

# **Evaluation of engineering degree programmes in Norway 2008**

Summary of key conclusions and recommendations

## Foreword

The evaluation of Norwegian degree programmes in engineering (2006-2008) performed by NOKUT (Norwegian Agency for Quality Assurance in Education) was commissioned by the Ministry of Education and Research. The background to the commissioned evaluation is described in the Ministry's letter of instruction. The evaluation was required to provide the best possible basis of information and expert opinion for further development of the study programmes. All relevant issues of significance for standards were to be evaluated.

The outcomes of the evaluation have been published in four reports:

*Evaluering av ingeniørutdanning 2006 – 2008. Del 1. Hovedrapport [Evaluation of Norwegian engineering degree programmes 2006- 2008. Part 1. Main report]*

*Evaluering av ingeniørutdanning 2006 – 2008. Del 2. Institusjonsrapporter [Evaluation of Norwegian engineering degree programmes 2006- 2008. Part 2. Institutional reports]*

*Evaluering av ingeniørutdanning 2006 – 2008. Del 3. Faglig rapport [Evaluation of Norwegian engineering degree programmes 2006- 2008. Part 3. Academic report]*

*Evaluering av ingeniørutdanning 2006 – 2008. Del 4. Avtakerrapport [Evaluation of Norwegian engineering degree programmes 2006- 2008. Part 4. Employers' report]*

All the reports are available (in Norwegian only) on NOKUT's website:, [www.nokut.no](http://www.nokut.no).

The present summary covers the themes given special attention by the Evaluation Committee.

A total of 20 experts were engaged by NOKUT at different phases of the evaluation. Five of these (the evaluation executive) had the general responsibility for the evaluation and the assessments and conclusions in all the reports except *Faglig rapport [Academic Report]*. The evaluation executive was comprised of:

Manager: Birgitta Stymne Dr. Techn., former rector of the University of Gävle

Professor Mads Nygård, Dr.Techn., Norwegian University of Science and Technology

Professor Kai Borre, Dr.Techn., Aalborg University, Denmark

Annett Lundsgaard, engineer/project manager, Prosjekt- og teknologiledelse AS

Sam Zarrabi, student, Oslo University College, Norwegian Association of Students

NOKUT would like to thank the experts who performed the evaluation for their outstanding work. We would also like to thank everyone else who in various phases provided vital inputs and contributions for the evaluation. In particular, we would like to draw attention to the representatives of engineering degree programmes in Norway and thank them for their contribution in all phases of the evaluation.

Oslo, 18 September 2008

Petter Aaslestad  
Chair of the Board

Oddvar Haugland  
Director

# 1. The content and standard of Norwegian engineering study programmes

## 1.1. *Academic and vocational content and standards*

The academic standard of all the study programmes was found to be generally satisfactory. The requirements laid down in the national curriculum regulations for the distribution of credits (equivalent to ECTS credits) among core areas were found to be met in the majority of study programmes, with few exceptions. The number of credits is currently deficient for social science courses and also in mathematical and scientific core courses, especially in Chemistry and Environment.

The Norwegian engineering degree is a vocational degree, the purpose of which, unlike the now-obsolete title of 'sivilingeniør', now 'Master i Teknologi' (English: Master of Science), is to teach students to combine theoretical and technical expertise with practical skills. However, employers and others emphasise the importance of retaining the theoretical grounding, since it forms the basis for acquiring competencies in technological disciplines post graduation. Deficiencies were identified in respect of the opportunities for students to acquire practical skills over the course of their studies. However, the evaluation does not propose making work-experience compulsory within the constraints of the study programme's 180 credits. Instead, the proposal is for the education to be realigned in such a way as to promote more intensively contact between students and relevant business and industry, through activities such as project-based teaching and by business and industry becoming more involved in the study programmes, e.g. by offering mentoring schemes and summer jobs.

Technological advances in society have been and will continue to be considerable. In the present context, such advances are exemplified by the increasing importance of information technology not only in the field of computing per se, but also in disciplines such as surveying, photogrammetry, chemistry, biotechnology, design and production technology. In chemistry specifically, the advances are significant for surface and colloidal chemistry, and in materials engineering, nanotechnology is increasingly important. New combinations of disciplines have arisen such as mechatronics, which comprises elements from mechanical engineering, electronic engineering and computer engineering. The fields of design, environment and energy are evolving rapidly, and the global trend means that economisation of resources and sustainable development will be increasingly focal for technological advances.

It is essential that the Norwegian engineering study programmes be updated in step with prevailing trends, but without undermining their foundation or rendering them short-lived and rapidly obsolete. The national curriculum regulations allow for study programmes to be updated, but the evaluation indicates that the institutions of education to a great extent lack strategies for developing their programmes in this respect. Instead, development is by and large controlled by the requirements of local industry and by the level of access to resources. The institutions are also tempted to use the latest "trendy" programme designations in order to boost intake. Any update to study programmes should also not favour disciplines such as design to the detriment of science and technology. New study programmes should not be offered without allocation of sufficient resources in the form of teaching staff, teaching rooms and equipment.

## **1.2. Relevance of the Norwegian engineering degree**

“Relevant education” is taken to mean that the competence acquired from a first (BSc) degree is consistent with the expectations of business and industry, and meets the eligibility requirements for going on to take a master’s degree. Equally, the requirements of the national curriculum regulations must be met.

Those sectors of business and industry which employ engineers generally perceive the academic qualifications of new engineering graduates as being of a high standard and of relevance, but find their practical skills in engineering to be deficient. With respect to development and problem-solving, they are found to have limited ability for making financial and environmental assessments in combination with their technological assessments. They also exhibit limited aptitude for project leadership and project management. The national curriculum regulations’ requirement for engineers to be capable of identifying problems and specifying requirements for solutions is also not met, judging by the experience of employers.

The relevance of the degrees is often associated with the practical skills acquired by the students. For large companies, such skills in newly qualified engineers are of no practical significance, but may influence recruitment decisions if there are many applicants. Students admitted to a 3-year BSc engineering programme via the so-called “Y” path, that is, students who hold a certificate of completed apprenticeship, are often particularly attractive to companies.

The majority of BSc engineering programmes are adapted for continued studies at master’s level, provided that the students supplement their mathematical foundation by elective courses. The lack of academia-research links in engineering, means that the students fail to gain sufficient training in critical thought, analysis and use of scientific method and source evaluation.

The institutions perform hardly any systematic surveys of past students as to the usefulness of the education they received.

## 2. Areas requiring special initiatives to raise standards

### 2.1. *Research-based training*

By law, engineering study programmes are to be research-based. The importance of research-based training has been much discussed, but if the concept is interpreted as a requirement for tutors with research training to teach the core technology subjects, then many of the programmes are failing to meet this requirement. And if the definition also covers the requirement for there to be a research centre present in the given field, then certainly few study programmes are research-based.

Building up research activity calls for resources, well-founded, fully-backed strategies and long-range commitment.

With their existing resources, the institutions will even now be able to implement a number of initiatives to improve the research links in the training, but the evaluation indicates that resources are in too short supply to intensify R&D activities. To a certain extent, this form of development can be financed through external funding, although if this is the sole basis, it will render the institutions vulnerable. The authorities must ensure that the institutions of higher education receive sufficient State funding to develop their R&D activities as a basis for being able to perform their statutory obligations. Use of State funding must be subject to quality control through formalised contact with relevant external research communities. Use of the funding should also be coordinated nationally as part of a drive to create larger science and technology communities.

### 2.2. *The educational skills of the teaching staff*

The teaching staff have different, given preconditions for passing on skills and knowledge, and the students have varying views on the best way for them to acquire these skills and knowledge. It is therefore not possible to prescribe general rules or requirements to guarantee the aptitude of teaching staff. Against that, the institutions themselves could require that teaching staff complete relevant training in teaching skills.

There are deficiencies in the teaching skills among staff on the engineering degree programmes. Measures will need to be instituted to bring about improvements. Newly appointed staff should be required to meet the existing requirement of teaching skills, and all institutions offering engineering degrees should provide a compulsory teaching engineering course for those who do not have this or equivalent skills.

The course should be tailored to the scientific and technological disciplines and to the teaching methods employed on BSc engineering programmes. In terms of resources, this type of course should be designed at the national level, with expert educators to provide the training. The course should ideally consist of a foundation component to be completed immediately upon taking up an appointment, and then one or more supplementary courses to be taken after the member of staff has gained a certain amount of teaching experience. In total, the course should be worth 30 credits. It is important that teaching staff are given the opportunity for updating their teaching skills later on during their tenure. For staff with

inadequate language skills in Norwegian or English, individual arrangements will need to be made.

### **2.3. Internationalisation**

On the whole, the institutions do not give priority to international collaboration and the rate of both student and staff exchanges is low. The objectives and strategies for international collaboration embraced by the institutions are ineffectual. Although a number of institutions regard internationalisation as a quality driver, few of them actively use internationalisation as a means of raising standards. Internationalisation is commonly regarded as synonymous with student and staff exchanges, and even these are not given high priority.

The institutions should step up their international activities. The object should be for internationalisation to be an element in quality assuring the study programmes, and also for it to give the programmes international relevance in the interests of both further studies and job opportunities. International networks provide opportunities for comparing the content of the programmes and the academic level, for obtaining information about new educational methods, for making contacts to arrange student exchanges and for gaining insights into international trends. Management at the institutions should increase its commitment to international collaboration and exchange, allocate the necessary resources and in other ways facilitate internationalisation of the degree programmes.

### **2.4. Throughput**

Throughput is low. Only 44% of students who commenced their studies in autumn 2003 had been awarded degrees by 1 October 2006. The skills acquired by students in each academic year may be expressed as credit output per student, and this was on average 45 credits out of a nominal annual output of 60. The low throughput is due in part to the high drop-out rate, and to the fact that student progression is lower than the norm.

The low throughput entails financial loss for the student and the institution. Private-sector enterprise and other employers in society are not obtaining the skills which the State's investment in education presupposes. For the students, the drop-out rate also carries the risk of human tragedy as a result of a sense of personal failure. The institutions should without delay step up their efforts to improve student throughput.

The institutions earmark extensive resources for following up students, especially in the first year of their degree. This should be supplemented by other, more intensive measures. Greater attention should be devoted to the quality of student intake. The institutions should have routines in place for obtaining a systematic overview of the quality of students they have admitted, and in the case of local admissions should give priority to quality rather than quantity. The design and execution of study programmes for students admitted via the TRES and Y paths respectively, both of which exhibit deficiencies in respect of admission criteria for scientific and mathematical proficiencies, must be subjected to quality control.

At the national level, a review should be undertaken of the content of and requirements for mathematics at upper secondary school level. Since the high drop-out rate or studies deferral rate is attributable to inadequate grounding in mathematics, it is proposed that the Ministry

carry out a trial programme at a limited number of institutions, where admissions to study engineering would be subject to a minimum grade in mathematics.

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### 3. Problem areas with a national perspective

#### 3.1. Organisation

The institutions tend to offer a wide range of study programmes in order to cater for regional business and industry preferences for skills in diverse fields in order to extend corporate capability. The limited number of students is then spread across different programmes and disciplines, which results in many, but small, academic centres. Changes will need to be made to reverse this trend.

The institutions' activities should be coordinated in order to get more benefit out of the resources available in the interests of academic activity, administration and equipment. This could be achieved by coordinating at the national level the various study options within the various programme areas and within the regions. This would make it possible to offer the students stronger academic centres with high standards of teaching. A national system of coordination should also comprise the development of research centres and master's degree programmes.

In spite of the fact that the institutions regard each other as competitors for both students and resources, they should, in order to raise standards, economise on resources and reduce their vulnerability and strive for more extensive collaboration in several areas. Institutions in geographical proximity to each other should collaborate on staff resources.

Organisational/disciplinary networks should for example be able to join forces to draw up joint criteria for evaluation of the skills acquired by graduates of their study programmes

- discuss and devise benchmarking systems for existing and new study programmes, forms of joint examination, graduate surveys, courses in study technique and research methods, procurement and use of equipment

- discuss meaningful integration of the Chemistry and Environment course in the various programmes and disciplines

- improve the students' eligibility for admission to master's programmes in collaboration with institutions offering such programmes.

#### 3.2. Recruitment

The number of applicants for places on Norwegian engineering programmes has increased slightly in recent years – however, the majority of institutions tend to admit *all* eligible applicants. In autumn 2006, there were some 3,000 student admissions, approx. 14% of which were women. 23% found places through local admissions. Many of the institutions find that they have capacity for an increased intake. Local intake via the TRES and Y paths has increased in recent years, and an increasing number of university colleges are introducing an alternative first year of study for students admitted via the Y path.

The main problem in recruitment is that the number of students with the upper secondary school level qualifications (3MX=mathematics advanced standard level, 2FY=physics

standard level) required for a place on an engineering programme is limited, and that those who meet the requirement tend on the whole to apply for other degree programmes. The recruitment base has been extended in recent years through admissions via the TRES and Y paths, but even these have their limitations. Admissions via the Y path are likely to increase in future until the number of eligible applicants among young persons in employment who hold a certificate of completed apprenticeship decreases, after which applications will stabilise at a lower level. In order to achieve further increases in recruitment, measures at the national level will be necessary for promoting interest in science and technology among secondary school pupils and those in continuing education. Experiences from the measures instituted in Denmark and now also in Sweden should be useful to that end. In these countries, the authorities, allied with organisations associated with the companies that employ engineers, have, for example, launched a nationwide campaign designed to change perceptions of and attitudes to engineering as a profession.

The institutions in Norway must continue their efforts to actively recruit students. Previous measures should be evaluated more extensively, and unique study programmes should be better marketed nationwide. Companies and local organisations should to a greater extent be involved in recruitment activities.

Recruitment of women should continue to be given due attention, and the institutions should keep themselves abreast of research on choice of education. Various explanatory models seek to shed light on the conventionality of education choices among Norwegian women and men. In development of the study programmes in future, the academic content and teaching programmes should be designed so as to attract both sexes to the study programmes offered.

## 4. Competencies on graduation

The general finding of the experts was that the students' competencies on graduation from the study programmes is satisfactory provided that they achieve at least average marks. The evaluation was based on study plans and programme curricula and sample examination questions and main assignments. The competencies on graduation metric reflects the scholastic attainment of the students, but offers little indication as to whether the students have achieved the other national curriculum objectives of skills and attitudes acquired.

The institutions' own objectives for their study programmes tend to embody very little in the way of skills and attitudes. In the instances where such objectives are present, they are not described explicitly in concrete terms so that students may comprehend what they entail in practice. The extent to which the competencies have been acquired should be measured using other methods than those currently in use for measuring scholastic attainment; however, such methods have not been developed by the institutions.

Making the teaching more project-based offers a means of exercising and evaluating the students' communication skills, of participating in interdisciplinary collaboration and demonstrating professional and ethical practices. Project-based teaching also provides practice in project management and in making general technological and social science (including economics) evaluations. However, the deficient research links on the study programmes reduce the opportunities for giving students the skills and abilities to identify problems and specify requirements for solutions to problems.

The institutions have only to a very modest extent started the process of drawing up objectives for learning outcomes to describe the level of knowledge, comprehension and skills students are to have attained on completing individual courses. If the study programmes are to have any international value for the students, the process of producing such descriptions will need to be intensified.

There is a marked tendency for institutions to make differing requirements in evaluation of main assignments. Procedure regarded as a matter of routine at one institution, may at another be regarded as advanced technology. Differing requirements are also made for marking schemes. This may have come about as a result of reduced use of external examiners in evaluating examination papers and main assignments. The result may be that companies choose to employ applicants on the basis of which institution they obtained their degree from. This trend is cause for concern and could be avoided by the university colleges establishing disciplinary networks, joint examination schemes and more extensive use of external examiners.

## 5. The strengths of Norwegian engineering degree programmes

### 5.1. *Links with private-sector enterprise*

The majority of the institutions have close links with companies in the surrounding region. Many study programmes were developed on the basis of private-sector requirements, and know-how exchange takes place between the institutions and companies. The students are given opportunities for forging early links with their future profession; the degree programmes are vocational.

The institutions have demonstrated that it is possible to ally a stable theoretical grounding with vocational skills in a degree programme, which is consistent with the objects of the national curriculum regulations for the programmes, and which constitute the profile and strengths of this bachelor of science degree as opposed to that of the Norwegian master of science. Realisation of this objective has been made possible through the excellent links with business and industry.

However there is still potential for improvement for many of the institutions. Links with business and industry should to a greater extent be formalised by concluding long-term agreements. Collaboration in networks of companies renders the institution less vulnerable than collaboration with a single company. Organised competency building is scarcely practised at present, and could be improved through increased use of mentoring schemes, and assignment-based training. Serving on the boards of companies provides useful insights into how they operate, and here a certain reciprocity should be aimed for in establishing partnerships between an institution of higher education and private-sector enterprises.

### 5.2. *Study environment*

The majority of the engineering degree programmes have relatively new and suitable premises offering access to excellent libraries.

Small education centres offer possibilities for proximity between students and staff, and where this occurs, both sides find it to be a great benefit. Teaching staff often maintain an “open door policy” and can be a help to students outside the lecture theatres also. One risk of this proximity between students and staff is that the student’s formal recourse to influence their studies at departmental level will be given lower priority. However, constructive, informal contact cannot replace, but only supplement formal contact.

## 6. Key recommendations

### *Organisation*

Degree programmes within different fields of technology and within different regions should be coordinated at the national level. The development of research centres and master's degree programmes should likewise be coordinated.

Two or more institutions should to the greatest extent possible collaborate on teaching resources, administrative resources and equipment, and also on benchmarking and to some extent on course design.

### *Recruitment*

Measures must be implemented at the national level to promote interest in science and technology among secondary school pupils and those receiving further training.

Admissions to the TRES and Y paths must be quality assured, ideally by students being admitted by a national admissions procedure. The institutions must quality assure any such alternative programmes.

### *Research-based training*

The Ministry will need to provide the institutions with more conducive preconditions for making their engineering degree programmes more research-based, initially by the university colleges being granted funding for research. Use of this funding must be quality controlled.

### *The educational skills of the teaching staff*

It should be made compulsory for all members of teaching staff to complete a teaching engineering course, worth a total of 30 credits. The course should be oriented specifically towards the teaching of engineering skills, and should be designed at the national level.

### *Internationalisation*

The institutions should to a greater extent give priority to the international context of the study programmes by drawing up goals for internationalisation so that this activity contributes to quality development and gives the programmes international relevance in the interests of both further studies and job opportunities. Sufficient resources must be earmarked for internationalisation. Arrangements must be made to facilitate staff and student exchanges.

### *Throughput*

A trial should be carried out of applying grade attainment requirements for admission to study engineering.

At the national level, a review should be undertaken of the content of and requirements for mathematics at upper secondary school level. Relevant measures must be instituted.