now, however, international students show us that many of these desirable abilities have cultural foundations and have, until now, been taken largely for granted, because they are assimilated naturally during childhood and adolescence. This clearly demonstrates that possession of these skills has, until now, been a matter of chance or upbringing and furthermore that they are essentially invisible to – and therefore irrelevant to – university programs. This is particularly true of personal competence factors such as initiative, assumption of responsibility and communication behaviour.

International students cannot be expected to be aware of these issues, and yet at the same time the latter play a vital role for success in a Western professional environment. It is thus the responsibility of the universities to address them, if they any way take their self-definition of being "*berufsqualifizierend*" seriously. To do otherwise would be a disservice both to the students and to their future employers.

6. OBJECTIONS AND SOLUTIONS

There are several significant objections to overcome, if key qualifications training is to be introduced into existing programs in any substantial way. These objections include:

1. Non-acceptance.
2. Lack of time in program.
3. Lack of qualified teachers.
4. Inadequate teaching capacity.

The first objection has already been discussed in section 2 (the cultural axiom). Objections 2, 3 and 4 are, of course, rationalisations of the same underlying belief, which, however contain elements of truth which should be addressed. Objection 2 claims that the programs are already full with existing courses and that it would be impossible to either add more study hours to the students' already over-burdened schedules or to remove existing courses from the curriculum to create some space. The latter argument is just a re-statement of Objection 1 in terms of relative priorities. Objection 3 basically admits that something should be done, but that nobody (who is currently available) is prepared or qualified to do it. This may, in fact, be true in the short term. However, in the medium term, the ability to teach key qualifications could easily become part of the faculty hiring process. Objection 4 claims that such courses would necessarily require small classes, leading to an impossibly large overall total teaching load. This is the most serious objection, since it is essentially true. Many of the professional skills can only be trained effectively in small groups. This would lead to large numbers of classes in high-enrollment programs (which typically include Engineering).

The author's approach to solving the problem of introduction of key qualification training at University has been to lead by personal example. Courses have been offered to students both within their programs (where possible) and also as additional events carried out voluntarily during free time. These courses include creativity and problem-solving techniques, personal development, teamwork, intercultural communication and presentation techniques. They tend to attract successful, mature students, who clearly recognise the benefits to be gained from attending. The courses are also well-received and encouraged by partners from industry.

Of course, not all students are interested in these additional courses; for many, they may not even be appropriate, and in the author's opinion, students should not be compelled to attend them. This may seem to contradict the thesis that key qualifications are of vital importance. However, many issues require levels of maturity and self-confidence that have not yet been reached by all students by their early or mid-twenties, and it would be premature to confront them with them.

One promising strategy would be to create one or more slots for courses in existing programs for which students can choose either a traditional course or a key qualification course. In this manner, both students with traditional academic interests and those interested in professional skills can be provided for. Another approach is via summer schools and extra-curricular activities. One example of this is the *Bayerische Elite-Akademie* for students of Bavarian universities [9].

7. SUMMARY

Key qualifications are an essential factor for professional success for today's Engineering graduates. This is clearly documented by leading international technology corporations. In the future, as technical knowledge and training becomes generally available around the world, these factors will become even more important. Nevertheless, current Engineering programs, which are founded on traditional academic axioms, hardly address these issues at all.

By contrast to academic technical knowledge, which is rational, analytic and objective, many professional skills are subjective in nature and include psychological and personal factors. This partially explains the unwillingness of Engineering faculty to embrace them as a teaching subject.

The author has taught various courses for professional skills. These attract some of the best students and are encouraged by industrial partners. One promising strategy for providing such courses is to create a niche in existing programs for interested students, in which a key qualifications curriculum can be developed and established.

8. REFERENCES AND LINKS

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