Table of Contents

List of tables and figures

List of terms

English/*Norwegian* terms:	**Explanation:**
Institutions:	
Ministry of Education and Research *Kunnskapsdepartementet*	
National Committee for the Engineering Education *Nasjonalt råd for teknologisk utdanning (NRT)*	The advisory committee is to coordinate the engineering education and promote its political interests nationally. All the six universities and the 15 university colleges are members of the Committee. There are in addition representatives from students and industry.
Norwegian Agency for Quality Assurance in Education *Nasjonalt organ for kvalitet I utdanningen (NOKUT)*	Government agency for the evaluation and accreditation of tertiary education, and the recognition of international higher education qualifications
Norwegian Association of Higher Education Institutions *Universitets- og høgskolerådet (UHR)*	The interest organization for all public higher education institutions – university colleges and universities.
Norwegian State Educational Loan Fund *Statens lånekasse for utdanning*	Provides loans and scholarships to those taking higher education.
Norwegian Institute of Technology *Norges tekniske høgskole (NTH)*	The Norwegian Institute of Technology was established in 1910. The Institute merged with the newly founded NTNU in 1996.
Norwegian University of Science and Technology *Norges teknisk-naturvitenskapelige universitet (NTNU)*	Second-largest university in Norway. Located in Trondheim, central Norway.
Research Council of Norway *Norges forskningsråd (NFR)*	Government agency for the funding and evaluation of research in higher education and the institute sector.
SINTEF	Independent research institute established by NTH in 1950. Close cooperation with NTNU on research, laboratories and strategy. Largest research institute in the Nordic countries.
Student Welfare Organization *Studentsamskipnaden iTrondheim (SiT)*	
TEKNA	The Norwegian Society for Chartered Scientific and Academic Professionals. Largest labour organization for professionals with a master's degree in science or technology with 48 000 members.
Universities and Colleges Admission Service *Samordna Opptak*	
Other terms:	
Act relating to Universities and University Colleges *Universitetsloven*	
Adjunct professor *Professor II*	Fixed-term 20 % position, normally for five years, with mainly teaching duties. Many adjunct professors in engineering work at SINTEF or in industry.
Assistant professor *Amanuensis/universitetslektor*	Academic position with mainly teaching duties (for staff without a doctoral degree).

Associate professors *Førsteamanuensis*	Permanent academic position devoting on average half the time to research and teaching. After a national peer-review process many became full professors.
Course *Emne*	The engineering students typically follow four courses per semester of 7.5 ECTS each.
Curriculum Development Committee *Virksomhetskomiteen*	The reports of the Committee on the structure of the engineering education (1993) and its non-technology components (2003) have largely determined the current engineering education.
Database on Higher Education in Norway *Database for statistikk om høgre utdanning (DBH)*	Official statistics on HE operated by the Norwegian Social Science Data Services (NSD) on commission from the Ministry of Research and Education.
Dean *Dekanus*	Head of the Faculties. There are 7 Faculties at NTNU. The Dean of Engineering Education attends the Deans meetings with Rector and is the chairman of the Executive Committee for the Engineering Education.
Department *Institutt*	Basic level academic unit under the leadership of elected Heads of Departments. There are 53 Departments at NTNU organized within 7 Faculties.
Department of Industrial Economics and Technology Management *Institutt for industriell økonomi og teknologiledelse (IØT)*	The Department is responsible for the programme of study under the same name and is part of the SVT Faculty.
ECTS *Studiepoeng (SP)*	NTNU applies the European ECTS standard. 60 credits equal one year of full-time study.
Executive Committee for Education at NTNU *Utdanningsutvalget (UU)*	The Committee is chaired by the Pro-Rector for Education and Quality of Learning. It is appointed by Rector and serves as an advisory body to the Rector.
Executive Committee for the Engineering Education *Forvaltningsutvalget for siv.ing.-utdanningen (FUS)*	The Committee is chaired by a Dean appointed by Rector and reports to the UU. The Committee is to promote quality, equal opportunities and a common structure in the engineering education suitable to the needs of the society.
Interdisciplinary Teamwork *Eksperter i team (EiT)*	A one-semester project for 4th year students
Faculty *Fakultet*	Academic unit under the leadership of appointed Deans reporting to Rector. There are 7 Faculties at NTNU with 53 Departments.
Faculty of Engineering Science and Technology *Fakultet for ingeniørvitenskap og teknologi (IVT)*	
Faculty of Information Technology, Mathematics and Electrical Engineering *Fakultet for informasjonsteknologi, matematikk og elektroteknikk (IME)*	
Faculty of Natural Sciences and Technology *Fakultet for naturvitenskap og teknologi (NT)*	
Faculty of Social Sciences and Technology Management *Fakultet for samfunnsvitenskap og teknologiledelse (SVT)*	
Higher Education Institution (HEI) *Høyere utdanningsinstitusjon*	

Main profile *Hovedprofil*	The NTNU main profile is in natural sciences and technology.
Internship Praksis	In MSc in Engineering at NTNU there is compulsory 12 weeks internship in relevant industry or institution during the summer recess.
Learning outcome *Læringsmål*	
Major in the programme of study *Studieretning*	
Master of Science in Engineering *Sivilingeniør*	A five year integrated programme of study leading to an MSc Degree in Engineering.
NON-TECH *IKKE-TEK*	Non-technological courses in the engineering degree.
Examen philosophicum *Ex.phil.*	Foundation course in philosophy, psychology and logic for all Norwegian students (compulsory)
Professor *Professor*	Permanent academic position devoting on average half the time to research and teaching.
Programme Council *Studieprogramråd*	Responsible for the implementation of the programme of study. Advisory body to the Dean with regard to the development of the programme. Programme manager and representatives of staff, students and industry are appointed by the Dean.
Programme of study *Studieprogram*	NTNU has 16 programmes of study in engineering. They are five-year integrated programmes leading to a MSc Degree in Engineering.
Quality Reform *Kvalitetsreform*	Reform of Norwegian higher education responding to the Bologna Process implementing the bachelors and Master's degrees, the ECTS system and the A to F grading scale in Norway.
Rector *Rektor*	Rector is appointed by the Board of NTNU and is the academic leader and managing director of the university. He appoints the Deans.
Subject *Fag*	Discipline
Universities *Universitet*	Higher education institutions offering PhD studies in a number of scientific areas
University Colleges *Høgskoler*	Higher education institutions located in all counties offering studies primarily at bachelor's level, but with an increasing number of master's (and even PhD study).
Upper Secondary Schools *Videregående skoler*	
VK1 Virksomhetskomiteens rapport no 1 (1993)	The Curriculum Development Committee report "Vilje til forbedring" (NTH, August 1993) or "Engineering Education in the 21st Century" (English Summary).
VK2 Virksomhetskomiteens rapport no 2 (2003)	The Curriculum Development Committee report "Teknologutdanning med perspektiv" (NTNU, July 2003) or "Engineering Education with a New Perspective" (English translation).

Preface

NTNU is the nationally leading higher education institution in technology research and education in Norway. The university is responsible for almost 80 % of the MSc in Engineering Education and has been given the national responsibility for graduate engineering education. It is thus vital to the Norwegian society that NTNU offers an educational programme of high international academic standard and pedagogical quality.

The NTNU quality assurance system focuses on continuous improvement of educational courses and programmes. It is, furthermore, presupposed to conduct a more comprehensive evaluation of the learning objectives, programme structure and academic profile of the educational programmes every 5 - 6 years. The MSc in Engineering is undergoing such a comprehensive evaluation in 2007-2008. The objective of the evaluation is to further develop our MSc in Engineering Education with high international quality and relevance to the needs of working life.

Rector Torbjørn Digernes has conferred upon the Executive Committee for the Engineering Education (FUS) to serve as the steering committee for the evaluation:

- Bjørn Torger Stokke (Chair, Dean of Engineering Education)
- Olav Fagerlid (Vice-Dean Faculty of Social Sciences and Technology Management)
- Anne Borg (Vice-Dean Faculty of Natural Sciences and Technology)
- Svein Remseth (Vice-Dean Faculty of Engineering Science and Technology)
- Kristian Seip (Vice-Dean Faculty of Information Technology, Mathematics and Electrical Engineering)
- Øyvind Aass, Student representative
- Edina Christin Ringdal, Student representative
- Åge Søsveen (Secretariat, Senior Adviser, Student and Academic Division)

When designing the evaluation process, the involvement of academic staff and students as well as the management of each programme of study has been emphasized to foster ownership of the results of the evaluation and accept future changes. The internal evaluation process started in February 2007 when four thematic groups were appointed to assess generic issues, notably the programme structure, the non-technology content in the programme, international benchmarking and recruitment of students. Their reports were presented at a seminar 20-21 March 2007 and discussed with the heads of the engineering programmes. At the seminar the objectives and key issues of the internal and external evaluation were also discussed and identified.

There are currently 16 MSc in Engineering Programmes at NTNU, and each of them conducted their own self-evaluation from May through November 2007 based on a common mandate issued by FUS. The perception of key issues and potential for improvement varies between the programmes, and FUS has therefore emphasized that the self-evaluations should be seen as a tool to make improvements in each individual programme of study.

In December 2007, Rector formally appointed an international review team with a mandate to deliver their assessment and recommendations by September 2008. The external evaluation will be based on this self-evaluation report and key documents as well as interviews with stakeholders and general information obtained by the review team during a pre-visit and review visit at NTNU in spring 2008. The external evaluation will serve as essential input to

FUS when the committee is to develop and present a plan for the further development of the engineering education to the NTNU Board in the autumn 2008.

FUS has followed the internal evaluation process closely, determined the general structure and content of the overall self-evaluation report. This report includes reports on each individual MSc in Engineering Programme (volume II) and an overall report (volume I) where the main issues in the evaluation are identified based on the four thematic reports mentioned above and the reports of the individual engineering programmes. The report also provides some background information to enable the review team to better understand the engineering education at NTNU and the context in which it operates. Key documents have been translated to English and made available to the review team in the Annex to the self-evaluation report. We specifically point at the reports from the Curriculum Development Committee (VK1 and VK2) which have largely determined the current structure of the NTNU engineering education programmes (1993) and their non-technology components (2003).

1. Engineering Education at NTNU

1.1 Background – from NTH to NTNU

The engineering education and research at the Norwegian University of Science and Technology (NTNU) has its roots in the tradition of the Norwegian Institute of Technology (NTH). The institute was established in 1910 and located in Trondheim to serve national needs, - at the same time operating on an international arena.

The engineering education at NTH-NTNU has from the start and still is maintained as *one* education. The programmes of study have evolved according to the needs of the society and the international developments in science and engineering. Over the years, the executive committee for the engineering education has, with support from the professors and departments/faculties, coordinated and maintained a common programme structure for the engineering education. The students have a common base in natural sciences offered by the department responsible for the discipline. The programme structure has been flexible enough to allow new programmes to merge and new specializations to develop.

From the outset, NTH offered architecture, mining, construction, electro-technical subjects, chemistry and mechanical engineering. The programmes could not be too narrow in scope, but had to give a good basis for whatever challenge the new engineers were to take on in Norwegian society. The students and researchers from NTH played key roles in the development of the marine industry and the new industries based on the expanding hydro-electric power supply.

In the post-war period, the engineering education and research activity expanded rapidly to foster industrial development and growth. New industrial opportunities emerged and NTH-NTNU have been able to adapt rapidly to furnish industry with candidates and expertise in petroleum technology (1970s) and ICT (1980s) to take just two examples. A new programme of study in nanotechnology is currently implemented.

In the 1990s increased emphasis was placed on quality assurance. NTH was a pioneer in Norway by introducing systematic student evaluations and pedagogical requirements for academic positions. The students have since been active members of the committees in charge of the programmes of study and the overall coordination of the engineering education. The Curriculum Development Committee (VK) specifically tried to follow-up the advice of students and industry in their proposal for a revised structure in the engineering education.

There has always been an element of non-technology subjects in the engineering education and in the 1990s a new programme in industrial economics and technology management was introduced. In the mid-1990s, the Curriculum Development Committee (VK) recommended to expand the educational programme from 4 ½ years to a 5 year MSc programme to strengthen the non-technology component, make it possible to introduce technology earlier in the programme and open up for more specialization in the latter part of the programme. The new programme structure was implemented after NTH became part of NTNU in 1996.

NTNU 2020 – internationally outstanding

NTNU is a fully integrated university[1] with a broad academic scope covering most classical university disciplines albeit with a main focus on technology and the natural sciences. Of the 20 000 students at NTNU, 32 % are registered students in technology. The broad academic scope of NTNU offers new opportunities for interdisciplinary research and education. Wider access to non-technology competence in the engineering education from within the university is one of the advantages of the NTNU structure.

Even though some university colleges in Norway have obtained university status[2] and may offer graduate engineering education, NTNU maintains its nationally leading position educating almost 80 % of the MSc engineers in Norway.

The strong position of NTNU in research can largely be attributed to the close collaboration between NTNU and SINTEF.[3] The two institutions are the dominant technology institutions in Norway, enjoying also a high reputation internationally in many research areas. The two institutions work closely in many research areas to the benefit of industry and international research partners. By joining forces, it is has been possible to develop internationally advanced laboratories which otherwise would not have been possible for the individual institution. Many SINTEF researchers hold adjunct positions at NTNU and are a valuable additional teaching resource in the engineering education.

Research and higher education are global activities that can be characterized by increased competition for human and material resources. In the NTNU strategy "NTNU 2020 – Internationally Outstanding" (see Annex I), it is therefore emphasized that NTNU has to be continuously engaged in measures to enhance the quality of all activities. Our vision is that by 2020 NTNU is to be internationally recognized among the leading technological and scientific universities in Europe. The evaluation of the engineering education is to contribute to this vision.

1.2 Key figures – Faculties with Natural Sciences and Technology

Engineering students and candidates

There is fierce competition nationally for the graduates from upper secondary school with a natural science background. However, NTNU is for most engineering students the number one choice and is able to attract rather good students. In engineering, there are 9-12 applicants per student place. Most students complete their education on time - largely attributed to a

[1] The Norwegian University of Science and Technology (NTNU) was established in 1996 replacing the weak umbrella organization, the University of Trondheim (1968). The Norwegian Institute of Technology (1910), the College of Arts and Science (1922), the Faculty of Medicine (1975), the Music Conservatory (1968), Trondheim Academy of Fine Art (1979) and the Museum of Natural History and Archaeology (1767) were merged into a fully integrated new university structure.

[2] Norwegian University of Life Sciences (2005), University of Stavanger (2005) and University of Agder (2007).

[3] SINTEF was established by NTH in 1950 to handle applied research activities. The foundation soon grew to become one of Europe's largest independent research institutes with about 1700 employees today and operations all over the world. The collaboration includes strategic cooperation between the institutions as well as joint applications for larger R&D projects with national and international funding. In many areas the two institutions are closely interlinked in terms of personnel, infrastructure and research activities. Both institutions also aim to stimulate innovation and industrial development.

well-structured programme and the possibility to repeat the final course examination before the next semester. Drop-out rates, however, have increased in later years as will be seen from the self-evaluation.

NTNU is one of the larger engineering education institutions in Europe with 1400 new students admitted and nearly 1200 MSc graduates in 2006. The students are admitted to the 16 programmes of study which are administrated by:

- Faculty of Information Technology, Mathematics and Electrical Engineering (IME)
- Faculty of Engineering Science and Technology (IVT)
- Faculty of Natural Sciences and Technology (NT)
- Faculty of Social Sciences and Technology Management (SVT), Department of Industrial Economics and Technology Management (IØT).

Table 1: Engineering students and candidates at the NTNU Faculties with natural sciences and engineering. Source: DBH 2006

	IME	IVT	NT	IØT	Technology	NTNU
Registered stud.	1888	2696	1072	597	6253	19777
60 ECTS prod.	1334	1746	659	444	4182	13389
Applicants	3596	7478	2433	1495	15002	58361
Admitted stud.	376	688	243	123	1430	5702
MSc candidates	504	418	116	136	1174	2962
PhD candidates	37	52	38	3	130	244

Composition of academic staff

The engineering education has a very intensive teaching and learning programme compared with classical university studies with 20 hours a week of scheduled lectures and exercises. This is demanding for the academic staff responsible for the quality of the programmes of study. The professors give lectures and have the overall responsibility, while research fellows and assistant lecturers take care of most of the exercises. The number of professors per student at the faculties with natural sciences and engineering varies between 14 and 19 students per professor.

Table 2: Composition of academic staff at the NTNU Faculties with natural sciences and engineering (number of man years in selected positions). Source: DBH 2006

	IME	IVT	NT	IØT	Main profile	NTNU
Professors	101	127	101	10	339	551
Associate Professors	60	46	41	25	172	409
Reg.stud/Professor[4]	*19*	*16*	*14*	*17*	*16*	*20*
Adjunct Professors	4	11	7	2	24	47
Research Fellows	184	164	205	21	574	894

Operating income and expenses

NTNU obtains its basic funding for research, education and third stream activities from the Ministry of Education and Research. Part of the public funding is incentive-based related to candidate production and research output (doctoral candidates, scientific publications and

[4] It is difficult to distinguish between professors in engineering and professors in natural sciences. The student/staff ratio thus includes all engineering and science students at these faculties and the professors/associate professors responsible for the quality of these studies.

external funding from the EU and the Research Council of Norway). NTNU has chosen to use a similar model internally for the budget distribution between the faculties. Education is considered a public responsibility. External funding is primarily related to research activities. External funding represents 23 % at IME, 33 % at IVT and 36 % at NT of the operating income at these faculties.

Most faculties perceive that they have a very limited freedom of manoeuvre. Labour costs make up 60-70 % of the total operating expenses.

Table 3: Operating income and expenses of the NTNU Faculties with natural science and engineering. Source: DBH 2006

	IME	IVT	NT	IØT	Main profile	NTNU
Ministry of Education and Research, other Ministries	335 521	357 227	356 083	48 593	1 097 424	2 687 844
External funding	101 241	179 592	202 102	18 358	501 293	917 438
Other income	2 082	13 579	8 571	0	24232	156 797
Operating income	**438 844**	**550 398**	**566 756**	**66 951**	1 555 998	**3 762 079**
Wage costs	311 891	324 885	335 654	41 844	1 014 274	2 272 963
Investments	9 977	6 635	36 973	977	54 562	292 041
Other operating expenses	106 416	203 532	219 416	20 386	549 750	1 312 139
Operating expenses	**428 284**	**535 052**	**592 043**	**63 207**	1 555 379	**3 877 143**

1.3 MSc Engineering Education at NTNU

1.3.1 Learning outcomes

The VK2 Committee formulated the overall learning outcomes for the MSc Degree in Engineering as:

The education is to provide students with:

Knowledge

- *Sound scientific basic knowledge that will provide a platform for the understanding and application of engineering methods, adaptive versatility to innovation, development of scientific and technological knowledge and changing economic and environmental conditions and priorities*
- *Broad scientific knowledge in engineering*
- *Research-based specialization in specific areas*

Skills

- *Training in defining, analysing and modelling complex engineering challenges*
- *Training in creating a synthesis of comprehensive solutions that may involve several technological and non-technological subjects*
- *Training in creative work and innovative activities*
- *Training in assessing calculations and results*
- *Training in teamwork and communication*
- *Training in leadership and the motivation of colleagues*

Attitudes

- *Stimulation towards being innovative and creating economic and environmental viable activities*
- *Entrepreneurial ability that can translate research results into commercial opportunities*
- *Ethical values and basic attitudes that enhance the understanding of engineering knowledge and activities as an influential and integral part of a comprehensive social and environmental fabric*

1.3.2 Programme structure

The current principles for the engineering education at NTNU are described in the referred document *Engineering Education in the 21st Century* (1993, Annex II). The principles were built on the experience from the previous 80 years of engineering education at NTH and a broad questionnaire survey in 1993 and 2003. This was sent to engineers, industrial companies and the public sector in Norway and was a benchmarking to acknowledged higher engineering educations in Europe and in the US. The main change which was recommended by the Curriculum Committee (1993) was an increase in the duration of study from 4.5 to 5 years. The main argument for the expansion was the need for:

- more and new "non-technological" subjects in the curriculum (non-tech courses),
- standardization of size of the courses (7.5 ECTS or a multiple of 7.5 ECTS), and
- a curriculum structure based on the "fade in – fade out" principle; This means that the load of mathematics, basic science and (generic) engineering courses, that dominates the first 2-3 years of the 5 year curriculum, is gradually faded out, and so opens more space for the core engineering courses in the individual engineering programmes.

Figure 1: The basic structure of the engineering education at NTNU

Sem	7.5 ECTS	7.5 ECTS	7.5 ECTS	7.5 ECTS
10	MASTER'S THESIS (20 weeks)			
9	NON-TECH 4 (Elective)	SPECIALIZATION (project + complementary courses)		
8	Interdisciplinary Teamwork (course)	ENG –other programmes	ENG	Elective course (Bas/Eng/Non-tech)
7	TECHBAS 5	NON-TECH 3 (Perspective course)	ENG	ENG
6	MATHNAT 4	ENG	ENG	ENG
5	STATISTICS	NON-TECH 2	ENG	ENG
4	MATH 4	MATHNAT 3	TECHBAS 4	ENG
3	MATH 3	MATHNAT 2	TECHBAS 3	ENG
2	MATH 2	MATHNAT 1	TECHBAS 2	ENG
1	MATH 1	NON-TECH 1: Ex.phil	TECHBAS 1: ICT basis course	ENG Ex.fac

MATH = mathematics course **MATHNAT = natural science course**
TECHBAS = technological basic course **ENG = engineering course**
NON-TECH = non-technological course **Hatching indicates mandatory courses**

Currently, the overall structure of the curriculum consists of mathematics and statistics (totally 37.5 ECTS), natural science courses (totally 30 ECTS), engineering science courses (30 – 45 ECTS), non-tech courses (totally ECTS), and the Interdisciplinary Teamwork course (7.5 ECTS). The fifth and final year consists of one of the non-tech courses, a project work (15 ECTS), one course that is related to the project work, and the more independent MSc thesis (30 ECTS). These topics are organized in a way that the more generic topics included in certain groups of the courses are taught early in the programmes thus making a foundation for several of the other courses. This is illustrated in Figure 1.

All engineering programmes start with a common portfolio of basic introductory courses in mathematics, physics, computer science, a course in Philosophy of Science and Ethics and basic engineering subjects depending on the specific engineering programme. When the students have established a sufficient basis in these subjects, new, more advanced courses in engineering, natural science are faded in together with 3 more courses in "non-technical subjects".

In the 8th semester, called *the multidisciplinary semester*, students have to select an engineering course from other engineering programmes (ENG-other programmes) and start on their engineering specialization ("main engineering profile") by selecting two courses from a limited list of courses, engineering and/or an elective BAS/ ENG/ NONTECH course. In this semester the students are also required to take part in a project course called Interdisciplinary Teamwork (EiT) where together with master's students from other programme of study at NTNU they are expected to work as a team to contribute constructively and creatively in mastering a multidisciplinary challenge.

In the 9th semester the students are to do their main specialization: the in-depth project, combined with one or two complementary courses to give a broader scientific basis for the research in preparation for the project work, all together 22.5 credits (3/4 of a semester). In the 10th semester the students are to do their research-based master's thesis work, 30 credits (one semester), within their area of specialization.

1.3.3 Portfolio of programmes of study

The degree Master of Science in Engineering at NTNU is an integrated 5-year master's programme currently within 16 different areas of technology. The various programmes of study address societal competence requirements in sectors as indicated by their names (e.g. Civil and Environmental Engineering), or generic technological competences needed in many sectors (e.g. Industrial Economics). In addition to enrolment from upper secondary school to the programmes of 5 years nominal duration, most programmes also recruit some students to corresponding 2-year MSc programmes, which are similar to the 2 last years of the 5 year programmes, based on a completed Bachelor of Engineering. In 2007, 1500 students were enrolled in the regular MSc Engineering programmes at NTNU (see Table 4).

NTNU has in recent years also established a portfolio of international 2-year MSc in Engineering programmes (see Table 5). The programmes (with the exception of three older programmes) are in principle build on the same structure as the last 2 years in the ordinary 5-year programmes of study, but the courses are taught in English, and are in general focused within a more narrow and specific research areas.

The Executive Committee for the Engineering Education (FUS) has established procedures to avoid parallel teaching in closely related topics within the international MSc programmes and those for the MSc Engineering degree.

Table 4: Programmes of study in engineering and number of admitted students 2007

Name of programmes of study, 5 year	**Faculty**	**Students/ year (07)**
Master of Science in Applied Physics and Mathematics	NT	115
Master of Science in Chemical Engineering and Biotechnology	NT	95
Master of Science in Materials Science and Engineering	NT	30
Master of Science in Nanotechnology	IME	30
Master of Science in Communication Technology	IME	50
Master of Science in Computer Science	IME	110
Master of Science in Electronics	IME	90
Master of Science in Energy and Environmental Engineering	IME	120
Master of Science in Engineering Cybernetics	IME	110
Master of Science in Civil and Environmental Engineering	IVT	210
Master of Science in Earth Sciences and Petroleum Engineering*	IVT	105
Master of Science in Engineering and ICT	IVT	50
Master of Science in Marine Technology	IVT	100
Master of Science in Product Design Engineering	IVT	25
Master of Science in Product Design and Manufacturing	IVT	140
Master of Science in Industrial Economics and Techn. Management	SVT/IØT	120
Total number of students admitted per year (2007)		1500

* Divided in two programmes from 2008/2009

Table 5: International MSc programmes in engineering at NTNU

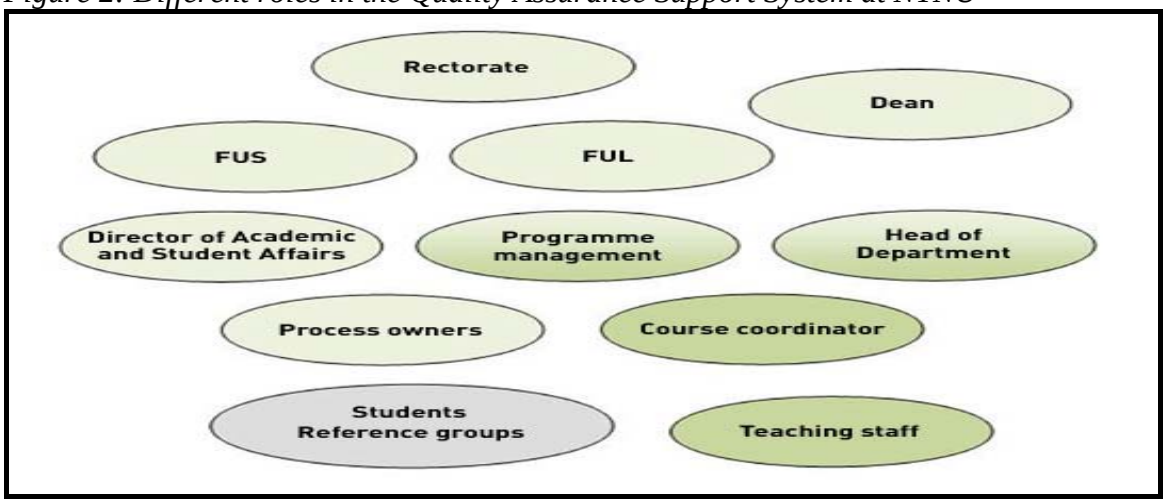
Name of international programmes of study, 2 year	**Faculty**	**Students/ year (07)**
MSc in Light Metals Production	NT	5
MSc in Medical Technology	NT	2
MSc in Information Systems	IME	4
MSc in Electric Power Engineering	IME	18
Master's Programme in Security and Mobile Computing (Joint degree)	IME	17
Master of Science in Coastal and Marine Civil Engineering	IVT	2
Master's Programme in Coastal and Marine Engineering and Management (Erasmus Mundus)	IVT	18
MSc in Petroleum Engineering	IVT	16
MSc in Petroleum Geosciences	IVT	8
MSc in Geotechnics and Geohazards	IVT	8
MSc in Hydropower Development	IVT	10
MSc in Industrial Ecology	IVT	9
MSc in Marine Technology	IVT	8
MSc in Reliability, Availability, Maintainability and Safety	IVT	3
Master of Science in Project Management	IVT	7
Sum of admitted students International Programmes in 2007		135

1.4 Quality assurance system at NTNU

In accordance with the Bologna process, and as an important part of the implementation of the Quality Reform in Higher Education in Norway 2003 (Quality Reform 2003), all Norwegian higher education institutions have to implement a quality assurance system for their educational programmes. The Norwegian national system is based on audits, where the Norwegian Quality Assurance Agency (NOKUT) is responsible for the accreditation of higher education institutions and their programmes and courses. It also evaluates the internal quality assurance schemes at these institutions to see if they fulfil their stated criteria. This approach gives the institutions freedom to define quality assurance processes that encompass the educations offered, and that provide feedback needed to enhance quality as defined by the institution.

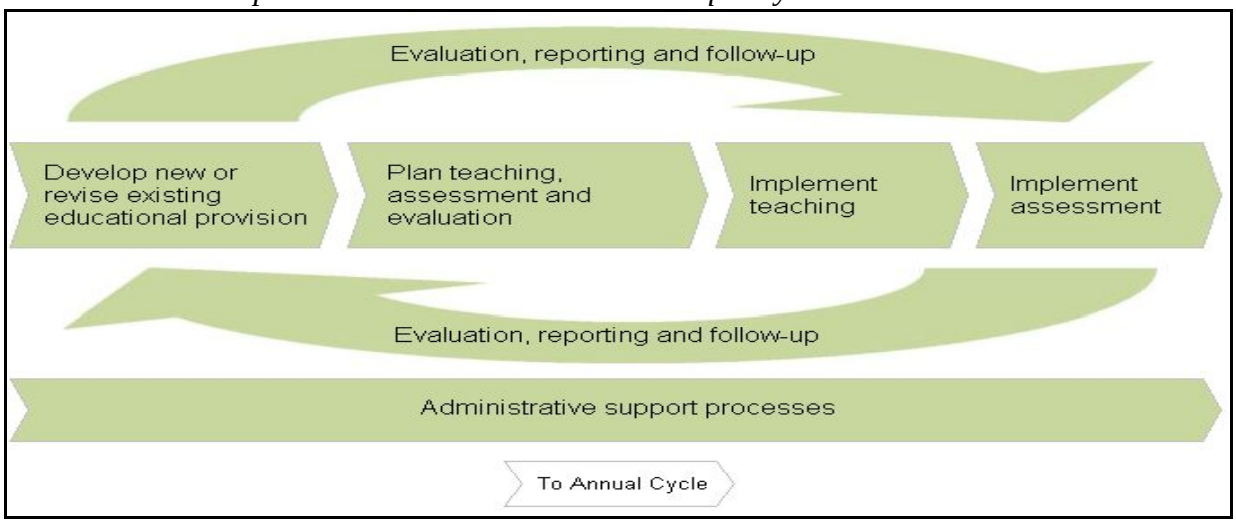
At NTNU the principles for quality assurance system state that the primary objective of the quality assurance is *not control, but improvement*, (see the document on the principles for quality assurance at NTNU, dated November 2003, Annex III). The system defines processes to be performed as part of the quality improvement process, with clearly stated responsibilities for the different roles involved, ranging from the students to the Rector, Figure 2.

Figure 2: Different roles in the Quality Assurance Support System at NTNU



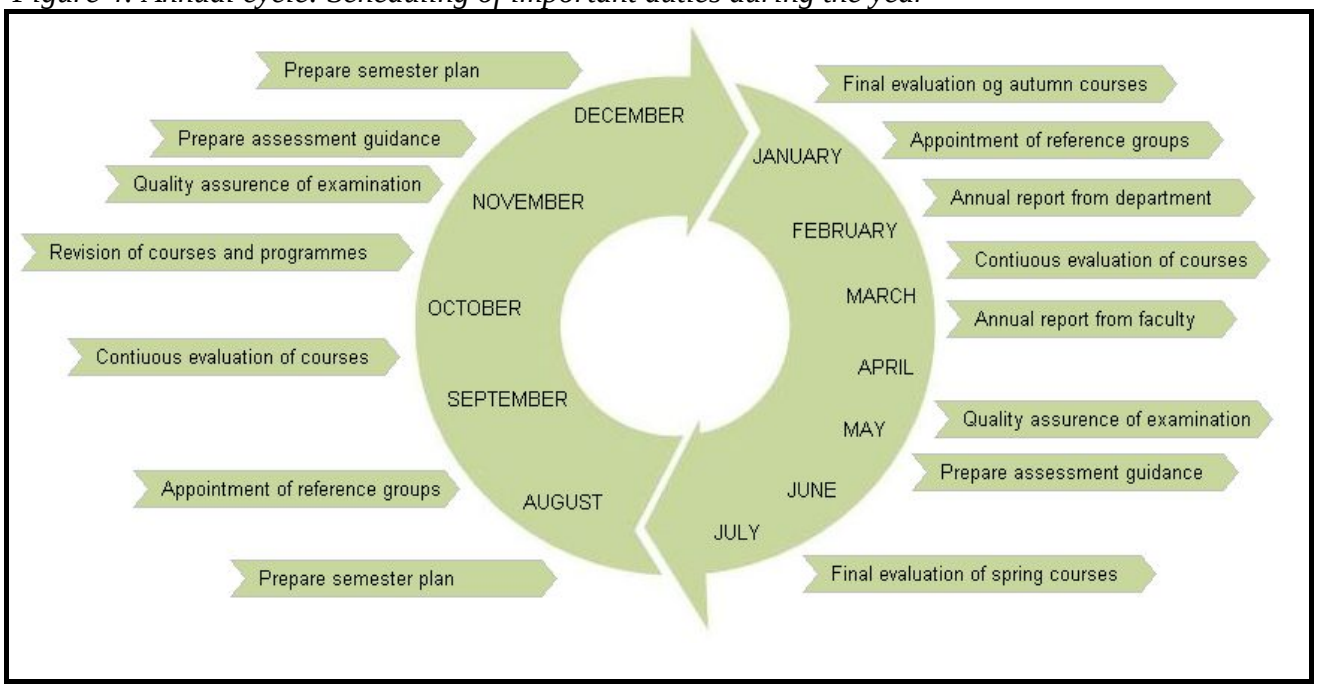
As the process of enhancing quality requires a functional feedback loop, every time a programme of study is completed or a course is taught, it is regarded as an independent project with four phases: Planning, implementation, assessment of the achievement of objectives and quality, and improvement/ adjustment, Figure 3.

Figure 3: Education regarded as a project with feedback loops. The main entry point to KVASS. Source: http://www.ntnu.no/studies/educationquality2



The NTNU quality support system (KVASS) is built upon these principles and activities. In the graphical interface at the webpage, all processes are represented graphically in flowcharts indicating the role responsible for each activity. For each activity the system provides suggestions, examples, checklists, templates, links to regulations and support units, as well as especially developed applications. Applications include a tool for developing student surveys with a set of predefined questions and responses to choose from, a tool for generating relevant statistics for evaluating the quality of courses and a tool for tracking the execution of core quality improvement activities in each course, see Figure 4.

Figure 4: Annual cycle: Scheduling of important duties during the year



1.4.1 Learning methods and examination systems

Within the Master of Science in Engineering at NTNU, there is emphasis on learning methods, examination in and the evaluation of each course. There are given separate regulations for the assessment of courses (see Annex IV "Assessment regulations and the use of examiners in MSc engineering education at NTNU"). The Curriculum Development Committee gave much attention to learning methods in their first report (VK1:1993). The Quality Reform 2003 gives further attention to learning methods as well as forms of assessment, for that purpose to enhance learning quality, including stronger focus on the learning process and a closer follow-up of the student. As a consequence of the Quality Reform and the intention to have a closer follow-up of the student's learning process, the Norwegian University Act was revised and now gives the teacher the opportunity to carry out examinations in each individual course during the whole semester without using external examiners.

Throughout the whole history of engineering education at NTH/NTNU there has been given considerable focus on applied engineering, with different methods of problem/project-based learning (PBL), broad use of mandatory calculation and laboratory exercises, combined with projects based on relevant cases from industry. NTH/NTNU, often in close collaboration with SINTEF, and with substantial support from industry, has build up several modern, well-equipped laboratories which are widely used in research as well as in teaching. Within each course of nominal workload 7.5 ECTS, there are typically 2 – 4 hours lessons per week (14 weeks per semester), 2 – 4 hours calculation exercises, laboratory work or project work, and with time for self-studies in-between. Exercises and self-studies are often based on teamwork with teams of typically 4 – 6 students. In some courses the students are to give oral presentations as a part of the exercises or examination. 1 ECTS corresponds to 30 hours of total work.

Depending on the nature of the subject and the judgment of the teachers, different forms of assessment are used in evaluating the students' learning outcome. Typical forms of assessment are: assessment based on only a written project work; only a final examination (written or oral), portfolio assessment or combinations of midterm examination(s) and a final examination where each grading are weighted, all-together 100 %. The grading Passed/Not passed is used in a few courses. More details regarding form of assessment and the use of examiners are described in the "Assessment regulations and the use of examiners in MSc engineering education at NTNU" (Annex IV).

1.4.2 Grading System at NTNU - a short description

As a part of the Quality Reform in Norway, a six-letter A-F grading system was introduced. In this system, A is the highest, and E is lowest passing grade. Grade F is a fail. In addition to the qualitative description in the regulations at NTNU, more specific description of the various grades within the MSc in Engineering at NTNU is given in the guidelines for this degree. Details of the practical application of the letter-based grading system in Norway are additionally provided by the Ministry. According to this, it is expected that the national distributions of the grades of large population are so close to the European ECTS standard, that a separate translation to ECTS grades is not needed.

1.4.3 Student advisory service

A well-functioning student advisory service is an important motivating factor as well as preventive effort to help student's well-being and for achieving good results in their studies. During the last two years, a project has been established to define roles, responsibilities and qualifications for student advisers. There are student advisers at the faculties for each programme of study. At NTNU-level the Student and Academic Division has special advisers giving assistance concerning recruiting of students, general study and welfare questions, international exchange issues and guidance for students with disabilities and special needs. On average there is one adviser (not all full-time) per 100 students.

1.4.4 Government incentives to stimulate credit production

The student financing system from Norwegian State Educational Loan Fund ("Lånekassen") is an important factor influencing learning quality. The student gets a part of the loan converted to a scholarship according to how many credits they achieve per semester. On the other hand, the Government assigns a great part of the university's budget according to the production of credits by its students.

Generally speaking all Norwegian higher education institutions are not allowed to charge a tuition fee from their students, but the students have to pay for books and other individual learning equipment used in the studies.

1.5 Organization and Management

We refer to the mandate for the Executive Committee for Engineering Education at NTNU (FUS) (Annex V) and the Executive Committee for Education at NTNU (Education Committee) (Annex V). FUS is an inter-faculty executive committee with the mandate to:

- oversee, develop and execute common solutions for the MSc in Engineering Education at NTNU and
- promote proposals on the principle structure and curriculum to the Education Committee (which in fundamental and overall questions functions as the board of FUS).

FUS meets 8 to 10 times per semester, and is managed by the Dean of Engineering Education who chairs the meetings and has delegations from FUS to make decisions regarding some current tasks. Besides the Dean of Engineering Education, FUS consists of the current Vice-Deans for education from the four Faculties having master's programmes in engineering, and two student representatives. The secretary is organized in the staff of the Director of the Student and Academic Division, who reports to the Pro-Rector for Education and Quality of Learning.

The Dean represents engineering education at NTNU on behalf of the Rector, and is a representative in the Education Committee (without formal right to vote). The Dean also is one of NTNU's four members of The National Committee for Technological Education (NRT), which is one of the strategic units of The Norwegian Association of Higher Education

Institutions (UHR).[5] The Dean of Engineering Education at NTNU is the current elected chair of the National Committee for Technological Education.

Every programme of study has a Programme Council, appointed by the Dean at the Faculty which is administratively responsible for the programme (decided by the NTNU Board). The Programme Council consists of representatives from the academic staff/Department which gives substantial teaching to the programme, students, external representatives from industry and a programme secretary at the Faculty. The Programme Council is responsible for the annual:

- reception of the new students,
- planning, implementation and evaluation of the teaching of the programme and
- review and suggestion of revisions in the programme of study (incl. implementation of the results of the self-evaluation undertaken in 2007).

There are guidelines for the Programme Councils giving more specific descriptions of the tasks for the committee.

Some of the programmes also have an "Industry Ring" with representatives from industry to:

- give support to the programme of study on recruitment of students, as well as
- make professional recommendations to the content of the programme of study.

1.5.1 Student democracy and student welfare

The students play a constructive role in the various committees and councils at NTNU. There are in general two student representatives on each committee or council, as well as on the University Board. The student democracy is in general considered to be a very important contribution to the student's well-being and the attractiveness of NTNU as a well-functioning institution of higher education.

The Student Parliament of NTNU is the highest governing body of the student democracy at the university. 25 students are elected for one year and represent all students at the university. These students are independent from the Student Councils. The Student Councils at the Faculties are run by representatives elected by the different engineering programmes. On each level, from the class to Faculty, there are two student representatives. The Student Council is led by two student representatives. In matters which are important for all engineering programmes, NTNU has its own Student Council for Engineering.

The Student Welfare Organization (SiT) provides many services to the students such as health services, student housing and child care. On campus SiT has bookstores and restaurants. The welfare organization also operates sports centres on the two main NTNU campuses. All the students have to be members of SiT to be enrolled as students at NTNU (regulated by Norwegian legislation). Many of the positions in the Board of the Student Welfare Organization and representative committees are held by students.

[5] The Norwegian Association of Higher Education Institutions (UHR) is a cooperative body for the universities and university colleges in Norway. It facilitates cooperation and coordination among Norwegian HEI and advocates shared positions on central issues concerning higher education and research policy towards the Norwegian government, parliament and society in general.

1.5.2 Student social life

Trondheim is known for its rich student life owing to a multitude of activities organized by the students themselves. The NTNU sports association has 8000 members and offers a wide range of sports or activities.

Trondheim is also known for the student festival UKA. It has been organized by the engineering students since 1917. Today students from all parts of NTNU are engaged. The student revue is the main attraction, supplemented with numerous concerts and parties for current students, alumni and local residents. The festival is the main source of income for the maintenance of the Students' Association building (Studentersamfundet), which is a landmark in Trondheim. The Students' Association is run by students on a voluntary basis, involving thousands of volunteers for the student festivals UKA and the "newcomer" ISFiT (the International Student Festival).

Engineering education in Trondheim is, furthermore, known for the student fraternities (Linjeforeninger). They play an important role during the introductory weeks, but also arrange all sorts of social and professional activities during the entire academic year.

Trondheim is truly a student town. During the academic year one in five citizens in Trondheim is a student. The city and the university cooperate to develop Trondheim as an attractive student town and facilitate contact between students and regional working life. The entrepreneurial talent of the engineering students is an asset which is highly valued by prospective employers. The students themselves are actively seeking contact organizing business fairs and industry visits. NTNU operates an on campus incubator for students who want to start their own business and the student organization START NTNU promotes innovation and entrepreneurship among their fellow students.

2. Presentation of main issues in the evaluation

2.1 Relevance of the Engineering Programme to the needs of the society

The societal relevance of the MSc Engineering Programme can be viewed from three different angles:

1. Does the degree have a portfolio of programmes of study and specializations where the content and quality satisfy the need for society in the future *as we see it now?*
2. Does the degree prepare the students for an uncertain future that is inherently difficult to foresee when it comes to new knowledge, changing economic ramifications and opportunities for engineering activities, where there are new societal and political priorities concerning viable economic and environmental development?
3. What should be the guiding principles for determining the number of MSc engineers graduating from NTNU from the different programmes of study?

Due to the complexity of the market situation NTNU has unfortunately not been able to establish sufficient statistics or data that provide a good analysis of the needs for engineers in society either in the short or long terms. In 2003, the Curriculum Committee (VK2:2003) carried out a survey among a large and fairly representative sample of Norwegian MSc

engineers. This survey asked different questions related to the relevance of different topics in the MSc Engineering degree at NTH/NTNU (VK2 Appendix 2, questions 9-18).[6] The respondents also gave information on their current employment, function and role in their organization (VK2 Appendix 2, questions 1-8). But although these data give a fairly comprehensive picture on employment and the professional careers of MSc engineers in Norwegian society, it is a static snapshot with limited bearing for curriculum planning where societal relevance usually should be high on the agenda.

The departments at NTNU that are involved in planning and teaching the different programmes of study have extensive industrial contacts, and external representatives from industry and the public sector are often involved in discussions and evaluations of a programme of study. Most of the programme councils have external members. In addition, the portfolio of research activities reflects external financing and industrial demand. These external relations will to a certain degree help to keep the development of teaching and research on track with the needs and priorities of society as *far as we see the future needs now*.

However, it is more important how the MSc Engineering degree prepares the students for changing future needs and ramifications of engineering possibilities and challenges, - changes that are difficult to perceive today with reasonable precision. These concerns were part of the Curriculum Development Committee's (VK1 in 1993) discussion and recommendation for reforming the curriculum of the MSc Engineering degree.

VK1 opted for a curriculum structure that was intended to secure educational flexibility by building the engineering specialization in different programmes of study on a fundament of mathematics, basic science, information technology and (generic) engineering topics. This way of thinking was confirmed by the Curriculum Committee in 2003 (VK2) which completed a more specific analysis and recommendations concerning the role, structure and content of "non-technological" topics in the MSc Engineering degree.

The curriculum structure recommended by VK1 has the following characteristics:

- A five-year integrated study with heavy emphasis on mathematics, basic science and information technology and basic (generic) engineering topics in the 2 -3 first years of study.
- A widening string of engineering courses specific for individual programmes of study and starting in the first semester
- A string of 4 "non-technological" courses including a course in Philosophy of Science and Ethics
- The two last years of the study are dedicated to specialization but also includes a semester that opens for courses from other programmes of study and a mandatory team-building course (Interdisciplinary Teamwork).

The VK1 Committee's intensions for giving strong priorities to mathematics and basic science in the first years of study were to build robust flexibility for changing future needs into the curriculum as follows:

[6] VK2 Appendix 2 is in Annex II to this report. The VK2 report is available in English translation, while the questions and the results of the survey are in Norwegian only.

- Give the engineering students a broad and versatile analytical platform for different tasks and challenges in their future role as MSc engineers and likewise give them a robust platform for lifelong learning
- Give the students within the specific programmes of study a platform for specializing in a wide variety of topics at the end of their study depending on their interests and what they find relevant when they complete the MSc Engineering degree. This will to a certain degree give the student the possibility to decide on his/her direction of specialization relatively late in their study and enhance his/her competence profile to the perceived needs of society.
- Give a robust platform for the individual programme of study to gradually change the content and portfolio of specialization and even introduce new programmes without changing the basic template of courses in the 2 to 3 first years of the MSc Engineering degree.

The answers given in the VK2 survey may be interpreted as a strong confirmation of the importance of a sound platform of mathematics and basic science in the MSc Engineering degree. But of course, the VK1 Committee's recommendations have built several compromises in when trying to strike a balance between competing aims. These conflicting choices are still with us. Besides, the (3+2) model of the Bologna process has added new challenges for a 5-year integrated MSc in Engineering – especially if the 3 first years of study are going to be a well rounded-off Bachelor in Engineering.

The main dilemmas inherent in the VK1 curriculum structure can be summarized as follows:

- How does the curriculum structure in the MSc Engineering degree at NTNU compare to well-regarded MSc degrees in Engineering at other universities in Europe when it comes to enhancing the possibility for fulfilling the core learning outcomes stated in Section 1.3.1?
- The content, composition and priority given to "non-technological" courses and Interdisciplinary Teamwork course have been a persistent topic of debate since the introduction of the VK1 curriculum structure. These important questions are far from resolved yet.
- The quality of the learning outcomes reached in the individual programmes of study are dependent on how far the learning activities in the programme can take advantage of the common foundation of mathematics and basic science in the MSc Engineering degree. Is this implicit intension in the VK1 curriculum structure realized?
- The VK1 curriculum structure implies that the students at the beginning of the MSc Engineering degree experience what many of them perceive as heavy theoretical teaching without grasping the use of it before they get to the third year of study. This represents a challenge for the motivation of the students for the first two or three years. To what degree does this represent a challenge to the coherence of the VK1 curriculum structure?
- The first years of the study set a threshold that is difficult to pass unless the students recruited are from among the best qualified candidates from upper secondary school. This sets narrow limits for how many students that can be recruited to the different programmes in MSc Engineering degree today. The output of MSc engineers from NTNU is in foreseeable future not limited by the demand in society, but by the possibility to recruit the most talented of the qualified candidates from upper secondary school. If one wishes to alleviate the last restriction, NTNU has to

implement a more active and systematic policy of recruiting students from abroad. How can that best be done?

- In the VK1 curriculum structure the learning outcomes in a programme of study are realized through a five-year integrated course plan. In this curriculum structure the first three years give the student the theoretical fundament for the specialization in the two last years. It is not meaningful to say that the first three years represents a well-rounded Bachelor in Engineering. Strictly speaking, such a well-rounded Bachelor in Engineering should be the learning outcomes for the first three years in the (3+2) Bologna model. There are different ways to circumvent this challenge, but the main question remains: what are the strengths and weaknesses of the VK1 curriculum structure for international student mobility within the future framework of the Bologna process?

2.1.1 Learning outcomes defined for each programme of study

An important part of the self evaluation has been to formulate learning outcomes for the engineering programmes. One challenge was to find a common model for formulating learning outcomes for the programmes since this has not done before. The next step was to redefine the earlier individual freely formulated learning outcomes in accordance with this model. We chose a model used at Delft University of Technology, the "QANU protocol" (Quality Assurance Netherlands Universities), which is based on the Dublin Descriptors, an European standard for description of learning outcomes.

The QANU protocol specifies the total learning outcomes in eight categories,

1. *Broad and substantial knowledge of mathematics, physics and computer science. Capability to apply this knowledge at an advanced level to the programme of study disciplines.*
2. *Broad and profound scientific and technical knowledge of the programme of study disciplines, and skills to apply this knowledge effectively. In selected areas, the knowledge reaches the forefront of scientific or industrial research and development. The knowledge level makes a good basis for innovative contributions to the disciplines.*
3. *Thorough knowledge of practical methods and tools within the programme of study disciplines and skills to actively apply them for analysing, modelling, simulating, implementation and testing.*
4. *Ability and skills to independently solve complex problems in a systematic way*
5. *Ability to work in (multidisciplinary) teams, interacting effectively with specialists and taking initiatives where necessary.*
6. *Good communication skills in Norwegian and English*
7. *Ability to identify, assess and evaluate ethical and social impact of own work*
8. *Attitude and ability to independently maintain professional competence through life-long learning*

Most of the Programme Councils found it very useful to do this "exercise". In the next step they could judge the relevance of every course in the programme to which extent the course contributes to reach the learning outcomes. Some programmes evaluated the contribution of the intended learning outcome from each individual course to the overall programme learning outcome as well. This way of attacking the evaluation work led to a new way of thinking in more holistic terms about the relevance and quality of the programme. The experience also showed that the first four categories of learning outcomes to a large extent were individually different for each programme, while the last four categories were more common to all the programmes, and correspond well to the learning outcomes formulated in the VK2 report as the more generic learning outcomes for the engineering education at NTNU. In the next step their findings will be used, in combination with the recommendations from the evaluation

committee, and the more general conclusions from FUS and the Board of NTNU based on these recommendations, in a more systematic improvement process for each programme.

2.1.2 The self-evaluations of individual programme of study – highlights

The general opinion and judgement of the structure of the MSc Engineering programme at NTNU is that the principles and the practical experience during the implementation of the programme are very useful. Changes in the market needs are coming increasingly faster, and the requirement for a structure with a broad basis of mathematics, natural science and technology, and the flexibility to adapt the professional profile of the programme to specific and individual needs, are well undertaken by the curriculum model designed by VK1 and VK2. The figures for programme swop and drop-outs indicate some problems, and the experience from the Programme Councils show that there is potential for improvement. In the self-evaluation reports of the programmes of study some challenges are mentioned which must be met.

One challenge is the amount of different courses of various types which the programme wants to offer relative to the total framework of the given structure. The complexity of technological challenges within each professional area requires both broad scope as well as deep insight in many technological subjects. At the same time there is a requirement that each engineer is to have a broader perspective on their profession which represents an enhanced requirement for non-technological subjects. But one important question is how widely these subjects are to cover and to which extent the student is to select such subjects. This was a main issue in the VK2 report, and the recommendation from the committee was to be more restrictive and give more specific guidelines for choosing non-technological subjects according to the professional needs in the programme selected.

Another challenge mentioned in some self-evaluation reports is the rigidity of the structure regarding standardized size of each course and the given mandatory place for specific courses in the programme structure. There are well-motivated arguments behind these solutions, primary the option to exchange between alternative elective courses and the possibility to manage the timetable. Some programmes have special needs for different reasons (regarding progression, use of common courses with other programmes etc.), and FUS has been given the right to make exemptions in some cases.

A third challenge is the amount of assessment work relative to teaching. Even if NTNU uses three weeks for assessments every semester, the amount of selections and the possibility to combine some preferred courses is limited by the examination requirements. This problem is obviously connected to the size of the subjects and is the main reason why it is not necessary to make the course size smaller. But are there other possibilities to increase the amount of selection?

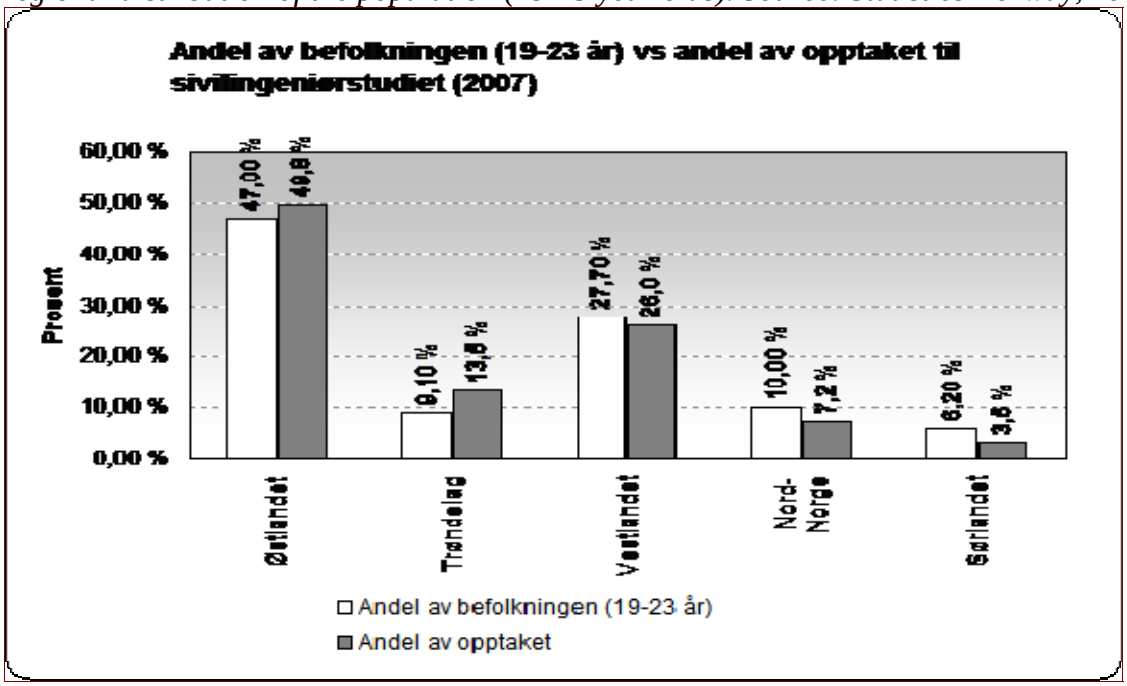
Overall, due to the needs for flexibility in the market it is important to undertake the possibility to individually adapt the professional engineering profile and specialization relatively late in the studies.

2.2 Recruitment and admission requirements

Up to the 1990s NTH (which merged into NTNU in 1996) nearly had a monopolistic position and a high reputation in the market for recruiting students to higher technological education in Norway. In general the quality of the incoming students was high. But due to the development of mass universities and a declining interest of learning mathematics and technology among youth in society, the competition to recruit the best students increased. In general NTNU has extended its requirements for admission from Upper Secondary School - academically oriented programmes so that it requires an upper level course in Mathematics and a next to upper level course in Physics for admission to the 5 year MSc Engineering programme. Additionally, the applicants have to compete for a limited number of places. There have normally been 2 to 6 applicants per admitted student to MSc Engineering, depending on the professional field of the programme, as their first choice of study among the national programmes of study. From 2006, NTNU is also are allowed to require a mark in Mathematics, upper level ("3MX"), of 4 or higher (where 6 is the highest mark). Already from 2004, NTNU decided to require grade C or better as an average grade from the Engineering University Colleges, corresponding to a Bachelor of Engineering degree, for the admission to the national 2-year MSc Engineering programmes.

Because of the limited number of qualified applicants in Norway, NTNU has given priority to recruitment activities to secure a sufficient amount of high quality applicants. In addition to informative brochures and web pages to present the engineering programmes, every year NTNU participates in several educational fairs at different places in Norway and visits a lot of Upper Secondary Schools. Figure 6 indicates that the recruitment to the 5-year MSc Engineering degree is nearly proportional to the size of the 19-23 year cohorts in the various regions of Norway. This clearly indicates that NTNU is a national university within higher technological education in Norway.

Table 6: Regional background of the NTNU engineering students admitted in 2007 and the regional distribution of the population (19-23 year olds). Source: Statistics Norway, 2007



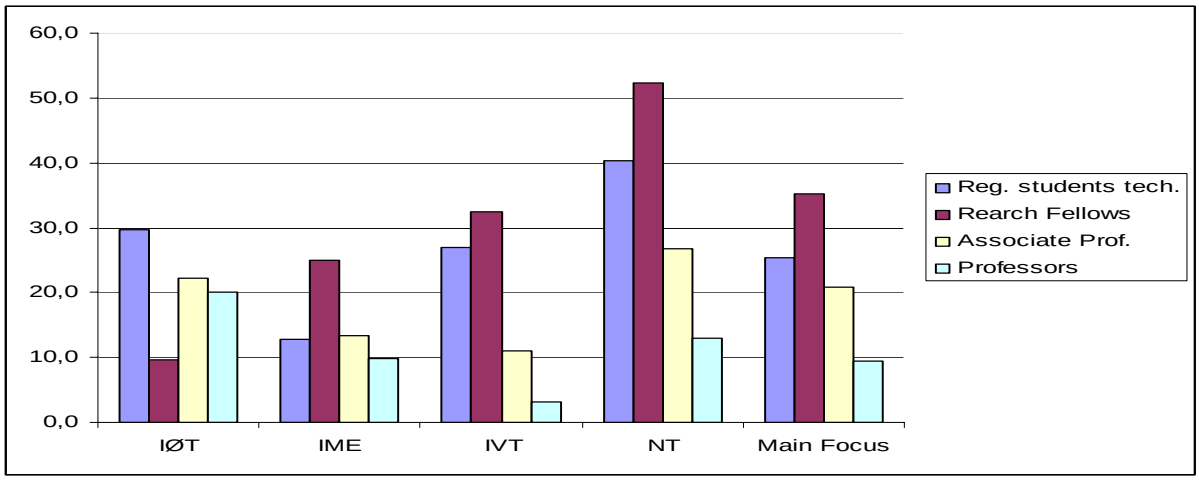
NTNU also hosts the National Centre for Mathematics and the National Centre for Recruitment in Science and Technology (RENATE). Both centres are established by the Government to improve motivation among youth for mathematics, natural science and technology in Norway. The centres cooperate with individual schools in trying out new learning methods and programmes, offer seminars for teachers and school management, and are also engaged in developing new course material, which portray technology in positive terms and the usefulness of mathematics to solve everyday problems.

In the last five years NTNU also has made efforts for recruiting a larger number of international students by offering 12 different international 2-year master's programmes and a couple of Joint Degree/Erasmus Mundus programmes in engineering, and NTNU is in an alliance with KTH (Sweden), CTH (Sweden), DTU (Denmark) and TKK (Finland) named Nordic Five Tech (N5T), to promote internal student exchange and give support to recruitment of international students as well as promoting research and dissemination.

2.2.1 Equal opportunities in the MSc engineering education

In the Norwegian society, equal opportunities are emphasized in all walks of life. To increase the number of females in a traditionally male-dominated field such as technology is a particular challenge. NTNU is working long term to stimulate the recruitment of females among the students as well as our academic staff. After a long period with only 20 % females among the new technology students, the number has improved each year in the last five years reaching 30 % in 2007. Among the academic staff only 9.4 % of the professors are females, but the recruitment base is promising with 21 % females among the associate professors and 35 % among the research fellows. The figure below illustrates the challenge at the four units with engineering education.

Figure 5: Percentage females among academic staff and registered students in natural sciences and technology at the relevant faculties/department individually and collectively. Source: DBH 2006



In our opinion, a better gender balance will increase the attractiveness of NTNU among potential applicants and contribute to a good working environment. Females may, furthermore, bring in new perspectives to the research agenda and learning process. To

achieve real equal opportunities, it is recognized that radical measures is called for, and in the action plan 2007-2010 it is stated that 50 % of all newly employed academic staff requiring a PhD should be female.

NTNU is nationally respected for the equal opportunities work among staff and students with an earmarked budget of NOK 3 million annually at NTNU level. The most well-known programme is called “Females and data” and offers female ICT students a professional meeting place during their studies. Reduced drop-out rates has been a positive effect. Similar network activities for females are introduced also in other technology programmes. NTNU also takes pre-emptive steps and female applicants to the engineering studies are invited to a one day programme at NTNU before the first semester starts to encourage them to actually choose NTNU. Of those who take part in that day, 95 % actually come to study engineering at NTNU. The five most popular programmes among female applicants during the past two years have been:

1. Industrial economics and technology management
2. Civil and environmental engineering
3. Chemical engineering and biotechnology
4. Earth sciences and petroleum engineering
5. Product design and manufacturing

2.2.2 Student accomplishment, programme swop and drop-outs

The increasing drop-out rate discovered in the statistic data for this evaluation work is a new challenge to engineering education at NTNU. While in earlier years we experienced a drop-out rate of 5 to 10 % and a completion rate of more than 90 % within the nominal duration of study, the new data indicates an increased drop-out rate, in particular for some specific programmes. On average 20 % of incoming students drop out, and 8 % swop to another engineering programme, while only 72 % complete their initially selected programme. To shed light on the problem, we have searched for information about:

- how many students complete their studies within their initially selected programme,
- how many students swop to another engineering programme during their studies, and
- how many students drop out before they graduate.

There may be many reasons for such relatively large swop and drop-out rates. There are some guidelines, limitations and instructions in the Examination Regulations at NTNU and the Supplementary Regulations for the MSc Degree in Engineering at NTNU (Annex IV), to assure progression and prevent drop-outs during the studies. Some reasons for drop-outs may be for the benefit of the individual student. But the indicators can and ought to be read as challenges to improvements regarding:

- recruiting information and activities, reception of incoming students,
- structure, content and progression in the engineering curriculum/programmes of study,
- pedagogical qualities, admittance to and quality of infrastructure,
- relevance of programmes to the needs of industry and society,
- the framework and regulations for studies at NTNU, and at last, but not least,
- the conditions for an attractive student environment.

All these factors are to be taken into account during the evaluation process.

Table 7: Drop-out analysis of the 5-year integrated MSc Engineering degree among students admitted in 2003 and 2004

	Students admitted 2003		Students admitted 2004	
	Number	Per cent	Number	Per cent
Continue original MSc programme	904	61.2 %	927	71.3 %
Continue in another MSc programme	271	18.3 %	102	7.8 %
Dropped out of MSc programme	302	20.5 %	271	20.8 %
Total	1477	100.0 %	1300	100.0 %

2.2.3 Motivation - introductory course "Teknostart"

The statistics indicate that most of the drop-outs occur during the first two years of the studies. In 2004 NTNU therefore established an introductory programme of two weeks duration, "Teknostart", for the admitted students in the 5-year MSc Engineering programme to help them having a positive and motivating introduction to their engineering studies. Teknostart includes working in groups, introduction to mathematics and the intention to show the students the necessity of using mathematics in their prospective profession as engineers by solving a simple exercise within the profession of their selected programme. Teknostart has been evaluated every year, and is judged to be a success. But we still assume that there is potential to improve the structure and content of especially some of the engineering programmes to enhance the motivation for the studies.

2.3 Student mobility – nationally and internationally

The judgement of our engineering programmes has been that we have competitive programmes compared with our most relevant competitors. Up to 1990s NTH educated nearly 100 % of all graduates with an MSc degree in engineering in Norway. At present, NTNU educates about 80 % of the graduates with an MSc degree in engineering in Norway. Some of the other universities and university colleges in Norway are now accredited to educate MSc Engineering students.

NTNU has established parallel 2-year MSc Engineering to the integrated 5-year MSc Engineering programmes to admit candidates with a bachelor of engineering from a university college to take an MSc Engineering degree at NTNU. In 2007 NTNU admitted 140 candidates to these programmes of study. On the other hand very few students from NTNU apply for the 2-year master's programme in engineering education at a university college, mainly due to the integrated 5-year programmes at NTNU. This is despite the fact that NTNU offers its engineering students a document which confirms that the qualifications after the first 3 years at NTNU are sufficient for admittance to a 2-year master's programme.

Regarding international student mobility, NTNU has actively participated in the European cooperation associations within Higher Engineering Education (SEFI, CESAER) since 1990, and much of the conditions for the engineering programme development over the last 10-15 years have been based on experience from international guidelines and the Bologna process. Historically the Norwegian model for engineering education is based on the German model, like most Scandinavian engineering education. International exchange of student and the formal conditions regarding collaboration on higher engineering education with international universities have been rather informal. In 2006 there were approx. 400 students going out on exchanges and 400 coming in (nearly balanced student exchange).

Following the Bologna process several collaborating universities have introduced a "3 + 2" model, where they give a bachelor of science degree after 3 years of studies and offer a 2 year master's degree based on the bachelor of science within a relevant professional area. NTNU judges the integrated 5-year model for the master's engineering education as a competitive advantage. This is based partly on the current relative strong recruitment situation to the integrated 5-year programmes, and the fact that this total duration is considered necessary for a good programme of study design, in particular in the multidisciplinary fields such as industrial economics and technology management, engineering and ICT, and nanotechnology. At the same time, it is realized that there is a need to find ways where students may complete their studies at NTNU with a 3-year programme and continue on with a 2-year master's programme at another university, and make it easier for candidates with a bachelor of science degree from another university to continue in a 2-year MSc programme at NTNU.

2.4 Learning quality

Important parts of a quality assurance for learning quality were already implemented for the engineering education at NTNU when the Quality Reform was introduced in 2003, as a need for assuring quality in *one* common engineering education given by *several* faculties. During NTH's history there have been many committees to evaluate and enhance the quality of the engineering education given.

In general we operate with 6 different types of quality regarding learning,

1. Quality of incoming students (recruiting quality), as discussed in Section 2.2
2. Quality of programme of study, discussed in Sections 2.2 and 2.4
3. Quality of Graduates, discussed in Section 2.1
4. Quality of teaching
5. Quality of framework and learning environment
6. Quality of education management

Quality of learning depends mainly on four aspects, the quality of incoming students, the quality of the academic staff, learning methods and forms of assessment and the infrastructure. The way of organizing and managing the education also have a substantial impact on learning quality. More of these aspects are discussed below.

Of course the total financing of the studies is an important aspect. In addition, the student financing system as well as budget model used by the Government may be a threat to quality in education as the student as well as the institution both benefit from producing credits, and the explicitly documented requirements for knowledge and competence may be reduced.

2.4.1 Learning methods and assessment systems

The Quality Reform changed the focus from teaching to learning. This had a substantial impact on which learning methods and assessment systems were to be preferred. At the same time the budget framework was not increased to the same extent as the costs, so it was necessary to compromise. The objective of the reform was to use more student-activating learning methods and develop methods for closer follow-up of the students learning process. The practical implementations to attain these objectives resulted in wider use of project and

teamwork where the teacher should be more a facilitator in a process than a teacher. But still the ordinary lectures and exercises are the most commonly used learning method.

The purpose of using a detailed form of assessment system is to assure a more continuous follow-up and assessment of the student throughout the semester. But the widespread use of mid-term assessment is now much discussed among the teachers, where the viewpoint is that the mid-terms require too much time and administration, especially mentioned is the volume of appeals. Moreover, mid-terms give the students the wrong focus on improvement because attaining a good grade is being more important than developing better learning processes. Portfolio assessment and final examination seem to be increasingly preferred.

Internship is regarded as an important part of the learning process in the engineering education at NTNU. There has always been a requirement for a certain amount of internship in "real work life" as a precondition to start on master's thesis work. Over the last 10 – 15 years it has been increasingly difficult to get such internship positions. The regulations for internship in engineering education at NTNU were revised few years ago. The requirement is now 12 weeks internship before the thesis in the 5-year integrated model and 6 weeks for the 2-year model. At least 50 % of the 12 week internship is to be professionally relevant, the remaining is to be relevant working experience, "to be an employee".

There are a lot of collaboration projects between the teachers involved in MSc Engineering at NTNU and various industries. This supports the option for numerous MSc Engineering students to perform a thesis either on an industrial topical area working at NTNU, or even performing their thesis in an industrial environment. In addition, to further assist students and teachers to get relevant tasks for projects, thesis work and internship jobs NTNU initiated the development and implementation of "Idéportalen". This is a network and a computerized system for collecting project tasks from industry and society in general for students in higher education in Norway. There are developed procedures for registration of project ideas, guidelines for quality assurance of these project ideas, and standard agreements regarding intellectual property rights and general regulations on "employees' rights". So far Idéportalen is well received and seems to be a very useful network.

2.4.2 Grading system and application of grades

To survey and guide the future use of the grading system, national reference panels are established by the Norwegian Association of Higher Education Institutions in the main disciplines. Within higher education in technology, all grades from MSc in Engineering at NTNU are included in this national survey. The general trend is a more frequent use of the two highest grades (A and B) compared to the total of D and E. The median is between B and C. For the master's thesis, there is even more frequent use of the two highest grades.

Table 8: Distribution of grades in regular courses and for the master's thesis in MSc Engineering Education at NTNU, 2005

	N	A	B	C	D	E	F
	Tot. num.	%	%	%	%	%	%
Spring courses	21 309	17	26	22	14	12	9
Master's thesis	825	27	45	21	6	2	0

From this national survey it is recommended that the institutions focus on the communication of the description of the grades. Furthermore, it appears inappropriate that more than 70 % of the students in their master's thesis work are judged better than the supposed average

performance (grade C), and that the institutions should implement routines that ensures a more balanced practice of the grading system for the theses.

2.4.3 Quality of scientific staff

Several evaluation reports on single-courses pinpoint the quality of the teachers. Generally the teachers' professional qualifications are judged to be high. Very often they actively are doing research activities on an international level in the same subject area as they teach, and it is common to connect exercises and project work to these research projects and thus bring motivating and updated topics to the teaching. Many of our researchers have an impressive international network, which secures a deep and broad knowledge base for the teaching. But, traditionally most of the teachers are recruited with emphasis on research qualifications, and especially within technological areas only a few candidates have a formal pedagogical qualification when they accept a permanent academic position.

During the last 15 years the pedagogical skills have been underlined and focused in the appointment process, and NTNU has developed an introductory pedagogical programme for newly appointed teachers, *Pedagogical Development Programme* (PEDUP), which is now mandatory for all newly appointed teachers without formal pedagogical qualifications. The programme is run by pedagogically skilled teachers from the University's Pedagogical Department (UNIPED), which also operates as pedagogical adviser for individuals as well as groups of teachers and programmes of study. There are also development projects regarding the use of ICT in teaching and learning, the use of alternative learning methods and forms of assessment, and there are awarded prizes for *best pedagogical practice* every year to promote and motivate teachers to improve their pedagogical performance. There are ideas and plans to develop a more systematic programme to enhance teachers' pedagogical qualifications and pedagogical services at NTNU.

2.4.4 Infrastructure and learning environment

Due to increasing enrolment of students, introduction of new pedagogical methods, enhanced requirements on learning environment and a rapid development of ICT tools in teaching and education, it has been a substantial challenge to maintain the quality level of facilities. Despite these challenges NTNU is said to have a relatively adequate standard for its infrastructure and learning environment. This is due both to the emphasis on this aspect by the organization as well as collaboration with industry and SINTEF, to be able to maintain and further develop modern laboratories. There is current focus mainly on two areas that need attention for further improvements:
- the lack of rooms for group activities while the needs have increased/changed substantially
- the lack of resources (economic and manpower) to utilize the options in laboratory-based learning.

In principle all the students have sufficient access to the common ICT network at NTNU. Most of the students have their own PC with network card and access to dedicated computer programmes. NTNU helps the students with a reduced price on PCs, and some programmes of study obtain individual laptops for their students.

Attention to students with disabilities is emphasized in the University Act. NTNU has also put much effort to make the university accessible for students with different types of disabilities - physically, pedagogically as well as socially.

Generally many of the activities regarding the learning environment except the core learning activities is undertaken by the Student Welfare Organization (SiT), - canteens, student apartments (many with Internet, some prepared for students with disabilities), healthcare services etc. The students themselves also organize many social activities of different kinds. Last summer SiT organized a questionnaire to all active students regarding social and learning environment at NTNU, and the results were rather satisfactory.

2.5 Organization and management of engineering education

While there are four faculties giving MSc in engineering education at NTNU it is important to have a competent FUS with sufficient ability to develop solutions and make effective decisions when necessary. With the current delegated authority from the Board of NTNU and Rector, FUS feels free to operate within its main area of responsibility. This is positive, but FUS also experiences the lack of a more strategic follow-up from the university leadership. FUS also experiences a lack of more effective decision-making regarding overall issues and principal questions. After implementation of the Quality Reform in 2003 all the educational activities are more similar for all educational disciplines at NTNU, and there ought to be greater opportunities to develop more common solutions, especially within the administrative and pedagogical organization for the education, refer the Examination Regulations at NTNU and the Supplementary regulations for engineering education.

2.6 SWOT analysis with some recommendations

The self-evaluation reports from the 16 MSc Engineering programmes (Volume II of this report) conclude that the generic 5-year integrated model for the engineering education at NTNU has been successful. The model gives a broad and strong general scientific basis whereupon the student has the opportunity to build a flexible/ adaptable engineering profile, with wide possibilities to specialize his/her engineering profile in the last two years of study. To a certain degree this gives the student the possibility to decide on his/her direction of specialization relatively late in the studies, and then have the opportunity to increase the relevance of his/her professional competence profile to the needs in society at the end of his/her studies.

The management of each programme of study was asked to pinpoint the strengths, weaknesses, opportunities and threats to their programmes. There are some common trends in their comments:

Strengths:

- Strong research-based courses with great diversity, given by partly very highly qualified researchers and research groups, and many well equipped laboratories
- High level of qualifications among incoming students, good rate of applications
- Collaboration with SINTEF (solves the issue of how to employ several critical groups of researchers with high reputation which NTNU could not afford alone)
- Close network to Norwegian industry and public administration
- Strong international networks with international universities as well as companies
- Sufficient exchange of international students
- Highly acknowledged student society and learning environment
- NTNU educates approximately 80 % of Norwegian master’s engineers

Weaknesses:

- Lack of qualified applicants to certain programme of study
- There is a mismatch between number of applicants to some programmes of study and the needs for candidates in the market
- Lack of qualified professors within certain important subject areas
- Too small budgets for the maintenance and renewal of laboratory facilities
- Problems with flexibility in the curriculum connected to the rigid standardized course size

Opportunities:

- Strong international networks with universities as well as international companies. Gives opportunities for establishing alliances and collaboration agreements with acknowledged participants regarding education as well as research and dissemination.
- Close network to Norwegian industry and public administrations - gives good opportunities for projects, summer jobs and master's thesis work in companies, which gives relevance to candidate's qualifications and good job opportunities. NTNU has the leadership of Idèportalen which seems to be a useful tool to get relevant project ideas as well as to open doors to admittance to small and medium-sized companies.
- NTNU has leading research groups within a broad domain of important scientific areas
- NTNU could give higher priority to collaboration projects with SINTEF
- NTNU has a portfolio of relevant international MSc programmes which gives great possibilities to increase the exchange of international students as well as researchers

Threats:

- Increasing international competition regarding recruitment of students as well as teachers/ researchers
- Lowered qualifications and motivation of applicants from upper secondary school and colleges
- Lack of qualified professors due to large amount of people reaching retirement age in the next 10 years and few PhD qualified candidates in the market.
- The huge negative differences in wages for professors with respect to engineers in private industry make it hard to recruit highly qualified academic staff.
- Too small budgets for maintenance and renewal of laboratory facilities
- Too small budgets for giving laboratory-based teaching
- Need for better pedagogical qualifications for teachers

Some recommendations are also given in the internal evaluation reports:

- Better integration of and stronger guidelines for electing non-technological courses
- More flexibility regarding course size and election of alternative courses (less mandatory)
- All lessons and teaching in 4^{th} and 5^{th} year of studies are to be given in English. This suggestion will pave the way for increased recruitment of international students without needing to establish separate educational programmes. Gives the possibility

to merge some of the current national programmes with the already established international programmes.

- NTNU should establish a possibility to give a degree *bachelor of science in engineering* (BSc) after 3 years of studies in the integrated 5-year programme. It will make it easier for our students to apply for a master's degree at another institution or in another field of studies, and, most important, students with a BSc from another (international) institution can apply for an ordinary master's degree programme at NTNU. It will also simplify the formal conditions regarding Joint Degree programmes with other universities.

3. Thematic Reports - International Benchmarking

In February 2007, FUS appointed four working groups under the leadership of the four Vice-Deans in the FUS Committee. Each working group was given a mandate to review selected issues, notably:

- the learning outcomes and structure of the engineering education (VK1)[7]
- international benchmarking[8]
- the non-technological content of the education (VK2)[9]
- recruitment of students [10]

Their observations and points of view were presented at a seminar 20 – 21 March 2007. Later on the Vice-Deans made written reports from their respective working group as input to the self-evaluation report. Key issues raised by the working group on learning outcomes were integrated in the mandate to the Programme Councils and further elaborated upon in their self-evaluation reports. The input from the working group on learning outcomes has, furthermore, been integrated in Chapter 2 to this report. The three other working group reports are presented in Chapters 3, 4 and 5.

3.1 International benchmarking – main issues

When the working group on international benchmarking was appointed, FUS raised a number of questions to indicate some of the most important issues:

- How does the structure and academic level of the engineering education at NTNU compare with similar educations internationally?
- In which areas and with which institutions is it the most relevant to cooperate with internationally?
- In what way is it most relevant to cooperate – joint programmes, joint degrees, student exchange, distant learning?
- How do you perceive the five-year integrated model versus a "3 + 2 model" or a "3 + ½ + 2 model" with respect to international mobility and recruitment to the NTNU master's programmes?

3.2 Why internationalize?

Norwegian industry is becoming more international. In order to compete, it is essential that the competence in technology holds the best international levels with respect to production and development in companies, technological research and development within priority areas.

For Europe it is essential to stimulate sustainable growth in technology-driven industry production in order to maintain and develop an advanced society. Today, China, Brazil and India have become powerful centres of industrial development. The EU recognizes that our

[7] Olav Fagerlid (FUS/SVT-IØT), Ola Hunderi (NT), Marvin Wiseth (IVT), John Krogstie (IME), Otto Lohne (NT), Bjørn Torger Stokke (FUS), Edina C. Ringdal (student, IME).
[8] Svein Remseth (IVT), Bernt Leira (IVT), Bjørn Nygreen (IØT), Ivar Wangensteen (NT), Bjørn E. Christensen (NT), Eivind Bratteland (IVT), Johan M. Røthe (student, IØT).
[9] Anne Borg (FUS/NT), Jon Rismoen/ André Liem (IVT), Kjell Wiik (NT), Stig Frode Mjølsnes (IME), Helge Brattebø (IVT), Bojana Gajic (IME), Tore Prestvik (IVT), Øyvind Ass (student, IVT).
[10] Kristian Seip (IME), Trond Andresen (IME), Tim Torvatn (IØT), Trygve Foosnæs (NT), Bjørn Andersen (IVT), Ole Ivar Sivertsen (IVT), Catharina Lindheim (Student and Academic Divsion), Asle Opsahl (student, NT), Kjetil Hope Tufteland (student, IME), Kjersti Vrålstad (student, IVT).

education of engineering excellence will be the single decisive factor determining our future competitiveness. Many of these engineers will take on management positions in industry and through continuing education in management be able to master both technology and business challenges. The industrial renewal process must start with engineering education and Norway must be closely integrated to the European process to foster such a development.

We must educate MSc engineers at a high international level. Through cooperation with reputable universities, we can offer our students international experience, utilize each others strengths in education, and possibly release time for more research. It would be most fruitful to cooperate in areas where the universities have complementary strengths within comparable programmes of study.

If we are to cooperate with high-ranking universities, we must have something to offer. Benchmarking against reputable universities will give insight into where we have to enhance quality in order to be an interesting partner in our MSc engineering education. Cooperation in education should also lead to stronger international research networks, not least new research networks within the EU/EEA.

3.3 Who are we to compare with?

In the strategic thinking of NTNU and supported by political signals, it is natural to seek cooperation with the best Nordic technical universities and universities with an engineering education. The NordicFiveTech cooperation began in 2007 (KTH, Chalmers, DTU, TKK and NTNU). In Europe, NTH used to participate in the Leuven Network and the Santander Group. Today we should aim at cooperating with the IDEALeauge universities (Imperial College, TU Delft, ETH Zürich, RWTH Aachen, Paris Tech). NTNU has, furthermore, good contacts with several universities in the USA, Canada and in Asia (Japan, China and Singapore). We should aim at developing joint degrees. At the same time it gives a direct opportunity for benchmarking with our equivalent programmes of study.

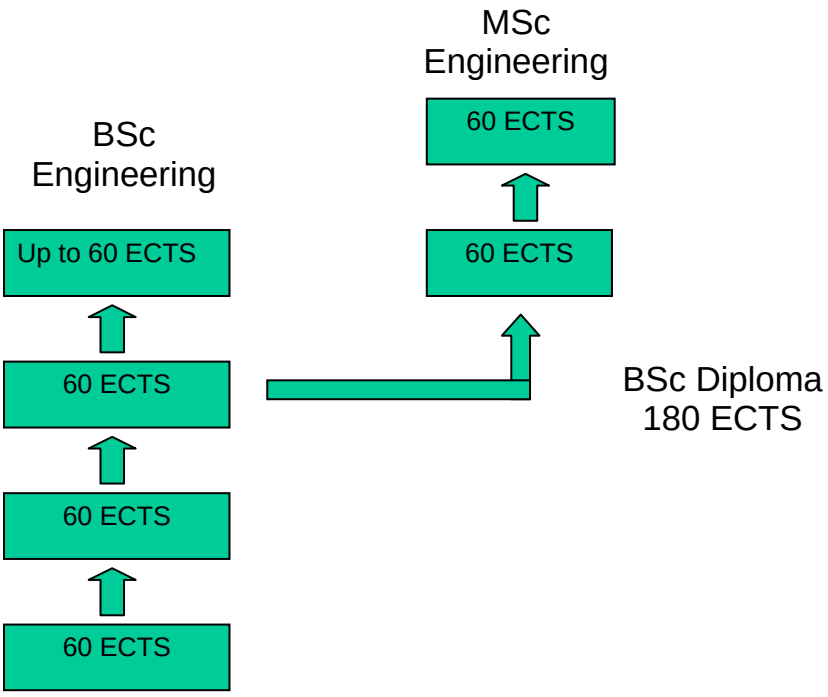
International cooperation with high ranking universities will also contribute to making NTNU better known internationally. With this respect we should also mention the Erasmus Mundus Programmes which may be established through international networks in areas where our university is perceived to offer high quality education. Such programmes presuppose that we arrange for double and multiple degrees.

3.4 Educational structure in European engineering education

The Bologna Declaration aims to harmonize the structure in the engineering education throughout Europe to increase mobility of students and professors. Increased mobility is particularly an opportunity at masters' degree level. Many European universities and technical colleges place a great deal of weight on basic knowledge in mathematics and natural sciences in the first part of the studies to ensure quality in their engineering education. A sufficient knowledge base will not least be important to ensure satisfactory learning outcomes for students transferring to another institution during their masters' study.

The figure below visualizes the educational model largely supported by European universities with technology education. The structure includes the integrated five-year model, at the same time as it allows bachelor's degree candidates to enter the graduate engineering education at master's degree level to the extent that their knowledge base in mathematics and natural

sciences is satisfactory. A bachelor's degree in engineering normally requires a fourth year of study.



If we were to transfer this European model to Norway, the integrated five-year model applied at NTNU fits neatly into the model. It would, however, be a challenge to implement a "time-for-time" policy and accept a three-year engineering degree from the university colleges as a satisfactory basis for admittance to a two-year masters' programme. Implementing such a policy would require a political decision and cooperation between NTNU and the engineering colleges concerning adaptations to the programmes of study. Many of the students from the engineering colleges choosing to move on to an MSc engineering education at NTNU are very motivated, but may in many major and profile areas struggle with the theoretical basis. Compensatory measures for these students might be called for to improve their learning outcomes and maintain the quality at master's level.

3.5 Quality of the MSc Engineering education compared internationally

It is our perception that within most programmes of study we maintain an acceptable to high international quality level. It is, however, difficult to make an objective judgement without international benchmarking and evaluation. This is difficult as long as we do not have a common framework for learning outcomes and programmes of study. Meanwhile we may get an indication of the quality level through the international experience of our academic staff. Another source of information is our students who have spent some time at foreign universities (mainly during the 4th year) and students from foreign universities staying at NTNU during their master's study. Within the timeframe of the working group in charge of this report, we have not considered making any systematic inquiry among students or staff. We therefore base our judgement on examples from the programmes of study which the working group members knew best.

3.5.1 Chemical Engineering and Biotechnology

The programme of study is from the outset a chemical-technical study which might be compared to what internationally is known as chemical engineering. The education offered around the world in this field of study contains by and large the same main elements. Direct comparison is difficult due to variations in the level of the basic education and the structure of the university education. In the USA, students typically are one year younger when they enter higher education, and a significant amount of humanity courses is common in the engineering education. The typical US-structure is a four-year BSc followed by a 4 to 5 year PhD. In Europe many countries are moving in the direction of the Bologna model of 3+2 years of study towards a master's degree. The integrated 5-year MSc engineering education at NTNU should therefore be compared to the BSc+MSc in these countries. It is common with a basic science profile in the BSc and in-depth studies and specialization in the MSc. The NTNU model and the Bologna model are quite similar, but they differ with respect to the thesis (although rather limited) in the bachelor's education.

In the table below we have compared the first part of our integrated study with similar studies at Chalmers and the BSc educations in the USA and France. We may compare the scope of the various subjects, but not the quality or level. Internationally, there are many similarities, but also variation in the way chemical engineering is taught. Various highly reputed universities have different approaches, but basically with a comparable content. The mathematics part is relatively similar, with approximately 30 ECTS during the first two years. The chemistry programme in Toulouse and at MIT both have little mathematics. NTNU, furthermore, stands out having more chemistry in comparison with the specialization in chemistry at Toulouse. The BSc education at MIT emphasizes Engineering chemistry with a focus on heavy process industry. In addition to what can be seen in the table, NTNU has a larger non-technology component in the engineering education than other comparable chemical engineering programmes elsewhere in Europe.

Table 9: Comparison of courses at NTNU, Chalmers, MIT, University of Delaware and Toulouse (2 out of 5 majors in Toulouse)

Institution Years	NTNU 1-2.5	Chalmers 1-2.5	MIT (BSc) 1-4	UDEL (BSc) 1-4	Toulouse BSc Process	Toulouse BSc Chemistry
Humanities			60		16	16
Mathematics	30	30	24	30	30	12
Chemistry	52.5	45	24	50		54
Eng. Chemistry	30	36	84	75	66	38
ICT/programming	7.5	Part of math.				
Environment		5				
Other subjects			56 (elective)			
Projects		15 (during 2.5 years)				

In the USA in recent years been a debate about the content of the engineering education (chemical engineering), while the debate in Europe has been on organizational aspects to stimulate mobility (Bologna). The American debate has resulted in a proposal to revise the contents of the education along these lines:

- Change of focus from one industry (petrochemical) to many industries (based on biology, chemistry and materials)

- Maintain close linkage to basic topics (chemistry, physics, mathematics, biology)
- The core education must be evident and not too strongly influenced by niche research interests (at the same time, students must be exposed to research activities and new developments)
- Understanding of quantitative analysis, systems analysis and multiscale analysis
- Variation in the use of learning methods
- The use of examples, PBL with open problems
- Teamwork and communication skills (written and oral)
- Non-technology subjects (safety, environment, ethics, economy, laws and regulations, IP-rights, market, social relations)
- Practical training should be part of the basic education

Most of these points are already addressed in the MSc engineering education at NTNU, and it seems that the USA is coming closer to the NTNU approach.

If we compare with different engineering programmes in Europe and the USA, the NTNU programme in chemical engineering and biotechnology falls well within the "chemical engineering tradition" with respect to content and level. The specializations offered at NTNU correspond with the offers elsewhere. The NTNU scope of the basic education is rather heavy in mathematics and chemistry, comparable in physics and ICT, while (compulsory) biology is absent.

Some topics which are focused upon at NTNU are currently almost absent internationally. Examples are safety and environment. Students at NTNU meet various forms of teaching and learning, real engineering problems and open problems. In recent years, some practical training in communication skills and teamwork has been introduced in the course Interdisciplinary Teamwork, laboratory work and projects in other courses.

With the specialization (22.5 ECTS) in the 9^{th} semester and the master's thesis of 30 ECTS, most students at NTNU will be exposed to and work on subjects approaching the research front.

3.5.2 Civil and Environmental Engineering

This example is mainly based on the work and the results of the thematic network EUCEET (European Civil Engineering Education and Training).

Categorization and scope of subjects

In the EUCEET the subjects taught in European civil engineering education have been categorized in eight subject groups and a proposal has been developed as to the recommended scope of each subject. The categorization and scope of the various subjects are listed in Tables 10 and 11.

Table 10: Categories of subjects in the civil engineering education

	Name of category	**Examples of subjects**
A	Basic Sciences	Mathematics, Physics, Chemistry
B	Engineering Sciences	Mechanics, Strength of materials, FEM, Computer science, Drawing graphics
C	Core Civil Engineering Subjects	Statics, Dynamics, Hydraulics, Soil Mechanics, Fluid mechanics, Elasticity & Plasticity, Building materials, Surveying, Reinforced concrete, Hydrology
D	Engineering Specialization	Steel structures, Reinforced concrete structures, Foundation Engineering, Earthquake engineering, Non-linear design of structures, Hydraulic systems in transitory regime, Hydraulic structures
E	Economics and Management subjects	
F	Humanities, Social sciences, Languages and Physical Education	
G	Field Work	
H	Final Project	

Table 11: Proposed scope (in ECTS) of core subjects in the civil engineering education

No	CORE SUBJECTS IN CURRICULA FOR CIVIL ENGINEERING	Credits for course:		
		Integrated	Two-tier system	
		10 sem	1st cycle 8 sem	2nd cycle 2 sem
1.	Mathematics and Applied Mathematics	19.0-27.0	13.0-19.0	5.0-7.0
2.	Applied Chemistry	3.0-4.0	2.5-3.5	
3.	Applied Physics	5.5-7.5	4.5-6.5	
4.	Computer Science and Computational Methods in C.E.	7.0-9.0	5.5-7.5	1.5-2.5
5.	Drawing and Descriptive Geometry	4.0-6.0	3.5-4.5	
6.	Mechanics	5.5-7.5	4.5-5.5	1.0
7.	Mechanics of Materials	8.0-11.0	6.5-8.5	1.5-2.5
8.	Structural Mechanics	9.0-13.0	7.0-10.0	1.5-2.5
9.	Fluid Mechanics & Hydraulics	5.0-7.0	4.5-6.5	1.0
10.	Engineering Surveying	4.5-6.5	4.0-6.0	1.0
11.	Building Materials	5.5-7.5	4.5-6.5	1.0
12.	Buildings	3.5-5.5	3.5-4.5	
13.	Basis of Structural Design	3.5-5.5	3.5-5.5	
14.	Engineering Geology	3.5-4.5	3.0-4.0	
15.	Soil Mechanics and Geotechnical Engineering	7.5-10.5	5.5-7.5	1.5-2.5
16.	Structural Concrete	8.0-11.0	6.0-9.0	1.5-2.5
17.	Steel structures	6.5-9.5	5.0-7.0	1.5-2.5
18.	Timber, Masonry and Composite Structures	3.5-5.5	3.0-4.0	
19.	Transportation Infrastructure	3.5-5.5	3.5-4.5	
20.	Urban and Regional Infrastructure	2.5-3.5	2.5-3.5	
21.	Water Structure and Water Management	3.5-5.5	3.0-4.0	
22.	Construction Technology & Organization	6.0-8.0	4.5-6.5	1.5-2.5
23.	Economics and Management	6.0-9.0	5.0-7.0	1.5-2.5
24.	Environmental Engineering	3.5-5.5	3.5-4.5	
25.	Non-technical subjects	7.5-10.5	5.0-7.0	2.0-4.0
Core subjects total		175.0	140.0	30.0
Specialization subjects total		125.0	100.0	30.0
Total		300.0	240.0	60.0

Table 12 is based on an effort to compare the Civil and Environmental Engineering programme at NTNU with the EUCEET proposal. Direct comparison is somewhat difficult due to some variations in the structure of the programme of study.

Table 12: Comparison between the scope of each subject according to the proposal by EUCEET and current practice in the Civil and Environmental engineering programme at NTNU

Subjects	**EUCEET**	**NTNU Civil Engineering**
Mathematics, Statistics	23	37.5
Applied Chemistry	3.5	7.5
Applied Physics	6.5	7.5
Mechanics (+?)	27	15
Hydro mechanics	6	7.5
Computer – ICT	8	7.5
Land surveying	5.5	~0
Building materials	6.5	7.5
Geology, Geotechnics	13	7.5
Building, Construction	13.5	7.5
Concrete Constructions	9.5	3.75
Steel Constructions	8	3.75
Infrastructure	7.5	7.5
Water, Environment	9	7.5
Economics, Organization	14.5	7.5
Drawing, Geometry	5	~0
Non-technology (incl Interdisciplinary Teamwork)	9.0	30
Core subjects total	**175.0**	**165**
”Specialization” subjects	**125.0**	**135**

Contact time

At NTNU and internationally, contact time is a frequently used term which is a suitable quality measure. According to the findings of the EUCEET network, the average contact time in the integrated 5-year programmes of study was 3900 hours, varying between 2700 and 5100 hours. Weekly contact time averaged 26.8 hours a week, with a minimum of 18.5 and a maximum of 36 hours a week. A comparable number for NTNU would be 24 to 30 hours a week.

Development trends and changes – general perceptions

Through the EUCEET network we see the following development trends and changes in the engineering education:

- Basic subjects - mathematics and natural sciences – seem to have had the same extent over the past 20-35 years, perhaps with a minor increase. Such basic subjects typically make up 20-30 % of the programme of study.
- There is a trend towards a reduction in core subjects in engineering, while specializations seem to increase. Core engineering subjects make up 20 – 30 %.

- Applied and specialization subjects are often elective. The extent varies a lot between the universities, with everything between 15 and 45 % of the total programme in these subjects.
- There is a trend in the direction of more non-technological subjects - humanities, social sciences and economics.

Non-technological subjects
The most important non-technological subjects can be classified in the following seven groups:
a) Subjects relating to management and economics
b) Laws and regulations
c) Communication and negotiation skills
d) Humanities (including management attitudes and ethics)
e) Arts
f) Foreign languages
g) Ecology and environment

Non-technological knowledge and skills are introduced through:
- *formal learning* in terms of elective non-technological subjects such as courses in communication skills
- *integrated learning* by which students gain non-technological competence in technological subjects for instance gaining communication skills through presentations/ defence of term papers
- *informal learning* via participation in activities outside the formal programme, such as learning communication skills in the student radio, newspapers etc.

Recruitment and student exchange
More than 100 000 students annually take part in student exchanges in Europe. The exchanges may take various forms, but the total illustrates that this is an important and often integrated part of the studies for many students. The timeframe is normally up to one year. The number of student exchange agreements varies between countries. Germany, Spain, Italy and France have a high number of student exchange agreements (more than 60). In 2/3 of these agreements, the exchange is based on approval of individual courses, while 1/3 of these agreements offer a general approval semester by semester. The exchange of academic staff has fallen by about 40 % from the academic year 2003/04 till 2004/05.

3.5.3 Industrial Economics and Technology Management

Part of the subjects taught by the Department of Industrial Economics and Technology Management for the engineering students in industrial economics and technology management at NTNU is also taught at business schools and technical universities throughout the world. It is largely speaking only in the Nordic countries that industrial economics is offered as an engineering programme. Engineering programmes in industrial engineering are found in many places elsewhere; these studies normally have less economics than the programme of study in industrial economics and technology management at NTNU.

The NTNU programme has close contact with the comparable studies in Linköping and Chalmers. The quantitative part of our programme has many similarities with Linköping, while the qualitative part has more in common with Chalmers.

Based on informal discussing with exchange students – incoming and outgoing – the programme management has got the impression that our students have no difficulty following the courses at foreign universities (e.g. the Vice Dean of Engineering at Auckland University report that he is very satisfied with the NTNU students), while incoming students express that they have a positive learning outcome during their NTNU stay. The NTNU programme may, however, be more structured and school-like than some students are accustomed to from their home institutions (e.g. comment made by a student from Darmstadt and impressions from Edinburgh where students tended to work more independently on individual problem solving.

The engineering programme in industrial economics and technology management is largely multidisciplinary during the first three years of study. The students will thus not have reached as far in their core economic-administrative subjects during these years compared to the engineering students who to a greater extent may concentrate on their core engineering subjects. This implies that it might be less relevant for these students to be offered a degree after three years compared to other engineering students. Again this means that it is less likely that there will be enough students with equivalent knowledge to the industrial economics students, if the programme is divided in 3 + 2 years. A two-year master's programme would probably not bring our students as far as they are within the current five-year integrated engineering programme. For the Department of Industrial Economics and Technology Management it is thus important to maintain the integrated programme.

A transition to a 3 + 2 model requiring separate admission to the last 2 years, would probably not increase the number of applicants to the technology studies at NTNU.

It is important that NTNU is visible and participate internationally, but until NTNU possibly is ranked among the 10 best technical universities in Europe, it is not likely that very many foreign students will want to take their full master's degree at NTNU. With the current student exchange opportunities and/or joint degrees, we will probably receive more foreign students. It would, furthermore, be a prerequisite that all subjects in certain programmes of study are taught in English if we are going to have a large increase in the number of foreign students at NTNU.

In our experience, our students visiting recommended foreign universities are often perceived as good students by these universities thereby promoting and making NTNU visible abroad.

3.5.4 Marine Technology

This comparison of subjects and subject contents is based on information from student exchange with other universities in Europe, Brazil, the USA and Australia. At any point of time, approximately 20 % of the marine technology students in the 4^{th} and 5^{th} year stay abroad. Their programme and subjects abroad is approved by the person responsible for the relevant specialization chosen by the student.

Subjects offered (comprehensiveness)

The educational offer in marine technology at foreign universities is generally less comprehensive than at NTNU, although in certain areas comparable to NTNU. It is our perception that we have a comprehensive offer of subjects fully comparable with the best internationally. As mentioned below relating to the joint programme with TU Delft, they have a broader offer in ship management and ship production. The Department of Marine

Technology is on the other hand known for having a particularly broad and good offer in hydrodynamics and structural analysis.

Level of competence
The level of competence largely follows the educational offer. There is generally a rather good correspondence between the research activity at the Department and the educational offer (in the latter years of study). Repeatedly students returning after a period of study abroad, have to take courses at lower levels in order to catch up for their specialization. The work load per ECTS credit varies significantly between different universities; in particular certain universities in the USA have a heavy work load.

Requirements as to previous knowledge
The students have in most cases good previous knowledge. For our students, the choice of subjects at an equivalent level abroad is largely unproblematic.

Forms of teaching and examination
The types of teaching methods and follow-up differ at some universities from what we are accustomed to at NTNU. There is in particular large variation in the use of project work and mid-term examinations.

General impression
The general impression is that the programme of study in marine technology at NTNU has a scope and level at the forefront internationally. There are, nevertheless, universities who may offer a wider and better offer in special areas as the description of the cooperation with TU Delft below illustrates.

Joint programmes of study between TU Delft and NTNU
We have started a joint programme of study in the 4th year for students at TU Delft and NTNU. It involves NTNU students who have chosen to specialize in Marine Design and Marine Engineering. A stay in Delft is compulsory for NTNU students who have chosen these specializations.

In the first round of this joint programme cooperation the students spent the autumn semester 2006 at NTNU and the spring term 2007 at TU Delft. Practical matters - enrolment, stay and exams - are handled by the partners. Initially we will have 10 to12 students in this joint programme, but the aim is to gradually expand.

TU Delft is recognized as one of the top 10 technical universities in Europe. TU Delft – Department of Marine & Transport Technology – has, furthermore, a complete programme in marine activities. The programme of study is thoroughly prepared and has a very good quality. The subjects offered are, not least, largely complementary to what we offer at NTNU.

3.5.5 Statements made by two foreign students from Germany

German student from Technical University Darmstad
I took my master's degree in industrial economics in 2002 at the Technical University Darmstadt, Germany. From August 1999 until June 2000, I was an exchange student at the Norwegian University of Science and Technology in Trondheim. During this year, I followed

two classes at the Department of Industrial Economics and Technology Management (Operational Analysis 2, in fall 1999 and Operational Analysis 3, spring 2000), and one class at the Department of Materials Technology (Materials Technology 2).

The two classes in Operations Research corresponded to the exam in the OR specialization, whereas the class in Materials Technology was recognized as equivalent to the class taught at my home university.

The general impression I had (which is – of course – entirely subjective), was that the Norwegian system of teaching is more organized than the German system. It is more like a school, thus also requiring less independent work by the student. As much as I like the clear structure, I think it is an advantage of the German system to put more responsibility on the student.

A big advantage of the Norwegian system is the availability of the teaching staff. The professors were in general always willing to answer questions and help in solving all kinds of problems. The standard in Darmstadt is that here is one hour in the week the professors sees his students. The rest of the teaching staff usually has also just one hour per week each, which is a big contrast to the common open-door-policy I experienced while staying at NTNU in Trondheim.

Experiences of a German exchange student

Frank Henning was an exchange student at NTNU Department of Marine Technology in the academic year 2002-2003. He describes his experiences as an exchange student in this way.

The reason for choosing NTNU as university for an exchange period was twofold. Norway has a reputation for being a shipping nation and a good maritime education is expected. In addition it seemed to be an attractive foreign country in which English is a common language. Course lists were available which claimed flexibility in the language of instruction.

It turned out that it was no problem to communicate in English; however, there was in fact no flexibility in the language of instruction. My concerns about me being able to follow courses without having the same background as Norwegian students turned out to be unnecessary. My impression was that the education in Germany (in engineering at least) is to a greater extent based on theory, e.g. in mathematics or engineering subjects, which enabled me to tackle the problems I studied in Norway without too much trouble. In my studies in Germany heavier weight was placed on the delivery of well done exercises (both content and layout) and a deeper in-detail understanding of the study material was expected. That attitude made it relatively easy to succeed in my studies in Trondheim.

I came to Trondheim also because I could take classes which were not offered at my university at home. In fact, the content of those courses was much more interesting than what my own institute had to offer. The content was closer to real and current applications. Altogether my studies in Trondheim were very motivating for me.

Apart from problems which arose out of language, some administrative issues posed difficulties for me. In some sense I had to fit in the Norwegian course system. I was not allowed to take subjects from different lines of study and I had to take the same type of exams as the Norwegian students. Since my university's regulations about exams were different from the NTNU regulations, I had difficulties to get a type of exam which would be acceptable in

Germany. In general, I got the impression that it is not very beneficial if foreign students have to fit in the host university's study system or if the home university insists on the use of their regulations.

My studies in Trondheim were closer related to real applications. Group work was expected to a greater extent and a greater responsibility in how to interpret exercises was demanded of the students. The study material covered a broader range of topics and put less emphasis on the understanding of the theoretical or practical foundations. I perceived the studies as motivating. In Germany exercises were defined more precise, but had to be carried out with greater care. There was less responsibility in interpreting assignments, but there was greater responsibility in organizing one's own studies. The studies were less structured. I realized that I had great benefit from my methodical and theoretical background. At the same time it was less motivating to study large amounts of theory. In general, the studies were less broad with greater emphasis on the theoretical foundations.

If I would have taken my whole studies in Norway, I believe I would have had motivating studies and as a result great belief in being able to find creative solutions to industry problems. However, I am convinced that the base for solving industry problems was laid in Germany. I perceive the theoretical part of the education as a crucial element that is less emphasized in Trondheim.

4. Thematic reports - Non-technological Courses in the Engineering Education

The working group appointed by FUS to review the non-technological courses in the Engineering Education (non-tech), were invited to address and give recommendations regarding the following topics:

- Interplay and integration between non-tech courses and other courses during the engineering education.
- How to include entrepreneurship and innovation in the MSc engineering programmes of study?
- Globalization/project management/economics/ Intellectual properties/Legal issues as part of the engineering studies.
- Interdisciplinary Teamwork as a course in the engineering studies.
- Which possibilities for non-tech courses are available at NTNU and which are most relevant for the engineering studies?

4.1 Background

4.1.1 Recommendations from the Curriculum Development Committee

The amount and content of non-tech courses were originally described by the Curriculum Development Committee in their first report (VK1:1993). In VK1 it was recommended that non-tech courses should comprise half a year of study (30 ECTS) with 4 courses of 7.5 ECTS. The motivation for including such courses in the programmes of study was to place engineering into a social context. These courses could either be directed towards the engineering profession or be of a more general character. An introduction to philosophy (Ex. phil) for engineering students was to be included in one of these courses. VK1 included the following topics in their recommendations: ethics, law topics, communication skills, environmental topics, organization, psychology, languages, technology history, and economics.

One of the other recommendations from VK1 was that all engineering students were to carry out an interdisciplinary project during the 8th semester. The project was to be performed in groups of students coming from different programmes of study or Faculties. This interdisciplinary project was the basis for Interdisciplinary Teamwork, which initially was a course for the engineering studies only, but later has been developed to a common course for all master's students at NTNU.

The non-tech courses were reviewed through the work carried out by Curriculum Development Committee in their second report (VK2:2003). The committee agreed that the engineering studies should include 4 non-tech courses. IKKETEK 1 (Ex.phil.) was recommended placed in the 4th semester rather than the first. IKKETEK 2 was suggested as a compulsory course “Technology Management”, placed in the 5th semester and with the following topics:

- Organization and management/Work and organizational psychology (30%)
- Economics (30%)
- Legal issues (30%)
- Business development and innovation (10%)

VK2 recommended that IKKETEK 3 was placed in the 7th semester and chosen from a list of courses selected by the Programme Councils, suitable to the profile of the various programmes of study. Finally, VK2 suggested IKKETEK 4 to be chosen freely by the students among courses provided at NTNU and placed in the 9th semester. VK2 also recommended that NTNU offers opportunities for graduate engineers to take further and continuing education in non-tech courses.

4.1.2 Courses that are common to all NTNU students

According to the Act relating to Universities and University Colleges, the Ministry of Research and Education may require that specific courses up to 20 ECTS must be included as part of any academic degree programme. Today an introductory course in philosophy (Ex.phil) is required by the Ministry. The Board of NTNU has decided that at least 20 ECTS of "common courses" is to be included in all bachelor's and integrated MSc programmes at NTNU. This requirement comprises 3 courses: Course 1 is Ex.phil, Course 2 is Ex.fac. and Course 3 is a so called "perspective course". The first two courses are preferably to be part of the first year of study.

The Executive Committee for Education at NTNU gave the following guidelines for the perspective course: NTNU has a special responsibility with respect to interdisciplinary cooperation. The perspective course is to give the students training in a different scientific tradition and approach and give insight into new areas. Moreover, it is to broaden the perspectives of the studies chosen by the students and provide insight in their own and other disciplines as well as serving as a basis for future interdisciplinary collaboration and communication. For the engineering programmes, FUS, decided to assign IKKETEK 3 as the perspective course.

A list of perspective courses is decided by the Executive Committee for Education at NTNU every academic year. The requirement is that the course chosen is to represent a different study culture. The lines between study cultures are drawn between different organizational units but such that technology, natural sciences and mathematics are seen as the same study culture. This means that only one department providing courses for the engineering studies, Department of Industrial Economics and Technology Management (IØT), is allowed to offer courses for IKKETEK 3 and IKKETEK 4. Only the MSc in Industrial Economics and Technology Management programme does not have this requirement on non-tech courses as it already containing a mixture of economics and engineering.

4.2 Current status - non-technological courses and Interdisciplinary Teamwork

Currently, the status of the non-tech courses in the engineering studies is rather weak, both among the engineering students and the academic staff. The working group finds that the term "non-tech" gives associations to topics not being relevant to the engineering programmes and that it thus contributes to lower the recognition of these courses. The attitude, both among students and academic staff, is that these courses are of little relevance to the engineering studies. This is evident from the answers to some of the questions addressed by selected engineering programmes during the self-evaluation process. The term "non-tech" also implies a distinction from technological courses, which may be an asset or drawback depending on the role these courses play in the engineering programmes. This issue will be addressed below. In the following, we comment on the current status of each of the non-tech courses.

4.2.1 Ex.phil. (IKKETEK 1)

The engineering students find that the introductory course in philosophy (Ex.phil) is of little relevance. One reason is that the content of the course has not been directed towards the study interests of these students as recommended by VK1. When entering university studies, the students are eager to learn as much as possible within their own field of study at an early stage. Moreover, the suggestion from VK2 regarding connecting the IKKETEK 2 course Technology Management to Ex.phil., has not been followed up. Except for a couple of engineering programmes, these two courses are now taught with significant separation in time.

4.2.2 Technology Management (IKKETEK 2)

The course content of Technology Management is today in line with the recommendations from VK2. The topics suggested by VK2 were carefully chosen based on a survey performed. The feedback from the students is that the content of this course is an important part of their studies. However, the course contains too many topics to be covered in too limited time and for this reason appears fragmented. Therefore the content of this course needs reconsideration.

4.2.3 IKKETEK 3 and IKKETEK 4

The engineering students choose IKKETEK 3 from a list of perspective courses. IKKETEK 4 can, in principle, be chosen among all courses available at NTNU, provided that the definition given for the perspective course is fulfilled. However, to a large extent students are also choosing this course (IKKETEK 4) from the list of perspective courses. It should be noted that the number of courses available on this list decreased significantly for the academic year 2007/08 due to the economic situation at the faculties. In the table below, the choices made by the engineering students in 2006 are given. In particular, “Medicine for Non-Medical Students, Introduction”, is a favourite course to a large number of students, even though this course is of clear relevance to only a selection of the programmes of study. The reason for this popularity is at least twofold: Medical topics are of general interest to the individual, and in this course the students have been graded based on a multiple-choice exam with marks Pass or Fail. This practice has made it possible to pass the exam with limited effort.

At present, the non-tech courses available for the engineering students and the choices made by the students fulfil the intensions given in VK1 and VK2 to only a limited extent. The Programme Councils have had no influence on the choices of the students, except for those programmes, which have made a specific topic for IKKETEK 3 compulsory to all of their students. Thus, the current regulations led to weak interplay between IKKETEK3 and IKKETEK 4 and other courses in the programmes of study as well as with Technology Management (IKKETEK 2). As a result, the relevance is not seen by the students, a situation which results in low motivation and a minimum work load invested.

Table 13: Perspective courses chosen by the students in 2006 (IKKETEK3 and IKKETEK4)

Course	**Number of engineering students**
Medicine for Non-Medical Students, Introduction	516
Spanish 1	97
Operations Research, Introduction	89
German 1	71
The Cultural Dimension of International Business	63
Design as a Creative Process	55
Work and Organizational Psychology	43
French 1	40
A Different Country	39
Energy, Environment and Society	36
Psychosomatics and Health Psychology	33
Digital Communication and Organizational Challenges	30
Market Oriented Product Development	27
Italian 1	26
Production Economics and Markets	25
Legislation of Environm. and Nat. Ress. – Plan. and Manag.	19
Health and Working Life	16
IT-based Organizational Development	11
Japanese Culture	10
Evaluation of Polical Risk	9
Group Processes, Organization and Leadership	8
French 2	7
Natural Resourses Management – Theories and Concepts	7
Our Global Society	5
Psychological Anthropology	4
Ethics	3
Globalization	3
Academic Thinking and Presentation of Academic Work	3
Organizational Design and Information Technology	2
Total number of students	1297

4.2.4 Interdisciplinary Teamwork

Substantial resources are allocated to the course Interdisciplinary Teamwork at NTNU. The working group notes the same challenges for this course as pointed out by the Strategic Committee on Interdisciplinary Teamwork (spring 2007). In general, the engineering content of this course is considered too weak for the engineering students, and the learning outcomes vary dramatically depending on which "village" the students have been assigned to. It should be emphasized that when asked, many students answer that they have learned about group dynamics and processes during this course. However, the committee is of the opinion that this (important) part of this course also depends on having adequate professional problems to be addressed by the various groups.

4.3 Discussion and recommendations

In general, the working group has used the work done by VK1 and VK2 together with input from the different programmes of study as a basis for its recommendations. The reason for this is that the studies done by VK1 and VK2 to chart the opinion of the "market" for engineers still are our most important source of information regarding the relevance to the work market for those with MSc Engineering education at master's level. Because the work and recommendations of VK1 and VK2 partly took place before - and independent of - the national and local regulations (common courses for all students), we do not find it appropriate to discuss non-tech courses as part of the engineering programmes within a framework that is in conflict with the regulations set by the Board of NTNU. Therefore, the working group wants to take a pragmatic approach in which the regulations that are valid for all NTNU students become an integral part of this discussion.

The working group finds that most points where we are not satisfied with the current situation are where the suggestions and recommendations of VK1 and VK2 have not been followed. Another evaluation should be done four years from now to see whether the changes recommended below (if implemented) have increased the satisfaction with respect to learning outcomes and relevance.

4.3.1 Status and level of the non-tech courses

In general, the working group is concerned about the reputation of the non-tech courses in the engineering studies. They are not fulfilling the goals of VK1 and VK2 in the present form and are not regarded as relevant by the students and partly not by the academic staff. The committee strongly recommends that measures are taken to improve this situation. A change of name for these courses is imperative, and the committee suggests that they should be called "Complementary courses".

The working group finds that the existing portfolio of "Perspective courses" is experienced as irrelevant. Courses offered are not geared towards being relevant to the engineering students. Instead, existing courses, usually at the bachelor's level in other programmes of study in medicine, humanities or social sciences are offered to the engineering students. This creates severe problems with relevance and with respect to the level of the courses. IKKETEK3 and IKKETEK4 are both coming at a late stage in the engineering programmes and should hold at least a third year bachelor's level, taking into account that the students are mature at this point in their education. In this respect, the working group recommends that IKKETEK 3 and

IKKETEK 4 should be above introductory level, i.e. above the 1000 level which corresponds to introductory/basic courses during the first 2 years of study in a bachelor's degree.

4.3.2 Number of Complementary courses

The working group has been discussing the amount of complementary courses in the engineering programmes. The different engineering programmes and specializations have different requirements in terms of professional and complementary courses. Moreover, the interests of the students vary widely. Based on these considerations the working group suggests that in addition to Ex.phil. and Technology Management at least one more complementary course should be compulsory. In addition, depending on the requirements given by the Programme Councils and/or FUS, one (or even two) more complementary course can be chosen. A description of how this can be done is outlined below.

4.3.3 Course content and organization

Ex.phil.

Most engineering programmes find the existing IKKETEK 1 to be of little relevance. To solve this problem and strengthen the role of Ex.phil. in the engineering programmes, the working group recommends that the content of Ex.phil. for engineering students is changed in direction of topics of particular interest for this field in accordance with the original recommendation given by VK1. The precise content of such a changed course needs to be discussed, but may include science theory and science history with emphasis on engineering and natural sciences. The committee believes that this will strengthen the relevance of this course among the students and also make it a more integrated part of the engineering programmes. On the other hand, it can be argued that having a "different" course like Ex.phil. during the first year of university studies may provide a sound, topical contrast to the courses in mathematics, science and introductory engineering. If a link is to be obtained between Ex.phil and Technology Management, these two courses need to be placed in sequential semesters. For a couple of programmes this is the situation already today, and it seems to be a good solution, even though there are no obvious links in content between these two courses as they are taught today.

The current flexibility with respect to which semester Ex.phil. is taught in the different programmes of study, is considered as an asset for the overall structuring of the courses in the programmes. The working group recommends that this flexibility is maintained also in the future. A good overall structure of programme specific courses and basic courses in mathematics, natural sciences and computer science during the first part of the programmes of study is more important in this respect. Due to its status through national regulations, it is recommended that Ex.phil. is referred to with its proper name rather than "Complementary course 1".

Technology Management

The working group has discussed the content and status of Technology Management. As it has been developed in accordance with the recommendation given by VK2 and the topics included in the course were chosen as a result of thorough investigations of what former students and representatives of the companies and organizations employing engineers believe should be taught, the working group recommends that Technology Management continues as a compulsory course for all engineering students and suggests that it is referred to as "Complementary course 1". This course includes topics, which should be part of all

engineering programmes of study. However, the number of topics covered by the course should be reduced. Thus, the working group supports the suggestions made by IØT, that legal issues are removed as topic in Technology Management. Legal issues require the introduction of so much basic terminology and understanding that it is not compatible with covering several other large topics in the same course. A new, full course covering legal issues more deeply should therefore be offered as an elective possibility under Complimentary courses 2 and 3 (see below).

The current flexibility, with respect to which year and semester Technology Management is included in the different programmes, is considered as an asset for the structuring of the courses in the programmes. This flexibility should be maintained also in the future.

Complementary courses 2 and 3

Regarding Complementary course 2 the working group again wants to turn the attention to the recommendations given by VK2 on IKKETEK 3, but also to the original suggestions by VK1. According to VK2, IKKETEK 3 should be chosen on the level of the programme of study. In addition, care should be taken to ensure a sufficiently high level of the courses offered and ensure relevance through a choice between a limited number of courses. The working group recommends that Complementary course 2 is regarded as "Perspective course" for the engineering programmes.

In Table 14, two options are illustrated. Option 1 has a total of three complimentary courses, whereas option 2 *requires* only two complimentary courses and has a choice among a technological course and complimentary course 3. It should be noted that even one more complementary course can be selected at the expense of "the engineering course from a different engineering programme" during the 4th year.

Table 14: Illustration of the options with respect to Complementary course 2 and selection of Complementary course 3 or a technological course

	Option 1	Option 2
4th or 5th year	Complementary course 3	Technological course/Complimentary course 3
3rd or 4th year	Complementary course 2	Complementary course 2
2nd or 3rd year	Technology Management*	Technology Management*

* Technology Management = Complementary course 1

There were different views with respect to these alternatives (options) in the working group. Some argue that the norm should be three complementary courses (option 1), and that option 2 should be an exception which should be discussed with FUS in each case. This view is founded on the work by VK2 and its recommendations regarding strengthening different complementary aspects of the programmes including topics like organization, legal issues, entrepreneurship and IPR. However, there is a considerable topical spread among the various (16) programmes of study and some have problems finding sufficient room for their technological specialization courses. Consequently, some members of the working group argued that it is more important to address this problem than requiring a fixed number of complementary courses. The boards of the programmes of study have the expertise to make the suggestion concerning options 1 or 2. The most flexible situation would be to let the individual student choose between Complimentary course 3 and a technology course, based on their academic interests. It should be up to the programme councils to suggest if this alternative should be possible for their students.

To ensure sufficient level and progression between the complementary courses, the working group recommends that a selection of “building blocks” is offered to the engineering programmes. Each “block” should consist of complementary courses building on each other in order to ensure progression and a sufficient level of these courses. Students who take two or more such courses will then have a group of courses, which functionally could comprise a “minor”. A list of suggested “blocks” building on Technology Management is described in the textbox below. Each engineering programme can then decide which “blocks” are relevant for its students, including “blocks” not directly building on Technology Management. The number of “blocks” for each programme should be limited and the working group suggests an upper limit of 5 “blocks”. If necessary, the programme could also list one “block” as their only choice. This would in effect make Complementary course 2 (IKKETEK 3) a compulsory course in that programme. The available blocks should be approved by FUS.

Currently IKKETEK3 and IKKETEK4 are taught in the autumn semesters - the 7th and 9th semesters, respectively. The working group foresees no change in this respect for Complementary course 2 and 3 unless Technology Management is taken at an early stage in the programme of study, which opens for a Complementary course 2 already in the 5th semester and Complimentary course 3 in the 7th semester. Flexibility with respect to autumn or spring semesters may be considered if some of the courses attract so many students that parallels can be provided.

4.3.4 Interdisciplinary Teamwork (EiT)

In the context of the total amount of non-tech courses in the curriculum, the committee wants to emphasize that the engineering content and relevance of the course EiT has to be improved. Again, the interplay between professional and group dynamics contents of this course must be stressed. Also, good quality learning outcomes must be obtained for all students independent of villages. The committee wants to underline the importance of addressing engineering problems based on proposals from industry or other external “customers” in the project part of EiT. The competence required for attacking these problems should be reflected in the disciplines to be covered by the group members in the villages.

If NTNU is not able to develop EiT in this direction, the committee recommends that it be made elective. If NTNU chooses to keep this course as compulsory without strengthening the engineering content for the engineering students, the committee suggests that it is turned into a perspective course. It should however be stressed that the committee feels that making EiT an elective course or a perspective course in the long run will be detrimental to this course.

Textbox 1: Suggested "blocks" for Complementary course 2 and Complementary course 3

Examples of possible "blocks" for Complementary course 2 and 3.
Existing courses are listed with their course numbers (incl. Department abbreviation), courses that should be revised or new courses are marked with xxx.

Economy and accounting block:
Complementary course 2:
TIØ 4111 Economy and accounting (finance and internal accounting, accounting principles)
Complementary course 3:
TIØ 4142 Finances and investments (investment analysis, financial issues related to loans, real and capital investments, disk analysis) or
SØKxxxx Macroceonomic Project Evaluations (how to evaluate projects and the impact they have on the societal level)

Entrepreneurship and innovation block:
Complementary course 2:
TIØ4230 Market oriented Product development (product development and commercialization)
Complementary course 3:
TIØ4320 Strategic Negotiations (negotiations connected to external investments for enterprise establishment) or
TIØxxxx Contract Law and Intellectual Property Rights

Legal issues block:
Complementary course 2:
TIØ xxxx Contract Law and Intellectual Property Rights
Complementary course 3:
TIØ4xxx Company Law and Labour Law or
TIØ4xxx Environmental Law and Corporate Social Responsibility

Organizational development block:
Complementary course 2:
TIØ5200 Project Organizations
Complementary course 3:
SISxxxx Virtual organizations and change management
SISxxxx Organizations and the use of ICT

Project Management block:
Complementary course 2:
TIØ5200 Project Organizations or
TIØxxxx Project Economics and investments
Complementary course 3:
TIØ5215 Programme and Portfolio Management or
SØKxxxx Macroeconomic Project Evaluations (how to evaluate projects and the impact they have on the societal level)

Intercultural work environments block:
Courses given by geography and anthropology.

4.4 Summary

As part of the evaluation of the 5-year integrated Master of Science in engineering programmes at NTNU, a committee was appointed to discuss and give recommendations regarding the courses included in these programmes entitled non-tech courses as well as on the interdisciplinary course Interdisciplinary Teamwork. The recommendations from this committee are given in this report. The main aspects that need to be strengthened for the non-tech courses are their relevance, academic level as well as their progression. The main recommendations are:

- The term “non-tech” courses should be omitted. The committee proposes the term “complementary” courses.
- All complementary courses must be at an appropriate academic level.
- The content of Ex.phil. (IKKETEK 1) should be revised with the aim of changing the curriculum to include more relevant topics for the engineering students.
- The course Technology Management (TIØ 4258) is recommended kept as an obligatory course for all engineering programmes, but with a reduced number of topics. More specifically, it is recommended that Legal issues are not taught in this course.
- The flexibility with respect to the semester where Ex.phil. and Technology Management are taught in the different programmes of study, should be continued.
- As a minimum, one more complementary course, in addition to Ex.phil. and Technology Management, should be obligatory. This is the Perspective course, which is obligatory for all BSc and integrated MSc programmes of study at NTNU.
- It is recommended that the complementary courses are chosen as “building blocks” with progression from one course to the next and that a limited number of these “blocks” is chosen for each programme of study.

5. Thematic Reports - Recruitment of Students

The working group appointed by FUS to review recruitment of students, was asked to address and give recommendations regarding the following topics:

- Relevance of Science Education (ROSE project). How to use the information about young people's preferences in the recruitment strategy?
- The strategy for natural science of the Ministry of Education and Research – what can we do at NTNU?
- Admissions requirements – entrance tests - different paths to admission
- Insufficient background – who ensures that young people can improve their qualifications – a year zero at the universities?
- International dimensioning and recruitment – which international master's programmes in engineering should NTNU have and which joint degrees and joint programmes?

The working group has collected some relevant statistics about national and international recruitment, and has provided information about the completion rate among students admitted to the engineering education at NTNU (see Section 5.4). The working group focused on recruitment of students to the 5-year integrated engineering education at NTNU, but has not discussed recruitment of students with a bachelor's degree in engineering from Norwegian university colleges.

5.1 The general picture

Engineering education at NTNU should have two main goals for its recruitment policy:

- achieve and sustain strong national recruitment
- build strategy for international recruitment policy

We begin by addressing the challenges related to the first goal. ROSE (Relevance of Science Education, see http://www.ils.uio.no/english/rose/) is an international comparative research project intended to shed light on factors of importance to the learning of science and technology. The target population is students towards the end of secondary school (age 15). The results of ROSE are highly relevant for a discussion of recruitment of students to the engineering education at NTNU. In short, the results so far reveal that young people seem to acknowledge the importance of science and technology, but in highly developed countries, that does not seem to affect their choice of career: Remarkably few are interested in working in these fields, and this lack of interest is particularly strong among females.

There is a widespread international concern about this situation, clearly visible in official EU policy statements, such as the EU's *Science and Society Action Plan.* In Norway, the Ministry of Education and Research has launched a strategy and an action plan (2006), "Et felles løft for realfagene", to increase the recruitment of young people to science and engineering education. There is broad participation from industry and society at large in this political initiative.

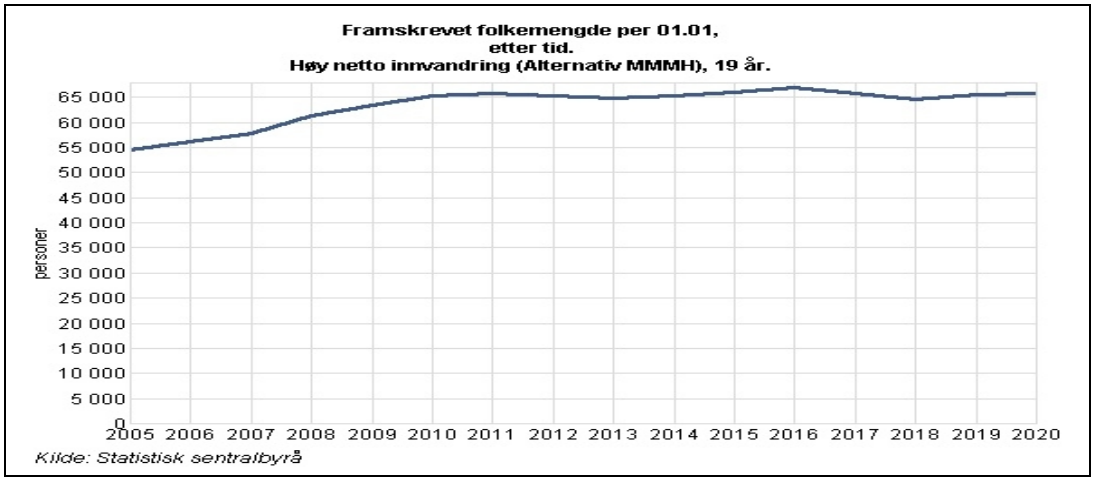
Over the last three years, the annual number of upper secondary school graduates that fulfil the formal requirements[11] for admission to engineering studies at NTNU, has been slightly more than 5000. On the other hand, some 1300-1400 students are admitted every year; the number of applicants with engineering studies at NTNU as their first priority has been roughly twice the number of students admitted. This means that roughly half of those formally qualified for engineering studies at NTNU apply, and roughly one quarter of them are admitted. These numbers indicate broad national recruitment as well as crucial dependence on such recruitment. Demographic predictions show no drastic changes in this situation towards 2020.

The main concern is that roughly 10 % of Norwegians of age 19 have the required upper secondary school curriculum for admission to engineering education at NTNU. This percentage, which is low even in comparison with other highly developed countries, is in accordance with the findings of the ROSE project.

A peculiarity that affects the recruitment policy of NTNU is the fact that NTNU is not only an engineering school; it is also a comprehensive university with a broad range of research and education within fine art and the humanities, the social sciences, architecture and medicine. While NTNU has a national position and responsibility within the field of engineering, its recruitment policy must always be sufficiently balanced so that the whole spectrum of disciplines is clearly visible. Finding the right balance is not an easy task; NTNU as an engineering school is an institution with a strong and leading national position, while NTNU as a comprehensive university is one among seven universities in Norway.

Figure 6 shows that the number of 19 year olds in Norway will increase from about 55 000 in 2007 to about 65 000 in 2011, a number that will be quite stable until 2020. Based on such national trends, one may predict that the number of applicants may increase quite significantly over the next few years.

Figure 6: Projection until 2020 of the number of 19 year olds in Norway.
Source: Statistics Norway (SSB)



[11] The formal requirement was until 2006 3 years of the highest level of mathematics and two years of the highest level of physics (or some equivalent of this) from upper secondary school. From 2007, as a 2-year trial project, an additional requirement was added: mark 4 or higher in the third year of upper secondary school mathematics. (Marks 1-6, with 6 the highest mark.) As a result, the number of upper secondary school graduates that are formally qualified, has dropped significantly from 2007.

5.2 Organization of recruitment work at institutional level

5.2.1 National recruitment

At the institutional level, the work promoting recruitment of students is conducted by a group of four consultants in the Student and Academic Division, Section for Recruitment and Student Admission ("the recruitment unit"). In addition, much work is done at the Faculty and department levels as well as within the different programmes of study. Currently, the recruitment unit is working out an overview of such activities, aiming at running NTNU's activities as efficiently and coherently as possible. The self-evaluation reports of the individual programmes of study give descriptions of some of this work.

The recruitment unit is governed by the *Steering Committee for Recruitment* which meets 5-6 times a year. The committee is currently composed of:

- Pro-Rector for Education and Quality of Learning
- Information Director
- Director of the Student and Academic Division
- Dean of the Faculty of Arts
- Faculty Director, Faculty of Natural Sciences and Technology
- A scientific representative from Faculty of Engineering Science and Technology
- A student representative

In addition, an administrative body named *Forum for Recruitment* has been established, in which representatives for all Faculties, Information Division, Section for International Relations, "Females & Data"[12] and the Executive Committee for the Engineering Education take part. This group meets every two or three weeks, and it:

- constitutes a discussion forum for NTNU's work on recruitment and serves as an advisory body for the recruitment unit,
- gives information about recruitment efforts to and from the Faculties and departments,
- has operational responsibility for several tasks conducted at institutional level (like production of folders and participation in education fairs).

Strategic guidelines for the work of the recruitment unit

The recruitment unit should promote all programmes of study at NTNU, but put additional weight on its main profile. In addition, the recruitment unit should give priority to the following aspects:

- Its primary target group is young people aged 17 – 21
- Recruitment from certain selected geographical regions, such as Trondheim, Oslo, Bergen, Stavanger, and surrounding areas of these cities
- Recruitment of female students to engineering education
- Recruitment of students belonging to a lingual minority group

[12] A project aimed at increased recruitment of female students to ICT studies.

- Recruitment of students to the 2-year international MSc programmes at NTNU.

Activities

The following is an overview of the most significant activities of the recruitment unit:

- Participation at major higher education fairs (approximately 10 in Norway)
- Upper secondary school visits (the number of schools visited has in recent years increased from approximately 200 to close to 300)
- Visits of upper secondary school students to the campus (significant increase of number of visits in recent years)
- "Teknolos" (project aimed at motivating pupils in 10th grade for mathematics and science; these are 15 year old pupils in secondary school that are about to choose their upper secondary school education)
- Marketing (Newspapers, magazines, cinema commercials etc.)
- Production of folders
- Seminars and general information for upper secondary school advisers

An anomaly in the organization of recruitment activities, is that the Information Division (under the Director of Organization and Information) is responsible for the *recruitment web* http://www.ntnu.no/. An administrative webforum with representatives from the Faculties takes care of the development of the recruitment web, and the members of this group are responsible for keeping the web pages of the respective Faculties updated. There is partial overlap between this group and the Forum for recruitment.

5.2.2 International recruitment

The recruitment unit is also responsible for recruiting self-financing students to the two-year international MSc programmes. This is a relatively new task. So far, the following organizational moves have been made:

- A working group with representatives from the recruitment unit and the Section for International Relations has been established (both units are within the Student and Academic Division).
- There has been a meeting with those responsible for the 2-year international master's programmes, a group that is likely to be developed as a consulting body for the work group, much as Forum for Recruitment is for the work on national recruitment.

Activities

A number of activities have been launched, among these are:

- Production and distribution of a catalogue of international MSc programmes
- Production of English web pages
- Agreement with Student Recruitment Media (SR Media)
- "Polish ambassadors" (local student representatives at Polish universities)
- Production of an "information package" for NTNU students and employees travelling abroad
- NTNU was responsible for the 19th Annual EAIE conference (September 2007)

- Collaboration with ESN (European Student Network) about using students travelling abroad as “ambassadors”, as well as about spreading information among foreign students at NTNU.
- Stands at educational fairs in Berlin, Minneapolis, and St.Petersburg during 2007.

A number of additional activities and actions are being planned. However, strategic guidelines are still missing. A need for such guidelines is strongly felt by the recruitment unit.

5.3 Important factors, recommendations, and possible actions

5.3.1 Reputation

The single most important factor for recruiting students to engineering studies at NTNU is our *reputation*, which should be expected to be strongly correlated with the quality of our programmes of study and our research activities in a long time span. Our reputation relies on other factors as well, such as how the attractiveness of student life in the city of Trondheim is conceived among upper secondary school students. The advice of friends, parents, and other close relatives is likely to play a decisive role for students’ choice of school and field of study. From this perspective, the quality of our engineering education decades ago plays an important role for present recruitment, since parents are likely to base their advice on their own experience.

5.3.2 Organization

The central unit for recruitment and admissions seems to function well. In particular, it is our impression that it has found a reasonable balance between recruitment actions for engineering education and other fields. There is however a lack of contact with the academic leadership at Faculty level in the way it is managed at present. This situation could be remedied by letting the Executive Committee for Education at NTNU take on the responsibility of governing the NTNU policy for student recruitment.

5.3.3 Web pages

Surveys show that the web pages of NTNU are of great importance for recruiting new students. Young people are adept at navigating on the Internet and use the web frequently to acquire information. Information about courses, about future job opportunities and about facilities like computer labs and laboratories are questions the prospective students expect to find answers to through www.ntnu.no.

NTNU as a technical university is on display through our web pages. The outside world, including potential students, should expect our web pages to be based on the best technical tools available at any time. The programming behind the pages should be state of the art, so that it will be easier to transfer information to other devices, for instance cell phones. It is essential that our pages are easily accessible for disabled people and detectable by search engines such as “Google”.

A basic requirement is that the pages should be up-to-date; the information must therefore be corrected and updated regularly, and old pages with outdated information should never be accessible. The main focus for prospective students is to read about the programme of study to which they are applying and also to see available opportunities at NTNU. Thus there should be only one active page per programme of study which contains the desired, correct and the updated information. The possibility to change and make correction to these pages should be easy and flexible so that it is easy for the different programmes of study to maintain

its pages. There should also be automated systems for maintenance. There should also be ways of individualizing the pages while maintaining the overall similarity.

Prospective students will access our web pages mainly in the period from November to June. During this period it is important that the web pages are stable and that the information we want our future students to read is up-to-date.

The information about NTNU available in English, for instance about courses and individual programmes of study, should be much more extensive than it is at present.

5.3.4 Recruitment of female students

The table below shows the percentage of female students admitted to the different programmes of study. These numbers show that roughly one quarter of the students admitted to the programmes of engineering at NTNU are female. A few of the programmes have a majority of females among their students, while electrical engineering and ICT are fields that do not attract many female applicants.

Table 15: Total number and percentage of female students admitted at the programmes of study in engineering 2004-2006. Source: DBH

MSc in Engineering:	2004			2005			2006		
	Total	Female		Total	Female		Total	Female	
MASTER 5-YEAR:	No.	No.	%	No.	No.	%	No.	No.	%
Computer Science:	102	10	*9.8*	101	4	*4.0*	111	15	*13.5*
Engineering Cybernetics:	83	6	*7.2*	98	10	*10.2*	70	6	*8.6*
Electronics	98	2	*2.0*	75	4	*5.3*	66	6	*9.1*
Communication Technology:	65	10	*15.4*	57	8	*14.0*	65	18	*27.7*
Industrial Design:	21	8	*38.1*	19	12	*63.2*	26	15	*57.7*
Ind. Economy & Tech.:	91	26	*28.6*	101	22	*21.8*	112	34	*30.4*
Earth Sci & Petrol:	75	20	*26.7*	80	26	*32.5*	106	55	*51.9*
Phys/Math:	121	34	*28.1*	98	29	*29.6*	92	36	*39.1*
Marin Tech:	86	17	*19.8*	83	15	*18.1*	92	15	*16.3*
Chem.Engineering and Biology:	89	51	*57.3*	68	34	*50.0*	93	60	*64.5*
Civil and Environ. Eng.	168	58	*34.5*	157	39	*24.8*	146	49	*33.6*
Product Des. and Manuf.:	118	25	*21.2*	122	23	*18.9*	128	35	*27.3*
Materials Sc. and Eng.	28	5	*17.9*	34	4	*11.8*	30	8	*26.7*
Energy and Environment	114	25	*21.9*	89	18	*20.2*	109	45	*41.3*
Engineering and ICT:	41	3	*7.3*	65	8	*12.3*	64	11	*17.2*
Nanotechnology	*	*	*	*	*	*	30	10	*33.3*
	952	272	*28.6*	916	230	*25.1*	1028	373	*36.3*

Measures have been taken to improve the situation, such as specific projects aimed at female students ("Jenter og data" http://datajenter.ntnu.no/jd/jenterogdata.php and "Piker med spiker" http://org.ntnu.no/pikermedspiker/main.php) and "Jentedagen" – a one day welcome programme in late July for female students that have been admitted to ICT studies, sponsored by NTNU.

An increase of the number of female applicants without a corresponding loss of male applicants would imply a significant increase of the quality of students admitted to

engineering education at NTNU. The current situation shows a particular need for continued focus on recruitment of female students to electrical engineering and ICT studies.

5.3.5 Alumni

Alumni can be used as a positive factor in recruitment of students in several indirect ways, and there should be a well-thought link between the NTNU recruitment policy and the alumni organization. With the help of selected alumni we could show the rich variety of interesting job opportunities available for candidates with a degree in engineering. Alumni may serve as role models for potential students, and we believe that in particular young female alumni (below 35) should be used actively as role models for girls in secondary school and upper secondary school, cf. the results of the ROSE project. NTNU should present alumni in their recruitment information. Such presentations should show what the selected alumni work with and how they use their education in their daily work. Interviews with potential students, as well as with first- and second-year students show that this information is important to some student groups when they make decisions about their education, and the information is also important in providing a motivation and "goal" for younger students.

5.3.6 International aspects

Ongoing and planned actions to recruit students to the international MSc programmes at NTNU are described in Section 5.2.2. In addition, we would like to address the following issues of principle importance:

- The current international recruitment policy concerns mainly admissions to MSc programmes (2 years). Currently it seems unrealistic to admit students to the integrated engineering education (5 years) without sufficient knowledge of Norwegian as, at present, teaching during the first 3 years of study is in Norwegian. However, our language policy may very well change in the foreseeable future.
- The most efficient and desirable way to increase international recruitment is to establish agreements about joint/double degrees and common quality management principles for educational programmes with attractive foreign partners such as IDEA League and Nordic Five Tech. A very essential difficulty in this connection is the difference in national policies regarding tuition fees. At present, Norwegian regulations only allow public higher education institutions to take fees for further and continuing education activities.
- Each separate programme of study should keep in mind that possibilities for spending time abroad may be an important factor for prospective students when making their choice about education. Well thought presentations of whatever exchange agreements, possibilities for joint degrees etc. that are available, should be on display for prospective students.

5.3.7 Interaction with industry

In Section 5.4 we have collected a number of tables regarding the recruitment to the engineering education at NTNU during 2003-2006. The reader may notice a positive trend for the programme in civil engineering during these four years in terms of number of applicants and admission requirements. In fact, numbers show that this positive trend started in1999; at the same time, a strong alliance between this particular programme of study and a consortium of civil engineering firms was established, called "Næringslivsringen". This industry forum is made up of some 45 companies and aims at increased recruitment of students as well as interaction with NTNU to make a best possible education. Civil engineering firms support the

industry forum financially, both for recruitment campaigns and for supporting students during their studies. All students within this programme are offered relevant summer jobs.

Approximately half of the programmes of study have such strong alliances between their particular programme of study and a consortium of engineering firms. For programmes with a similar close link to a specific segment of the engineering industry, similar collaboration forums should be encouraged. One may also consider the possibility of establishing an additional alliance with industry on a broader scale, serving several programmes within the engineering education, as major companies typically will be interested in recruiting students from several different programmes. The Cooperative Forum “Samarbeidsforum” at Faculty of Natural Science and Technology (involving 18 companies) is an initiative in this direction, aiming at increased recruitment to the fields of natural sciences and technology in general and in particular to the programmes of study in that Faculty.

5.3.8 Admission examinations

The ROSE project indicates that there are inherent limitations of recruitment measures in a well-developed, high standard of living country like Norway: too few young people are interested in careers in science and technology. This is a long-term and deeply embedded trend that one cannot expect to turn around in the short or medium term.

NTNU may consider launching a trial project with an admission exam as an alternative for those who cannot qualify based on upper secondary school grades. Admission tests are used in many countries, and one of these may therefore be copied and possibly modified for such a purpose. A possibility could be that some of the engineering programmes (those which have unsatisfactory patronage today) at NTNU set aside – say – 5 to10 per cent of their yearly admissions quota for students that pass an admission exam.

The admission exam should not be an easy alternative way into academic engineering education. The achievement level to be admitted via such a test must be so strict that the average mathematics and physics skills of the candidate should be at least at the corresponding skills level of the average (and not the weakest) students admitted today via upper secondary school grades. To ensure this, the admission exam should be tested beforehand for calibration purposes. One may recruit a satisfactory-sized group of volunteer first-year NTNU students and let them do the test. Calibration may then be carried out by deciding the required future minimum achievement for being admitted through this exam, by comparing the test group's results to their upper secondary school grades.

5.3.9 Role of NTNU in the effort to increase the interest in science and technology

In addition to actions that are expected to have *direct* impact on recruitment to engineering education at NTNU, NTNU should also be engaged broadly in the effort to increase the general interest in science and technology among young people supporting the strategy and action plan of the Ministry of Education and Research initiated in 2006. The results of the ROSE project indicate the profundity and the global nature of the problem, and one should therefore not expect any easy solutions. Over the last decade or so, we have however witnessed an increased awareness of the situation among politicians and industrial leaders. There is a fear that in the foreseeable future there will be a serious lack of engineers and scientists in Norway. At present, a number of initiatives are taken nationally and locally to

motivate young people for a career in engineering or science; a working group under the Ministry of Education and Research aims at coordinating such actions.

Besides the many actions mentioned above (see Section 5.2.1 on national recruitment), NTNU should contribute decisively in the following areas (some initiatives have already been taken):

- Technology has now been established as a separate subject in upper secondary school. NTNU should engage actively in shaping this subject and contribute to providing teaching material, both in terms of written texts and interactive tools. A separate web page should be established.
- Continuing education and professional development for teachers is essential for whether the new subject of technology will be successful. NTNU should develop adequate courses in this subject. It is also important to shape new courses in traditional fields as a response to the new school reform "Kunnskapsløftet" (2006). Within mathematics a quite popular Internet-based education programme for teachers exists; it is more challenging to establish similar courses in experimental fields.
- The Ministry of Education and Research has proposed a new kind of teaching position: Adjunct upper secondary school teacher. The idea is that some professional, e.g. an engineer, has say a 20 % teaching position in upper secondary school. NTNU should be active in shaping the requirements to such adjunct teachers and also in providing them with the necessary skills in didactics/pedagogy.
- There are professional advisers at every upper secondary school who advise upper secondary school students on their choice of curriculum and further career. Such advisers clearly play a key role. As a supplement to their traditional training, we propose that NTNU host separate conferences for upper secondary school advisers in order to make them fully aware of the range of possibilities for careers in science and engineering, as well as the need for engineers in modern society.

5.4 Some Key Data

Table 16: Number of applicants to NTNU through the National Admission Service (Samordna opptak) – total number of applicants and primary applicants

	2003		2004		2005		2006	
MASTER 5-YEAR:	Totally:	Prim:	Totally:	Prim:	Totally:	Prim:	Totally:	Prim:
Computer Science	1208	328	873	182	889	182	931	207
Engineering Cybernetics	1154	216	797	135	913	176	764	115
Electronics	1108	188	912	139	875	153	788	103
Communication Technology	1074	144	771	95	701	90	771	69
Sum ICT-related:	*4544*	*876*	*3353*	*551*	*3378*	*601*	*3254*	*494*
Industrial Design	907	167	838	143	824	127	770	119
Ind. Economy & Tech.Man.	1512	522	1329	496	1282	444	1362	470
Earth Science & Petroleum	1016	119	821	115	1009	137	1417	218
Phys/Math	1054	187	850	159	872	184	870	150
Marin Technology	871	127	887	144	905	144	1013	156
Chem.Engineering and Biology	748	139	628	110	613	99	806	128
Civil and Environ. Eng.	1510	322	1505	336	1626	392	1815	429
Product Des. and Manufact.	1191	184	1083	172	1108	135	1209	169
Materials Sc. and Eng.	856	56	696	60	639	60	653	52
Energy and Environment	1281	164	1043	120	1044	131	1140	122
Engineering and ICT	782	88	460	48	550	81	754	97
Nanotechnology							1429	265
Sum technology-related:	*11728*	*2075*	*10140*	*1903*	*10472*	*1934*	*13238*	*2375*
Sum MSc in Engineering	*16272*	*2951*	*13493*	*2454*	*13850*	*2535*	*16492*	*2869*

Table 17: Number of places at the different programmes of study 2003-2006 (incl. places in 2 year MSc programmes for students with a bachelor of engineering. Source: DBH

	2003	**2004**	**2005**	**2006****
MASTER 5-YEAR:				
Computer Science	165	155	145	112
Engineering Cybernetics	105	105	105	70
Electronics	105	105	105	67
Communication Technology	95	90	75	65
Industrial Design	20	25	25	25
Ind. Economy & Tech.	110	110	100	115
Earth Science & Petrol	80	80	80	110
Phys/Math.	120	110	100	95
Marin Tech	85	90	90	93
Chem. Engineering and Biology	90	90	90	96
Civil and Environ. Engineering.	165	185	190	148
Product Des. and Manuf.	125	130	130	130
Materials Sc. and Engineering.	35	40	35	33
Energy and Environment	115	115	115	109
Engineering and ICT	60	45	55	67
Nanotechnology	*	*	*	28

Table 18: Number of study places, students accepting and students who actually have met 2003-2006. Source: DBH

	Study places offered				**Students accepting**				**Students met**			
MASTER 5-YEAR:	2003	2004	2005	2006	2003	2004	2005	2006	2003	2004	2005	2006
Computer Science	263	160	151	153	210	124	133	141	146	102	101	111
Engineering Cybernetics	154	145	137	108	120	124	116	94	100	83	98	70
Electronics	183	151	108	100	151	132	93	86	108	98	75	66
Communication Technology	162	112	109	88	114	89	90	75	95	65	57	66
Sum ICT-related:	*762*	*568*	*505*	*449*	*595*	*469*	*432*	*396*	*449*	*348*	*331*	*313*
Industrial design:	33	30	33	36	27	25	24	29	24	21	19	26
Ind. Economy & Tech.	165	155	153	159	138	114	122	129	110	91	101	112
Earth Science & Petrol	125	125	116	154	100	103	95	133	80	75	80	106
Phys/Math	215	181	142	151	164	145	117	117	124	121	98	92
Marin Tech	134	140	119	138	117	116	100	117	88	86	83	92
Chem. Engineering and Biology	139	125	104	142	112	102	82	111	94	89	68	93
Civil and Environ. Engineering.	264	257	214	221	220	214	183	185	174	168	157	146
Product Des. and Manuf.	204	191	177	182	171	159	148	155	132	118	122	128
Materials Sc. and Eng.	42	55	59	59	32	49	48	48	24	28	34	30
Energy and Environment	186	174	142	151	145	154	113	126	111	114	89	109
Engineering and ICT	94	56	90	87	77	52	79	80	60	41	65	64
Nanotechnology	*	*	*	41	*	*	*	32	*	*	*	30
Sum technology-related:	*1601*	*1489*	*1349*	*1521*	*1303*	*1233*	*1111*	*1262*	*1021*	*952*	*916*	*1028*
Sum MSc in Engineering:	2363	2057	1854	1970	1898	1702	1543	1658	1470	1300	1247	1341

Table 19: Admission point limitations for admittance to NTNU - based on main admittance. Source: Universities and Colleges Admission Service

	2003			2004			2005			2006		
MASTER 5-YEAR:	Ord.	Prim	BE	Ord.	Prim	BE	Ord.	Prim	BE	Ord.	Prim	BE
Computer Science	48.7	51.3	3.6	45.9	47.0	2.5	46.8	50.0	2.5	50.8	55.5	2.8
Eng. Cybernetics	55.5	55.5	3.5	45.5	53.8	2.5	51.5	53.7	2.5	51.3	54.5	3.8
Electronics	47.9	51.3	2.6	43.5	48.0	2.5	50.0	52.3	2.5	51.0	52.7	2.8
Comm. Technology	53.3	54.5	3.4	49.3	52.7	2.5	47.7	50.5	2.5	53.0	54.9	3.0
Industrial Design	64.0	58.8		62.8	59.0	3.5	62.5	58.9	2.5	62.8	59.0	3.6
Ind. Economy & Tech.	63.8	60.3	4.3	64.7	60.7	4.2	62.5	60.9	3.9	63.3	63.0	3.4
Earth Sci & Petrol	49.3	52.0	2.5	46.3	49.4	2.5	51.2	53.0	2.5	55.5	57.3	3.0
Phys/Math	49.0	56.5		49.8	56.5		59.2	55.9		55.6	60.9	
Marin Tech	48.7	51.8	2.5	49.6	51.7	2.5	52.5	53.3	2.5	53.5	54.5	3.0
Chem. Engineering, Biology	52.5	56.0	2.4	51.0	55.3	2.5	51.8	55.8	2.5	53.5	57.8	2.9
Civil and Env. Eng.	52.3	54.1	2.5	53.5	54.8	2.5	56.7	55.9	3.1	58.0	58.8	3.5
Product Design	52.2	52.1	3.0	52.0	52.6	2.5	52.1	53.4	2.5	53.8	54.8	3.2
Materials Science	51.5	56.8		51.4	54.5	2.5	51.8	54.5	2.5	53.4	56.8	2.8
Energy& Environm.	47.9	54.8	2.6	45.5	51.5	2.5	51.0	54.3	2.5	53.1	56.3	
Engineering and ICT	48.3	50.5		44.9	47.8		47.8	50.7		52.8	54.9	
Nanotechnology										65.5	64.7	

Ordinary = All exams and additional point included (age, additional education, experience etc)
Prim = only exams from upper secondary school
BE = candidates from Norwegian University Colleges (Bachelor of Engineering). A grade point average of C or better is required for these bachelor's students to be admitted to the latter part of the integrated MSc Engineering programme at NTNU.

Table 20: Admittance of Bachelor of engineering candidates from the University Colleges to a 2-year MSc in Engineering at NTNU. Source: NTNU

Programme:	Study places (frame number)		No. of applicants		No. of places offered		No. of students accepting		No. of students met	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
Computer Sc.	40	33	146	100	60	38	54	28	47	26
Eng. Cybernetics	15	40	98	99	28	21	18	15	16	15
Electronics	25	13	146	79	34	22	26	15	20	13
CommTechn	10	7	119	64	18	6	12	3	9	3
Sum ICT:	*90*	*93*	*509*	*342*	*140*	*87*	*110*	*61*	*92*	*57*
Ind. Design	5	5	48	53	8	6	6	5	5	5
Ind. Econ&tech	5	6	124	67	8	7	6	4	6	3
Earth Science & Petrol	5	5	51	40	3	1	3	1	2	1
Marin Tech.	10	5	58	74	7	7	4	6	2	5
Chem. & bio.	15	10	34	44	12	13	7	9	5	6
Civil and Environ. Engineering.	40	76	137	157	60	53	48	42	46	39
Product Design	15	15	82	79	20	17	17	13	16	13
Materials Science	5	2	50	57	5	3	3	2	2	1
Energy and Env.	15	**	78	**	22	**	16	**	15	**
Sum techn	*115*	*124*	*662*	*571*	*145*	*107*	*110*	*82*	*99*	*73*
TOTAL SUM:	205	217	1171	913	285	194	220	143	191	130

** Energy and environment ended as a 2-year master's programme in the autumn 2006. It was replaced by an international master's programme in Electric Power Engineering.

Table 21: The regional distribution of young people (19-23 years of age) in Norway, 2004-2007. Source: Statistics Norway

Total number	Østlandet	Trøndelag	Vestlandet	Nord-Norge	Sørlandet	Sum
2007	131272	25441	77529	27964	17187	279393
2006	128793	24793	76746	27838	17344	275514
2005	127041	24347	76064	27903	17371	272726
2004	126233	24111	76247	27865	17568	272024
In percent	**Østlandet**	**Trøndelag**	**Vestlandet**	**Nord-Norge**	**Sørlandet**	**Sum**
2007	47.00 %	9.10 %	27.70 %	10.00 %	6.20 %	100 %
2006	46.70 %	9.00 %	27.90 %	10.10 %	6.30 %	100 %
2005	46.60 %	8.90 %	27.90 %	10.20 %	6.40 %	100 %
2004	46.40 %	8.90 %	28.00 %	10.20 %	6.50 %	100 %

Table 22: The regional background of the students admitted to the MSc in engineering education 2004-2007. Source: Statistics Norway

Total number	Østlandet	Trøndelag	Vestlandet	Nord Norge	Sørlandet	Sum
2007	666	180	348	97	47	1338
2006	641	164	370	109	67	1351
2005	585	177	335	84	77	1258
2004	603	181	377	76	62	1299
In percent	**Østlandet**	**Trøndelag**	**Vestlandet**	**Nord Norge**	**Sørlandet**	**Sum**
2007	49.8 %	13.5 %	26.0 %	7.2 %	3.5 %	100 %
2006	47.4 %	12.1 %	27.4 %	8.1 %	5.0 %	100 %
2005	46.5 %	14.1 %	26.6 %	6.7 %	6.1 %	100 %
2004	46.4 %	13.9 %	29.0 %	5.9 %	4.8 %	100 %

Table 23: Drop-out analysis – 5 year integrated engineering education (2004 admission)

Programme of Study	Status, category	Number	Per cent
Civil and Environmental Engineering	Continue, same programme	140	83.3 %
	Continue, another MSc programme	2	1.2 %
	Dropped out MSc programme	26	15.5 %
	Total	168	100.0 %
Computer Science	Continue, same programme	69	67.6 %
	Continue, another MSc programme	5	4.9 %
	Dropped out MSc programme	28	27.5 %
	Total	102	100.0 %
Electronics	Continue, same programme	62	62.6 %
	Continue, another MSc programme	8	8.1 %
	Dropped out MSc programme	29	29.3 %
	Total	99	100.0 %
Energy and Environmental Engineering	Continue, same programme	83	72.8 %
	Continue, another MSc programme	5	4.4 %
	Dropped out MSc programme	26	22.8 %
	Total	114	100.0 %
Applied Physics and Mathematics	Continue, same programme	88	72.7 %
	Continue, another MSc programme	10	8.3 %
	Dropped out MSc programme	23	19.0 %
	Total	121	100.0 %
Earth Sciences and Petroleum Engineering	Continue, same programme	47	62.7 %
	Continue, another MSc programme	4	5.3 %
	Dropped out MSc programme	24	32.0 %
	Total	75	100.0 %
Product Design Engineering	Continue, same programme	16	76.2 %
	Continue, another MSc programme	1	4.8 %
	Dropped out MSc programme	4	19.0 %
	Total	21	100.0 %
Industrial Economics and Technology Management	Continue, same programme	75	82.4 %
	Continue, another MSc programme	8	8.8 %
	Dropped out MSc programme	8	8.8 %
	Total	91	100.0 %
Engineering and ICT	Continue, same programme	23	56.1 %
	Continue, another MSc programme	10	24.4 %
	Dropped out MSc programme	8	19.5 %
	Total	41	100.0 %
Chemical Engineering and Biotechnology	Continue, same programme	62	69.7 %
	Continue, another MSc programme	7	7.9 %
	Dropped out MSc programme	20	22.5 %
	Total	89	100.0 %
Communication Technology	Continue, same programme	45	69.2 %
	Continue, another MSc programme	9	13.8 %
	Dropped out MSc programme	11	16.9 %
	Total	65	100.0 %
Marine Technology	Continue, same programme	67	78.8 %
	Continue, another MSc programme	4	4.7 %
	Dropped out MSc programme	14	16.5 %
	Total	85	100.0 %

Programme of Study	Status, category	Number	Per cent
Materials Science and Engineering	Continue, same programme	19	67.9 %
	Continue, another MSc programme	4	14.3 %
	Dropped out MSc programme	5	17.9 %
	Total	28	100.0 %
Product Design and Manufacturing	Continue, same programme	77	65.3 %
	Continue, another MSc programme	15	12.7 %
	Dropped out MSc programme	26	22.0 %
	Total	118	100.0 %
Engineering Cybernetics	Continue, same programme	54	65.1 %
	Continue, another MSc programme	10	12.0 %
	Dropped out MSc programme	19	22.9 %
	Total	83	100.0 %
Total	Continue, same programme	927	71.3 %
	Continue, another MSc programme	102	7.8 %
	Dropped out MSc programme	271	20.8 %
	Total	1300	100.0 %