

# Quality Management: Danish Engineering Education\*

HANS PETER JENSEN

Rector, Technical University of Denmark, DK-2800, Lyngby, Denmark. E-mail: hpj@admn.dtu.dk

*The article explains the institutional structure and statutory foundation for engineering education in Denmark. The methods used by the Danish Ministry of Education and Denmark's institutions of higher education to ensure and improve the quality of engineering degree programmes are described, and there is a brief discussion of the corresponding evaluation procedures used in the other Scandinavian countries: Sweden, Norway and Finland. The Technical University of Denmark is presented as a case in connection with the discussion of the internal evaluation methods used by various educational institutions. The final section deals with international prospects in connection with the evaluation and quality management of educational programmes in the engineering sciences.*

## INTRODUCTION: STRUCTURE OF EDUCATION IN DENMARK

To allow readers with little or no knowledge of the Danish educational system to understand this article better, it starts by sketching out the structure of this system. The focus in this brief introduction will naturally be on education in the engineering sciences and the routes by which students gain access to these programmes.

First of all, Denmark generally has two basic degree programmes for engineering education:

1. A five-year programme which leads to a master's degree in engineering, but which also qualifies the degree holder to the three-year doctoral programme leading to a Ph.D. degree. The master's programme is offered at three universities in Denmark, of which the Technical University of Denmark (DTU) is the largest institution of engineering education with its approximately 6,000 students, including about 600 studying at the doctoral level. Unlike similar programmes in most other countries, graduates of this programme do **not** earn a formal bachelor's degree first, then go on to receive their master's. Students cannot stop part way through the programme and receive any kind of degree: it is all or nothing (except for transfer of credits as we have it at DTU).
2. A 3½-year undergraduate programme which leads to a bachelor's degree in engineering and which is more oriented towards industry and applications. Holders of this bachelor's degree can go on to earn their master's by taking a specially designed two-year graduate programme. The undergraduate programme in

engineering is available at three universities and five engineering colleges.

To qualify for either of these degree programmes, most students have first completed a three-year programme of upper secondary education, which emphasises the basic subjects of the three classic fields of science: mathematics, physics and chemistry. Many of the students applying for the undergraduate programme have vocational training in one of the trades supplemented with a concentrated programme that brings them up to upper secondary school level in the three above-mentioned subjects plus Danish, German and English.

All Danish institutions providing higher education in the engineering sciences are state-owned, state financed, and under state control. However, ministries do not directly control these institutions; they are self-governing to a great extent in all significant areas. These institutions act within a framework of legislation and regulations, which provides organisational, financial and educational guidelines on a general level only. Students do not pay tuition fees and may even get state grants to support them.

### Universities

The three universities (the Technical University of Denmark, the University of Aalborg, and the University of Southern Denmark) which offer a master's programme in engineering are governed by the Danish Universities Act, which lays down the general framework for all of Denmark's universities. The Universities Act (passed in 1992) specifies the overall object of Danish universities: research and education at the highest scientific level.

According to the Act, the Ministry of Education sets the rules and regulations for quality control, hiring of university teaching and research staff.

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Each university decides which educational programmes it wishes to offer, and it is the individual university that takes decisions on the research to be carried out under its auspices. Otherwise, the most important function of the Act is to set out general regulations for the areas of authority of the various collegiate bodies and for the administrative and financial aspects of running a university.

#### *Engineering colleges*

Engineering colleges, which offer the 3½-year undergraduate programmes in engineering are governed by the Act on Administration of Engineering Colleges. This act serves the same purpose as the Universities Act: to establish a framework for the administration, faculty hiring, finances, etc. of these institutions.

The framework for the content of engineering education is set out in the Ministerial Order on the Engineering Degree Programmes. The Order applies to all educational institutions which offer master's and bachelor's degrees in engineering and specifies the overall scope of these programmes, their basic structure and their content. The Order also contains guidelines for how these educational institutions should establish curricula for the engineering programmes they offer.

Staff-student committees at these institutions prepare curricula and usually lay down typical rules and requirements regarding the content and level of the degree programmes. These committees also set out guidelines for how the institution wants courses to be organised and taught.

#### *Examination regulations*

To ensure that engineering educational quality goals are maintained and improved, Danish universities and engineering colleges are also governed by a set of regulations for examinations in the form of a ministerial order. These regulations specify, among other things, rules for examination design, testing methods, external examiners, and issuing diplomas. On the basis of these general guidelines, the individual institution determines which types of examinations it will accept, taking into account both educational methods and content.

## **QUALITY MANAGEMENT IN DENMARK**

### *The formal danish system for quality management of higher education*

1992 saw the establishment of the Danish Centre for Quality Assurance and Evaluation of Higher Education (the Evaluation Centre), an independent institution under the Danish Ministry of Education. (At the time of publication the Danish Centre for Quality Assurance and Evaluation of Higher Education has undergone some radical changes. The Centre, now named the Evaluation Institute of Denmark, has by law been given the responsibility of all national

evaluations of education in Denmark – from primary school to university level, thus creating the opportunity to assess the education system as a whole.)

The object of the Centre is to ensure the quality of higher education by:

- implementing the evaluation of higher educational programmes with a view to ensuring a high quality level of education;
- ensuring a dialogue about evaluation and quality between the Evaluation Centre, institutions, and potential employers of the graduates of these institutions;
- gathering national and international experience in the evaluation of educational programmes and quality improvement;
- developing methods of evaluation and by inspiring and guiding institutions of higher learning in matters of evaluation and quality (excerpt from the statutes of the Evaluation Centre, 1992).

The Centre deals only with higher education. Since its inception it has evaluated about 60 fields of education in Denmark ranging from literature to chemical engineering, and it performs assessments in a set rotation of subject areas. By the end of 1998 all the engineering sciences had been evaluated as planned.

Alongside the actual evaluation process, the Evaluation Centre – often in collaboration with educational institutions – works on developing methods and tools for use in improving the quality of the educational programmes it reviews. The Centre also functions as a 'depot' for national and international experience in the evaluation of higher educational programmes, and it participates in international project work and networks.

The evaluations of the Evaluation Centre are always performed in close cooperation with the educational institutions offering the programme or field of study to be evaluated. A typical evaluation of a study programme in the engineering sciences would involve the following steps. The case described here is an evaluation of the mechanical, production and marine engineering programmes carried out in 1996 [1].

First, a steering committee is formed which consists of experts whose professions are related to the field of the study programme to be evaluated. The next step is an initial look at the study programme: the Evaluation Centre collects documentation about the programme, i.e. student guides, curricula, information materials and any previous study or evaluation results. The Centre also gathers various information from students, graduates of the programme and the organisations which hire these graduates.

Afterwards, the educational institution in question is contacted. After a preliminary meeting, the institution sets up a self-evaluation committee that includes representatives from the institution's administration, faculty and students. The committee prepares a report in accordance with a set

of Evaluation Centre guidelines. The report is forward-looking and explains the institution's own assessment of the strengths and weaknesses of the study programme in question; it is also intended to supply documentation for the final report to be prepared by the Evaluation Centre. This self-evaluation report contains quantitative as well as qualitative data, and it seeks to shed light on a number of factors central to the quality of the programme. The case described here is an evaluation of the mechanical, production and marine engineering programmes carried out in 1996 [2]. The report contains information on the objectives of the programme, its content, its structure, the teaching methods and types of examination employed, and the organisational and administrative conditions for the programme. The process of data collection, processing and reporting usually takes three to four months.

While the institution is preparing its self-evaluation report, the Evaluation Centre performs a number of surveys of students, graduates, and current and prospective employers of programme graduates. The purpose of these surveys is to solicit assessments of the content, structure, didactics, and study environment of the programme in question and – as far as graduates and those that hire them are concerned – assessments of the entire study programme, the level of qualifications attained by graduates of the programme, and the weak and strong sides of the graduates as regards their business skills. This step of the evaluation process also ends in a report containing data, which will usually be included in the final evaluation report.

After the above steps are completed, Evaluation Centre representatives visit the institution in question, possibly taking with them experts in, for example, didactics, finances and organisation if this is deemed necessary for the evaluation process. Visits to the institution usually take the form of a number of separate meetings with students, administrators, faculty and administrative staff.

The evaluation ends with the preparation of an interim report on the study programme and on the institutions, which offer it. In the case of engineering programmes, such a report often is as long as 120–170 pages. The report is submitted at a conference attended by all the parties involved in the evaluation process. The purpose of this conference is essentially to lay the groundwork for implementation of the recommendations and analyses in the report. After the conference, the Evaluation Centre writes the final evaluation report, which is then published concurrently with its submission to the Ministry of Education.

On the basis of the recommendations in the evaluation report, the Ministry of Education indicates to the educational institutions in question the areas in which they are necessary to improve the quality of their programme. In certain cases, the evaluation report may also contain

recommendations aimed at the Ministry itself or at the national advisory boards.

Denmark has national advisory boards whose task it is to advise the Ministry of Education on topics such as general educational policy and to take the initiative in performing analyses, etc. that can be implemented in the political decision-making process. Such initiatives include suggesting general evaluations of areas of education and contributing to the improvement of the quality of educational programmes. There are five boards for higher education: the National Advisory Board for the Humanities, the National Advisory Board for the Natural Sciences, the National Advisory Board for the Social Sciences, the National Advisory Board for Health Education and the National Advisory Board for Technology. The last-mentioned board deals with engineering education.

#### QUALITY MANAGEMENT AND NATIONAL EVALUATION SYSTEMS IN SWEDEN, NORWAY AND FINLAND

Like Denmark, the other three Scandinavian countries have a public body in charge of evaluation and quality management of university education. The structure of the educational system in these three countries is generally the same as that in Denmark: before being admitted to university, students have completed nine years of primary and lower secondary school and two to three years of upper secondary school.

##### *Sweden*

Sweden performed an evaluation in 1995–1998 of existing quality management systems at all Swedish universities and other institutions of higher learning. In charge of this very extensive evaluation was the Swedish National Agency for Higher Education (*Högskoleverket*). It should be noted that this evaluation did not include an assessment of the education itself, but of the processes whereby the educational institutions endeavoured to improve the quality of educational programmes and the instruction provided.

The 1995 evaluations were implemented against a background of, among other factors, the greater degree of autonomy gradually attained by Swedish institutions of higher learning in the 1980s. The higher degree of self-governance in connection with higher educational programmes comes, however, at the cost of a greater responsibility for the quality of the education. As is the case in Denmark, Swedish universities and their ministries hope that increased independence against a background of a system of state funding through basic allocations based on the performance of the institutions will not cause a decline in quality due to the desire for increased efficiency.

Sweden intends to carry out a similar study in 1998–2002 in order to lay a solid foundation for an evaluation of developments in quality management efforts by its educational institutions. Like the

first evaluation, this study is to include all higher educational levels, i.e. from undergraduate to doctoral programmes.

In both studies, detailed questions are asked about each institution's preparedness to ensure quality. The specific measuring points were determined from a number of general questions (here only extracts) [3]:

What methods and what kind of organisation does the university/college have to plan, carry out, ensure, continually develop, follow up on and communicate its activities?

Have the projected results and the anticipated effect of quality improvement efforts been achieved relative to the institution's objectives?

How do you keep a continuing improvement going?

In practice, evaluation of individual institutions takes place in two stages that correspond to those of the Danish system. After preliminary discussions between the National Agency for Higher Education and the administrative management of the institution in question about when the evaluation should be performed and the persons to be appointed to an external evaluation committee, the institution performs a self-evaluation. After this is completed, an external evaluation committee is set up, made up of experts from Sweden and abroad who possess the necessary professional qualifications and experience. This committee prepares an assessment and then publishes its results in the form of an evaluation report that concludes the evaluation process. (The 1995–1998 evaluations included reports on the Chalmers University of Technology, the Royal Institute of Technology, and Lund University, which also deal with engineering education in Sweden.)

#### *Norway*

On the basis of a decision by the Norwegian parliament taken in March 1977, Norway established the Network Norway Council (*Norgesnett-rådet*). The task of the Council members, appointed by the Norwegian government in 1998, is to advise the Norwegian Ministry of Education and Church Affairs on matters concerning the long-term development of higher educational programmes, especially in cross-institutional fields. The Council advises on Norwegian recognition of foreign degrees and certificates, manages the quality of higher educational programmes on a national level, and organises supplementary education for instructors at all levels of the educational system. The Ministry of Education and Church Affairs can also assign to the Council responsibility for other cross-institutional tasks and information assignments, national as well as international.

On an organisational level, the Network Norway Council works closely with the Norwegian Council of Universities and the Norwegian Council of State Colleges. Also included in this collaboration is the Norwegian Engineering Council

(*Ingeniørutdanningrådet*), which consists of representatives from all institutions offering engineering education in Norway. The Network Norway Council handles cross-institutional matters of education, didactics and organisation that have to do with high-level education in the engineering sciences.

#### *Finland*

In Finland, responsibility for improving the quality of institutions of higher learning and thus university-level engineering programmes as well lies with the Finnish Ministry of Education and Research. In 1996 this ministry set up a working committee to develop a national evaluation system for Finland's higher educational programmes.

The committee's work resulted in a national system of evaluation, which, like the Danish system, performs regular assessments of the Finnish educational system. These assessments are intended as a form of support provided to educational institutions in their targeted quality development efforts and as assistance in their efforts to obtain adequate data on the performance of the educational system from both a national and an international perspective. Another function of these assessments is to follow up on the implementation of national educational strategies.

The assessments include a survey of educational needs, access to education, student flow, institutional structure and organisation (local as well as national), connections between resources and quality, and development trends and changes in the educational system. As in the other Scandinavian countries, the results of these evaluations help lay the foundation for political decisions in the field of education. Developing and performing evaluations of the higher education programmes in Finland – including engineering programmes – is the responsibility of the Higher Education Evaluation Council.

On a more concrete level, the Council's evaluations under this system target the interplay between higher educational programmes and the world outside, the content of these programmes, the effect of the instruction provided, curricula, didactic methods and the application of resources by the relevant institutions. One of the methods used is to monitor selected parameters on both an institutional and a national level. The data thus gathered helps lay the foundation for more extensive qualitative surveys, whose results are then implemented as a part of the basis for agreements between the institutions providing higher education and the authorities funding them.

### **INTERNAL QUALITY IMPROVEMENT AND EDUCATIONAL EVALUATION AT INSTITUTIONS OFFERING GRADUATE AND UNDERGRADUATE ENGINEERING PROGRAMMES**

Independently of centralised evaluation processes as described above, both internal assessment

processes and continual efforts to improve the quality of the engineering programmes are ongoing at Danish institutions offering graduate and undergraduate engineering education (a category which includes universities and engineering colleges). Some Danish universities feature dedicated centres or staff units working with research into and development of didactics, educational theory and practice, and other subjects related to education.

At DTU it is considered a vital success criterion that our educational programmes and the instruction provided as a part of these programmes continually meet a high international standard. In recent years, this has manifested itself in the form of a series of steps taken and objectives published and implemented by the University. These objectives are specified in DTU's most recent strategic plan for 1998–2001 (*Strategic Plan '98*), whose main themes are the University's engineering programmes and the instruction provided in this connection. The plan sets out a number of general objectives for these programmes and provides guidelines for the skills – other than those strictly to do with engineering – which the University believes are a vital part of its programmes. These objectives and guidelines are to be implemented over the next few years, and they are aimed at maintaining the competitiveness of DTU's engineering programmes on an international level.

The *Strategic Plan '98* also states the overall guidelines for teaching given at DTU. The guidelines known as 'Thirteen expectations on the quality of instruction' states that DTU adheres to the following definition of educational quality [4]:

1. DTU's organisational structure should inspire and facilitate sustainable development of its educational activities based on close contact with potential employers.
2. The scientific content of the instruction should be on an international level.
3. DTU should inspire its students to take responsibility for their own progress in knowledge, so that they can continue a life-long learning process in their subsequent professional lives.
4. Good teaching work should be recognised and teaching experience and results given due weight when appointments are made.
5. The physical facilities should be such and the administrative routines adapted, so that they foster quality development of the instruction and a good study environment.
6. DTU should endeavour to attract able new students of both sexes.
7. Instruction should be performed and evaluated by teachers and students in a dialogue of equals with respect for the role of each side.
8. Departments should follow up on the evaluations. The results of the evaluations should be included in the process of educational quality development.
9. Planning and provision of instruction and choice of teaching materials should be a joint matter for students and instructors in each department.
10. Course planning should respect prior attainments and ensure that the competencies obtained by students can be optimally utilised in subsequent courses when taken.
11. Instructors at DTU should show commitment to teaching and interest in the improvement of communication of knowledge. They should continue to develop their teaching skills, e.g. by supplementary training, study visits, participation in conferences, and work in development and research.
12. The instruction should create optimum conditions for students' personal development.
13. The instruction should have the effect of conferring on students both theoretical understanding and the ability to exercise a range of specialist skills.

Along with its adoption of *Strategy Plan '98*, DTU established a centre for research and development in connection with didactic methods at the beginning of 1998. The purpose of the Centre for Engineering Educational Development is to initiate and participate in the development of teaching methods and methods of examination at the University.

The Centre provides expert support, which DTU faculty members can draw upon in their development and improvement of courses and the methods used to teach the courses. This support to University faculty and its 32 departments includes supplementary educational training, help in forming teacher networks, and development and improvement of examination methods.

In addition to training, consultancy and seminars, the Centre for Engineering Educational Development disseminates its results through the publication of reports, articles and books. The Centre also works together with the University's three staff-student committees, which are the collegiate bodies with the overall responsibility for planning and improving the quality of DTU's educational programmes and courses.

There is a staff-student committee for each of the three basic programmes offered by the University (undergraduate, master's and doctoral), and each committee consists of elected students and tenured faculty members. As elected bodies, the committees are responsible for general educational and subject planning. (The staff-student committees for the undergraduate and master's programmes are also supported in their work by a number of advisory committees with technical expertise.) In this connection, DTU has been evaluating all courses offered in the two engineering programmes on a semi-annual basis for several years.

Since the autumn of 1998, optically readable questionnaires have been used in DTU's evaluation

process. This solution was chosen because of the large number of courses, about 1200, to be evaluated at the end of each semester. Students taking the courses being evaluated receive a three-page questionnaire: the first page asks students to evaluate the content and organisation of the course and the second page the role and teaching skills of the instructor; the third page provides students with an opportunity to express at length their remarks, praise, criticism and suggested changes to content and teaching methods. Since each student takes an average of five courses per semester, DTU's administration receives many thousand forms to be processed before courses are over at the end of the semester, since the idea is for the instructor and students on each course to have the opportunity to discuss evaluation results.

Statistics detailing student response to each course are sent to the relevant instructor, department, staff-student committee and subcommittee. All groups review the evaluation results and, if the evaluations contain a great deal of criticism, then the head of the department offering the course is contacted and usually also provided with a recommendation of how the content or teaching methods can be changed to better the quality of the course. In the future there is a plan for a second evaluation system to run parallel with the questionnaires, a system that would provide evaluation across the individual courses of the programmes. In *Strategy Plan '98*, a great deal of importance is attached to engineering programmes having a clear progression in what is learned, but also to students receiving training in a number of non-engineering subjects such as communication skills in Danish as well as in English, cross-disciplinary collaboration skills, project management, working environment and environmental subjects. To ensure implementation of these aspects to the extent desired, it is necessary to have an internal evaluation system which looks more at the connections between the individual elements and levels of these educational programmes than at the courses themselves.

### INTERNATIONAL PROSPECTS

It is part of a natural progression for the institutions in Denmark offering engineering degree programmes to increase their collaboration with universities and engineering colleges abroad in the future. Although the above-mentioned national evaluation systems are greatly beneficial, an assessment of the educational value of these degree programmes may be problematic due to the small number of institutions. Until recently, only two Danish universities (Aalborg University and the Technical University of Denmark) offered a master's degree programme in engineering. Although the evaluation system is interdepartmental and includes both engineering programmes (undergraduate and master's), there is a need for collaboration across national borders.

However, the number of institutions should not be the most important reason for setting up an international evaluation system. In the light of the increased mobility of highly educated workers on a global level, educational institutions in many parts of the world will have to prepare for a future in which they will to an increasing degree be compared not to their own country's institutions, but to institutions in other nations.

At the same time, we are experiencing a rising demand from students and the business community that degree programmes be internationalised; students also want a system where they can transfer academic credit for courses they have taken abroad back to their 'home' institution. At a time when a number of Western European countries especially are experiencing a decline in student applications for admission to educational programmes in the natural sciences and technology, internationalisation is also one way the door can be opened to students from abroad. However, this is possible only if the quality of the engineering education provided to international students can be ensured.

In order to tackle these challenges, universities and other institutions of higher learning will have to work towards methods of evaluating educational programmes across national borders so that they can continue to improve the quality of the engineering degree programmes they offer.

In addition to the quality management aspect, international evaluation will also present an opportunity for co-operation in other areas of engineering education. The resulting familiarity with the curricula and studies structure of institutions in other countries will make it easy to approve student wishes to receive academic credit for study abroad, and it will certainly promote mobility among students. Universities will be able to provide better guidance to students wishing to study abroad so that what students end up choosing also fulfils their expectations. Students can then also expect to complete their studies without unfortunate delays due to non-transferability of academic credit from universities abroad.

An increased mobility of masters programme students will presumably also have an effect on the mobility of doctoral students. Doctoral students will have formed research and social networks with their fellow students and researchers at the university where they earned their masters degree, and will thus have a better chance of success during their stay at a university in another country.

Such efforts will be a natural extension of the international collaborations traditional in research and development in the engineering sciences. As the fields of engineering research have become more complex, we have seen a development towards an increasingly international orientation in research collaborations. This trend should also be reflected in the educational collaboration among universities. This does not mean that

universities or engineering colleges should be identical or offer the same educational programmes, nor should universities offer the same selection of fields of study. Universities must endeavour to work together, each within its areas of specialisation, towards a goal of providing the highest level of education – internationally – for engineering students, whatever their field of study.

Regarding international cooperation, it is not realistic to expect that all institutions offering engineering education within a specific field should be evaluated together. One realistic solution is for universities, through recognised international collaborative organisations, to establish general guidelines for how a university can voluntarily implement benchmarking in collaboration with selected comparable sister institutions abroad.

The nature of universities as educational institutions makes it necessary for such comparison to be more than a simple copy of the quantitative methods of measurement used in benchmarking in the business world. When a university performs poorly, the consequences are not necessarily that it is out-competed or forced to move the production to another country – contrary to what can happen with private-sector companies – for which benchmarking was originally designed. Bad performance means first and foremost that the university produces low quality engineers and inferior scientific research. As a result, the main focus in benchmarking at universities must be on development and improvement. Benchmarking is a specific challenge for universities for the following reasons:

- Their core services (research and education) produce unique results with a very long delivery time.
- Many universities may have almost a national monopoly on the education they provide, and they educate primarily for their ‘domestic market’. This means that they cannot use measurements of customer satisfaction, salaries earned by graduates, unemployment, etc. for purposes of comparison.
- Competition does exist on the research side, but possible central measuring criteria may to a certain extent lie outside the control of a university. DTU’s ability to recruit researchers, for example, depends very much on Danish tax policy and how attractive Copenhagen is as a place to live: neither of these things presumably say very much about DTU as an educational institution.
- Universities are driven by supply. They supply the services for which they receive money or from which they can earn money by supplying. When DTU spends a certain amount of money on education, it is primarily as a result of the state funding that follows each student admitted.

It must be emphasised that universities should not implement benchmarking within the borders of a

single country. Firstly, universities in smaller countries often have close to a monopoly in one or more fields with a unique obligation: this makes it difficult to compare the institutions on a national level only. Secondly, benchmarking implies comparing oneself with one’s best competitors, and a university should never be satisfied simply to be the best in the country.

#### *Benchmarking*

For universities, three types of benchmarking seem at first glance to be the most relevant, either separately or in combination with one or more of the others:

1. *Key figures.* Figures and other quantitative indicators of central importance can be carefully selected and an attempt made to compare them. *Advantages:* This lives up to the widespread perception that comparing something statistical automatically gives it some kind of objectivity. However, it would be relatively interesting to compare a number of statistics: faculty/staff and staff/student ratios, number of square metres per student or staff member, non-governmental research funding, publications and others. *Disadvantages:* Relevant statistics are difficult to find: the important things simply cannot be measured. Differences in starting points, etc. would make comparison very difficult, and it would be possible to come up with an explanation for any result obtained. The numbers would put the focus on less important factors.
2. *Peer reviews.* A peer review system could be used. Let researchers and professors from recognised universities evaluate the quality, content and organisation of, for example, research groups or educational programmes. *Advantages:* If good evaluators are selected, universities will benefit from relevant contributions to their improvement and, not least, inspiration to do things better (which is certainly the main idea behind benchmarking). The technical approach – experts looking through the lens of their area of expertise – will give their results a great deal of credibility. Evaluations will generally be constructive. *Disadvantages:* This method is costly and slow. The technical approach requires a relatively precise and detailed look at individual subject areas or educational programmes, which means that it would hardly be possible to evaluate an entire university at once. Results are difficult to evaluate and compare with others.
3. *Quality and management systems.* Evaluation focuses on ensuring quality and management. In other words, for example, quality and management systems are described and compared, but the primary focus is not on the results of this process. The idea is thus to ensure that teaching is evaluated and to look

at how it is done, but not to consider the results produced by the evaluation process. *Advantages:* The focus on management and quality is oriented towards change and more than simply a description of the status quo. These areas can presumably better be compared and evaluated than the purely technical side. The focus is on the process and directly on changes and quality improvement. *Disadvantages:* Perhaps this does not quite live up to the expectations of the world outside, which expects an explanation of how well universities perform these tasks. The danger may lie in a tendency for this focus to move away from the research groups and thus perhaps also away from the core services of universities.

International evaluation under such a framework might promote the collaboration already existing between many universities without strangling it in a formal structure. This would help promote internationalisation in our particular area of education, which is necessary if engineering education is to continue to produce graduates with both technical and human qualifications corresponding to the needs of society and technological advancement.

## CONCLUSIONS

Seen from a Scandinavian point of view, there is no doubt that an evaluation of education and educational programmes performed in a methodical and politically sensible manner can help contribute to an improvement of the quality of engineering education. The national quality management systems of the Scandinavian countries make it easy for their educational institutions to compare performance – both organisational/management and educational/didactics – on a national level. This usually provides a strong motivation for these institutions to continue improving the quality of their educational programmes and the teaching students receive. It is important to remember that the institutions providing engineering education in the Scandinavian countries are to a great extent self-governing, but they remain state institutions which, in the final analysis, are under ministerial control. These same ministries also commission the evaluating organisations mentioned in this article, which is why the evaluation systems currently in place must

be considered tools for both development and management. Evaluation as a management tool is most clearly seen in the Finnish system, where there is a direct connection between the educational and research performance of an institution and the agreements it makes with the authority providing its funding.

From an international point of view, there is no doubt that there should be international co-operation in the field of quality management of engineering education: not only in the Scandinavian countries, or in countries with a small number of educational systems, but for engineering education in general all over the world. As mentioned above, we should not attempt to construct a single, huge and complex system for inter-institutional evaluation and comparison for the purpose of accrediting educational programmes across national borders. Such a system would not only be extremely costly – a factor which is prohibitive in itself – but it would also build up so much inertia that *instead of promoting change and improvement, it would bring progress to a halt.*

Quality management on an international level should be based on goal-oriented and voluntary collaboration between institutions working together to shed light on development activities and teaching standards. This kind of collaboration should be promoted with a view to the opportunities for development and the exchange of ideas and competencies and in order to help students prepare for the challenge of rising competition for jobs, whether they wish to work at educational institutions as researchers and teachers or in the corporate sector as practising engineers.

The most important point in connection with the evaluation and quality management of engineering education is that their chief purpose must never be lost from view: development in the direction of better and modern educational programmes which ensure that educational institutions can continue to recruit students and provide them with a high standard of engineering education. If educational institutions and authorities simply use evaluation as a guideline for the allocation of resources or rights, the result may be that these institutions begin planning on the basis of what is more profitable in the short term rather than on the basis of what is best for the engineering profession from a professional standards and educational point of view.

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**Hans Peter Jensen** is Rector of the Technical University of Denmark (DTU). He earned his M.Sc. in Chemistry at the University of Copenhagen, and his Ph.D. at Chalmers University of Technology. He has been awarded honorary degrees at three universities: D.Sc.H.C., Shenandoah University of Winchester; Dr.Tech.h.c., Helsinki University of Technology; and D.Hl.h.c., State University of New York. Since the mid-1980s, Dr Jensen has taken part in a large number of national and international collaborations on the development of education in the engineering sciences. He has performed in educational planning work as a member of the Council of Europe, is currently the chairman of the UNESCO International Committee on Engineering Education, and has participated in World Bank efforts to export educational systems and methods to developing countries.