Positions to Mathematical Education of Engineers

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Abstract

The authors representing a network of active lecturers in northern Germany state the following current dilemma in the country: On the one hand competitive industrial regions need many well educated and highly motivated engineers. This should include profound knowledge in Mathematics, Physics and Computer Science. On the other hand there are not enough beginners in engineering studies and their knowledge in basic sciences is often poor. Similar situations are known from other countries. Some general causes of the dilemma are named: trend to poor entertainment, bad position of Mathematics in public and politics, quickly changing and ineffective reactions of politicians to proven deficits in basic education, negative attitude of many pupils and students towards Mathematics, bad working conditions of teachers, decreasing time budgets for mathematical education, obsolete teaching methods in schools and universities. The consequences of the dilemma will be social and cultural decline as well as loss of jobs and a bad trade position on the international market. Developing high technology needs more and more high Mathematics, especially Analysis and (numerical) Linear Algebra. While theoretical knowledge becomes more important to solve practical problems on the computer, elementary calculation skills are pushed into the background. Some general demands are postulated to reverse the negative development: upgrading of Mathematics in public and education (key technology of societal progress, general thinking and cultural technology), upgrading of teaching profession, statement of uniform (and possibly central) minimum requirements for mathematical competencies at beginning and end of engineering studies, securing of satisfactory staff and IT resources for mathematical education in Engineering. Last but not least, the influence of modern developments in education and of staff activities on the dilemma is mentioned.

Introduction

Engineers use in practice mathematical models and methods which mathematical lectures in engineering studies do not offer. Unfortunately these gaps between education and profession increase further.

Contradictory causes of maldevelopment:

- Many beginners to study have insufficient pre-knowledge in Mathematics.
- Therefore mathematics lectures are often adapted to a low level.
- Quantity and quality of important mathematical subjects increase.
- Nevertheless available time for mathematical subjects in schools and universities is reduced stepwise.

Berger and Schwenk (2001, 2006), Brüning (2004), Polaczek (2006), Strauß (2006).

Counter steps:

- Mathematical pre- and complementary courses for weak students,
- New teaching methods, means and media,
- Cooperation of school teachers and lecturers in the domain of Mathematics,
- Didactic workshops and conferences of lecturers in Mathematics.

The resulting problems increase so dramatically that the counter steps will not improve the situation essentially. The announced theses are not new but of increasing relevance. They are to put new life into the discussion about true reforms in the educational sector.

Young generation problem in engineering

Thesis 1: A competitive region needs well-educated and highly motivated engineers. Their number is an important parameter for the future prospective of a society. Already now this number of engineering experts is too low.

Thesis 2: There are not enough study beginners in the engineering disciplines. At the same time too many young people abandon engineering studies, often because of poor knowledge in Mathematics.

Müntefering (2006)

Consequence: Well-educated young engineers will be missing in the near future. The demographic change will aggravate the situation. It is only a temporary solution to import engineering experts from abroad. Without changing the educational conditions the problem will increase. A social decline would follow.

Key position of Mathematics in science and engineering

Thesis 3: Mathematics is a very old cultural and thinking technology in the heart of science and a global science language independent of ideology which is indispensable to ensure the future of mankind. In a modern society therefore the strengthening of Mathematics has many positive effects.

Thesis 4: The huge growth of knowledge enhances the importance of basic sciences, especially of Mathematics. This must be considered in engineering education. Mathematics is a key qualification, which determines the quality of an engineer essentially. Mathematics is necessary to model, analyze and simulate technological systems as well as to calculate and to evaluate solutions of model problems.
In the past engineers could contribute essentially to mathematical disciplines and thinking. This tradition has to be continued.

Grünwald, Kossow and Schott (2000), Pesch (2002)

Mathematical education in engineering studies

Thesis 5: In mathematical education a solid basic knowledge is crucial. Further, modern means (as computer, internet) have to be used as an important ingredient.

Schott and Grünwald (2001, 2004), Schott (2004, 2005a)

Thesis 6: Including computers in the mathematical education needs a change of teaching contents and a shift of priorities. In this process the demands on both mathematical basic knowledge and computer software knowledge increase.

Schramm (1998), Schott (2006), Strauß (2006)

Mathematics as a stepchild in society

Thesis 7: Mathematics has (for some decades) a bad reputation in public and only a small lobby in politics. It does not seem to fit in the spirit of this age.
Mathematics is a neglected subject in education at schools and universities. Negative attitudes of pupils and students towards Mathematics are often accepted and partly supported with pleasure. Without reason teachers are usually blamed for the misery.

Public reactions

The discussion to reduce the known deficits in basic sciences such as Mathematics is often covered by ideological reservations. Sometimes reasonable demands are ignored or even defamed as nonsense of backward directed persons. Many politicians react helplessly and ineffectively with quickly changing proposals and activities.

Conclusions

Thesis 8: Decreasing numbers of beginners in engineering studies and increasing drop out rates of students in engineering subjects have societal roots whose effects are already visible in schools. One crucial reason for the conflicting situation is the position of Mathematics in society and education. A deep reform of the educational system is urgently necessary.

Grünwald and Schott (2000), Schott and Grünwald (2001, 2004), Schott (2006)

Upgrading of Mathematics

Evidently, the counter steps already initiated at schools and universities named in the introduction have to be continued and developed further with full power. Below we list some of the activities we offer and practise.

Cooperation with schools

- Snooping weeks for pupils at university,
- Use of laboratories at university by pupils,
- Coaching of projects for pupils by university members,
- Further education of school teachers at university,
- Development of attracting events and materials to train imagination and creativity.

Support of study beginners

- Refreshing course in the introductory week of study,
- Entrance test in the first weeks of study,
- Consultation hours for students headed by lecturers or good students,
- Online courses to train basic mathematics.

Special offers

- Computer aided Mathematics (MATLAB, MAPLE),
  Schramm (2002a, 2002b, 2006, 2008), Schott (2004, 2005a)
- Project work in Mathematics (e.g. Dynamical systems in Engineering and Ecology), integration of interactive teaching units and team work,
  Risse (2001, 2002), Schott (2005b)
- Facultative special and complementary courses in Mathematics,
  Strauß (2003), Lutz and Lutz-Westphal (2005)

General demands

- Politicians have to recognize the decisive role which Mathematics is playing for the development of science, engineering and society. Mathematics must achieve its true position in public and society.
- In (engineering) education Mathematics has to be upgraded (satisfactory staff and IT resources as well as sufficient time budget with respect to the corresponding specialization, strong promotion and recognition of mathematically gifted and motivated young people).
- More special schools with focus on Mathematics, Natural Sciences and Engineering have to be established, but this should not lead to a new division of labour in engineering practice.
- Uniform (and central) minimum requirements for mathematical competencies at beginning and end of engineering studies have to be fulfilled which are orientated at the true requirements in society and practice.
- It is necessary to modernize mathematical education on all levels continuously.
- A central commission of (not too many) true experts should initiate and supervise the reform process.

Schott, Strauß, Schramm and Risse (2007)

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