J. Fonselius, M.K. Hakala & K. Holm

Evaluation of Mechanical Engineering Education at Universities and Polytechnics
The evaluation of the study programmes in Mechanical Engineering is the third project focusing on the programmes in technology implemented by the Finnish Higher Education Evaluation Council (FINHEEC). The two previous evaluations of the same type looked at the study programmes of Industrial Management and Engineering (in 1998) and Information Industry (in 2000). All study programmes will not be evaluated systematically, but the programmes are selected for specific reasons.

There were several reasons that influenced the decision of FINHEEC to initiate the evaluation of the study programmes in Mechanical Engineering. The mechanical engineering industry is important for the Finnish economy, being also one of the country’s leading employers. But will it remain the same in the future? The rapidly changing competition calls for close collaboration with higher education and research. The timeliness and quality should be cornerstones of state-of-the-art engineering education. In addition, the significant expansion of higher education has increased the need to evaluate the regional and national influence of the universities and polytechnics in general. Although this evaluation was not specifically directed to research, it includes aspects on the research conducted in collaboration with the industrial and economic life.

The evaluation consisted of three main phases, all performed in close cooperation with the Universities and Polytechnics involved. The starting seminar and the comprehensive self-assessment, based on instructions given by the Steering Committee, were common to all study programmes. Thereafter, the External Evaluation Committee visited half of the study programmes, again selected by the Steering Committee. The material in this report was mainly compiled during these visits. The final phase was the preparation of the report, and the respective feedback procedure. The chairman of the External Evaluation team and the Project Manager were mainly responsible for the report and feedback phases of the project.

The Steering Committee sincerely hopes that the evaluation performed is valuable to all study programmes involved, also to those who could not be included in the external evaluation. The evaluation will prove successful only if it will be really used to develop governance, teaching and learning opportunities and the contents of the programmes. We are convinced that the findings and recommendations of the Evaluation team are helpful in further improving the quality of higher education in Mechanical Engineering and hope that the quality work will become part of the daily routine of the study programmes.

The Steering Committee would like to thank all who have participated and contributed to the success of the Evaluation Project. The Chairman of the External Evaluation Committee, Research Professor Matti Hakala, and all Mem-
bers of the Committee deserve special thanks for their professional and successful work. We also wish to thank Mr. Karl Holm, the Project Manager, for his valuable contribution during all phases of the evaluation. Finally, the co-operation of all Study Programmes in Mechanical Engineering was greatly appreciated.

September 3, 2001

Professor Toivo Katila
Chairman of the Steering Committee
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1

Introduction

1.1 The premises of the project

In 1998, the Finnish Higher Education Evaluation Council (FINHEEC) organised a preliminary enquiry to chart out the need of evaluation in the field of technical education. A questionnaire was sent to universities, polytechnics, various federations of industry as well as to several companies. As a result, FINHEEC decided to launch evaluation processes and included them in its plan of action. The evaluations were to be performed, after the programme evaluation of Industrial Management and Engineering, in the following disciplines in the field of technology: Information Technology, Mechanical Engineering and Civil Engineering.

The evaluation project focusing on information technology was made in 2000 while the project to evaluate programmes in Mechanical Engineering has been mainly done in 2001. The Civil Engineering project will take place in 2002.

When the need of evaluation of Mechanical Engineering was discussed in 1998 the following considerations were raised by FINHEEC:

• highly important area from the economic point of view
• the image of Mechanical Engineering is relatively poor
• a need to develop the area of Mechanical Engineering
• serious shortage of experts, quality in danger
• need for education is obvious; some of the educational units have already decided to increase the number of first-year students
• relatively low threshold to get into the degree programmes. Increasing the number of first-year students does not increase the quality of the students
• students do not tend to stay in the Mechanical Engineering programmes.
• varying quantity and quality of the education
• Mechanical Engineering includes a wide spectrum of different areas: production, materials, heating, transportation, energy, HVAC, strength of materials, etc.
• some of the areas of Mechanical Engineering have received less attention
• there is clearly less production technology than in the past, especially in the polytechnics
1.2 EU Mechanical engineering – a globally competitive industry

Mechanical engineering is one of the major branches of industry in the EU [EU Mechanical Engineering – A globally competitive industry, 2001. UDMA Publications 2001]. The production value reached a figure of € 321 billion in 1998 and while the demand amounted to € 259 billion. The EU is a global leader in machinery production. There is much support for the view that the bulk of machinery manufacturers in the EU are more competitive today than they were at the beginning of the nineties.

Key industry for the whole EU economy

In the EU mechanical engineering is responsible for 8.2% of industrial production, 10.0% of industrial value added and 9.6% of all employees in industry.

Mechanical engineering is one of the major branches of industry in the EU. It is characterised by the following key data for 1998: more than 2.2 million persons were employed in approximately 20,400 companies, with production amounting to € 321 billion.

Strong differentiation by country

With a production share of 41%, Germany is the dominating machine supplier in the EU. Italy ranks second with 18%, followed by the United Kingdom with 11% and France with 10%. This shows that these four leading production countries alone provide four-fifths of the entire EU production. At the other end of the scale Portugal, Ireland and Greece have only modest production shares. In the centre lie the remaining seven member states with percentage shares varying between 2 and 4%. The corresponding figure for Finland is less than 3%.

OECD dimension

The mechanical engineering industry accounts for approximately 12% of the total production in OECD countries, and the corresponding figure for the Finnish mechanical engineering industry is about 0.5–0.6%.

1.3 Mechanical engineering in Finland – important domestic industrial sector and international market leader

In Finland mechanical engineering (machinery and metal products) is one of the three major industrial branches, along with the traditional forest industry and the very rapidly developed electronics and electrotechnics industry. Its production in 2000 rose to € 17 billion (gross value), and its share of the Finnish export was 18%. With about 125,000 employees, mechanical engineering is still by far the single most important branch of industry or in terms of employ-
ment. The metals, engineering and electronics industry together constitute the largest industrial sector in Finland, accounting for nearly 50% of the industrial output and almost half of the total labour force, see Table 1 and Figure 1.

World market leaders and domestic subcontractors

Approximately half of the production of the Finnish mechanical engineering industry is exported. In some products, the Finnish industry has a rather strong global market position, see Table 2. Quite a few Finnish companies rank among the top ten in the world market, while there are plenty of small manufacturers which concentrate on the domestic market, acting more or less as subcontractors for the bigger companies.

The strong commitment to the future is evident, as reflected by the heavy expenditure on research and development: the metals, engineering and electronics industry now account for 80% of all industrial R&D in Finland. Unfortunately, the traditional mechanical engineering does not excel in this respect, having R&D investments as low as about 2% of the total turnover. This figure is somewhat higher only in the case of some top companies.

Effective and flexible manufacturing, small but comprehensive manufacturing series and custom-design products are further factors behind the success of the Finnish mechanical engineering industry. Over 90% of products are designed directly in accordance with customer wishes. In-depth understanding of customer production technology provides them with a competitive edge, and their products become leaders on both the domestic and the world market.

Table 1. The subsectors of the metal, engineering and electrotechnical industry in a nutshell in 2000 (MET Federation of Finnish Metal, Engineering and Electrotechnical Industries)

<table>
<thead>
<tr>
<th></th>
<th>1 Electronics and electrotechnics industry</th>
<th>2 Mechanical engineering</th>
<th>3 Metals industry</th>
<th>4 Metals, engineering and electronics industry, total</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRODUCTION (in billions of FIM)</td>
<td>24</td>
<td>17</td>
<td>7</td>
<td>47</td>
</tr>
<tr>
<td>Gross value</td>
<td>8</td>
<td>6</td>
<td>1.3</td>
<td>15</td>
</tr>
<tr>
<td>Value-added</td>
<td>0.7</td>
<td>0.7</td>
<td>0.3</td>
<td>1.7</td>
</tr>
<tr>
<td>Investment</td>
<td>1.7</td>
<td>0.3</td>
<td>0.05</td>
<td>2</td>
</tr>
<tr>
<td>R&amp;D, WORK FORCE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of employees (1,000)</td>
<td>70</td>
<td>125</td>
<td>17</td>
<td>212</td>
</tr>
<tr>
<td>- white collar, % of total</td>
<td>55</td>
<td>32</td>
<td>30</td>
<td>39</td>
</tr>
<tr>
<td>Total labour costs</td>
<td>2.5</td>
<td>4</td>
<td>0.7</td>
<td>7</td>
</tr>
<tr>
<td>EXPORTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exports</td>
<td>15</td>
<td>9</td>
<td>3.5</td>
<td>28</td>
</tr>
<tr>
<td>- % of total Finnish goods exports</td>
<td>31</td>
<td>18</td>
<td>7</td>
<td>56</td>
</tr>
<tr>
<td>Number of companies (with &gt; 5 employees)</td>
<td>600</td>
<td>2,400</td>
<td>80</td>
<td>3,100</td>
</tr>
</tbody>
</table>

Source: Statistics Finland, National Board of Customs
Figure 1. Labour in the metals, engineering an electronics industry. Number of employees by subsector

Table 2. Strong Finnish mechanical engineering products in the global market

<table>
<thead>
<tr>
<th></th>
<th>Net sales in billions of EUR</th>
<th>Global market share percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lifts and escalators</td>
<td>2.4</td>
<td>9%</td>
</tr>
<tr>
<td>Pulp and paper machines</td>
<td>2.3</td>
<td>45%</td>
</tr>
<tr>
<td>Diesel and gas engines</td>
<td>2.0</td>
<td>25%</td>
</tr>
<tr>
<td>Cranes and hoists</td>
<td>1.6</td>
<td>20%</td>
</tr>
<tr>
<td>Stone and mineral working equipment</td>
<td>1.2</td>
<td>15%</td>
</tr>
<tr>
<td>Special vessels, special ships</td>
<td>1.0</td>
<td>25%</td>
</tr>
<tr>
<td>Forestry machines</td>
<td>0.8</td>
<td>45%</td>
</tr>
<tr>
<td>Agricultural tractors</td>
<td>0.6</td>
<td>9%</td>
</tr>
</tbody>
</table>
1.4 Trends and challenges for the industry – poor image, ageing, weak productivity development

The public image of the mechanical engineering industry is generally rather low. It is regarded as an old-fashioned sunset industry with dirty factories and a blue atmosphere, not very attractive to modern young people. A typical picture of a mechanical engineering worker is a welder in a smoky environment, or a dirty and sweating man in a burning hot foundry. It is a challenging task for the industry to try to do something about this image. To improve the situation, the Federation of Finnish Metal, Engineering and Electrotechnical Industries (MET) has launched some projects such as “Challenging workplace of the future” [Haastava tulevaisuuden työpaikka]. Of course, educational institutes should have also an important role in this PR activity.

However, machines are high-tech products, not only “iron”. For example, automation and information technology are increasingly important in the field of machinery, other equipment and vehicles. “Machines” are no longer merely pieces of iron, but very complicated multi-technical systems, the design of which requires the combination of skills in many disciplines. The business environment is also changing: today, services or capacity is delivered instead of single machines or products, machine systems are assuming more intelligent features, they are operating in intelligent environment, etc. In mechanical engineering, this also calls for new and different kind of competencies and combinations of various skills.

The mechanical engineering industry is also facing an ageing problem. It is anticipated that about 40,000 employees will be retiring within the next decade. The total number of employees needed in this sector is estimated to remain unchanged or slightly increase. A common problem faced by the whole Finnish industry is the lack of young people interested in technology, and due to its poor image, this applies to mechanical engineering, in particular. That is why it is and will be increasingly difficult to replace the retired employees.

A major and specific concern of the mechanical engineering industry is the very modest productivity development compared to, e.g., that of the electronics industry. During the nineties, the Finnish average annual growth rate of productivity was 2.5%, while the corresponding figure in electronics and electrotechnical industry was 13.4%. This seems to be a common problem in other countries, too. Today, the growth rate in the Finnish mechanical engineering industry seems to be slightly improved, reaching the level of 3–3.5% within the next ten years. The “new economy” way of thinking, e.g., the more effective exploitation of the Internet, networking as well as information and communication technologies is one way, which is also strongly in the agenda of MET. Correspondingly, this is also an important aspect regarding the planning of future education in mechanical engineering.
1.5 Need for mechanical engineers

Currently there are about 9,500 polytechnic engineers and 4,500 university engineers working in the mechanical engineering industry. Mechanical engineering skills – design and manufacturing – are nowadays needed also outside the traditional metals industry. The electronic equipment contains a lot of mechanical parts, and the respective manufacturing is one of the key competitive factors in the electronics industry. Therefore, the need for mechanical engineers does not stem only from the success of the metals industry but also from the rapidly developing electronics industry.

The need for education in mechanical engineering is by no means diminishing. According to the scenarios of MET, the demand for mechanical engineers within the next ten years will slightly exceed the number of graduates from polytechnics and universities. [Metalli- ja elektroniikkateollisuuden osaajien tarve vuosina 2000 - 2010. MET toukokuu 2000]

A common problem regarding the whole Finnish society is the lack of young people interested in the study of mathematics and physics in schools, or more generally the level or volume of teaching of these subjects in comprehensive and upper secondary schools. This is further reflected as a difficulty to get a sufficient number of qualified applicants for the higher level mechanical engineering education. These problems are particularly emphasised among girls, generally and traditionally not very attracted by these subjects or engineering professions.

1.6 Universities and polytechnics in the Finnish education system

Traditionally, the long-term objectives of Finnish education policy have been to raise the general standard of education and to promote educational equality. Efforts have been made to provide all population groups and regions of the country with equal educational opportunities. The Finnish education system consists of the comprehensive school, the post-comprehensive general and vocational education, higher education and adult education. The government’s goal is to streamline the system and develop it in accordance with the principle of lifelong learning, as well as to make it internationally compatible.

The Finnish higher education system includes two sectors: universities and polytechnics. The polytechnics are more practically oriented, training professionals for expert and development posts. The higher education system seen as a whole offers openings for 66% of the relevant age group (universities 29%, polytechnics 37%). Polytechnics also arrange programmes for adult students. (For additional information, see www.minedu.fi)
University education

There are a total of 20 universities in Finland: ten multi-faculty universities, three universities of technology, three schools of economics and business administration, and four art academies. The basic mission of the universities is to carry out research and provide education based on it. The underlying principle in university education is the freedom of research and university autonomy, which gives them extensive latitude for independent decisions. All Finnish universities are state-run, with the government providing some 70% of their funding. Each university and the Ministry of Education conclude a three-year agreement on target outcome to determine the operational principles.

Universities select their own students, and the competition for openings is tough. All fields apply numerus clausus, in which entrance examinations are a key element. Universities offer openings for about one third of the age group. The annual number of applications is nearly 66,000, and only 23,000 candidates are admitted. The annual number of degrees in Finland is 16,000, of which 11,000 are Master’s degrees and 1,000 doctorates. The average duration of studies is 6.5 years.

Polytechnics

There are 29 polytechnics in Finland; most of them are multidisciplinary, regional institutions which give particular weight to contacts with the business and industry. Polytechnics are developed as a part of the national and international higher education community, with special emphasis on their expertise in working life and its development. The polytechnics also carry out R&D relevant to their teaching and to the practical working life.

The polytechnics were created gradually over the 1990s. The standard of former higher vocational education was raised and incorporated into multidisciplinary polytechnics. The national polytechnics network was completed by 1 August 2000. Since then, all the polytechnics have operated on a permanent basis.

The polytechnics award professionally oriented higher education degrees, which take 3.5 or 4 years to complete. The entry requirement is either an upper secondary school certificate or a vocational diploma. At present about 70% of all entrants are matriculated students and 30% vocational graduates. The Ministry of Education confirms the degree programmes. There is no tuition fee for degree studies.

The polytechnics have two categories of teachers: senior lecturers with a postgraduate (licentiate or doctorate) degree requirement, and lecturers who must have a Master’s degree. Both categories of teachers must have a minimum of three years of work experience.
Finnish polytechnics, which are either municipal or private, are co-financed by the government and the local authorities. The Ministry of Education and each polytechnic conclude a three-year agreement on target outcome to determine the objectives, intakes, and project and performance-based funding.

1.7 Education in mechanical engineering in Finland

There are 4 universities and 18 polytechnics giving mechanical engineering education in Finland. In the past, technicians and engineers were trained at the institutes of technology, integrated into the new polytechnics in the late nineties. This was part of the upper secondary and higher education reform in Finland. In that context, the training of technicians finished, and the requirements of engineers were somewhat lowered.

* * *

All polytechnics and universities giving mechanical engineering education are listed in Appendix 5 together with a brief description of their specialisations. Key figures regarding students, staff, graduation times and intake are given in Appendix 6.
2
Evaluation procedures

2.1 The framework of the project

The evaluation of the degree programmes consists of self-evaluations undertaken by the higher education institutions and an evaluation carried out by the external evaluation team. The degree programmes to be evaluated are determined by the steering group.

In its self-evaluation, each higher education institution has evaluated its own degree programme and written a report for the use of the external team. The major evaluation objects are in general:

- aims and strategies of the degree programme
- content and structure of the degree programme
- teaching staff
- students
- teaching and learning processes
- operational and economic resources
- international contacts and co-operation outcome
- relations with business and industry
- internal quality schemes for developing the degree programme

The self-evaluation report, written in English, constitutes the most important source of information concerning the degree programme and the unit providing it. The study guide for the programme and the relevant teaching plan are attached to the report.

The external evaluation team made a site visit to the institutions in order to evaluate the degree programme in depth on the basis of the self-evaluation reports. During their one-day visits, the external team interviewed those in charge of the degree programme as well as the institution management, the teaching and other staff responsible for the degree programme, students, and representatives of local business and industry.

The team also examined the facilities, the teaching methods, the textbooks used, as well as students' assignments and projects. An essential feature of the process was the fact that at the end of their visit, the external evaluators gave the staff and students verbal feedback concerning their observations and tentative suggestions for development.
Reporting

Based on the self-evaluation material and the personal evaluation reports submitted by the members of the external team, the project manager compiled a preliminary draft report of the outcome and conclusions of the project. This draft was sent for comments to the members of the evaluation team and later also to the representatives of the degree programmes which had been evaluated. Comments were taken into account in the final report.

The evaluation report has been publicised at a seminar for the representatives of the higher education institutions involved in the project. The purpose of the seminar was to collect feedback on the degree programmes evaluated and raise points to be taken into account in future evaluations. (See Appendices 1, 2 & 3 for additional views of reporting.)

2.2 Project plan

The following four principle areas were taken into account when Mechanical Engineering programmes were selected for the evaluation process: 1) Mechanical Engineering is one of the biggest and the most traditional degree programmes; 2) the competitiveness and attractiveness of the programme among the students has not been optimal; 3) general concern about the quality of Mechanical Engineering and insignificance of the research tradition; and 4) the significance of mechanical and electrotechnical industry for the export in Finland.

The project started in August 2000 and the steering group (see page 18) of the project assembled for the first meeting in November 2000.

On a general level, the steering group represents FINHEEC and it

- determines and approves the aims and the timetable of the project;
- submits proposals to the Higher Education Evaluation Council (FINHEEC) concerning personnel and other resources, including the members of the external evaluation team;
- is responsible for the supervision and practical implementation of the project;
- approves the intermediate reports of the project; and
- makes a proposal concerning the termination of the project to the FINHEEC.

The division of work between the steering group and the Finnish Higher Education Evaluation Council is as follows:

- FINHEEC selects the field of education to be evaluated and appoints a steering group for the purpose.
- FINHEEC appoints the external evaluation team on the proposal of the steering group.
- FINHEEC allocates resources at its disposal to the evaluation.
- The steering group, together with the FINHEEC secretariat, draws up the project plan.
- The Secretary General decides on the publication of the external evaluation team’s report in the FINHEEC publication series.
The project manager is responsible for the project: practical arrangements, planning, implementation, supervision and reporting. The project manager’s primary tasks include the compilation a detailed project plan, the supervision, reporting and practical implementation related to the project, as well as acting as the secretary to the external evaluation team.

The external evaluation team evaluates the degree programmes. In general its members write their own reports of the evaluations in which they take part and contribute to the drafting of the final report.

The primary aim of this particular project was to support higher education institutions in assuring and improving the quality of engineering degree programmes as well as to encourage them to develop the evaluation of the education they provide and enhance its quality. To this end, the project aimed at:

- providing an overall idea of the state of engineering education;
- producing tools for quality assessment and assurance for the degree programmes;
- generating proposals for national and programme-specific development measures; and
- creating a culture of constant quality assessment.

In addition to this, the project had the following specific objectives:

- to appraise the present situation in engineering programmes as compared with the needs and demands of society, business life and the labour market;
- to identify the similarities and differences in the content of education provided by the universities and polytechnics;
- to make qualitative and quantitative data available in view of international comparisons of engineering education;
- to measure the satisfaction of employers recruiting from the degree programmes and other business and industry;
- to ensure student satisfaction;
- to ensure continuous quality assurance and updating in the degree programmes.

The following criteria were used to select degree programmes for the external evaluation:

- the significance of the degree programmes as providers of engineering education;
- the diversity and extent of the degree programmes, with a special focus on a diverse selection of degree programmes of different ages;
- the language of instruction; and
- geographical location.

Based on these criteria, the steering group selected 50% of the degree programmes for the external evaluation.
2.3 Selecting the programmes for the external evaluation

Covering most of the Finnish territory, there are 22 institutes (4 universities and 18 polytechnics) which provide education in the field of Mechanical Engineering, and all of them were included in the evaluation process. There are a total of about 6,000 students in the subject programmes within the degree programme of Mechanical Engineering. All 22 institutes were asked to write a self-assessment report, and based on the decision made by the steering group, half of the institutes (11) were evaluated by the external evaluation team during the period from 28 March 2001 to 20 April 2001.

Project organisation

In October 2000 the Finnish Higher Education Evaluation Council nominated a steering group for the project. Chaired by professor Toivo Katila, the members of the group were Mr Juha Ehrola Valmet Oy; professor Kenneth Holmberg VTT (the Technical Research Centre of Finland; Mr Antti Huttunen SYL; and Mr Jorma Tuominen Vaasa Polytechnic. The secretary (project manager) of the project was planning officer Tapio Huttula until the end of the year 2000. Project manager Karl Holm continued as the secretary of the project from the beginning of the year 2001.

In February 2001 following persons were selected by the evaluation council for the external evaluation team: Professor Matti Hakala, VTT, chairman; senior lecturer Jaakko Fonselius, Jyväskylä Polytechnic; professor Christer Johansson, University of Linköping; professor Klaus Hein, University of Stuttgart; professor Erwin Hasenjäger, Bingen Polytechnic; Ms Virpi Kuismin, SAMOK (the Union of Finnish Polytechnic Students); Mr Ville Laine, SYL (the National Union of Finnish Students); Mr Mikko Karvinen, Metso Oy; Mr Erkki Kare, Plustech Oy; Mr Rainer Penttala, Wärtsilä Oy; Mr Ilkka Jokioinen, Metso Oy; and Mr Jorma Nevaranta, Valtra Oy.

2.4 Structure of the visit

In line with the above mentioned criteria the steering group selected the following institutes for the external evaluation: Helsinki Polytechnic Stadia 28 March, North Karelia Polytechnic 29 March, Helsinki University of Technology 30 March, Turku Polytechnic 2 April, Swedish Polytechnic 3 April, Vaasa Polytechnic 4 April, Lappeenranta University of Technology 5 April, Tampere Polytechnic 17 April, Tampere University of Technology 18 April, University of Oulu 19 April, and Oulu Polytechnic 20 April.

The evaluation team regrets that due to the lack of time and funding it was impossible to visit in all of the 22 institutes in question.
The institutional deadline of the self-evaluation reports was 9 March 2001. Most of the reports came on time to FINHEEC. The Arcada Polytechnic (Nylands svenska yrkeshögskola) never sent their self-evaluation report.

The reports and different material concerning Finnish higher education system were sent as early as possible to the members of the team. Invited to the FINHEEC office on Tuesday 27 March 2001, the aims of the project were presented and more detailed information was given to the whole team.

The members of the evaluation team visited different institutes according to the following schedule:

Table 3. The programme of the evaluation day*

<table>
<thead>
<tr>
<th>Time</th>
<th>Programme</th>
<th>Persons involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:00-9:30</td>
<td>Arrival at the Institution</td>
<td>Evaluation team members</td>
</tr>
<tr>
<td></td>
<td>Preparatory meeting of the evaluation team</td>
<td></td>
</tr>
<tr>
<td>09:30-10:00</td>
<td>Initial welcome &amp; introduction of the Institute</td>
<td>Dept. representatives (max. 8 persons)</td>
</tr>
<tr>
<td>10:00-11:00</td>
<td>Meeting with the programme students</td>
<td>Students (max. 6 people, 1-5th year students)</td>
</tr>
<tr>
<td>11:00-12:30</td>
<td>Meeting of the programme staff</td>
<td>Staff members (max. 8 people, professors, teachers, lectures, assistants)</td>
</tr>
<tr>
<td>12:30-13:30</td>
<td>Lunch with students and staff</td>
<td></td>
</tr>
<tr>
<td>13:30-14:45</td>
<td>Meeting with the representatives of commerce, and industry</td>
<td>Representatives of industry (max. 6 persons)</td>
</tr>
<tr>
<td>14:45-15:15</td>
<td>Time reserved for student exercises and thesis work</td>
<td>Display of materials, thesis work, project papers, and course book</td>
</tr>
<tr>
<td>15:15-16:45</td>
<td>Visit to lecture halls, laboratories, and introduction of equipment, etc.</td>
<td>Persons in charge of facilities and individual teachers</td>
</tr>
<tr>
<td>16:45-17:15</td>
<td>Meeting of the evaluation team</td>
<td>Evaluation team members</td>
</tr>
<tr>
<td>17:15-17:45</td>
<td>Feedback</td>
<td>Students and staff of the Department</td>
</tr>
</tbody>
</table>

* The programme of the one-day site visit in each institution followed a certain fixed timetable. The only exceptions were to do with reasons related to travel timetables but even then the real time spent for each interview and laboratory visit was the same.
3

Common findings

3.1 Challenges for the mechanical engineering education

Mechanical engineering is a traditional field of engineering which is also reflected in respective education. The progress made in the field has been rather stable without any bigger needs for rapid changes in the contents of the degree programmes, or in the number of students. The degree programmes have, of course, been under continuous evolution, but the trends in the modern information society, and in the rapidly changing industry and business, are continuously creating new challenges for mechanical engineering education, too.

In addition to the metal industry proper, mechanical engineering skills are needed also in other industrial sectors, such as the electronics industry. Moreover, modern machines or metal products are nowadays very complicated multitechnological systems which require the combination of various engineering skills, although the thorough understanding of the underlying physical phenomena is today more important than ever. The product development and manufacturing of such systems requires new methodologies. The modern business networks and flat organisations relying more and more on team work make it also necessary for the mechanical engineers to possess “soft skills”, e.g., communication, negotiation, language, co-operation and other similar skills.

Mechanical Engineering has a somewhat poor image, and the respective education institutions have problems in attracting students. The drop-out rate is high, especially in some polytechnics. It seems that many students start at the institutions just to spend the time while looking for better places to study, or to refresh their basic mathematics and physics skills for university entrance exams. Some students evidently find studying simply too demanding. In universities there are also quite a few drop-outs, one major reason being that some students change to other, more attractive departments. A major challenge for universities is perhaps the long study times. This is basically an element of academic freedom, one underlying reason being the part-time jobs held by the students. Students, however, do not seem to complain about the situation. Part-time jobs are more common in the Helsinki region, for quite natural reasons, because more jobs are available, while they are quite rare, for example, in Lappeenranta.

Due to the rather stable situation in Mechanical Engineering, there have been rather little changes in the permanent teaching staff. The average age is generally rather high, and in many places there are quite a few people representing the same age group. This may cause problems when these people start
to retire all at the same time. Continuous staff development and recruitment of young competent teachers is therefore one further challenge.

Research is an integral part of higher education, especially in universities. Unfortunately, Mechanical Engineering does not generally have a very long and good track record, especially as far as basic research is concerned. This is also part of the image problem, and is further shown by the fact that very talented students are not interested in Mechanical Engineering because they find that it does not offer sufficient challenge. During the past few years, the research activities have been developing rather rapidly, partly because universities have been forced to seek for additional external funding.

The co-operation with industry has also been developing very well, but there is a danger that university research starts to become excessively industry-driven problem solving, at the expense of longer term basic research. Basic research that meets the best international standards is a prerequisite for generating truly novel knowledge, and this is in turn reflected in high-level and up-to-date education. This further helps the Finnish industry to maintain its global market position.

The number of doctors in Mechanical Engineering has been traditionally rather low, although it is today increasing rapidly, thanks to the overall increase in research activities and the graduate school system, in particular. A further challenge in this context is the fact that the Finnish mechanical engineering industry is basically not willing to employ doctors, because “there is no need for doctors in industry”, as one of the representatives of industry expressed this attitude.

The basic government funding has been decreasing in the field of mechanical engineering education, at least relatively, since major investments have been directed to the IT sector. The shortage of basic funding has, to some extent, been compensated through the use of research funding in education, another factor that makes it increasingly difficult to carry out top-level research in universities.

During the evaluation visits, there were some discussions on the need for technicians. This line of education ended through the higher vocational education reform in the 1990s. Some companies would still like to have technicians for foremen and similar positions because they find that the polytechnic engineers have too long a training for their purposes. Others clearly stated that teamwork is the way to work today, foremen are no longer needed, and thus there is no need for technicians, either.

In this situation, it seems that the contents and methods of mechanical engineering education both in the universities and polytechnics should be carefully and critically analysed to meet the future challenges. Education should create a desire for personal development and an ability to acquire new knowledge. The image problem is one of the reason why Mechanical Engineering does not attract young people in general, and females in particular. Revising education and putting forward new topics and titles can change these attitudes, too.
3.2 Strategic and administrative issues

One of the major targets of the present kind of evaluation is to help educational institutes in establishing and enhancing their self-assessment and continuous improvement procedures. An integral part of this kind of development is strategic thinking, with clearly stated common missions, visions, objectives, etc. Generally, it seems that there are considerable differences between institutes in the level and implementation of strategic planning, although the self-assessment reports suggest that each institute has made a strategic plan. The missions and visions presented in the reports were rather general, and only few institutes had a clear and separately stated vision or strategy for mechanical engineering.

In universities, there is, of course, a built-in dilemma between academic freedom and strategic planning. The creation of a common strategy is therefore a very delicate and challenging task, requiring real co-operation and good motivation among independent professors. The grand missions and visions formulated at the university central administration level are not necessarily easily adopted and implemented at the department or degree programme level. As regards the future challenges of mechanical engineering education, a dedicated strategy process within the department or degree programme becomes, however, more and more important.

The organisational structures are traditionally not very flexible. In universities the traditional institution of permanent professorships can have a slowing and impeding effect on changes. Typically, each professor may have his own fixed specialisation, which makes the degree programme very rigid. Many fields within Mechanical Engineering are so small that there are unique professorships, or only a couple of professors in the same field in Finland. Naturally, this normally results in a lack of resources, and it is difficult to create a critical mass, but it also means that there is practically no competition, which may slow down the development.

There seem to be clear differences in the level of strategies of the four universities providing mechanical engineering education. HUT tends to emphasise the independence of individual chairs or laboratories, and there seem to be rather little co-operation among them. One evident explanation to this is the fact that there are quite many unique professorships with very little in common. Alternatively, they may also have been acting rather isolated, in close co-operation with the corresponding specific industrial branch.

Perhaps TUT has taken the longest step in creating a real and concrete common strategy for mechanical engineering. They have defined their focus areas, and new professorships have been established to support this strategy. TUT has also developed a matrix organisation: the education is arranged like a matrix so that individual institutes may also contribute to several appropriate degree programmes of other departments. Each institute has, however, a home department, where the decisions regarding resources are made. The aim of this arrangement is to offer more flexibility in degree programmes as compared to the pure department based system.
LUT has also created an specific strategy for mechanical engineering with focus areas highlighting their special expertise areas. New professorships have also been established to support this strategy. However, both LUT and TUT tend to be a little bit closed or clannish; new professors are typically their own graduates.

Oulu University is somewhere in between HUT and TUT regarding strategic thinking. The Mechanical Engineering Department has a jointly developed module system of courses, or optional course packages, within the degree programme. This provides more guidance for the students, but also more flexibility compared to the situation where each chair has its own fixed specialisation. Vacant professorships are redefined according to anticipated needs.

Polytechnics constitute a quite new concept in Finland, but in many cases their mechanical engineering education stems from very long traditions of former Institutes of Technology. Correspondingly, their organisational structure is also rather rigid and lecturers have generally a long experience. There is, however, a lot of potential in exploiting the internal synergy and development within each polytechnic. Because the polytechnic system is rather new, the overall strategy planning is still at a rather general level, and many of the Mechanical Engineering departments or degree programmes do not have their own clear strategy so far. The municipal administration is in some cases rather heavy, and local political interests can influence the contents and emphasis of different degree programmes.

There are also some interesting new approaches in the organisation of the polytechnics. For example, the Vasa Swedish Polytechnic has adopted a matrix organisation in which departments (supply of resources) and degree programmes (demand of services) are separated and they have independent responsible heads. This system seemed to work well and makes the contents of degree programmes more flexible.

Most polytechnics have a working quality system, and some of them have also an ISO certificate. This is less common in universities, probably because they want to emphasise their academic freedom. Whilst a certified quality system alone does not guarantee good education, some sort of a systematic process in strategic planning and development of education and staff would, however, be advisable. This can be accomplished also through the use of a self-evaluation procedure, e.g., the EFQM (European Foundation for Quality Management) Excellence Model. Some institutes have already started to adopt this method.

There is a lot of variation between the institutions as concerns the students' participation in the administration or planning of studies or strategies. In some institutes students have an essential role in administrative or planning bodies, bringing forward their own fresh ideas. In other places, the students have virtually no formal role at all, which may be quite a waste of resources.
3.3 Roles of universities and polytechnics

A common feature in the strategies of mechanical engineering in universities is that the regional role or at least national role is still rather clearly put forward. For a university that claims to be top-level by international standards – an objective included in each and every vision statement – the only league is the international one. Naturally, competition is also harder than at the national level. This, again, emphasises the need for high-level basic research and sufficient volume in post graduate studies also in Mechanical Engineering. Some industrial companies stress the importance of starting university education in mechanical engineering in their home cities as an answer to their difficulties in hiring graduate engineers. This is rather contradictory to the above reasoning on the importance of international level research and ensuing education as such research and education will require sufficient resources and focusing of activities.

According to the Finnish education system, the polytechnics are more practically oriented, training professionals for expert and development posts. They have also a clearly defined role in the Finnish regional policy, according to which the institutions of higher education and centres of excellence built around them should have a major role in regional development. On the basis of the strategies described in the self-evaluation reports, the polytechnics have generally understood their role in the above manner. There are differences, however, in formulating specific strategies for mechanical engineering. Some institutes do not have a separate strategy for mechanical engineering, or the strategy work has only just started. This is quite understandable as the whole polytechnic system was permanently established as late as in 2000.

The local role of polytechnics was also quite well reflected in the opinions of industry. In some regions, the companies had even chosen their site on the basis of the vicinity of a polytechnic. One of the representatives of industry expressed it in this way: “Polytechnics should keep their local role and concentrate on SMEs (Small and Medium size Enterprises), big companies take care of themselves”. In smaller cities, the local importance of polytechnics is clearly seen; the city management is very proud of them. In bigger cities, polytechnics do not have such a central regional role, and they tend to be lost in the city bureaucracy, which evidently causes some identity problems, especially for small Mechanical Engineering degree programmes.

Many of the polytechnics emphasise research or R&D work in their strategies. In practice, research means providing consulting services mainly for local companies through the use of existing (teaching) facilities. Most of the Mechanical Engineering degree programmes in polytechnics are rather small and resources are correspondingly limited. Focusing on one or two specific subjects is therefore reasonable. To meet all regional needs means co-operation and networking with other institutes.
The roles of universities and polytechnics are not overlapping, and there should be no contradiction between them, either in education or in research. The strategies of universities and polytechnics are generally in line with this principle, although they could be more explicit in this respect, and state clearly the importance of networking also between universities and polytechnics. The possible continuation education in polytechnics is one issue which should be planned in co-operation with the universities.

3.4 Education versus research

The fundamental difference between universities and polytechnics is that research is the basic mission of a university, and education should be based on it to ensure the diffusion of the newest scientific knowledge, while polytechnics train professionals and the respective education is more practically oriented.

In principle, this seems to work also regarding mechanical engineering education in universities; research staff is taking part in teaching and vice versa. Moreover, undergraduate and especially postgraduate students participate in research projects. Many theses are also quite naturally linked to research projects. In fact, research in universities is largely carried out using students, also undergraduate students. This is not always a good thing, considering the objective to carry out research that meets the highest international standards. Unfortunately, there are some Mechanical Engineering chairs which have rather scarce research traditions. There the combination of research and scientific education does not work.

Internationally relevant basic research in Mechanical Engineering is generally still rather limited in Finland, and as such it does not offer enough challenges for very talented young people. In Mechanical Engineering as elsewhere in the research community, it would be extremely important that universities (and other research institutes) be capable of creating genuinely new ideas and technical solutions enabling radical breakthroughs in industrial applications; they should not only concentrate on solving today's technical problems but lead the development and create new potential/ knowledge. The prerequisite for this is that the volume and level of longer-term basic research is sufficient, and that this research is closely connected to education. This also requires sufficient volume in postgraduate studies.

As far as polytechnics are concerned, research means providing consulting services mainly for local companies through the use of existing (teaching) facilities. Some polytechnics have managed to invest in rather specific and expensive testing facilities which are more purely aimed at providing external services for industry. This activity is, however, limited by the fact that they have no - and perhaps should not have any - special research service personnel; their normal teaching or laboratory staff is in charge of these functions. Polytechnic teachers engage in some academic research individually in the context of their
personal postgraduate studies, e.g., when developing their competence to meet the requirements set for principal lecturers.

It does not seem rational to increase the volume of research in polytechnics since teachers are already overloaded, and research would require additional special staff and investment in equipment. As a whole, it might be better to join forces with universities and research institutes, and create co-operation within research networks, making better use of each others' facilities and special expertise. There are some good examples in this respect, such as the FMS centre in Tampere, Technobothnia in Vaasa, or the IMTEC centre in Joensuu.

3.5 Learning and teaching

Mechanical engineering education has a long tradition, the permanent teaching staff tends to be ageing, and there is a shortage of basic funding. Moreover, teaching is not very highly regarded in universities. It is sometimes regarded as a "second rate activity" among top scientists, and there are no formal pedagogical requirements for professors. In polytechnics, the teaching duties of the lecturers are rather heavy, which makes it difficult to develop teaching or personal skills. At the same time, teaching is faced with a myriad of other challenges. In view of the development of education, the situation is therefore by no means easy.

Regarding the contents of mechanical engineering education, the basic engineering skills are still important. A competent engineer should know the underlying physical phenomena of a complicated machine, or see behind the fascinating user interface of a simulation program. This means that mathematics and physics, as well as mechanics including strength of materials, are as important as ever. However, it seems that the teaching of these subjects is in some cases too theoretical, and too far from mechanical engineering applications.

At the same time, the product development and manufacturing of modern machine systems and electronics products call for new skills. Automation, materials and production technology, applications of ICT, combination of multidisciplinary skills, etc. are becoming increasingly important. Today's business networks and flat organisations emphasise the importance of social skills.

Teaching and learning are still mostly based on traditional lectures and exercises, which do not necessarily help in developing the necessary social skills. The adoption of these skills as well as team work skills could perhaps be integrated in normal education as an essential part of the learning process. Problem-based learning and project-based studying is already very popular in most polytechnics. The Internet can be exploited also in international co-operation. Some institutes have already arranged joint exercise works with foreign institutes via Internet.

There are some separate e-learning experiments, such as using the Internet in distant learning, or the recently launched Virtual University initiative. Clearly, the proper exploitation of modern ICT technology in mechanical engineer-
ing education is a challenge regarding teaching and learning methods. This no
doubt calls for co-operation, at least on the national level.

The students’ involvement in the process of developing education varies
quite a lot. In some institutes there is a specific study planning body with a
student participation while in other places students have virtually no role at all.
There are also rather big differences as concerns student feedback and its sys-
tematic exploitation. Tutoring is arranged in every institute, but there are still
some shortcomings.

In many institutes, especially in bigger municipal polytechnics, the heavy
administration is reducing the resources of teaching and limiting the flexibility
of the programme. At least partly, this is due to the fact that the new polytech-
nic concept is only just taking its first steps in Finland.

In most institutes the premises and the laboratories are in rather a good
condition for educational purposes. The biggest challenge is to maintain the
present status, i.e., to ensure replacements and re-investments in equipment.
The computer facilities could, of course, always be better.

3.6 Links to industry and national co-operation

Mechanical Engineering degree programmes have traditionally rather good
contacts to the respective industry. Most theses are made for industry in practi-
cal service in industry, especially in polytechnics. The co-operation between
universities and the industry is generally quite good, and companies also con-
tribute to the funding of research projects. This is a positive fact in principle,
but it can also have some drawbacks in the sense that the time span of research
may shorten: rather than create new knowledge, the universities start to serve
today’s needs. However, external funding is extremely important, especially for
universities, and in order to secure the necessary funding it is therefore a must
to have good relations with industry.

One important way of linking industrial experience to education is the use
external part-time teachers from industry. Generally this system is working quite
well. The students like the up-to-date and practical knowledge of external teach-
ers, although there might be some shortcomings in their pedagogical skills. For
industry, this is a way to create contacts with students and identify competent
future engineers. Some institutes have, however, had difficulties to recruit part-
time teachers from industry; people working in practical are too busy and over-
loaded.

A very good way to transfer knowledge and experience from education to
industry and vice versa is the exchange of personnel. This arrangement is un-
fortunately systematically used only in very few places, although all parties are
in principle in favour of it.

Many of the industry representatives said that they would appreciate a more
formal forum for discussions regarding educational and strategic issues with
universities and polytechnics. Some institutes have advisory boards for this purpose, while others rely on more informal discussions.

The alumni activity, which is just taking the very first steps in Finland, is one good possibility to create closer contacts between the working life and educational institutes. In addition, it may help in improving the low image of the mechanical engineering field.

Typically, the Finnish universities and polytechnics are used to standing on their own without any particular mutual co-operation. Some sort of clannish behaviour can still be found, although the situation has been improved, thanks also to graduate schools or projects funded by TEKES (the National Technology Agency). Both forms of activity require co-operation between institutes.

The Virtual University initiative is a good step towards developing joint education and reducing overlapping efforts, which in turn will release resources for other purposes. Some polytechnics have jointly started similar efforts.

Universities still seem to have some prejudices against polytechnics; probably they are afraid of some sort of competition of resources. In reality, it is quite evident that the two systems complement each other, and co-operation would be much more rational than competition. Similarly, research institutes, such as the VTT, could constitute good research network partners for both universities and polytechnics.

3.7 Mobility and the international dimension

For the past few years, the hot topic of higher education has been international activity. For some years now, educational institutes in virtually every part of the world have been looking for new methods to enhance their competence – universities and polytechnics are also part of the globalised world.

For universities and polytechnics it has been clear that the international dimension is one of the key factors to gain extra benefits for the organisation. Mobility of students and teachers is the main tool to enhance international activities.

In general, there are two major elements of mobility. The first one is merely mobility in the name of science, associated with researchers. The second concept of mobility is wider and linked to students and teachers. Mobility in the field of research has been obvious for centuries and is also more attached to the tradition. In that respect the mobility of students and teachers is a relatively new phenomenon.

In Mechanical Engineering, the international co-operation between universities is, however, still rather limited, even in research. One explanation to this is that currently it is quite easy to receive national funding for applied research, for example from institutions such as TEKES. Getting EU funding is for example, more laborious and much more uncertain.
For quite a few years now, international mobility within Europe has received organisational and financial support through different EU programmes. Universities and polytechnics have been advised to build up international networks in the name of co-operation. They have numerous agreements with sister organisations abroad, but all connections are not very active. Be it how it may, active students have outstanding possibilities to add study packages from foreign educational institutions to their personal curricula.

However, the quantity of student and teachers exchange has been gratifying only to a certain extent. Despite the financial support and good information packages students have not been extremely eager to travel – this has also been the case in Mechanical Engineering. In fact, among students of Mechanical Engineering, mobility linked to practical training has been much more popular than exchange studies.

One reason for scarce mobility is the attraction of the working life. It has been rather painless for the students to find appropriate jobs which are related to their studies. To spend one or two terms studying abroad means in most cases that the student will have no chance to work along with the studies. For teachers it is often rather difficult to free oneself from the daily routines. With no extra financial benefit involved, the teaching experience abroad is often not very attractive.

However, teachers should encourage the students in this respect, highlighting the benefits of international studies. Most teachers and researchers have good contacts to their colleagues around the world. These opportunities should be used more in order to convince students to be mobile. It is also important to guarantee a certain level of financial support – at least to cover travel and extra accommodation costs – for those who are going abroad for to study or to teach.
General recommendations

Based on the entire information collected during the process, the evaluation team would like to bring forward the following issues and present them as general recommendations relevant for all the degree programmes of Mechanical Engineering in universities and polytechnics.

Meeting future challenges

Mechanical Engineering is a very important industrial branch in Finland, and its products are assuming more and more complicated multi-technical and intelligent features. Mechanical engineering skills are needed also in other industrial sectors, such as the electronics industry. High-level education and research in this field are of utmost importance for the future success of Finnish economy. Therefore,

- The contents and methods of Mechanical Engineering education both in the universities and polytechnics should be carefully and critically analysed to meet the future challenges;
- Improving the image of Mechanical Engineering calls for co-operation between all the parties involved. As concerns the universities, the level of research is one of the decisive factors in this respect while the polytechnics should strengthen their regional role and make more efforts to develop their co-operation with the local industry and the universities;
- Allocation of government basic funding must be carefully considered bearing the importance of the industrial branch in mind;
- The universities and polytechnic must understand that they themselves bear the main responsibility for the development. This calls for, e.g., systematic strategic planning, development of methods and contents of teaching, raising the level of research, staff development, co-operation and internationalisation, etc.

Need for strategy process development

The challenges for the Mechanical Engineering education are so diverse that the strategy process both at universities and polytechnics should be enhanced. The development cannot rely solely on the general strategy of the institutions, nor on the separate activities of individual teachers or professors. Therefore,
• Mechanical Engineering degree programmes/departments need their own specific and focused strategies and visions, carefully formulating the objectives of the degree programmes, focus areas, and their own identity or role in the national and international framework. Clear common visions and objectives will help in directing the future development, release the administrative burden, and make the communication with various interest groups easier;

• The roles of universities and polytechnics are not overlapping, and there should be no contradiction between them, either in education or in research. The strategies of universities and polytechnics are generally in line with this principle, although they could be more explicit in this respect, and state clearly the importance of networking also between universities and polytechnics;

• A working quality system can help in systematising the strategy process and in developing education and staff. A certified quality system is advisable, but does not alone guarantee good education. It is more important to adopt a systematic self-assessment procedure, e.g., the EFQM (European Foundation for Quality Management) Excellence Model;

• Good examples of strategies and quality systems exist in some universities and polytechnics. It is recommended to use benchmarking and exploit the best practices also in this respect

Level of education and developing degree programmes

It is anticipated that the need for mechanical engineers is increasing in the future and their competence should meet the internationals standards. This calls for qualified and motivated students, and continuous development of the contents and structures of degree programmes. Therefore,

• Efforts should be made to develop student recruitment and motivation. More interest could be aroused among the potential students considering mechanical engineering studies by presenting the possibilities offered by the degree programmes in schools, in the press and through other channels. The institutes need to take the Mechanical Engineering student motivation problems seriously, for example, by alternating the study of professional skill subjects and theory subjects in an appropriate manner;

• The level of students in Mechanical Engineering is not too high, and there are quite a number of dropouts, especially in some polytechnics. The study entrance requirements should be tightened to ensure that students are well qualified and motivated. This will also contribute to improving the image of Mechanical Engineering;

• The structure of degree programmes should be harmonised with the European tendencies and agreements. The possible continuation education in polytechnics is one issue which should be taken into account in this con-
text. Unfortunately, this issue was not touched upon in self-assessment re-
ports, nor in the discussions.

• The universities and polytechnics need to develop flexible study entities
  which the students can utilise, if necessary, through the mobility between
  various institutes of study. There are several good attempts in this direc-
  tion, e.g., implementations of matrix organisations or so-called module sys-
  tems in some institutions. Again, benchmarking and adoption of best prac-
tices are recommended;

• As regards the contents of education, the basic subjects, such as mathemat-
  ics, physics, mechanics, materials technology, etc., still constitute the basis
  of Mechanical Engineering skills, and should not be overlooked in teaching,
  although there are plenty of other more specialised subjects needed in
  modern mechanical engineering;

• In addition, management and economic capabilities and “soft skills”, e.g.,
  communication, negotiation, language, co-operation and other similar skills
  are getting more and more important, and should be correspondingly incor-
  porated in education;

• Student involvement in planning and development of studies should be
  systematically organised, as well as gathering of feedback. This is not the
  case in all institutions. The same applies to tutoring.

Top-level research by international standards
is a must for universities

Research is an integral part of higher education, especially in universities. Un-
fortunately, Mechanical Engineering does not generally have a very long and
good track record, especially as far as basic research is concerned. This is also
part of the image problem. Therefore,

• Universities should strengthen their efforts in basic research that meets the
  best international standards. This is a prerequisite for generating truly nov-
el knowledge, and this is in turn reflected in high-level and up-to-date edu-
cation, eventually benefiting the respective industry. International bench-
marking in research is a good way to ensure the sufficient level;

• The number of doctors in Mechanical Engineering is still rather low, and
  should be increased to raise the level of research and education. The Finn-
ish mechanical engineering industry, for its part, should also understand
the importance of employing doctors.

• Although research is the basic mission of a university, teaching should also
  be appreciated. No formal pedagogical requirements are set for university
  teachers, be they permanent or external part-time teachers, but universities
  should, however, arrange pedagogical training and support. All universities
  have individual good attempts into this direction, and they should join ef-
  forts in this respect.
Role and specialisation of polytechnics

The polytechnics system is quite new in Finland and there are quite many diverse expectations as regards their future role. Therefore,

- It would be advisable for the polytechnics to specialise in accordance with the local needs and requirements. However, specialisation calls for co-operation and networking with other universities and polytechnics. Both practical business representatives and students should be involved in the specialisation planning process;
- Focus the education; in Finland, the Mechanical Engineering education in polytechnics is geographically dispersed and the respective units are of many sizes - the Mechanical Engineering degree programmes of certain polytechnics are simply too small. For education purposes, it would be more rational to concentrate the resources allocated to teaching;
- The role of research or R&D work in polytechnics should be considered carefully. It does not seem rational to increase the volume of research in polytechnics since teachers are already overloaded, and research would require additional special staff and investment in equipment. As a whole, it might be better to join forces with universities and research institutes, and create co-operation within research networks, making better use of each others' facilities and special expertise.

Need for new teaching methods

It is vital for any university or polytechnic to make full use of the new teaching methods. Such methods include learning by doing, e-learning, team work, project-based learning. In order to save the scarce resources available, the universities should collaborate in developing the new teaching methods - e.g., the virtual university. Therefore,

- Universities and polytechnics should join the forces to accelerate the development of new teaching methods, especially those based on the ICT technology and Internet;
- The virtual university initiative, for example, is a good start, and should be fully exploited also in Mechanical Engineering education.

Staff development is also necessary

Due to the rather stable situation in Mechanical Engineering, there have been rather little changes in the permanent teaching staff. The average age is generally rather high, and in many places there are quite a few people representing the same age group. Therefore,
• Each institution should develop a systematic staff development program, as an essential part of the strategy process. This should include the planning of staff structure in line with the anticipated future needs, as well as personal development programmes to ensure the up-to-date skills of teachers;
• Especially new teaching methods require support and training for the teaching staff. The institutions should also take care of this.

Co-operate and make use of links to industry

Meeting the myriad of challenges for the development Mechanical Engineering education is an enormous task. There is not much sense in each separate institution trying to struggle with these challenges in isolation. In addition, the customer, i.e., the industry has, of course, a great interest in participating in the development. Therefore,

• The institutions should join forces in developing their activities, e.g., in novel teaching methods such as e-learning, and use benchmarking systematically where applicable in order to identify best practices;
• Specialisation in education and research is a must, which in part also calls for deeper co-operation.
• Systematic use of part-time teachers from industry is a good way to keep contacts to everyday business life. A very good way to transfer knowledge and experience from education to industry and vice versa is the exchange of personnel. This arrangement should be encouraged;
• Industry in general is willing to participate more formally in the strategic and education development activities of universities and polytechnics. It is advisable that each Mechanical Engineering degree programme/department establish an advisory board, if not already existing, and intensifies the efforts in the alumni activity.

Go for international mobility

The globalising business and research calls for more international engineers and education, respectively. Therefore,

• The universities and polytechnics should recognise the importance of international mobility. For example, the transfer of credits between various institutes should be made simple and smooth. The European efforts and agreements in harmonising the degree structures should be fully exploited;
• The companies should be involved already during the planning of international studies and training. Some companies are also willing to offer trainee jobs in their offices abroad.
5

Programme-specific findings

5.1 Helsinki Polytechnic (Stadia)

Basic information
Programme established in 1956 (1881). Number of students: male/female 451/32. Teaching staff 40.65. Student/teaching staff ratio 11.9. Median time for graduation 3.8 years. Average age of graduation 24 years.

The Helsinki Institute of Technology became an educational establishment maintained by the City of Helsinki on 1 August 1995. A provisional polytechnic, part of which was the Institute of Technology, began to operate on 1 August 1996. The government granted a permanent licence on 5 February 1999. The Helsinki Polytechnic started to operate as a permanent institution on 1 August 2000.

Vision, mission and strategy

According to its vision statement, Stadia is an internationally respected institute of higher education comprising top-level units whose students will find employment immediately upon graduation.

The mission statement is as follows: the task of Stadia is to increase professional expertise and to improve competitiveness in the greater Helsinki region. Values pursued in our work are growth within the profession, inspirational work, and excellence in achievement and customer awareness.

The strategy is based on the following idea: the focus is on education and training. In Stadia's development strategy, four key objectives are defined: profitability, the client and interest groups, processes and services and competent personnel.

Besides the strategy of the whole Polytechnic there is also a preliminary strategy focusing on the Department of Mechanical Engineering. According to this document the mission is ‘to provide a good education for an ordinary student’, whereas the vision focuses on high quality of work. High quality is defined as providing satisfaction to all clients and interest groups.

The operational idea of the Department is that it will reach the above vision of high quality by continuous improvement in educational skills, industrial co-operation and student recruitment. The Department will thus become a centre of know-how. In addition to this, the Department will take strategic steps which are a) curriculum development b) quality development c) personnel development.
On the basis of the discussions conducted during the site visit by the evaluation team with different groups, it was found that the strategy was carefully and profoundly elaborated. However, students and industry representatives thought that actions related to the strategy were not clear.

Teaching and learning

According to the self-evaluation report teachers are constantly participating in personnel development. Every staff member takes part in annual personal development discussions. On the basis of these discussions personal development outlines are created. Work on the Department is based on the respect of human dignity and professional skills as well as on openness and liberty to pursue one’s own independent critical work. However, according to the staff interviewed by the evaluation team, the objective of the personnel development project has not been fully reached.

The continuing development of personnel is guaranteed, also through the fact that 2.5% of the total salary expenditure is allocated for this purpose. In addition to this, other focus areas for improvement are curriculum development and project learning. Special attention has also been given to difficulties in recruiting new students.

All members of the department have both theoretical and pedagogical education to meet the qualification demands. Sometimes these two sectors do not meet in real life. Students are saying that the highlights of the mission and the vision do not materialise in daily life of education.

The degree of an AMK (polytechnic) engineer in Finland contains 160 credits. Only 5 credits out of the whole are optional credits. As a result students, in particular, feel that there is not enough flexibility within the studies. This easily creates a situation where the whole structure is rigid. This is against the principle of mobility and objectives of the strategy. But then again – fairly incongruously – students felt that the education given by the degree programme is good and gives a solid package for the one’s life after studies. Moreover, the students emphasised that the average age of teachers is relatively high. Occasionally, this could mean that teaching methods are also relatively old. This contributes to low motivation in relation to certain subjects.

The evaluation team got an impression that students are not properly advised and encouraged by the teachers to select courses other than those which are strictly linked to the subject.

On the contrary, students were not very actively taking any real and concrete action towards flexibility in their own studies, and they were reluctant to go abroad for their studies. The reason for this is not only a personal choice of the students but also the relatively active and alluring job market in Helsinki area and the inflexible study structure. The culture of completing one part of the studies as an exchange student has not yet been rooted at Stadia’s Mechanical Engineering Department.
It is a fact that basic mathematics and physics courses do not necessarily cheer up students but without the knowledge gained in these courses engineering studies can not exist. The key for increased motivation could be developing teaching methods and the structure of the basic courses.

For the Mechanical Engineering degree programme it is a challenging task to fulfil the requirements pointed out in the strategy. The argument of the curriculum development is that the staff, students and co-operation partners are taking part in ongoing and wide-ranging reforms in training planning. The work is performed annually but every fourth year a more profound reform will be made according to the information gained from experience.

More flexibility for students

The students, who attended the evaluation, seemed to be highly motivated. They reported positively that the annual in-house evaluation (by 4th years students and staff), including detailed discussions and feedback within and across the groups, is essential to upgrade and update course contents, provided that the concluding results are accepted by the responsible authorities and will lead to the expected consequences towards modernising education for the benefit of the students and their future tasks in the society.

However, the students are still not fully satisfied with the fairly tight and fixed course programme. More flexibility and a wider offer for optional courses for individual choices would be desirable. Some complains were also raised regarding the insufficient availability of books at the library, especially as regards the literature recommended by the teachers. The students representatives agreed that the computational equipment is sufficient for their needs even if 3-4 persons have to share one computer. But all students stated that the (mechanical) laboratory is out-of-date and by no means up to the required standards.

Students were in general fairly content with the teaching. Contacts between students and teachers were direct but distant. It was also mentioned during the interview that some measures should be taken in order to improve the attraction of the study for female students.

Teaching

The allocation of 2.5% of the salary expenditures as an incentive and motivation of the staff is a very positive strategy. The Departments should be able decide autonomously on the use of the budget, e.g., for image improvement, external activities, acquisitions, investments, additional staff to satisfy short-term requirements.

The comparatively high number of external teachers – 26 external vs. 17 internal teachers – could be used more actively; for example, they could be used as tutors for projects, especially in line with their own industrial interest,
in order to improve the ties between the education institution and the industrial “clients”. This bridging function could be useful in recruiting skilled graduates for the industry as well as in making use of the Polytechnic as a source of knowledge/expertise and as solver of external problems.

As concerns the contacts with industry, the regular feedback via the Departments’ Advisory Board is certainly positive and one way to foster co-operation. But there are alternatives suggested by and discussed with the representatives from industry which could be applied for further improvements.

**Commerce and industry**

Companies which are co-operating with the Polytechnic are different in size. In general the reputation of Stadia and Mechanical Engineering is good and constructive. The representative from the industry emphasise how important it is to constantly develop the Polytechnic – this is a fact which sometimes is not understood by the owner, i.e., the City of Helsinki. According to the industrial representatives the financing is not at the best possible level. This means that some laboratories are not well equipped. The machinery in laboratories for teaching purposes is occasionally relatively old.

It is absolutely vital to improve the image of mechanical engineering. According to the industrial representatives the general ‘feeling’ of mechanical engineering has not gained any positive attractions during the past few years. Due to this, the MET is starting a project to improve this relatively poor image of the branch in Finland.

It was quite clearly mentioned that there is a lack of management studies as well as teaching for communications skills. The impression of the industrial representatives is that for many students teachers are too distant. Also in mechanical engineering education should be a kind of a glue or joint between the needs of industry and society, and here the role of teachers is highly important. The representatives from industry found that the teaching methods in this particular programme do not always provide the best skills for students to meet the ‘real world’.

The industrial representatives also thought that there is a lack of co-operation between polytechnics and universities and Department of Mechanical Engineering. Stadia is not an exception among Finnish polytechnics. The co-operation is a question of life and death in many respects. The question reflects another problem, i.e., how to improve knowledge and research in a small country like Finland.

The industrial representatives agreed, in principle, with the study course offered by the institute. But some more flexibility – based upon own previous experience – is desirable and should be considered in close contact with the industry in order to fill gaps in knowledge of modern mechanical engineers. Therefore, the industry is very willing to share their own considerations on the extent of necessary specialisation with the education institute.
Co-operation and networking

According to the self-evaluation report a notable revision of the curriculum has been made in 1999–2000. The aim of the reform was to more effectively meet the training targets set by future student employers and give a more attractive education for students. This led to changes in training, laboratory practices, and project learning.

During the interviews the evaluation team got an impression that there could have been more co-operation between the teachers and the industry. The team spirit among the teachers and students seemed to be one of the positive remarks but on the other hand links to the outer world could have been better. There was also a relatively strong vision that the administration of the Polytechnic is too far from the staff.

In particular, interdisciplinary clustering within polytechnics as well as exchange and co-operation between polytechnics may provide the “critical mass” which is necessary for any added value to education without extending the scope and efforts of each individual institute. Such networking is very much favoured by industry, regardless of “historical” frictions and questions of responsibility between educational bodies.

Main collaboration partners for the programme are Helsinki University of Technology and the Commercial college HELIA. As concerns the improvement of student mobility, international co-operation, teachers training and ties with the working life, all polytechnics in the province of Uusimaa are collaborating with Stadia.

International mobility

As underlined in the strategy statement, Stadia is and will be an internationally respected polytechnic. Most likely this means that there are clear and working contacts to foreign partners and at least certain amount of mobility among students and the staff.

With regard to the international exchange it was noted that such connections are well under way as far as the staff is concerned. However, the students’ exchange is presently still modest. Therefore it is recommended that the staff should consider means to motivate the students and to convince them that some time abroad will not only widen their horizon but is also advantageous in view of their future position in industry and society.

The aim is to include international activities in the Stadia’s core operations in all the strategically essential development areas. The most significant co-operation contracts have been concluded in the framework of the EU programmes Socrates and Leonardo da Vinci. Separate contracts with 61 institutes have been signed.
Facilities and equipment

Laboratories and other facilities were old but well organised. The laboratory of manufacturing should be modernised. Although the various buildings on site are at different locations, students – although complaining – have to adjust to the present situation. The library is small considering the number of students. The technical facilities certainly need to be updated.

Good practice

• the Polytechnic has a good reputation and it is well known
• highly skilled students with high motivation
• solid basic studies.

Recommendations

• technical facilities and equipment in laboratories need to be updated and the number of laboratory staff should be reconsidered
• more study flexibility. Students could join the planning process from the beginning and new ideas of teaching should be invented to motivate both teachers and students
• the relationship between the programme and the central administration should be more functional.

5.2 North Karelia Polytechnic

Basic information

Programme established 1961. Number of students: male/female 132/5. Number of teaching staff 6.7. Student/teaching staff ratio 20.5. Median time for graduation 3.5 years. Average age of graduation 34.5 years (contains the relatively large adult group which graduated in 2000).

Engineering education started in 1961 in the Wärtsilä Institute of Technology, with Mechanical Engineering and Civil Engineering as the first lines of study. The Polytechnic started with four engineering degree programmes: 1) Mechanical Engineering including Machine Automation, Machine Construction Design and Production Technology, 2) Plastics Engineering with Plastics Processing and later also with Mould Technology, 3) Civil Engineering with Buildings Construction and Stone Engineering, 4) Information Engineering with Electronics, Software/Programming, Telecommunication and Automation. The most recent addition is the degree programme in Environmental Engineering. Courses of Mechanical Engineering are based on the areas of Automation, Engineering Design/Mechanics Planning and Production Engineering.
The North Karelia Polytechnic is an independent business unit of the City of Joensuu. Besides the central administration, the polytechnic premises contain the service and development centre, the Injection Moulding and Tooling Engineering Centre (IMTEC) and the design centre.

Aims and strategy of the easternmost polytechnic

The strategy, vision, mission and operational policy are the same for the whole Polytechnic and for the degree programme of Mechanical Engineering.

The idea of the vision is as follows: The multi-sectorial North Karelia Polytechnic provides for the needs of transforming regional and national industries, commerce and other working life by offering broad-based, high-level, and internationally competitive advanced, further and supplementary professional training and education as well as research and development aimed at its own activities and the working life. In 2002 the Polytechnic will be among the most successful polytechnics within the European Union in international co-operation and in co-operation with industry and the working life in general. The Polytechnic also utilises its advantageous location in the easternmost polytechnic in the EU.

The mission of the Polytechnic emphasises the success of the enterprises and other working life in North Karelia within its recognised areas of strength (education, stone technology, food products, forestry, plastics and metals, welfare, information technology, tourism and culture), by taking the clients needs as the starting point, to generate new skills and abilities in entrepreneurship and professional expertise.

North Karelia Polytechnic operates in an active, client and result oriented way for the regional development by producing internationally competitive know-how, professional expertise and entrepreneurial skills both independently and in co-operation with industry, commerce and other working life.

Beside this the Polytechnic aims at being able to answer the demands and rise to the challenges of regional development, and it tries to direct and concentrate resources and the regionally important areas of industry, commerce and labour market without forgetting nationally important aspects.

However, there is no separate or specific mission for the Mechanical Engineering programme. The evaluation team got an impression that the mission is regarded so self-evident that it is not formulated in a written form. In the discussion it was formulated orally as “to combine theory and practice for industry”. The staff clearly sees the importance of the local role of the Polytechnic.
Contents of the programme

Courses in the Mechanical Engineering programme are based on three areas – Automation, Engineering Design/Mechanics Planning and Production Engineering. The principle is that the structure of the programme allows a wide choice within the professional subjects modules.

Years of developing work and many changes were introduced as an independent technical institute became a polytechnic. The changes have been turned into good procedures, and the co-operation between degree programmes is working well. In the near future one major step will be the extension of IMTEC through the introduction of a product development centre and extra laboratory facilities which can be used by the programme.

According to the self-evaluation report the major changes and improvements of the Mechanical Engineering programme have included:

• the first and only Plastics Engineering degree
• a provincial development project in order to have new flexible manufacturing technology
• the development of the Injection Moulding and Tooling Engineering Centre.

Teaching and learning

The basis of the teaching at North Karelia Polytechnic is the whole range of teaching technology – lecture, pair work, team work, oral presentations, portfolio work, etc. Assessment is based on written and oral tests, distance tasks and continuous assessments. The Polytechnic makes full use of computer assisted learning and networks. There has been also one teaching project with FH Aalen in their virtual robotics laboratory project.

Students participate in developing the courses and education by filling in an evaluation form with pros and cons and suggestions for improvements. However, the feedback was not working as it should. Students have been lazy in completing the questionnaires constantly throughout their studies. In general, students were happy with the study possibilities and the contents of the programme. The only thing they were complaining about was the fact that study groups are occasionally too crowded. Students regarded the present groups to be too large, and more experiments to improve the practical part of the education and the inclusion of business courses are desirable. Also the course programme is somewhat too stiff and there is only little time available to follow optional courses which, unfortunately, often overlap with other courses. Therefore, an improvement of the course schedules by more flexibility, especially during the last year, would be desirable. As a solution it was recommended to reserve on day, e.g., Friday – at least half day – for the optional courses if possible.
Cosy environment for students

The students regarded the facilities offered by the institution, e.g., the library and the laboratories as well equipped and sufficient for their educational needs. The high-quality teaching and the wide range of courses were, in particular, positively mentioned. External teachers and supervisors in projects, also from abroad, are very welcome as enrichment in education; a further increase of these activities will be a positive step forward.

The involvement in the self-assessment during the study time was regarded as positive and sufficient although this is probably somewhat too late during the terms. Student get feedback in various ways: written feedback, at the end of the written task, oral comments from teachers or fellow students after an oral presentation. The feedback may concern a single oral or written task or the whole course. According to the self-assessment report the feedback works well in both directions. Because of the easygoing atmosphere, students continuously give feedback on teaching and the contents of the courses.

International co-operation among students could have been more active. It can be argued that this also applies to contacts to local companies. There are no systematic visits but some excursions are, however, possible if students arrange visits by themselves. The arrangements with the industry run by the recruitment office of the Polytechnic do not work well in practice.

In general the impression about the study facilities and the students were affirmative. However, not all students were very well motivated. Some of the students felt that courses like basic mathematics and physics were too difficult. This situation reflects the situation in which the programme can not attract motivated students with relevant educational background to the programme. The image of the programme of Mechanical Engineering is recognised by students and staff. A huge campaign for recruitment and advertisement was arranged just recently, but without any notable results. In fact, there is a competition going on among the educational units in Finland in order to recruit good students.

Teachers and industry

Mechanical Engineering at the North Karelia Polytechnic is a rather small unit (137/3400 students). The small size means that the unit can be effective but at the same time there might be a lack of resources.

Teachers reported a positive relation and co-operation with the administration and the management providing the required support. There were some complaints about the restricted budget but more students would be desired and necessary to satisfy the industrial demands. In this respect the university, despite the co-operation in language courses and courses delivered in foreign languages, is regarded as a competitor in some educational areas which is probably due to the general trend of the young generation towards higher level education.
The Polytechnic is proud of their close relation with the industry as a result of its strategy to provide an engineering education which is required by the future employers of the students. Another positive fact is that the institute supports the entrepreneurship of their graduates. Unfortunately, there are currently only five external teachers and the chances to increase this number are limited, irrespective of the students’ desires. Possibilities to alleviate this situation may be to further strengthen the contacts with the neighbouring industry and, in particular, by engaging graduates in discussions. Developing the alumni association might bring some solutions for this problem in the future. Hopefully there are some preliminary plans to start alumni activities.

In order to improve the attractiveness for young people, some recruiting measures may be helpful. Constructive methods could be school contacts, exhibitions, an attractive Internet home page, public recognition of course completion without delays and with high marks, job availability, etc. In such activities the involvement of the industrial partners and of the students is certainly recommendable.

**Industrial view and local co-operation**

The industrial partners expressed their general positive impression about the Department with regard to the programme, especially the basic education. They also emphasised that the Polytechnic is very “customer” oriented both in teaching and in the practical education. Graduates also show a good professional quality in serving the needs required in industry. It is for these reasons that the Polytechnic as the major source for the engineering workforce in the region is highly respected. Furthermore, it was positively stated that the North Karelia Polytechnic offers possibilities for lifetime learning and education.

Any real competition with universities, in general, and with the University of Joensuu in particular is regarded as non-essential due to the different educational goals. Universities provide graduates for – in principal – management positions based on a more scientific and interdisciplinary oriented education whilst polytechnics emphasise their role of producing graduates who are able to provide practical engineering solutions. Furthermore, the local university does not offer courses in competing areas.

The representatives also stated the positive co-operation within the triangle School-Town-Industry but emphasised their concern regarding the future need for technically educated engineers from polytechnics in order to overcome the envisaged shortcomings caused by the present “age pyramid” of the engineering force. There was also some concern about the observable decay of knowledge of the graduates regarding the basic skills in Mechanical Engineering, a general tendency throughout the country. Therefore, the local industry is willing to further strengthen the support provided for the institute through, for example, excursions, consultation, regular knowledge exchange, project supervision, part-time teaching, etc.
Moreover, it was suggested that regional specialisation plus a demand-oriented, sufficiently broad engineering education could be supported by networking between several polytechnics, between polytechnics and industry, and even across boarders.

Facilities and equipment

The inspected facilities and the laboratories, in particular, impressed the visitor by their modern equipment of high technical standard, serving as important tools for a high level practical education. Library facilities were well organised and there were computer classes. Especially the technical equipment in the laboratories of IMTEC were outstanding.

Mobility

At the North Karelia Polytechnic this challenge has fulfilled only partially. It was furthermore stated that a fairly low percentage of the students tend to go abroad although the promotion by the Polytechnic is sufficient and well accepted by the students, and no negative effects on their study time is expected or experienced. However, if international mobility is one of the key issues at the Polytechnic, students should be encouraged to go abroad more efficiently. The dominant atmosphere among the students was a strong bond with the regional services. This is in many ways an asset when students have a strong motivation for the local services and industry. On the other hand the most challenging task for an educational unit is to combine benefits from regionalism and internationalism. When students have good local services it is highly important to take care of international co-operation.

The Mechanical Engineering programme at the North Karelia Polytechnic has several industrial partners. There are ten international partners among different universities and polytechnics. Students exchange in the year 2000 consisted of fourteen outgoing months and four incoming months. Staff mobility limits to five outgoing weeks and six incoming weeks.

Good practice

- co-operation with the Science Park, IMTEC and the local vocational school
- positive and motivated students
- strong specialised and local role.

Recommendations

- strengths of the programme should be emphasised
- tools for co-operation should be improved and external teachers from the industry should be used
- more flexibility in studies and more business and management studies.
5.3 Helsinki University of Technology

Basic information

Programme established in 1909. Number of students: male/female 1630/185. Teaching staff 53.5. Student/teaching staff ratio 33.9. Median time for graduation 7.25 years. Average age of graduation 27 years. Median time for graduation (PhD) after the MSc-degree 9.4. Average age of graduation (PhD) 38.3.

Helsinki University of Technology is the oldest and largest technical university in Finland. In 1849 the Helsinki Technical School was founded and in 1872 the school became the Helsinki Polytechnic School and further in 1879 the Helsinki Polytechnic Institute. In 1908 the institute became the Helsinki University of Technology, and that is the year in which the teaching of technology at university level started in Finland.

Presently, the Department has one degree programme which includes the following options: naval architecture, aeronautical engineering, mechanics of materials, design engineering, manufacturing engineering and energy and HVAC technology.

Technical, cultural and social values

According to its mission, the Helsinki University of Technology is characterised by the combination of research and education. The technical, cultural and social values of the Helsinki University of Technology lies in its research and education that produce and distribute knowledge that is essential in the building of the future.

The undergraduate education of the Helsinki University of Technology shall give the student a true understanding of the field of study and thus the capability for the evaluation, extension and creative application of the knowledge. The postgraduate education shall be scientific research education.

The goal is to become a world-class technical university. By the end of the decade HUT is one of the best technical universities in Europe. HUT excels in science and can thus co-operate with the best universities and the most innovative corporations. The co-operation of HUT is international. Due to this HUT attracts the best researchers, teachers and students from Finland and internationally. International interaction leads to the rise of the scientific level of the university.

The Department of mechanical engineering at HUT stands at the highest international level in the special areas of expertise. The Department is versatile enough to co-operate extensively with other departments, and with domestic and foreign universities.

The main objectives of the programme are firstly, to encourage scientific thinking and the use of scientific methods, and secondly, the building of professional competence. The students first learn natural sciences and how to use
mathematical aids in engineering. The objective is that the student understands fully the phenomena and theories behind mechanical engineering applications. The graduates should master the core knowledge of their own professional field so that they are able to understand and develop further design and manufacturing methods, as well as to carry out product development tasks.

Teaching and research

There are five focus areas in the Department – energy engineering, vehicle engineering, engineering materials, production and manufacturing engineering and fluid mechanics. Six of the major subjects are nationally unique at the university level – automotive engineering, naval architecture, aeronautical engineering, HVAC technology, internal combustion engine and foundry engineering.

According to the self-evaluation report the general position of the Department is stable and there are no expected changes in the area of working and operational environment. Basically the Department can function only with a relatively large amount of staff, required to assist in the research and to maintain large facilities and the equipment. It has been rather difficult to recruit qualified staff for some research projects. At the same time the Department thinks that shunning of technology and lack of appreciation are social phenomena that make the recruitment of new students difficult. One deficiency is that the Department has not enough female students and researchers.

One threat is that when the intake has increased from 200 to 300 in five years the financing has practically decreased. However, at the same time research activity has increased because of a growth in external financing.

Students are following more ‘fashionable’ subject and this might create problems in the sense that in some of the areas there are not enough students to fulfil the requirement set by industry for a particular subject.

In addition to permanent budget based vacancies there are quite a few researchers and project workers working on fixed term contracts. Total number of vacancies is 151 containing 25 professors, 36 other teaching staff, 14 laboratory managers, 49 auxiliary staff for teaching and research and 27 administrators. Total number of foreign researchers and trainees was 40 in the year 2000. The staff paid by budget funds and staff paid by acquired funds (external funds) totals to 359, and 63 out of that are female.

Research is an essential part of education. In many cases research results are used for the education. The aim is to give to students the latest knowledge of a particular study field. Practical projects can be utilised in lectures, and research laboratories are used for education. The location of different units might not always be the best possible – for example, there are no common coffee breaks. In the ship laboratory research is integrated into the teaching with strong bonds – both under- and postgraduate students participate in research projects and some researchers give lessons too. According to some labo-
ratories the level of mathematical skills has decreased which is a really a challenging situation for teachers.

The Department is committed to developing the teaching as a part of the personnel strategy of the university, and there has been a working group for developing teaching since 1998. The objectives are to reduce average studying times and to reduce the number of dropout students. The activities are as follows:

- tool box for teachers
- advising students to complete the first package in four years maximum
- upgrading personal study plans
- education and support materials for tutors
- feedback from a tutoring experience involving the generation of mechanical engineering related examples for the chemical engineering teachers
- student feedback from maths and physics lessons
- negotiation with physics teachers regarding the specific mechanical engineering needs
- comparing the amount of work and credits in individual courses.

Graduate schools are working well. There are courses which are knit specially for older students just to allure them back to finalise their studies.

Competent graduates

So far there has been enough good and motivated applicants for the degree programme in mechanical engineering but the general feeling is that the most talented young people are selecting other engineering subjects. One assignment of the working groups for developing teaching and improving information is to create a new and positive image for the Department. This improves the possibilities to recruit increasing numbers and motivated students to the Department. These groups are also systematically co-operating with Abi-info, the office in the central administration of the university involved in the work with different schools in order to inform about the studies in the field of technology. In addition to this the student association of mechanical engineering organises information events in co-operation with the Federation of Finnish Metal and Electrotechnical Industries – the target group is constituted by the pupils in the ninth grade of comprehensive schools.

In general, the mechanical engineering graduates in Finland have a relatively promising job situation with numerous opportunities. On average graduates from the Department of Mechanical Engineering have better employment opportunities than graduates from other departments of HUT. According to the statistics from last spring, 90.3% of graduates of the Department were employed which is higher than the average value of 85.7% for HUT. This extremely good recruiting situation for graduates is incompatible with the relatively low image of the degree programme in the eyes of secondary school pupils who are looking for different routes for further education.
The average graduation time is relatively high – 7.25 years. On the other hand the time approximates graduation times in general in Finland. Unbound-ed study time and academic freedom need not constitute a problem but an asset. Dropout rate should be lower but it is partly high because of the relatively good job market and the changing of the departments and degree programmes.

Learning means quality

Among those students who have started their studies in the Department, the reputation of the Department is simply good. Students were highly motivated and they seemed to know that industry has a great need of high level engineers. Students who were interviewed thought that there is enough flexibility in studies to choose different subjects. The advisory and tutoring systems were also regarded to be very positive.

It was obvious that for quite a number of students the Department was at first a kind of a second study option but the longer students have stayed the better motivated they seemed to be.

On the other hand there were criticism regarding certain aspects in teaching. According to the students, the quality of teaching of some professors was not the best possible. Especially first year students were not happy with big courses and the workload was considered to be too heavy in basic mathematics and physics. Students were emphasising that teaching methods were occasionally old fashioned and unimaginative. It may make sense to integrate mathematics into professional studies, so that the students can see their application at once. It could help if the vision could be sharpened and the teachers could take a more active role to fulfil that vision. The strategy could be more concrete if the number of laboratories were reduced. The students’ representatives stated that the course programme is adaptable to their personal interests through the available options, in particular. However, compulsory courses in the advanced stage of the study are too different and more flexibility is desired. There were also some complains about the pedagogic quality of the teaching staff in the first year courses.

The education of mechanical engineering should be more designed to serve the job market in a more optimal manner. From the industry point of view, it is not the number of areas of specialisation that makes a programme attractive but the fundamental mathematical, physical and technical education, the ability of methodical thinking, problem solving and professionalism.

The financing system of universities seems to be one that cannot satisfy everybody. Apparently the budget money will remain at a relatively low level also in the future and laboratories are forced to finance of the project activities with external money. This situation places different financial units in unequal position, and for some laboratories it is easier to find projects than for others. There could be more synergy between different laboratories.
According to the evaluation team, however, the laboratories were well equipped and there was enough space and possibilities for students to fulfil study requirements.

Industry and commerce

HUT could have more co-operation with other institutes such as VTT. The industry seems to be more interested in dealing with the university in general and with specific departments such as that of mechanical engineering.

The other important question is how to team up with other universities and polytechnics in the Helsinki metropolitan area. Teachers are emphasising that co-operation works well but students and the representatives of industry keep saying that there should be more activity in that field.

The representatives from industry confirmed the very good reputation of the Department as well as the high level of knowledge of the graduates. A comparative judgement about the education of various universities with the same or similar study courses is not possible because each mechanical engineering department has its branch-specific specialities. A preference for graduates from polytechnics or from universities is neither justifiable because the two types of educational institutions have quite different goals.

The very often observed tendency of universities to emphasise the publication of scientific papers as a measure for academic quality and student skills is only of minor importance for an employment in industry. The flexibility of young graduates with a broad and application oriented scientific background, combined with the capacity to quickly adjust to different tasks and situations, is of much higher priority.

It was also suggested that clustering of courses from different disciplines in a university or even from different educational institutions may be a solution for increasing the scope of knowledge for the individual student within the limited budgets available.

In line with this an intensification of the contacts between the Department on one hand and the industry on the other is desired. The already existing industrial week and other similar events – so far own initiatives generated and arranged by the students – are regarded as a first step in the positive direction; an active role of the institute and its staff would be advantageous.

Mobility

Possibilities to spend some time abroad are increasingly available but students who take such a chance are still very few despite of the fairly positive statistics given in self-evaluation. Apart from personal reasons and well-paid job opportunities in Finland, the hesitation seems to be due to excessively limited information available within the university, fear from the “unknown”, or just missing motivation. The students unanimously agreed that international experiences
might be pivotal steps for their future careers. Here again an active role of the staff, a stronger support by the administration, and an efficient use of the experience of students who have returned from a foreign exchange term, would be helpful.

In order to intensify the present situation, for example, in international mobility it may be recommendable to intensity the dialogue between the students and the Department of the university respectively in order to define means for the collection and subsequent processing of complaints, wishes, and reactions of the young generation.

**Good practice**

- highly motivated and talented students
- strong and unique study fields
- university has an excellent reputation.

**Recommendations**

- the programme should conduct careful strategy-level work on the means of maintaining the good reputation
- contacts and co-operation between students and teachers should be improved
- more co-operation between the research laboratories and education.

### 5.4 Turku Polytechnic

**Basic information**


**Southwest dimension**

Turku Polytechnic takes the responsibility for the development of higher professional education and expertise in Southwest Finland. Future-oriented education and R&D measures contribute to prosperity and well-being based on ecologically and ethically sustainable development. Turku Polytechnic produces new applications of nation-wide significance and publicity. R&D absorbs at least 10% of the total financing.

R&D activities seem to have an important role in mechanical engineering. The real needs of the local industry should be considered when planning the focus areas and R&D activities. There is enough metal industry near Turku to emphasise the important role of technical education.
Long traditions

The Mechanical Engineering programme has very long traditions in education starting from 1849. The name of the institute has been changed many times during the years. The specialisation areas are the following, quite traditional fields: Production Engineering and Management, Product Development Technology, Energy Technology, Shipbuilding and Naval Architecture, Ship Production, Machine Automation Technology and Production Automation Technology. It is difficult to see any synergy between the different fields of specialisation. The evaluation team considers that strategy of Mechanical Engineering could be more explicit.

Polytechnic organisations are very new in Finland and it seems that a lot of effort has been spent on the administration of the polytechnics. In the Turku Polytechnic the administration seems to be quite strong and it is possible that it will reduce the resources and motivation in the Mechanical Engineering programme. The customer-oriented organisation could do better in meeting the needs of the industry.

There are currently many ongoing activities in the laboratories, for example a measuring vehicle project and some computer-aided product development processes. There seems to be many computer programmes in 3D modelling and FEM analysis. It is important to know what is behind the programmes, not just to use them. Anyway, the need for all these things should be reconsidered, because the use of the equipment requires resources and time in the future. Focusing the activities together with the local partnership industry could benefit from further elaboration.

Contents and structure of the programme

The programme in Mechanical Engineering is based on traditions of the former institute of technology. Anyway, the structure of the programme is quite incoherent and there is quite many specialisation fields at the moment. In the self-evaluation report the Polytechnic presented some incoming changes, but it is difficult to see clear focus on these ideas. The role of research should be considered because the technical education is the most important thing.

Shipbuilding is one speciality in the polytechnic education in Finland. It could be one of the strengths in Turku. Of course, the need for that kind of education should be discussed with the shipbuilding industry. There are possibilities for co-operation with Helsinki University of Technology in that field. Energy technology is important, but the same kind of education is provided by the Helsinki and Vaasa Polytechnics and Helsinki University of Technology. Cooperation could be possible with these institutes and each of the institutes could find their own profile in energy technology.

The contents of the programme should be reconsidered after the focus areas are selected. At the moment the programme is following the old traditions and some courses are quite theoretical. Self-study and project learning are becoming more popular in the future.
R&D activities

Turku Polytechnic has pointed out that 10% of the total financing is coming from R&D activities. During the past few years, most of the projects have been done for the industry which is quite a normal situation. Research projects are focusing more on the development of services. One of the main questions is how to link the services to the education and how to make the co-operation with other educational units function - universities should be seen as partners also in the future.

Laboratory equipment in Turku is suitable for R&D projects, but it is more important to think how to use this equipment for R&D needs. Special fields in R&D should be close to the focus areas of the curriculum such as Energy Technology, Shipbuilding and Naval Architecture.

The teachers should be involved with the R&D projects, because students cannot do these things on their own. Most of the projects could be practically oriented rather than basic research, a task which is more suitable for the universities. One important and difficult thing is the confidentiality of the R&D work. Furthermore, the teacher should be more active with the contacts to the industry.

Students

Most of the students are recruited from the region close to the city of Turku. The evaluation team got an impression that the motivation among the students is high. So far there has been enough applicants to the Mechanical Engineering programme. For many applicants Mechanical Engineering has not been the first option among degree programmes but it looks like that most of the students, after they have studied some time in the programme, are later highly satisfied with the Mechanical Engineering studies.

One of the weaknesses of the students is the general educational background at polytechnics. There are students of upper secondary background and well motivated students of vocational background. This bipolar situation can create problems especially in the teaching of mathematics, physics and languages. It is difficult to motivate all the students by providing them with similar knowledge and skills. The lack of motivation simply increases the number of dropouts which is also very high at the Turku Polytechnic.

During the recent years the employment situation has been very good. The largest recruiters have been Wärtsilä and the engineering companies of the region. Shipbuilding and Naval Architecture is more depending on the volume of orders although at the moment the situation is quite good. The mobility of the students could be higher and the industry representatives were asking for “the soft skills” of the students.
Co-operation with big companies

Most of the co-operative companies are quite large such as Elomatic, Sisu Diesel, Wärtsilä and Kvaerner Masa Yards. According to the representatives from commerce and industry the reputation of the Turku Polytechnic is good, but seven specialisation areas are too simply too many. However, the co-operation between the industry and Polytechnic seems to work well. There could be more teamwork between the teachers. Research is important for the companies, but the students are not capable of conducting research work on their own.

International contacts and skills are getting more and more important in the future. It means that the Polytechnic should take a more active role in that field. Teachers and students should be encouraged to go abroad. The Polytechnic could have international contacts together with the industry. International experience is highly important for the companies. Companies need maintenance operators and similar, in other words practically oriented persons, much more than they need pure researchers.

Practical trainees are taken but they are usually expected to also write their final theses at the company. It is easy for the students to get a job and some of the students have part-time jobs while studying.

The Metal Know-how Centre project is an interesting way to promote the co-operation between educational organisations and the local industry.

The Turku Polytechnic is one of the biggest polytechnics in Finland. No doubt there is a need for technical education in Turku. By concentrating the education in certain fields of technology in collaboration with the local industry, the Mechanical Engineering programme will be successful in the future.

Laboratory resources

Laboratory and other facilities of the Mechanical Engineering programme are in a relatively good condition. A lot of money has been spent on laboratories and other facilities. One speciality is the measurement vehicle project which is just starting. It could support the R&D activities in the future. Most of the laboratories are quite traditional and laboratories could support more teaching. Some of the laboratory work seems to involve demos rather than real projects. Laboratory persons are needed to maintain and develop laboratory work. The ship laboratory is unique among the polytechnics in Finland.

International co-operation

Turku Polytechnic has a certain type of strategy for international activities. The international co-operation is mainly constituted by teacher and student exchange. There is quite a good list of educational partners, mostly in Europe. Unfortunately the number of exchanges is quite small.
Teachers think that the international mobility is relatively active among the students. The autumn term in the third study year could be the best time for studies abroad. Teaching should include internationalisation, and teaching in foreign languages could be increased.

**Good practice**

- contacts with local industry work well
- laboratories are well equipped
- good special fields of education in Energy Technology, Shipbuilding and Naval Architecture.

**Recommendations**

- specific strategy and clear profile of Mechanical Engineering is missing and should be introduced
- there could be more co-operation with other institutes and the mobility of teachers and student could be increased
- the role of R&D should be considered.

**5.5 Swedish Polytechnic**

**Basic information**


**West dimension**

The aim of the Swedish Polytechnic is to become one of the leading polytechnics within its fields of education and to win international recognition within its target areas. Through networking with other institutions and in close co-operation with the (working life) industry, the objectives of the Swedish Polytechnic are as follows:

- To give a high quality polytechnic education that is adapted to working life and its development and to offer customer-oriented further, continuous and supplementary education of higher standard
- To carry out applied research and development work and perform company and other customer services
- To develop target areas within the disciplines of the degree programmes in which the Polytechnic has a prominent status within the country and in which the Polytechnic has won international recognition.
The strategy of the Polytechnic is clear and well constructed. The fact is that the unit is very small and mainly serving Swedish speaking people. In Vaasa region there are several companies which are using both Finnish and Swedish as their official languages. In that way it is possible for the Swedish Polytechnic to be a driving force for the region and to educate specialists with good professional skills.

The matrix organisation of the Polytechnic, presented for the evaluation team, is very interesting. Briefly the matrix organisation means in Mechanical Engineering that subjects can be easily chosen among the fields of Industrial Management, Energy Technology and Textiles and Clothing. Matrix might cause some confusion but the evaluation team got an impression that is really working well and providing more flexibility for the studies.

Warm atmosphere

The atmosphere is very warm at the Polytechnic, it is like a family, everyone knows each other. Mechanical Engineering is an important programme at the Polytechnic. The graduating students are encouraged to start their own enterprises. Swedish language clearly ties the students and staff together and it is very easy for them to talk together. The local image is also strong, most of the students are coming from nearby localities. A small unit can be more flexible than the big ones and it is easier to meet the needs of the industry.

The Technobotnia project is a good example of a co-operation with the Vaasa Polytechnic although there could be more projects and courses organised together. According to the teachers language is not a big issue but naturally the language divides the Finnish-speaking and the Swedish-speaking Polytechnics; students often find the language situation more rigid than the teachers might like to express.

Contents and structure of the programme

The Mechanical Engineering programme includes specialisation areas: Mechanical Construction Systems, Operating and Maintenance Technology, Plastics Technology and Automotive Engineering. The Plastics Technology is the newest specialisation area. Before the polytechnic era, Automotive Engineering was a programme for the education of technicians. The focus of that programme should be reconsidered and the Polytechnic should pay attention to the needs of the industry for that kind of education.

Energy Technology has been thought to be the next new focus area in the mechanical programme. Because of the small resources it might make sense to reconsider the focus of the programme together with the local industry. At the moment it is difficult to see synergy benefits between the specialisation areas.
Side by side with the Vaasa Polytechnic

In order to enhance co-operation between the Polytechnics the focus areas should be reconsidered in the way that they together fulfil the needs of the industry and there is no overlapping between the programmes. A common international programme could be one possibility. The industry needs more and more internationally skilled persons, and by combining the resources it is possible to offer this kind of education to the students of the two Polytechnics. Co-operation also offers more options for the students.

The Swedish Polytechnic is one of the Swedish-speaking polytechnics in Finland and it has a special status among the polytechnics in Finland. Anyway, the unit is small and co-operation with selected partners could offer benefits for the Swedish Polytechnic.

R&D activities

The laboratories in Technobothnia is a good place for R&D activities. This is a good example of co-operation between the institutes. The number of R&D activities is currently still low but the situation is getting better in the future. Of course, the role of R&D should be reconsidered in a way that the co-operation could be practically oriented, supporting the education at the Polytechnic. The teachers must be involved in the R&D projects, students cannot conduct research on their own. Close contacts with Sweden are one of the benefits of the Swedish Polytechnic.

Students

The students are in general satisfied with the studies, the courses, education and teachers at the Swedish Polytechnic in Vaasa. The students have chosen the school because of the Swedish language. The structure of the education is traditional and the students have not much freedom of choice as far as courses are concerned. The students have only representatives in the Council of the Polytechnic but the relatively small size of the school makes it possible to have sufficient contacts between teachers and students at all levels.

The number of excursions and visits in industry are relatively low. Industry is involved in the education and provides external teachers. The student opinion is that it is very positive if teachers from industry have a good industrial experience. Besides the teachers from big companies, it is also important to involve teachers from SMEs in the education. The school has no tutor system and no organised programme for introducing newcomers to the studies. The students are satisfied with the environment and the facilities at the school.

The language skills in English are not very good among the students, and so it makes sense to offer more education in English. In recent years the employment situation has been quite good. The largest recruiter has been Wärtsilä. The students seem to have no problems with their studies, because many of them hold a part-time job at the same time.
Co-operation with companies

The industry representatives said that the reputation of the Swedish Polytechnical is good in general. The programme has an agreement with Wärtsilä company. The cooperation seems to be very active. It is sometimes perhaps even excessively “Wärtsilä oriented” because there are a lot of other, basically SME companies near Vaasa. The cooperation could be more systematic. Most of the graduates seem to have strong ties with the Swedish Polytechnical and they could take part in the alumni activities.

There seems to be a need for technical education at the technician level. Unfortunately the polytechnic system does not support this kind of education any longer. But then again, there is a need in industry not only for Bachelors but also for Master of Science level education. To meet all these requirements is a challenging task for the Polytechnical and thus it makes sense to co-operate with other institutes.

Laboratory resources

The laboratories are located in Technobothnia. The unit is also used by the University of Vaasa and Vaasa Polytechnical. It is an extensive facility located in the old cotton factory. There are several laboratory installations in Technobothnia. Unfortunately most of the installations are quite “ready-made” which means that the students cannot make the laboratory work on their own. Anyway, there are several possibilities in Technobothnia but more money and human resources are needed. Co-operation with the local industry is still quite modest.

International co-operation

International contacts and skills are getting more and more important in the future. It means that the Polytechnical should take a more active role in that field. Teachers and students should be encouraged to go abroad.

The Polytechnical could bind international contacts in collaboration with the industry. International experience is highly important for the companies. Teaching in foreign languages could be increased.

Good practice

• laboratories are new and well equipped
• atmosphere is good and there is teamwork between the students and staff
• the matrix organisation seems to work well.

Recommendations

• students could be more involved in the development of the programme
• needs of the SME industry should be considered
• co-operation with other institutes should be encouraged
5.6 Vaasa Polytechnical

Basic information


The Mechanical Engineering programme has very long traditions dating back to 1849. In the beginning the programme was taught in Swedish. The name of the institute has been changed several times over the years. The specialisation areas are: Mechanical Engineering, Mechatronics, Production Economy and Energy Technology.

West dimension

The Vaasa Polytechnic will be a nationally and internationally acclaimed institution of higher education. The Polytechnic supports the region’s strong export industries, international trade and tourism as well as social services, it works in close co-operation with the community and has a significant role in the development of the region’s industries and other working life.

The mission of Vaasa Polytechnic is to organise in all its fields multi-lingual, high-level theoretic-practical education and relevant applied research and other related services. The Polytechnic fulfils the international requirements on quality in all respects. The education and the supporting activities are planned and implemented in close co-operation with industries and other working life.

Contents and structure of the programme

The structure of the programme in Mechanical Engineering is based on traditions of the former institute of technology and the contents of the courses are quite traditional. The evaluation team got an impression that due to the rather small programme there is not enough resources to offer many optional studies for students. This should not be a major problem due to the fact that both the University of Vaasa and the Swedish Polytechnic are located practically in the same campus area.

The level and the standard of education and teachers are good. There is no formal way for the students to influence the education. There are no student representatives at any level of the organisation. In spite of that the students are satisfied with the education and feel that they have a possibility and it is easy for them to discuss with the teachers if they wish to influence the education, way of teaching, content of courses, etc.
3D-technology and robot automation

The focus has been sharpened towards 3D technology and robotics, which are interesting fields also in the electronics manufacturing. 3D simulations are one practical way of simulation and visualisation of complex manufacturing systems. 3D technology is specially used in design, modelling and manufacturing as well as for simulation purposes in the area of robotics and production.

New technologies are surely one way to attract young student applicants. For the students of 3D technology, the programme arranges an annual one-week visit to an England-based university.

Students

The reasons why the students choose Vaasa Polytechnic are in most cases friends, parents, relatives, etc., but also the extremely well equipped laboratory, Technobothnia. The Polytechnic has a tutor system to introduce the newcomer to the school. It works very well.

The facilities at the Polytechnic are very good. The computer classrooms and the access to computers and other equipment and facilities are also good. Students have lot of opportunities to visit companies and make industry excursions. As a result of poor planning, the time schedule is not always suitable for the students.

Very few students have been abroad for studies. The management of the Polytechnic does not encourage students to study abroad. However, there seems to be plenty of possibilities for students to go abroad.

Some students use the Vaasa Polytechnic as a “preparatory school” for university studies and in some cases these dropouts cause planning and statistical problems for the Mechanical Engineering programme.

Co-operation with companies

The industrial companies represented hire many engineers from the Vaasa Polytechnic. The companies also have students working with their theses. Furthermore, some companies also use the laboratory of Technobothnia for their R&D activities. Vaasa Polytechnic has a good chain from design to manufacturing as demonstrated in Technobothia, in particular - students design a product and manufacture a mould and finally manufacture the product by injection moulding machine. In 2002 first steps in rapid prototyping will be taken, strengthening the area even further.

The industrial representatives are satisfied with the education level at the Polytechnic, but they hope that the Department of Mechanical Engineering will emphasise the connection between design and manufacturing. They also think that the education should be more focused on basic skills and basic courses, like math, physics, etc.
The local industries have the possibility to influence the education, curricu-

lum and the course content to a sufficient extent, through the industrial Advisory Board. The representatives are worried about the poor interest of young people in the field of mechanical engineering. Industry, society, polytechnics and universities must “do something” to increase the young people's interest in working for industry, and their interest in the field of Mechanical Engineering, in particular.

The opinion of the representatives is that the two Polytechnics in Vaasa should collaborate. At present there is a lack of collaboration in the field of common courses and projects. However, the Technobothia is a good example of laboratory resources being easily combined.

Vaasa Polytechnic is a big polytechnic in Finland. There is no doubt a need for technical education in Vaasa. By concentrating the education on certain fields of technology, working in collaboration with the local industry, the Mechanical Engineering programme will be successful in the future.

Laboratory resources

The laboratories are located in Technobothnia. The unit is also used by the University of Vaasa and the Swedish Polytechnic. It is an extensive facility located in the old cotton factory. There are several laboratory installations in Technobothnia. Unfortunately most of the installations are quite “ready-made” which means that the students cannot perform the laboratory work on their own.

Anyway, there are several possibilities in Technobothnia but more money and human resources are needed. Co-operation with the local industry is still quite marginal, although the local industry is interested in co-operation, and therefore teachers could take a more active role to promote the use of Technobothnia.

As project-based learning is getting more popular, Technobothia is an excellent place for that kind of education.

International co-operation

According to the mission of the Polytechnic international co-operation is very important. In the self-evaluation report there is a long list of partners identified for the entire Polytechnic, but only a few partners for Mechanical Engineering specifically. International activities should be considered, and it is a good idea to focus the activities together with the industry representatives; in the Vaasa region there are several internationally working companies.

Teachers and students should be motivated to be involved in international activities. The Mechanical Engineering programme has some students studying abroad. International contacts and skills are getting more and more important in the future. It means that the Polytechnic should take a more active role in that field.
Teachers and students should be encouraged to go abroad. The Polytechnic could create international contacts in collaboration with the industry. International experience is highly important to the companies.

**Good practice**

- laboratories are well equipped in Technobothnia
- special fields of education in 3D technology and robotics.
- good atmosphere between the students and teachers.

**Recommendations**

- a quality system should be implemented
- there could be more co-operation with other institutes and the mobility of teachers and student could be increased
- more co-operation with local companies.

### 5.7 Lappeenranta University of Technology

**Basic information**


**Strong university in Eastern Finland**

The strategy of the University was adopted in 1999. The main tasks are: 1) to produce highest level and meaningful new technological and economical knowledge; 2) to educate international level experts who have high ethics and abilities - to continuous learning and self improvement; 3) to increase and improve entrepreneurship and increase all kinds of technical and economical education in the areas of South Karelia and Eastern Finland.

The vision underlines that in the year 2010 the University is an internationally known high level technology and economic centre of Eastern Finland with 5,000–6,000 students.

The operational and economical plans of the University specify the strategy of LUT to the near future. The primary focus areas are Basic Industry, Information Technology and Electrical Engineering and Economics.

The action of LUT is focused on the following subjects which link all the knowledge of the university
• expertise in forest industry
• high-tech metal structures
• know-how in Russian affairs and other transition economics
• electrical engineering and information technology
• environmental technology and energy
• business success factors and business know-how.

The focus areas of the Department of Mechanical Engineering are high-tech metal constructions and expertise in forest industry. The expertise of the Department in these areas ranks first in Finland, and is also of a significant international level. These areas will be improved so that the Department will be most the foremost in them both on the national and the international level.

The strategy for the future in to strengthen the fields of high-tech metal construction and expertise in forest industry in the Mechanical Engineering programme. High-tech metal construction will include two focus areas - Machine Design and Production Engineering - and five fields of specialisation - Machine Automation, Steel Structure Design, Virtual Engineering, Welding Technology and Sheet Metal Production. The focus area of forest industry is Mechanical Wood Processing Technology. The goal is to reach an excellent international reputation in research and at the same time serve the region with well-educated people.

Research and practical work

The aim of the Mechanical Engineering programme is to educate international top-level specialists in their own areas, to generate new scientific information and knowledge in the focus areas of the Department and to increase and improve entrepreneurship. The fields of specialisation of the Department are: Machine Design, Machine Automation, Steel Structure Design, Virtual Engineering, Welding Technology, Production Engineering, Mechanical and Wood Processing Technology.

The specialisation fields are selected so that they are in relation to the design and manufacturing of high-tech metal construction and mechanical wood processing machines and apparatus. According to the self-evaluation report the programme has held its status both at LUT and nationally. The excellent focus on steel structures, virtual engineering, welding and mechanical wood processing technology has given the programme a competitive status.

It is also mentioned that the basic structure of the programme will be maintained in the near future but the programme will be oriented more from basic industry towards electrical development, for example to Virtual Engineering, Sheet Metal Production and Joining Technology. In these study fields there has been co-operation with the Helsinki University of Technology and the University of Oulu.

The self-evaluation report also underlines that in recent years the focus areas of the programme have become more distinct. The quality of the pro-
gramme has been improved, as has its usefulness for the society. The Depart-
ment of Mechanical Engineering is integrated to the research team of the South
Karelia Centre of Excellence which combines the University and the manufac-
turing technology section of the VTT. The programme and the South Karelia
Centre of excellence constitute a synergetic entity in which students, research-
ers and industry work together performing different projects, exercises and dem-
onstrations.

Teaching and learning

The most appropriate teaching methods are selected according to the educa-
tional aims of the course and the goals of cost-effectiveness, especially as con-
cerns courses with relatively large numbers of students, to enhance oriented
education.

According to the self-evaluation report the selected teaching methods for
each course are integrated as an unbreakable chain to avoid unnecessary over-
lapping with contents and to ensure the possibility for the student to compose
an overall picture of the subject that is taught. Besides, this students are rep-
resented in all stages of administration of the University, and they have an
opportunity to present their opinions. After the final exam of each course the
students have a possibility to fill an evaluation form or send an anonymous
message via the Net to give feedback on the course. Although students are
officially entitled to offer their comments and remarks on the programme, stu-
dents who were interviewed mentioned that the opportunity is seldom used.

In general, the teaching at the Department of Mechanical Engineering has
relatively good technical conditions. Specific classrooms for computer-aided
working are reserved for the students. Computer-aided learning material has
also been developed at the Department for self-learning of the basics of Manu-
facturing Technology and for the purposes of Welding Engineering education.

In addition to the professional skills, typical for each technical and educa-
tional programme, students are also prepared for team work either within cross-
technological or business-oriented situations in leadership and communications.
The idea is that students should be able to produce application of the learned
theory material to industrial tasks. Every student must include six credits of
practical industrial experience into the programme before graduation.

Satisfied students

From the students’ point of view the University and the Department of Me-
chanical Engineering have a better image than is generally known. It was con-
stantly mentioned that the University is much better than its reputation. It is
obvious that for many students LUT and Mechanical Engineering had original-
ly been a second choice. However, after studying for some time at LUT, most
of the hesitating students have changed their minds and started to realise how
beneficial it can be to study at LUT in the Department of Mechanical Engineer-
ing. In many ways it is an asset to have a relatively small university. Students have good contacts with the teachers and the whole atmosphere is friendly and supportive. The facilities are very good, including the textbooks and other teaching materials. The laboratories are well equipped and the students are satisfied with the laboratories. At least in theory, the students can exercise influence on the education, courses, teaching methods and the curriculum. Excursions and visits to local industry are organised mainly by students themselves.

Each year a special Alumni days event is arranged to inform the newcomers about the studies and the University. The University also has a tutor system, arranged by teachers and the Student Union, to guide the newcomer during the two first years of study.

Student exchange has been relatively modest. Only few students study one or two semesters abroad, and only very few foreign students study in the Department. Teachers should encourage students to go abroad to get different perspectives for their studies.

The interviewed students complained that compulsory courses often overlap. The exam material often comes too late. However, some improvements have been introduced to the schedule during the past two years. For many students, the basic mathematics and physics courses have been unexpectedly difficult to pass.

Approximately 20% of the students starting their studies have polytechnics studies before entering the University. Usually these students have very high motivation and good basic skills. They provide a good example for other students. In fact, they can transfer 55–75 credits from their previous studies but in the future the figure will probably be even higher.

Teachers and pedagogy

So far the Department of Mechanical Engineering has been able to recruit qualified teachers but a real threat in the future could be how to attract good and motivated students who could later also take an interest in research. The staff has developed a strategy with three focus areas and seven tracks for specialisation. The starting point has been the need of the local industry and the resources of professors and equipment at the Department. Representatives from industry have also been involved in the process.

For teachers the goal is to be strong in research. The idea is that quality in research works as an engine for development in the education. An ambitious goal is to create a closer connection between the two parts of the University – the technical and the economical faculties.

The opinion of the staff seems to be that Mechanical Engineering is not a “hot” topic for students and this creates recruiting problems, among others. In order to make the Mechanical Engineering programme more alluring and more updated, Virtual Engineering – such as simulation of prototypes – will be introduced as a specialisation under the focus areas. The Virtual Engineering course, monitored by the national virtual university, can exploit the network of several
universities, and one of the main ideas is to strengthen the contents of the courses offered. Virtual Engineering also gives better possibilities for international activities.

It was also underlined by the staff that the Department has an Advisory Board with representatives from industry. The purpose is to discuss educational questions relevant to the local industry. In addition, the Department has relatively good contacts and collaboration with other universities in Finland and abroad.

The average age of professors is relatively low. The quality of students has been a minor problem and there are risks in the future. The problem is to loose students in companies before they finish their studies. In practice many of the researches in the Department are teaching whilst many undergraduate students are also involved in research projects.

According to the students the pedagogical competence of the teachers ought to be improved. Teachers thought that they just have too much to do, and they usually have no time to improve their pedagogical skills. Courses to this effect have been organised but the respective participation has not been the highest possible. According to the strategy of the University the quality of teaching will be one of the main items in the future.

Commerce and industry

The representatives from commerce and industry were aware of the fact that the Department of Mechanical Engineering is a relatively small department and cannot serve all industry in the region with sufficient expertise and knowledge. In spite of that, the common opinion among the companies of the region is that the level of education in the department of Mechanical Engineering is basically very good. Especially in the area of welding and steel structures the Department is unique in Finland.

It was clearly emphasised how valuable and important it is for the industry to have fresh graduates in engineering who have good knowledge in languages, management – for example, the capability to estimate the costs of a product – and economics. According to the industry representatives, today’s engineers do not unfortunately have sufficient knowledge and training in these particular areas.

Visiting lecturers from industry are involved in the education which is very good and important for the education. Students obtain knowledge of industrial problems and will be able to recognise the importance of theoretical skills to solve these problems in a proper way. A constructive idea to enliven the cooperation could be to let people from industry to work in the Department for a period of 6–12 months. Correspondingly, lectures from the Department could work in industry.
Mobility

There is fairly little international mobility associated with the studies at the Department of Mechanical Engineering. All parties interviewed by the evaluation team emphasised how important it is to have contacts and be capable to work internationally in the field of Mechanical Engineering.

Only four Mechanical Engineering students have been studying abroad and one foreign student has studied at the Department during the academic year 2000/01. One of the Department teachers has been involved in teacher exchange, one has studied abroad and the Department has received one foreign exchange teacher. Six visiting researchers have stayed at the Department.

On the national level the Department is networking with the Universities of Joensuu and Kuopio in the field of distance learning. With the Helsinki University of Technology there is a project to develop computer-aided education material to teach manufacturing technologies to first years students. The Department of Mechanical Engineering has also carried out several educational projects with the South Karelia Polytechnic.

Facilities

In general laboratories and classrooms are well but traditionally equipped. CAD is used a lot which in reality would require more room and in computer capacity. The current situation in the labs is most satisfactory but financing and ensuring the future development of laboratory resources calls for careful planning – how to keep up the high level of laboratories in the future.

Good practice

• the Department is linking theory, education and practice which also means easy and direct contacts to industry in practical problems
• students are well motivated and satisfied with good possibilities to influence
• strong basic areas like welding and steel structures.

Recommendations

• there is no need to try to cover excessively wide focus areas, and a high-level international integration profile should be built up
• the curriculum should contain more management, business, communication and language studies, and exchange studies should also be encouraged
• the procedure of teaching skill development should be improved by the University.
5.8 Tampere Polytechnic

Basic information

Programme established in 1996 (1849). Number of students: male/female 447/26. Teaching staff 25. Student/teaching staff ratio 17.9. Median time for graduation 4 years. Average age of graduation 25.7 years.

Polytechnic in an industrial city

The education of Mechanical Engineering has long traditions in Tampere, a city with a long industrial history. The School of Technology and Forestry has about 2,200 students, so the Polytechnic is one of the biggest in Finland. A new strategy is being compiled and a quality system is under construction. Tampere is a popular place to study and the reputation of the Polytechnic is good. The textile programme is unique in Finland. Automotive and Transportation Engineering will be separated from Mechanical Engineering.

According to the business idea, the purpose of the Polytechnic is to increase competitiveness of mechanical equipment manufacturers. This is done by focusing on the following key functions:

- engineering degree education and short courses
- providing technical services in the form of small projects
- practical education in close co-operation with equipment manufacturers targeting to professional skills.

The strategy of the programme is not explicitly presented in the self-evaluation report. However, the strategy was made together with industry in 1999 and completed as a part of the strategy of the Polytechnic in 2001. A clear focus will help in developing the programme in the future. Co-operation possibilities with the Tampere University of Technology, as well as with other institutes, could be reconsidered.

Contents and structure of the programme

The structure of the programme has been changing during the past few years and the exact structure is under work at the moment. At present, the specialisation areas of the Mechanical Engineering programme are:

- Automotive and Industrial Vehicle Engineering
- Machine Automation
- Aeronautical Engineering
- Modern Manufacturing Systems
- Product Development
It is difficult to see the synergy between the specialisation areas and it is a good thing to consider the focus areas so that they serve the needs of the local industry.

Virtual teaching

Virtual teaching methods have been developed for some years now. The Internet is used to search for new professional information. The web-based learning is used during the computer programming introduction courses. Virtual learning is mainly used for information search in relation to courses as well as for student-teacher communication. Virtual teaching will be more and more popular in the future.

Students

The reputation of the school is good, but there is still scope for improvement. As a rule, the students are satisfied with the teachers and the education at the school. Nevertheless, they would like to have more teachers from industry. In general the teachers from industry have a good knowledge of the subject they teach, but they are not so good in terms of pedagogy.

The first two years at the school are hard and cause problems for many students. The entire programme and the content of separate courses are in general good and up-to-date. The students are not very engaged in the development of the contents of new courses and the curriculum. The Students Union organises the introduction to newcomers. It works very well during the first year but not after that.

The Polytechnic is prepared to organise practical training for the students, but most of the students arrange their own practical training. Students arrange excursions and visits to industry. As a consequence of this arrangement some students visit many companies while others get a chance to visit far fewer places. Very few students go abroad for studies, due to the “language problem”. The Mechanical Engineering programme encourages the students to study abroad and offers them optional courses in English. The facilities, computer classrooms, etc., are sufficient but the laboratories and the equipment in the laboratories is not satisfactory. The polytechnic is currently building a new building for laboratories, and so the situation is going to be better in the future. Most of the students take their exams in four years.

Programme staff

Several big companies are located in the region. The Department of Mechanical Engineering co-operates with different universities and polytechnics in Finland and abroad. The Polytechnic introduced a quality system last year to em-
phasise the quality work. At present they do not yet have the quality certificate. Based on the quality work the courses and curriculum are revised every year.

The students are for some reason not interested in participating in the course development work. In the Department of Mechanical Engineering no research projects are underway, defined in “terms of university research”. The Department has some bigger development projects together with industry. About 30 students collaborate with a teacher to solve an industrial problem. The average age of the teachers is relatively high. The Department has no problems in recruiting teachers. The recruiting of teachers with good industrial experience is of high priority.

Students are in general very motivated and the school has no problems to recruit students. The number of dropouts is slightly too high. The reasons for dropouts are not easy to detect, but at least some students leave the Polytechnic to go to university.

Mechanical Engineering has an Advisory Group with the industry to discuss courses and the curriculum. The most important co-operation with industry is through final year projects. The education is relatively traditional with product design and manufacturing in two separate tracks. Virtual education is an interesting and good way to develop the education and to engage the students in different topics. Some teachers go abroad to teach, but very few foreign teachers come to Tampere. Mechanical Engineering encourages the student to go abroad to study, but very few of them are interested in studies in other countries.

The established quality control system, including the introduction of an advisory panel, provides a good possibility to positively influence the students’ education in line with the requirements of their future employers. The ongoing co-operation with external local bodies and with other educational institutions, and the exchange of teaching staff, in particular, constitute means to make use of synergetic effects and is, therefore, of high importance for an optimal study within a limited budget.

Co-operation with companies

In the Tampere region there are many companies which are related to Mechanical Engineering. The Polytechnic should consider which companies are the most important to collaborate with. The Tampere Automation Centre (TAC) and especially the FMS-training centre are important networking organisations in the field of automation.

It is important that the students get their industrial practice. The industries back up this ambition of the school. The school should find a way to encourage the students to study abroad because it is a very important for the industry that students can speak and understand foreign languages and cultures. Some of the companies offer jobs abroad for the students during the summers. A way to
update the competence of the teachers is to let them work in industry for a few months.

The Tampere Polytechnic is a big polytechnic in Finland. No doubt there is a need for technical education in Tampere. By concentrating the education on certain fields of technology in collaboration with the local industry the Mechanical Engineering programme will be successful in the future.

**Laboratory resources**

The laboratory halls are under construction at the moment, but in the future new laboratories will be available for the Mechanical Engineering programme. Hopefully the new laboratories will be well equipped and will provide a new standard in the future. The laboratories play an increasingly important role in education. There is also a possibility to use laboratory equipment for R&D activities.

**International co-operation**

The international co-operation is focused on Sweden, the UK and Germany. The partners are mainly universities. Co-operation means teacher and student exchange, which is now tolerable in number. The teachers should be encouraged to go abroad.

The industry also emphasises their need to have internationally experienced graduates. The Department should find ways and means to increasingly motivate their students to use the available chances for a part-time stay abroad. Industry is prepared to support such actions, for example by incorporating an overseas partner into a practical project of a student or by offering a summer course in a foreign partner establishment.

**Good practice**

- virtual learning activities
- the “telakka” system is a good concept for teachers and students
- good local co-operation (TAC, FMS training centre)

**Recommendations**

- strategy and clear profile of Mechanical Engineering is partly missing
- systematic and more active co-operation with companies should be increased
- continuing the work on the quality system
5.9 Tampere University of Technology

Basic information

Programme established in 1965. Number of students: male/female 1168/67. Teaching staff 71.5. Student/teaching staff ratio 17.3. Median time for graduation 6.6 years. Average age of graduation 28.3 years. Annual number of postgraduate degrees: Licentiate/PhD 5/3. Median time for graduation (PhD) after Master's degree 10.7 years. Average age of graduation (PhD) 35.3.

Dynamic department

The Tampere University of Technology offers education at the highest level in technology and architecture and carries out scientific research in these areas. It acts in close collaboration with industry and producers high-level research, development and continuing education services in its field. The first strategy for the Department of Mechanical Engineering was completed in 1999. In its strategy the Department identified several areas to make the Department more attractive during the coming years. In the strategy several critical success factors were identified and metrics defined for the follow-up of the development.

One of the biggest changes in the Department's activities was the establishing of new departments in the mid-1990s. The new departments with an impact on the activities were Automation, Environmental Technology and Industrial Engineering and Management – six institutes were moved to other departments. In the strategy the Department of Mechanical Engineering raised three main areas of development: Electronics Production, Application of IT and Virtual Technologies and Design of Light Structures. According to the strategy the Department is willing to enhance international co-operation in studies and in research, not forgetting environmental respect.

Teaching and learning

Instead of lecturing other methods of learning have been increased. This mainly means seminars, exercises and laboratory works with applied examples in smaller groups, etc. According to the self-evaluation report it is important to take into account that from the second year onwards most of the students are involved in working life – teaching is offered also in the evening hours. Besides this some of the institutes have also started to shift parts of their courses to the web so that learning could be more independent of time and place. Feedback has been asked and also given constantly. Students are engaged effectively by giving them the opportunity to build and improve the existing learning and research environment and to improve the exercises themselves.

A strong need to enhance communication and language skills arose among students and also among the representatives from the industry. Basically the structure of the curriculum gives a good opportunity for studies in the areas of
negotiation and communications skills, management and leadership as well as IT skills – there are 24 credit units to be chosen freely. For some years now, a lot of efforts have been put to make the learning more problem-solving oriented. This change can be seen especially in the courses taken during the academic year 1999/2000. Topics are normally received from industry and they require high-quality solutions to real life problems.

According to the report made about the contents and quality of the degree among new graduates in 2000, it was obvious that courses such as communication skills were considered to be most advantageous. Lot of researchers are used in the education. The idea is to transfer new technologies into the courses.

According to the teachers, roughly one third of the students do not have any particular study motivation – two thirds are studying diligently. However, the actual number of dropouts is not extremely high. During the academic year 2001/02 a new project called ‘individual studies’ will be starting, the objective of which is to enhance studies and to motivate students.

Committed students

Although the representatives of the students were not unsatisfied with the course programme of the Department with its two study direction options (Alternative 1: Material Science, Occupational Safety Engineering, Industrial Management, Paper Converting Technology, Hydraulics and Automation, Energy and Process Engineering, Production Engineering, Applied Mechanics and Optimisation, Machine Design; Alternative 2: Production, Product Development), the majority preferred alternative one – the broader field give a chance to choose according to their personal interests. However, newcomers find it difficult to decide which of the two alternatives to follow unless sufficient information is provided. As the latter seems to be difficult, better guidance at the beginning of the study courses is required. Nevertheless, the students tend to prefer alternative one and expressed their opinion that the alternatives may be omitted in the long run, being less attractive.

The present students’ assessment scheme is, in principle, regarded as positive. However, the feedback is still underdeveloped and needs to be reconsidered. In particular, the students would appreciate if their comments and proposals for improvements would be discussed or at least become visible, and this without too much time delay. Furthermore, the students would like to see an intensification of co-operative actions between various institutes and departments in order to widen their horizon through interdisciplinary projects.

The relation and co-operation of the Department with the industry is regarded as very positive because it provides an important insight into the problems and their solutions, aspects which the students will be facing after graduation.

The influence on studies seems to be quite modest. Feedback is used but students are suspicious over it. In theory there is the possibility to influence studies but students are perhaps not using the possibility as they should.
Teachers and pedagogic skills

The strategy of the Department is positively acknowledged because it incorporates the expectations of the industry and society vis-à-vis a Mechanical Engineering graduate, regarding such expectations as the driving force. It also recognises the need to increase the attractiveness of this discipline among the upper secondary school graduates who have to make their decisions about which education to follow.

It is also positive that the Department ambitiously aims at establishing interdisciplinary projects in research, projects which would significantly widen the horizon of the students. In order achieve this the ties between various institutes, presently still weak, have to be strengthened by bridging traditional gaps.

Furthermore, it is noteworthy that the Department explicitly includes maintenance and replacement costs for equipment into their budget considerations, a commercial approach which is fairly new and not yet common in educational institutions.

With regard to international exchange and co-operation the present performance is fairly poor and actions by the staff are certainly required in order to improve the situation. In line with these measure, the staff should consider means to initiate projects with foreign partners and to provide incentives for and motivate students to spend a certain period abroad during their studies.

Students which were interviewed by the evaluation team considered that teaching methods were mainly good but occasionally the lecturers are using old and uninteresting methods. The question is more or less pedagogical. The university offers the staff a possibility to improve their skills in many areas. One of the popular courses taken has been pedagogics. Most of the institutes actively support the staff according to the initiatives of the personnel. The Department has no problems to recruit new staff members. The Department has no recruitment plan in spite of the fact that the average age of the staff is considerably high.

Industry nearby

The industrial representatives were unanimously fully satisfied with the quality and knowledge of the graduates. The reputation of the Department is rated very high, with some disciplines ranking among the top in the country.

The industry also appreciates the well established regular exchange of views with the Department which is of mutual interest and beneficial for both sides. A good link between industry and the Department of Mechanical Engineering is the FMS Training Centre.

The representatives of the industry are not active in the Advisory Group of the Department but they do influence the education and the research through personal contacts to Department professors. In addition to this the Department arranges co-operation meetings with representatives from industry twice a year.
However, much criticism was expressed concerning the generally insufficient knowledge in foreign languages, Swedish and - to a minor extent - English, in particular. This is hardly acceptable to the Finnish industry operating across the borders. The university has to recognise this shortcoming in education and should act accordingly.

According to the industry the focus areas of Mechanical Engineering should be light structure electronics production and mechatronics. An interesting experiment could be to develop an exchange programme between companies and the University, especially in the focus areas - engineers from industry could work in the Department during a year while teachers from the Department could work in industry during the same period. The industrial representatives emphasised that this would also promote the much needed business-minded thinking in education.

Alumni co-operation exists on the University level, but not on the Department level. So far the alumni activities are relatively limited. However, such activities constitute a good way to keep contacts and to deepen the cooperation between the University and business world. There is a strong need to bring extra value to both sides through the alumni.

Mobility

The incentive and motivation to spend some time abroad as part of the education is judged differently. There are students with this experience, but the majority prefers to stay in their home country. However, most of the student representatives agree that such a move across the borders may be advantageous for their future and that the number of persons considering such a move may increase if the advantages vs. the possible drawbacks are clearly explained. They also agree that a discussion with those who have had such an experience would help decision-making.

In general the level of student exchange at the Department level has been moderate. In practice the number of places to send students to exceeds the real demand. The amount of incoming foreign students has been clearly restricted by the relatively low number of courses given in English. However, the situation is gradually changing because the general attitude at the University towards international mobility is supportive. Moreover, if the Department teachers are willing to encourage students to be active there is every chance to build up a beneficial mobility scheme for the Mechanical Engineering education in Tampere.

Facilities

The facilities – library and laboratories – seem to be well equipped and modern. Particularly noteworthy are the modern measurement and control techniques which constitute an important base for education and research. The
computer classrooms is also of good quality. The students have a very good access to the computer classrooms.

The library services are distributed between the University’s central library and the institute’s specific library. The central library offers the students text and course books as well as periodical professional newspapers considered important by the institutes.

According to the strategy of the Department, the major updating effort will be put in the PC class used in the general studies which are specific to the degree programme. It has been decided that the age of the hardware and software must not exceed three years. This is realised by recycling 1/3 of the computers on an annual basis and by continuously updating the software.

**Good practice**

- clear strategy and matrix organisation
- students satisfied with teaching and education, a fact that contributes to a positive and dynamic atmosphere. There is also flexibility in the choice of courses
- links between industry and education.

**Recommendations**

- encouraging international mobility of both students and teachers. Cross-cultural approach and management studies should be integrated
- the programme should be more engaged in international projects
- national co-operation in the field of light structures.

### 5.10 University of Oulu

**Basic information**

Programme established in 1965. Number of students: male/female 587/33. Teaching staff 24.1. Student/teaching staff ratio 25.7. Median time for graduation 6.2 years. Average age of graduation 27.3 years. Median time for graduation (PhD) after the Master’s degree 9.5 years. Average age of graduation (PhD) 37.

**Northern engineering education**

The fundamental reason to establish a degree programme in Industrial Engineering at the University of Oulu was the idea to provide labour force for the developing process industry in Northern Finland. Being part of a multidisciplinary university the Department of Mechanical Engineering at the University of Oulu is exceptional in Finland. However, the exceptional role has been also an asset for the higher education in engineering in Oulu. Evidently the Department benefits from the education provided by the whole University.
High-standard research and education

The mission of the Department underlines high level research and education which meets the needs of industry and society – especially local educational and research needs are taken into account.

The Department is an internationally significant scientific and educational community. Core competencies like Engineering Mechanics, Machine Design, Materials Science and Production Technology are effectively utilised. The focus of the programme is to provide a solid and versatile background in Mathematics, Physics, Engineering Mechanics, Materials Science, Information Technology and their applications. The main focus is to educate and train engineers who understand and manage with increasing insight and skill the fundamental phenomena of real life and are able both to develop and to assimilate new research results and technologies. Rather than contradictory, it is a challenging task to be locally important and internationally significant.

New structure of the programme

The self-evaluation report stresses that the students take very active part in the development of the teaching by working in the Study Development Council and by providing feedback on the courses. The tutor activity has also been further developed by introducing a primary teacher system. In this system each tutor group has a named teacher who is personally familiar with the students of the group.

Transferable skills are achieved during most courses. Many courses include exercises and seminars which develop team work, presentation and management skills. One lecture problem has been that the lecturers have not been able to make the learning situation interactive, nor have there been virtually any discussions between the lecturer and the students.

Computerised teaching is a long process and virtual instruction has not yet been fully adopted. The Department has certain plans to develop a virtual mechanical engineering programme together with the Helsinki University of Technology and the Lappeenranta University of Technology. Co-operation with industry in the field of teaching is increasing. Topics for practical assignments and seminars are coming frequently from the industry. Master's theses are almost exclusively made in the industry or on industry related topics. However, the curriculum does not include any regular formal discussions with representatives from industry.

The module system

The degree programme in Mechanical Engineering has been facing many changes during past few years. There are three major levels for improvements which are the structure of the programme, content of the courses and learning methods. One good example of these improvements is the module system which
enables students to gain the degree either as a generalist or a specialist. There is a wide spectrum of alternatives ranging from the most strictly specialised domains to the most general programme. In practice, students can choose between several alternative modules in addition to the basic module, including an individual module consisting of studies in other departments, faculties and universities. The module system means that there has to be some basics so that the graduates can be called Mechanical Engineers. The flexibility is created by the module system as such. Many courses are the same in different modules. A module is a collection of suitable interdependent courses.

In addition to this, an active tutorial system has been taken into use, extending from the first year to the end of the studies. The total programme contains quite a number of courses. A discussion is underway to reduce the number of courses and to get a better programme focus in the future.

The self-evaluation report also emphasises how important it is to have a two-directional system in which the programme is constantly supported and influenced by research. On the other hand students are participating in many research projects. New methods of education include the combination of lectures and practical assignments to make the learning process more interactive.

In many ways the content of the programme is quite similar to other Mechanical Engineering programs at other universities. The goal is to educate engineers with a broad knowledge profile to serve “all kinds” of industries with engineers. This approach gives the graduate the possibility to take jobs in various fields of industry. It is common that students work in some projects. At the same time postgraduate students are also teaching and laboratories are using even third-year students for teaching purposes. The lack of qualified teachers is a problem, currently partly resolved by employing third-year students as assistants teachers during the first.

Aging teaching staff

The Department has a permanent staff of 57 persons. The number of teachers is 37, including 11 professors, 8 senior assistants, 17 assistants and one lecturer. In addition to the permanent staff there are two donated temporary professor’s chairs and one joint chair with the VTT.

Professorships donated by the industry are illustrative of the real need of education and research. The target of the Department is to establish permanent posts for these research and teaching needs. Due to the more attractive working conditions provided by the growing industrial surrounding there is a lack of competent teachers. Therefore further incentives are necessary – probably in co-operation with the industry – in order to further guarantee the quality of education.

The requirement of the 8-month practical training is very positive because this supplies substantial technical knowledge and skills to accompany the study courses. In agreement with the industry a part of this training should be carried
out abroad to accustom the students to a certain degree of flexibility which will be advantageous for their future profession. Such a flexibility can also be achieved by taking part in an international exchange.

Focusing courses

The Study Development Council is a well installed institution with a long standing. But there is a certain danger of conservatism and of “ageing”. In particular, the system of diversified courses, which has been established for a long time, would need reconsideration and revision according to changing needs in the society and industry. The staff background is the heavy metal industry, and some individual members may have some difficulties to see new trends and demands of the industry.

It is, therefore, advisable to set priorities and to focus on certain key study directions in which the Department is particularly strong and probably unique in comparison with competing universities. Also interdisciplinary study courses and projects should be considered. Such modifications will provide more clarity for the students and improve the attractiveness in the eyes of the outside world.

Recruiting part-time teachers

The aim of the Department is to use part-time teachers from the industry according to the needs and resources. In practice, it has been found to be most feasible to assign a responsible staff teacher for each course, while external teachers can be used to provide a part of the instruction, or the instruction can take place in the industry in the form of seminars or excursions.

So far there has been a sufficient number of new students but the real problem has been the dropout rate which is close to 50%. Moreover, about 10–15% of the students are studying very inefficiently. The Department has had some difficulties to recruit PhD students, while they have had no problems recruiting new staff members. Only about 5 or 6 polytechnic students are accepted every year to the programme.

Motivated students

The students consider that the quality and the reputation of the University and of the Department are good. An additional advantage and attraction is the location. It is the only university with technical subjects in the northern part of the country, all other universities are far away and more crowded and, therefore, more difficult to enter. In addition, the prospects of finding a professional job after graduation are very good due to increasing industrialisation of the region.

The students also appreciate the wide choice of courses to serve their individual needs. The modular system is also good but some guidance is needed.
The tutorial system works well for the first two years, but advise and guidance though the “course jungle” for the 3rd year is required.

In general students feel that there is clear advising system and enough tutoring by teachers and older students. For example, the student guild offers a lot of information for structuring the studies but for some reason many students do not seem to find the service provided. Students feel that the modular system in studies brings a positive package into the studies. Apart from some mandatory courses, there is a lot of freedom to take different courses. Students also emphasised that studies are not too theoretical, contrary to what students in many other universities and polytechnics have expressed.

On the other hand students were criticising both the level of technical facilities in the laboratories and lack of money which complicates the enhancement of practical training. Moreover, students mentioned the unilateral language teaching which means that English is too dominant. The situation does not motivate students to seek exchange study possibilities in other than the English speaking countries.

In the Mechanical Engineering programme at the University of Oulu – as is the case in practically all the other educational units – the number of female students is relatively low. Female students account for only about 10% of the annual intake and around 5% of the total number of students. In order alter the figures, the traditional image of the programme needs a brush-up on a nation-wide scale.

Good and constructive business life contacts

The reputation of the University and the Department is very good. The interaction with the industry is well developed, including the strategic exchange on Board level. The quality, knowledge and versatility of the graduates is good. However, a modernisation of the study courses according to the changing requirements of the society is regarded to be advisable.

The industry is particularly in favour of the 8-month practical training. But a change of location during this time is obligatory in order to broaden the technical experience of the students. The available outside training facilities should also be used by the Department.

The representatives from the industry underlined that from their point of view the education is rather traditional than creative. It seems to be that it is not easy for the University to recruit teachers with the latest and highest quality.

In many cases companies are willing to further educate engineers only in view of a particular post. Sometimes the education is too traditional for developing companies, whereas the University is not efficiently utilising the educational facilities offered by these companies. In the electronics industry there is a constant need to co-operate in the field of education while in the other fields educational questions are raised mainly on daily a basis.
The representatives from the industry were strongly stressing the fact how important it is to have a versatile educational background. Technical skills can dominate but communication, negotiating and language skills are appreciated. Besides this, a relevant practical training is one of the essential cornerstones of the engineering education – the system has to be enhanced constantly.

Despite of international trade and production, a local engineering education is important for regional companies. Graduates from Oulu are usually willing to stay in the region. Basically companies recruit the best and most suitable engineers for the jobs in question, even if the situation for graduates from polytechnics or universities can differ significantly in this respect. Both types of education are certainly important but doctors are only needed occasionally by the companies.

Mobility

The mechanical engineering programme has several European Socrates agreements. There are also bilateral agreements with North American and Asian universities. Educational co-operation has started with the Luleå University of Technology. Chances to spend some time outside the country are available for the students, and support is also provided sufficiently. Although presently about 10% of the students make use of such opportunities, more motivation and encouragement by the staff would be very much appreciated.

The general mobility figures in the programme of Mechanical Engineering are relatively low. This means that the programme has to be more active and innovative in order to attract more students and teachers to go abroad for studies or for teaching.

Good practice

- growing region and positive job situation – good interaction with industry
- broad offer for individual education – modular system
- easy and constructive interaction between staff and students

Recommendations

- there should be a firm guidance through the course jungle
- formalised discussion with industry about future trends
- motivation should be enhanced towards international mobility and networking
5.11 Oulu Polytechnic

Basic information


Northern dimension

There are presently 324 students in the programme of Mechanical Engineering and a total of 1,780 in the technical programme of the Polytechnic. Forty-two out of 324 go to the adult education groups. Of the 324 students 59% have passed the secondary school while 41% have vocational school certificate. Most of the students are recruited from the region close to the city of Oulu.

The aim of the studies is professionally oriented academic studies leading to a polytechnic degree – professional specialisation. The aim of the degree programme of Mechanical Engineering and Transportation is to produce graduates who can contribute to design, engineering and development in commerce and industry.

The strategy of the Oulu Polytechnic emphasises clearly the important role of education in northern Finland. The Polytechnic is to develop know-how at the higher vocational level and to provide education to meet the requirements of commerce and industry in the region. Education, research and development activities at Oulu Polytechnic will promote:

- employment and welfare in Northern Finland
- the setting up of new projects and businesses
- the development of welfare services
- strengthen the know-how clusters in the area
- strengthen the transfer of technology to business.

The strategy is planned from top to down but it is also possible for the Department to take more active initiative in the issue. In fact, the degree programme in Mechanical Engineering and Production has drawn up a preliminary plan for their own strategy. The strategy underlines that the degree programme will improve the international competitiveness and there will be significantly more co-operation with the industry and other institutes by the year 2010. More business-oriented education also means more courses lectured in English.

The Institute of Technology in Oulu was not involved in the experimental period of the polytechnic system. Yet, the structure of the study programmes of the institute of technology was adapted to meet the structures of polytechnic programmes in 1993–95. The programme of Mechanical Engineering and Transportation was fully adapted at the same time as the Oulu Polytechnic became an established polytechnic during the summer 1996.
The current orientation lines in the programme are: Vehicle and Transportation Technology, Electronics Production Technology and Logistics, Energy Technology, Machine Automation and Product Development. The degree programme of Mechanical Engineering and Transportation will change its name as from the academic year 2001/02. The new name will be the degree programme of Mechanical Engineering and Production. The biggest change will take place in the orientation line of Electronics Production and Logistics which will focus more on production.

A project practise of 20 credit units will be included in the orientation line studies in addition to the present work practise of 20 credit units. It has been decided that within the new curriculum project-type teaching will be carried out.

According to the curriculum a graduate receives qualified knowledge about the technical subjects. However, there is a relatively strong need – expressed both by the commerce and industry as well as by the students – that the curriculum should contain more studies related to negotiation, communication and language skills. It is constructive to remember that in practice only one third of the engineering work in companies is strictly related to design. The rest of the workload is consulting with other people and organisations, etc. Nowadays there are practically no engineering jobs in industry without any links to communication skills.

**Traditional programme**

The student representatives were overwhelmingly enthusiastic about the Polytechnic and the Department. The study courses, the course material including multi-media applications and the equipment are all in line with their individual expectations. However, the evaluation team got an impression that there is a need for more courses to support communication, negotiation and language skills.

According to the self-evaluation report strengths of the programme are the long tradition and long expertise in teaching subjects in the field. The number of different teachers is high which means that the expert knowledge and skills available are comprehensive and excellent. On the other hand the programme has no clear strategy of its own which makes it difficult to focus on teaching and course development. The present curricula are seen to be inflexible, thus preventing the introduction of new teaching methods, such as a special web-based degree programme for adult students.

**Friendly atmosphere**

There is an efficient and successful guidance system by students and tutorial teachers. The relation between the students and the teaching staff, in particular in the final year, is rated very high; the students appreciate the positive feedback from the staff and feel that their comments and suggestions are well taken
care of – and they even consider to continue their positive contacts with the staff after graduation, because they anticipate this to be advantageous for their future life. The outside teachers are also much in favour of the students and an increase in their number and more contacts with the industry via projects, etc., would be welcomed.

Obviously both students and teachers feel that the atmosphere in the degree programme in general is supportive, open and encouraging. However, teachers were underlining that on the level of curriculum there is also a lack of co-operation between different units. It was mentioned that in principle education should combine various fields of study. The current educational situation is not the best possible – there might be too much bureaucracy involved and many times a certain lack of co-operation may inhibit the initiative aspect. At the Oulu Polytechnic there does not seem to be any strong culture for collaboration between different degree programmes.

Research projects tend to be focused on the development of services. One of the main questions is how to link the services to the education and how the co-operation with other educational units is functioning – universities should be seen as partners also in the future.

In most of the polytechnics it seems to be obvious that there is a need for practically oriented learning. According to the teachers at the Oulu Polytechnic, there will be good students also in the future but not necessarily motivated students if they do not have any professional background. In order to attract motivated students to the Mechanical Engineering programme the entrance regulations must be revised. Both teachers and the representatives of industry felt that the Mechanical Engineering programme could have more motivated and capable students if the entrance criteria were tougher.

The tutoring teacher system is one function which should be developed. Teachers thought that the motivation is high in general but at the same time activities directed to higher motivation should be supported by the Polytechnic. Moreover, the administration should be lighter and more flexible – the level which takes the decisions to promote new methods for teaching is, according to the teachers, sometimes too high.

New methods have, however, emerged. In collaboration with the University of Oulu, there is a project about computer integrated manufacturing. The Polytechnic exploits its chat groups and interactive WWW-based environments to support and diversify learning for adult students. Teachers use the virtual means to deliver the teaching material via the Internet to the students. The latest innovations in network learning environments are exploited in teaching. In the year 1999 a new BSc degree programme, focusing on teaching and learning on the Net was launched in Mechanical Engineering. Students have access to the network-learning environments such as WWW homepages, resources of the UNIX disk, boards of WebBoard learning environment and mailing lists.
In 1999 there was also a project for ‘project learning’, with the objective of identifying relevance between the needs of education and the working life. The project was based on the fact that the problems in education in technical fields derive from the education not reflecting the needs of the working life. Project learning helped to monitor the education in such a way that different aspects of working life, such as team work and business minded thinking, can be taken into account in the education.

Students from the North

As concerns the students, one of the weaknesses is the general educational background in polytechnics. There are students of higher secondary background and students of vocational background. This bipolar situation can create problems, especially in the teaching of mathematics. Providing students with similar knowledge and skills it is difficult to motivate them all. Lack of motivation simply increases the number of dropouts which is very high at the Polytechnic.

For many applicants, Mechanical Engineering has not been the first option among degree programmes but it looks like most students, after having studied some time in the programme, are later highly satisfied with their Mechanical Engineering studies.

Mobility and relations between teachers and students

As regards mobility, there is a contradiction between the reality and objectives. Students are complaining about the lack of possibilities while teachers suggest that mobility is on a good level. Be it how it may, the curriculum is full of courses which means that students at Oulu Polytechnic feel that they have no time to be active collecting other study modules from different educational units.

Contact and co-operation between students and teachers is close and constructive which is a very important phenomena. The friendly atmosphere is important as far as the motivation of existing students is concerned. Recruiting days for students have been organised annually, mainly by the companies. Students were complaining that teachers should be organising more contacts with the companies and working life. Currently the companies collaborate with students and organise events such as the recruiting days or excursions to companies.

Although international activities are a high priority, many students do not want to go abroad, and the lack of language skills is considered to be one big obstacle. Another reason might be the lack of money and other personal reasons, such as family bonds. The situation is a bit strange since the message from companies and teachers is ‘clear as a bell’ – mobility means extra value for the education. At the same time the Polytechnic has even a strategy for
international activities plus an office for international affairs. This means that it is relatively easy for the students to have information about study possibilities abroad. Most likely the teachers should be more efficient in activating student mobility. Students are willing to have more courses lectured in English.

Together with the industry

According to the representatives from commerce and industry the reputation of the Oulu Polytechnic is good, but not special compared to other polytechnics in Finland. The contacts between the Oulu Polytechnic and different companies have also been working well. The degree programme covers most of the areas of mechanical engineering well but there could be more profound knowledge about plastics engineering – also maintenance skills are important. The industry has a need for engineers who can work in different working life environments. There is also a need for profile teaching, and a lack of technicians. In addition to this, operating systems and automation are highly important for the industry. The representative of industry usually consider that graduates should have both general and special skills.

Practical trainees are taken but they are usually expected to write their final thesis at the company. However, the industry recognises that good and solid training is a great asset for the business life in the region.

International experience is highly important for the companies. Companies need practically oriented persons, such as maintenance operators and similar professionals, and not so many pure researchers.

The representatives of industry and commerce are committed to help and improve the public image of the Mechanical Engineering – actually this will be one of the main tasks in the future. Due to this, the co-operation in the form of the alumni activities is highly appreciated by the industry but the initiative should come from the Polytechnic. Industry wants to emphasise that there is a constant need for basic engineers, and good educational structures are more than essential both for the society and for the industry. Entrance examinations should be more difficult and the annual intake should be restricted in order to have more capable and motivated students in polytechnics.

Material resources

The facilities and especially the laboratory equipment is up-to-date and provides the required basis for the practical part of education. An extensive renovation project is underway, and this will result in a more convenient and functional environment for educational purposes. Laboratories of Mechanical Technology, Measurement Technology, Rapid Prototyping, Robotics Automotive Technology, Energy Technology as well as the laboratory for materials testing all have machinery and equipment for education purposes. Students were satisfied with the quality and quantity of the laboratory facilities and computers.
International co-operation

The Oulu Polytechnic has a well structured strategy for international activities. The aim of the strategy is interpreted so that internationalisation can be seen as a tool for developing the quality of education and for advancing the economic growth and employment. The vision to enhance international mobility is clear and well constructed.

Teachers think that international mobility is relatively active among the students. The autumn term during the third study year could be the best time for studies abroad. Internationalism should be incorporated in all teaching. According to the strategy, there will be an increasing number of courses lectured in English in the future. Language skills – at least English and Swedish – are essential in industrial life, and the educational bodies are requested to further increase their efforts in teaching and in motivating their students to spend some time abroad.

With regard to the internationalisation the compulsory courses in English and the offer of additional intensive courses are very much appreciated. Although some students already use the available opportunities to spend some time abroad during their study, more action by the staff towards stimulation and motivation of the young people is desired. In particular, the first international contacts required should be made by the staff in order to overcome the first hurdles experienced by the applicants.

Good practice

• use of virtual mode of delivery of education and project learning
• the motivation and commitment of teachers, friendly atmosphere
• co-operation with the industry is working well and teachers are able and willing to work and practice in industry.

Recommendations

• own strategy and clear profile of mechanical engineering is missing
• study guidance should be structured in a more supportive way – too high dropout rate
• there should be more teaching in communication and language skills.
APPENDIX 1:
Viewpoint of the German Member

Professor Erwin Hasenjäger, Fachhochschule Bingen

Having had an experience with national evaluation programmes, my first international project was the evaluation project of FIN HEEC. As I have been teaching in the Department of Mechanical Engineering at a University of Applied Sciences (Fachhochschule) for over 15 years, it was very interesting for me to learn about the Finnish polytechnics and universities. I am more familiar with the Finnish term ammattikorkeakoulu than with the term polytechnic.

The FIN HEEC steering group has asked me to make a few comments on the evaluation project concerning the programme of Mechanical Engineering at polytechnics and universities. The comments and recommendations are the results from the perusal of the self-evaluation reports and my personal visits at the institutions.

Evaluation Project by FINHEEC

The FIN HEEC project, according to my personal opinion, has a high standard with international recognition. The numerous documents and Internet information make it very easy for the participants of this project to prepare themselves as external members. The format and the procedure of evaluation are in accordance with the well-known Dutch two-phase-model with internal and external evaluation, and this method is also practised in Germany.

The FIN HEEC project was very well organised and the sequence of events is compact and efficient. The chairman of the external evaluation group Mr Matti Hakala had moderated the meetings in a cordial and friendly manner and at the same time was able to reach his goal. He created an atmosphere of professional discussion and not one of investigation. The project manager Mr Karl Holm guaranteed a trouble-free schedule of the visits and was responsible for a perfect caring of the evaluation group.

The participation of students and representatives of industry at the external evaluation part is a strength of FIN HEEC evaluation procedure. A special feature of the FIN HEEC project is that all talks take place and documents are compiled in English. This gives the procedure its own official and international character and with it a special meaning. Independent of the description, analysis and assessments of the individual institutions of higher education, the programme evaluation by FIN HEEC contributes to the reputation and accreditation of higher education institutes and programmes in Finland as well as with institutions abroad.

From the previous programme evaluations made through FIN HEEC you can recognise that the recommendations given for the improvement of studies and learning at the individual sites were helpful. In contrast to other evaluation processes in Europe, these Finnish recommendations have a somewhat non-committal character. To reach improvements in addition to the analysis, concrete measures should be recommended by the institutions and if accepted, actions should be taken in a pre-defined period of time.
Self-evaluation reports
The reports altogether have a very good structure and high quality. This is quite remarkable as they have been done in such a short time in relatively small working groups. Through the given standardised format of the reports they were very easy to read. The definition of visions, goals and strategies in the reports creates an up-to-date impression and gives a distinctive image to each institution.

In some cases it is noticeable that the first descriptive part of the report is written in a more positive view than the second part with the SWOT analysis. This leads to a contradiction in comparing the two parts. This can also be due to the fact that there is not enough documentation about the participating persons working on the second part. As a result - with one exception - a feedback of students and teachers is not distinguished. Whether the graduates have submitted their contribution, this is not known. An important component of self-evaluation reports are statistical data of the number of students related to the phases of studies and to the areas of specialisation. These statistics concerning the mean duration of studies, the dropout rate, the female and the foreign students ratio and examination results should be ascertained. It is recommended that this data should therefore be documented in a more consequent manner.

Site visits
The good preparation of the visits, the hospitality at the institutions and the extensive guided tours were a great experience and have made a long-lasting impression. To limit the visit of each institution for one day, this requires a very compact programme and holds the danger of overseeing important aspects or missing vital information. But looking back, everything went quite well.

The use of checklists for the meetings would be very helpful as well as recording observations by an individual not participating in the conversation in order to keep the discussions efficient. The participation of industrial representatives at the meetings was very positive, especially as several members were former students.

Students and industrial representatives were open to discussion, however, departmental staff on the other hand tended to be somewhat reserved. Statements were normally made only by a small number of participants. The behaviour in the tours through the laboratories was of a completely different nature. The involvement of the department here was well recognised.

Generally the Finnish students conducted themselves accordingly and were very friendly. Their knowledge of the English language is also very good. They spoke very freely about the situation of the their school and about the programme. However, I noticed that perhaps their conduct was due to the fact that they were more concerned with finishing their studies, which created a sense of egoism and this feeling does not bear any consideration for the following student generations, which means that they are not willing to take time to join committees dealing with the improvement of studies and teaching at the departments. For this reason there should be more co-operation between teachers and students. One way towards improvement could be the creation of certain social events.
Finnish programmes for Mechanical Engineering

Finnish institutions of higher education are very similar to those in Germany. This is true not only for universities but also the polytechnics (ammattikorkeakoulu), which are closely related to the German Fachhochschule.

The areas of specialisation and the contents of courses are the same as those at the German institutions of higher education. The problems that are commonly discussed among teachers and students are the same in nature. I was always reminded of these problems during my visiting and talking to individuals, realising that this situation in Germany is no different.

Mechanical Engineering in Finland as well as in other countries has an unattractive image, which is to a certain extent an injustice. This is due to the fact that there is not enough information about the good career opportunities for engineers and this should be brought to their attention by the schools. These young people should be informed that they are preparing themselves for a profession that is highly recognised as being a professional which requires creativity, innovation and the dealing with people on a national and international basis.

The ability of the students to study at an institution of higher education is not any lower than it has been in the past. However, due to social circumstances and newer media the learning processes of the students have changed while the methods of teaching have not. On the other hand, the engineering profession has also gone through several changes. Previously, engineers were only responsible for one speciality, for which today many skills are required and higher flexibility in team work is needed.

The programmes of Mechanical Engineering have to consider these new circumstances. A lot of didactic creativity is required of teachers today in order to motivate, activate and to impart knowledge to the students, so they can reach a high level of engineering competence. In Scandinavia and especially in Finland, these conditions are present, because there is a very good relationship among students and teachers at all institutions of higher education.

Studying Mechanical Engineering at Finnish institutions, a solid foundation in the preparation of an engineering career is offered. The basic subjects like mathematics and physics are problem subjects for all students and this leads to a demotivation, of course, because the expectation of a technical curriculum is different. A dialogue between engineers and scientists is necessary in order to make maths and physics more perceptive and interesting for the students. In addition, the students should come in contact with software tools, e.g., computer algebra systems.

In the first few semesters it is very important to present survey lectures about technical areas which will be covered more in depth later on. Doing so, information about the areas of specialisation will be given at an early stage of studies.

The system of specialisation is spread out too much in some programmes which means that too much energy is wasted by administration in the departments, whereas this specialisation is not recognised by industry, but general and fundamental education is required.

The Finnish programmes of Mechanical Engineering do not include many electives and few economic subjects are offered. Foreign language subjects, presentation techniques and project management should be augmented and at best carried out in combination with technical courses (studium integrale).
The integration of industry in teaching, i.e., seminars and excursions exposes the students to a better understanding of job requirements. Industrial lecturers should help the students to prepare themselves for a desired engineering profession by explaining projects and products. I would like to make a further recommendation: there should be more recognition given to the practical training part. During this practical training, emphasis should be placed on special engineering problems which should have a structured nature and monitored by a member of the teaching staff. Guidelines for this practical training should be created. Therefore practical training should not be simply a “summer job”.

Polytechnics and universities
The similarity of the Finnish polytechnics with the German universities of applied sciences (Fachhochschulen) has already been mentioned. The difference is that the Finnish polytechnics are younger than the German ones and this short experience in Finland of being accepted by industry has created a problem which has been seen during the seventies with the German Fachhochschulen. The high recognition of German Fachhochschulen will be experienced by the Finnish polytechnics as a positive development for the future. The advantage of the polytechnics is the fact that courses of study are practice-oriented and study time is much shorter and this will be appreciated by industry in years to come.

The characteristics of the polytechnics should be taken into consideration and clearly worked out in order to promote these advantages. In this way there is no need for the polytechnics and universities to compete.

As a foreign member of the external evaluation group, I noticed a very good organisational structure of all institutions at all levels as well as a sense of quality and communication. It is remarkable that this internationalisation of the Finnish institutions of higher education and study programmes offer excellent study information to the students. This includes also the presentations in the Internet and multilingual information given there.

A high motivation of the students was recognised all over. The laboratories were well equipped and the projects in research and development were very impressive at all institutions. Therefore it would be desirable if the students were more involved in the activities in the laboratories and the facilities would be used for extensive practice-oriented education.
The metal and electronics industry is by far the largest industrial sector in Finland. In the year 2000, this particular industry accounted for 46% of the total industrial production, while the corresponding share of exports and number of personnel were 56% and 45%, respectively. The companies in this field accounted for 80% of all industrial R&D expenses and for 35% of investments in tangible assets.

Need of experts in the metal and electronics industry

According to a survey made by MET, the metal and electronics industry is estimated to employ a total of 250,000 people in 2010, i.e., the number of personnel employed by the industry would increase by 45,000 during the current decade. The increase would take place within the electronics and electrotechnical industries.

During the same period of time, about 40,000 persons will leave the industry, the decrease affecting mainly the mechanical engineering and metal products industries. Thus the need for new personnel would amount to 85,000. According to the estimates, 75,000 of these new employees would need to have a technical training. Since the need for technically educated people also exists in other lines of industry, the estimated overall need for engineering graduates would amount to 135,000 persons during the first decade of this millennium.

It is anticipated that the need for mechanical engineers graduating from universities and polytechnics exceeds their actual number. Moreover, almost 50% of the polytechnic graduates work in branches other than the metal and electronics industry.

According to the estimates of MET, about 30% of the intake of polytechnics should be reserved for production-oriented engineering education. Besides a more theoretical training in engineering, the companies need persons with a good practical experience to manage their teams and production facilities, i.e., production supervisors.

The requirements placed on engineers vary considerably, depending on the modes of production and product range of the individual companies, as well as on whether they need multi-skilled or specialist engineers. However, the competence in basic engineering skills remains imperative: production control, production technology as well as design of product systems and product technologies on the one hand, and the cooperation skills between design and production on the other hand. IT skills are needed irrespective of the specific branch. Interaction and person skills as well as language proficiency are becoming increasingly important, as are quality and financial aspects.

The rapid development of technology, the globalisation trend, the developments in information and communications technologies, the information society development as well as the need to master value chains constructed upon company networks are among the factors which call for a good education basis. It is a foundation which is necessary for the flexible build-up of new capabilities, new skills made necessary by the constant change and acquired through adult education. During basic education the student should acquire a desire for self-development and the skills for the search of new information.
**Quality of education**

The quality of education and the respective evaluation is highlighted both on the national level and in the international arenas. High-quality education must also include the improvement of teaching, learning and student results, as well as the development of teaching contents. Side by side with the national and international evaluations, the self-evaluation work performed by the universities and polytechnics is becoming increasingly important.

The different forms of co-operation between the universities and polytechnics on the one hand and the practical business life on the other hand constitute a core factor for the teaching-related quality assurance work. The following forms of co-operation have provided favourable results:

- defining the competence needs of engineers
- joint project work and research projects
- lectures given by the representatives of business and industry at the universities and polytechnics
- company representation in administrative bodies of the institutes.

**Areas of development**

In order to implement high-standard education, sufficient basic funding is required to ensure the necessary resources and, in particular, the professional competence, practical working life knowledge and availability of teachers.

Study dropouts and shortened study periods constitute a challenge for the universities and polytechnics. The support of students during their studies is a question that needs addressing, as is the problem of providing a more flexible way to pass the degree through new teaching methods and exam alternatives. The dropout rate can be reduced and the intake of good students encouraged by presenting the engineering studies and the respective future potentials to comprehensive school and upper secondary school students, as well as to their parents and teachers. It is very important that the young people be offered a chance to familiarise themselves – through various means – with the professions, working environment and studies in the fields of engineering. Examples of such activities could include the working practice of upper secondary school students in various companies or universities and polytechnics, as well as presentations of the institutes at comprehensive and upper secondary schools.
APPENDIX 3: The view of the industry

Mikko Karvinen/Metso Paper

The aim of Mechanical Engineering teaching at universities of technology is to provide multi-skilled MSc graduates to fulfil the needs in industrial research, product development and design assignments.

Modern products combine automation and control technology to traditional mechanical engineering. The life cycle management of products is currently emphasised in business, which places added importance on the ease of service and maintenance in product design. Environmental requirements and low impact considerations gain increasing weight and must be integrated into products to give added value. The need for comprehensive product spectrum management requires the incorporation of improved management options through information technology.

The time available during the studies is not sufficient for students to learn all of these disciplines thoroughly. This is why it is important to create an educational environment which supports the models of these types of multidisciplinary operations, whereby the attitudinal training of students will produce engineers who seek out diverse co-operative relationships. New products call for new solutions that combine different types of know-how, sometimes in surprising ways.

A multidisciplinary approach can be introduced to any learning environment but in-depth expertise elements are also needed. Only some of these can exist at any one learning site at a given time. Universities and polytechnics must therefore link their research efforts and establish working contacts with natural sciences research typically carried out at the university level. Much remains to be done here, both nationally and especially internationally.

Mechanical Engineering must be able to compete for the best available students. The public’s view of the opportunities offered by, and the competitiveness of, the mechanical engineering field must be improved over student views to strengthen the choices students are currently making. Describing curriculum contents through sophisticated end products might help here. Joint efforts by the educational system and industry are required in this area.
APPENDIX 4:
Guidelines for the self-assessment

DESCRIPTION: QUANTITATIVE AND QUALITATIVE INFORMATION
(max. 15 pages)

THE FRAMEWORK
- Historical background of the university/polytechnic and the programme
- The organisation of the university/polytechnic and the position of the programme within it
- Aims (broad purposes), objectives and strategies of the university/polytechnic and the programme (how, by whom, when)
- Financial resources of the programme

programme
- Description of programme focus areas.
- The present situation of the programme and oncoming changes
- Major changes and improvements during the past five years
- Curriculum, aims and content in 2000 - 2001
  Appendix on curriculum and course contents in English
- Connections between research and programme
  Appendix on research and development projects (since 1.1.1998)

PROGRAMME/DEPARTMENT staff
- Staff profile
- Staff development programme
- Part-time teachers from industry and commerce
- Incentives

programme students
- Student profile and recruitment of students
- Graduates and their employment
- Interaction between programme and alumni (depth, breadth)

teaching and learning
- Teaching methods, student engagement and participation
- Use of learning resources
- Skills achieved (e.g. transferable, cognitive, subject-specific, practical/professional, language, personal)
- Latest innovations in teaching

assessment of students
- The range of assessment methods (e.g. written exams with essay questions or applied problems, continuous assessment of coursework, laboratory work, projects, use of learning diaries and portfolios)
- Criteria (e.g. clarity, students' understanding of criteria and assignments)
- Marking/grading policy
- The use of students' self-assessment (e.g. examples how students evaluate their own learning)
- Feedback to students and/or curriculum/course design
- Monitoring of student progression
STUDENT SUPPORT AND GUIDANCE
- General (e.g. strategy for support and guidance, written guidance on the programme/course level)
- Academic guidance (e.g. concerning course options, study skills)
- Tutoring and welfare support
- Career information and guidance

learning resources
- Relevant library services (e.g. course book and periodical stock, study space)
- IT facilities and equipment
- Laboratories and other special educational facilities

NATIONAL co-operation and networking
- Programme co-operation with other institutions (national)

INTERNATIONAL co-operation and networking
- Programme co-operation with other institutions (international)
- Teacher and student exchange

PROGRAMME INTERACTION BETWEEN INDUSTRY AND COMMERCE
(e.g. projects, thesis-work, advisory groups)
- Recognition of educational requirements in industry, commerce and public life

quality management and enhancement
- Internal arrangements for monitoring and evaluating strategies
- Revision of programme objectives, curriculum and course contents
- Assessment of student feedback systems

practical arrangements
- Organisation of the self-assessment process (timetable, names and positions of participating persons)
APPENDIX 5: Fields of specialisation

**Polytechnics**
- Central Ostrobotnia Polytechnic: electronics manufacturing technology, machine design, production automation and management, production technology for electronics industry
- Hame Polytechnic: construction technology, production management
- Jyvaskyla Polytechnic: machine and production technology, paper machine technology
- Kemi-Tornio Polytechnic: mechanical engineering, production logistics, product development
- Kymenlaakso Polytechnic: machine automation, machine design, maintenance management
- Mikkeli Polytechnic: machine automation, materials technology, electronics production
- North Karelia Polytechnic: machine automation, mechanics design, production technology
- Oulu Polytechnic: car and transportation technology, energy technology, machine automation, production development, electronics production and logistics
- Pohjois-Savo Polytechnic: machine design and product development, machine automation, electro-mechanical systems, production technology
- Satakunta Polytechnic: HVAC and energy, automation and maintenance management, machine design, total quality management and business processes
- South Carelian Polytechnic: machine design, logistics, automation and information management
- Stadia: energy and environmental engineering, machine automation, machine design
- Swedish Polytechnic: energy technology, machine construction, plastics technology, automotive engineering
- Tampere Polytechnic: machine automation, aeronautical engineering, production systems, product development
- The Sydvast Polytechnic: machine and materials technology
- Turku Polytechnic: energy technology, machine automation, marine technology, naval architecture, product development, production technology and management, production development
- Vaasa Polytechnic: energy technology, machine construction, mechatronics, production management

**Universities**
- HUT: energy engineering, vehicle engineering, engineering materials, production and manufacturing engineering, fluid mechanics, automotive engineering, naval architecture, aeronautical engineering, HVAC-technology, internal combustion engineering, foundry engineering
- LUT: machine design, machine automation, steel structures, welding technology, mechanical engineering industry, mechanical wood processing
- TUT: occupational safety engineering, production technology, industrial management, technical mechanics and optimisation, paper converting technology, machine design, hydraulics and automation, energy and process technology
- University of Oulu: machine design, engineering design, materials engineering, engineering mechanics, production technology
### APPENDIX 6:
**Key figures of the programmes**

<table>
<thead>
<tr>
<th>Polytechnics</th>
<th>num. of students male/female</th>
<th>num. of teaching staff ratio</th>
<th>student/teaching</th>
<th>median time of graduation</th>
<th>applications/primary option/intake</th>
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## APPENDIX 7:
Participants of the site visits

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<th>Hakala</th>
<th>Fonselius</th>
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<th>Hasenjäger</th>
<th>Hein</th>
<th>Johansson</th>
<th>Penttala</th>
<th>Nevaranta</th>
<th>Karvinen</th>
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