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Cross Border Quality Assessment in Physics

Evaluation Report

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PREFACE

The Cross Border Quality Assessment in Physics should be considered as a pilot project for the international evaluation of study programmes. It is inherent in a pilot project that the procedure followed cannot be fully determined beforehand; in part it will evolve in the course of the project itself. We could use the 1992 International Programme Review of Electrical Engineering[1] as an example; in some aspects, however, we chose a different emphasis. Whereas the IPREE concentrated on the equivalence of programme contents, it soon became clear that in physics the central problem is not so much the quality, but rather the attractiveness of the programmes: recently most physics faculties have experienced a significant decrease in the number of incoming students. Therefore, compared to the IPREE project we are placing rather more emphasis on teaching methods and on the organisational framework as well as on the internal quality control procedures.

The cultural differences between the countries and regions visited made our task more interesting, but more difficult as well. They influence the relations between different groups in the university and the way in which criticism is expressed and received. In Flanders and in the Netherlands, teaching evaluations already exist and the faculties have been evaluated at least once in a national context; the German faculties had their first experience with the evaluation of teaching in the present project. Also, the legal framework and the amount of freedom the faculties have in determining their curriculum and its implementation differ widely.

The factors indicated above would make a simple-minded ranking of the programmes ill-advised, and our findings should not be used to construe such a ranking. They would also make it worthwhile to repeat our project, which was restricted to a small corner of Europe, with a broader sample. This could provide a welcome addition to the wealth of information on European physics programmes already collected by the European Physics Education Network EUPEN[2], which covers a very broad sample, but cannot analyse the programmes in as much depth as the present project.

As to the legal constraints, we took them into account as far as possible in our assessment, but less so in our recommendations; we trust laws and regulations can be changed, especially when they stand in the way of rational solutions.

Universities and curricula are in a process of rapid change, and our assessment is but a snapshot, catching but one stage in this development. An important catalyst of change is the Bologna Declaration. We touched upon its impact in some of our faculty reports. However, since the Prague follow-up conference on the Bologna Declaration will take place between the writing of our report and its publication, an analysis of the effect on physics programmes could well be outdated by the time of its appearance. We therefore refrained from trying to include a broader analysis.

We hope the report will be of use to the faculties assessed and to other physics departments, which might find inspiration in some innovative ideas we encountered, in the solutions found by the faculties visited for problems that are also to be found elsewhere, and perhaps in our considerations as well.

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[1] International Programme Review of Electrical Engineering, A.I. Vroeijenstijn et al., VSNU, 1992

[2] Inquiries into European Higher Education on Physics, Vols. 1 - 5, H. Ferdinande et al., Universiteit Gent, 1997 - 2000

On behalf of the other peers and of the steering group, I wish to thank the faculties involved who volunteered for the project, put much work into it and met our frequent requests for additional information as our project evolved. The peers were received with kindness and openness in each of the participating universities, and the site visits were very well organised, producing a good atmosphere for fruitful co-operation.

We wish to thank Mr Dermot McElholm (Fremdsprachenzentrum der Universität Hannover) for his assistance in matters of style and Ms Joke Clays (Universiteit Gent) for drafting Appendix 1.2.

I wish to thank the sponsoring agencies for their support, and the co-ordinators and secretaries for their tireless efforts and for the good cheer with which they faced the barrage of requests the peers subjected them to. Finally, I wish to express my gratitude to my fellow peers for their dedication and tolerance, and for demonstrating that a shared sense of humour can be a powerful aid in bridging differences in background and opinion.

Linz, January 31, 2001

Urbaan M. Titulaer
Chairman, Cross Border peer group

INTENDED READERSHIP

This report is primarily written for the participating faculties and departments in order to provide them with some feedback on the information they provided and to formulate recommendations they may be able to use to improve the education they offer. The committee hopes their findings may prove helpful.

Faculties of physics in the European Union might constitute a second class of readers. Some specific features of the programmes assessed and some of our recommendations might be of interest to other universities as well in adjusting their programmes.

And finally of course, this report was also written for everyone within the European Union concerned with higher education, including university authorities, ministries of education and possible employers of graduates in physics.

THE STRUCTURE OF THIS REPORT

The minimum criteria used by the committee are laid down in Part I, Chapter 2, essentially as formulated by the peers before the visits. The executive summary that follows contains our main findings and recommendations. They apply in differing degrees to the various faculties. For more details, also with regard to this aspect, we refer to the general findings in Part II and to the faculty reports in Part III. The Appendices include factual background material on staff structure and academic careers as well as on the peers, the sponsoring agencies and on the procedures followed. The tables included are based on data provided by the participating universities. The opinions expressed, except where otherwise attributed, are solely those of the peer group.

EXECUTIVE SUMMARY

The programmes assessed all amply fulfil the minimum requirements for Master’s and Diploma studies in terms of the content of the education offered and of the basic knowledge and skills acquired by graduates.

Optimum achievement of the aims of an education in physics or technical physics would seem to make it highly desirable to have a five-year study programme. A uniform adoption of five-year programmes would also be a very positive contribution toward increasing the mobility of graduates.

In general, the programmes are well balanced between a core of obligatory courses and a broad range of electives. Considerable freedom to choose electives is appropriate in view of the range of subjects in physics and its applications which cannot be covered in the core curriculum, and of the very diverse job market for graduates. In some programmes, more options for choosing non-physical electives would be desirable.

A major shortcoming in many programmes is insufficient specific preparation for fields of employment outside academic research. To improve this aspect of the education, students should be confronted with problems or projects which originate in industrial applications of physics. Also, opportunities to meet potential employers and graduates working outside academic research should be arranged by faculties.

To ensure regular adjustment to the needs of the job market the committee recommends keeping a record of the initial employment of graduates after they leave the university, upon completing their Master's or doctoral degree. Regular evaluation among graduates should be carried out to obtain an overview of the qualifications graduates feel they need, and of the extent to which these were obtained during their studies.

In addition to its practical applications, the role of physics in culture should be conveyed. Contacts with society, in particular with secondary schools, should be cultivated and students should learn to communicate about physics with lay people.

The faculties take their obligation to provide a high-level and inspiring curriculum very seriously, and the courses are well designed and in general well taught.

The motivation of students is typically high in the final stages of the study and in the first year, but often less so in the intermediate stages. In order to increase motivation, the relevance of the subjects taught to recent developments in research and applications should be stressed. To this purpose, basic courses should be taught by active and successful researchers. Active participation by students, rather than a passive receptive attitude, should be encouraged.

In most faculties there is quite a high dropout rate and an appreciable discrepancy between the nominal and the actual duration of study. To identify the causes, and to design measures towards improvement, better data on the progress of individual students are required. The committee wishes to point out, however, that some reasons for a delay, such as a necessity to work part-time to cover living expenses, or a decision to follow outside interests or courses in addition to the regular programme, cannot be influenced by the faculty.

In general, sufficient attention is paid to developing oral and written communication skills. More systematic attention to the development of problem-solving abilities is recommended, however. Also, training in the use of libraries and other sources of information as a preparation for life-long learning, as well as training to work in teams, require more attention in most of the programmes.

In most of the faculties visited, the career possibilities for junior staff are unsatisfactory, due mainly to factors outside the control of the faculties. Junior staff members often have little responsibility and independence in their teaching tasks.

In decisions concerning hiring and promotion of staff, teaching as well as research activities are and should be considered. To facilitate this, as well as the mobility of staff, the establishment of teaching records is strongly recommended.

Increased attention to the development of academic teaching skills is required. In addition to supervision by experienced teachers, training programmes for academic teachers should be developed where not yet available; a co-operative and open-minded attitude towards such programmes on the part of faculties and staff members is recommended, even if these programmes are still incompletely developed and not fully evaluated.

PART I

FRAME OF REFERENCE

1 CROSS BORDER QUALITY ASSESSMENT IN PHYSICS

1.1 History and Procedure Followed

The "Cross Border Quality Assessment in Physics" took place in the framework of the 'Grenzländerzusammenarbeit' – a cross border co-operation between Bremen, Flanders, the Netherlands, Lower Saxony and North Rhine Westphalia. It was initiated by the 'Ministerkonferenz' in February 1999. The conference agreed that

> *A co-operation in the field of evaluation and performance measures is to be continued and intensified. Here the ministers have decided to let a team of experts define a pilot project, in which universities of all five regions will take part. In the course of this project, a comparison of procedures and quality criteria is also planned*[3]*.*

As a result of this decision, the "Zentrale Evaluations- und Akkreditierungsagentur Hannover", Germany (ZEvA) and the "Vereniging van Samenwerkende Nederlandse Universiteiten" in the Netherlands (VSNU) were commissioned with the task of defining a pilot project. Faculties of Physics and Applied Physics in the five regions were asked to participate in an evaluation of their physics programmes. The evaluation offices of Flanders, "Vlaamse Interuniversitaire Raad" (VL.I.R.) and North Rhine Westphalia, "Geschäftsstelle Evaluation Universität Dortmund" (GEU) were asked to participate in co-ordinating the assessment. Bremen later withdrew from the project. The aim was to compare the study programmes and to find out whether students received equivalent qualifications. The visiting committee was to formulate recommendations for the faculties concerning possible improvements.

In co-operation with the participating evaluation agencies, faculties were approached to volunteer for the assessment. The faculties then proposed possible peers for the visiting committee. Physicists of various backgrounds and outstanding scientific qualification were then approached by the evaluation agencies. Important criteria for selecting peers were an active knowledge of English and passive knowledge of German and Dutch. Also, the peers should have no connections to the universities assessed. The committee had to include one representative of physicists in industry and a specialist in teaching methodology. Depending on candidates' willingness and availability for site visits and a preparatory meeting, a final group of peers was then agreed upon.

The committee and the steering group came together for a preparatory meeting in Bommerholz, Germany on August 30 and 31, 2000. During that meeting, a chairman was chosen and a set of minimum requirements for a study programme in physics formulated. The peer group also assigned primary responsibility for various aspects of the assessment to individual members of the group.

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[3] "Gemeinsam fortgeführt werden soll ebenfalls eine vertiefte Zusammenarbeit beim Thema Evaluierung und Leistung. Hier beschlossen die Ministerinnen und Minister, daß auf Expertenebene ein Pilotprojekt definiert wird, bei dem Hochschulen aller fünf Länder einbezogen werden sollen. Ein Vergleich der Verfahrensweisen und Qualitätskriterien ist damit eingeplant."

"Ook een diepgaandere samenwerking op het gebled van de evaluatie en beoorderling van studieprestaties dient gezamenlijk te worden voortgezet. Hier hebben de ministers resp. de senator beslist, dat een pilootproject zal geinitieerd worden door een expertengroep, waarbij instellingen voor hoger onderwijs uit de vijf regio´s zullen worden betrokken. Een vergelijking van de procedures en kwaliteitscriteria is daarbij in de planning opgenomen."

(Press-release of the Ministry of Science and Culture of Lower Saxony, February 8th 1999)

The committee has assessed the programmes by studying the self reports provided by the faculties and other materials such as graduation theses, examination questions and seminar work, syllabi for lectures and tasks assigned in exercise courses. The site visits to the participating faculties constituted a central part of the evaluation process. Plenary discussions were held with those responsible for the programme and its implementation, and with representatives of the different status groups. The peers were also given a guided tour of the various institutes and facilities. In addition, individual discussions were conducted which allowed the exploration of certain topics in more depth. The agenda of a typical site visit is given in Appendix 2. The assessments were given against the background of the minimum requirements agreed upon in Bommerholz using the checklist given in Appendix 3. The peer group formulated its impressions of the programmes offered by the faculties in a meeting during the second day of the visit. These findings were presented orally to interested members of the faculties during the concluding meeting.

On the basis of the preliminary findings, first drafts both of the faculty reports and of the general findings were circulated among the peers and, after agreement among the peers had been reached, were sent to the faculties for comment. The peers and the steering group met on January 28 and 29, 2001 in Hanover, discussed the reactions received from the faculties and decided on revisions to be made in the report. The final version of the report was sent to the peers for approval and to the faculties. The faculties were given the right to add a comment of up to one page on the final version of the report. These comments are printed at the end of the respective faculty reports.

1.2 Participating Faculties

The following faculties or departments participated in the Cross Border Quality Assessment in Physics:

* Department of Physics at the "Gerhard-Mercator-Universität Duisburg", Duisburg, Germany
* Faculty of Science (Physics) at the "Universiteit Gent", Ghent, Belgium
* Faculty of Applied Science (Civil Engineering in Physics) at the "Universiteit Gent", Ghent, Belgium
* Faculty of Physics at the "Universität Hannover", Hanover, Germany
* Faculty of Applied Physics at the "Universiteit Twente", Enschede, the Netherlands

1.3 The Cross Border Committee and Steering Group

Based on recommendations by the participating faculties, the committee was composed of the following members:

Prof. Dr. Urbaan M. Titulaer, Johannes-Kepler Universität Linz, Austria (Chairman)

Prof. em. Dr. Jules Deutsch, Université Catholique de Louvain, Belgium

Prof. Dr. Frans H.P.M. Habraken, Universiteit Utrecht, the Netherlands

Prof. Dr. Klaus Lüders, Freie Universität Berlin, Germany

Prof. em. Dr. Gunnar Tibell, Uppsala universitet, Sweden

Dr. Udo Weigelt, Anwaltssozietät Grünecker, Kinkeldey, Stockmair & Schwanhäusser, München, Germany

Prof. Deutsch and Prof. Lüders did not participate in the site visit to Hanover; additional visitors to Hanover within the framework of the Lower Saxony Evaluation were:

Prof. Dr. Helmut Fischler, Freie Universität Berlin, Germany

Prof. Dr. Thomas Walcher, Johannes-Gutenberg-Universität Mainz, Germany

These additional peers participated in the local deliberations of our committee, but are not responsible for the final report.

The steering group consisted of the following members:

Mr Henning Schäfer, M.A., ZEvA (Co-ordinator and Secretary)

Dr. Christopher Schippers, ZEvA (Co-ordinator and Secretary)

Mr Hermann Reuke, director of ZEvA

Ms Edna Habel, M.A., GEU, for North Rhine Westfalia

Ms A. Van Linthoudt (up to May 2000), Ms Sophie Verfaillie (from May 2000), VL.I.R., for Flanders

Drs. A.I. Vroeijenstijn, VSNU, for the Netherlands

2 MINIMUM REQUIREMENTS FOR MASTER´S AND DIPLOMA STUDY PROGRAMMES IN PHYSICS

The following text was formulated on the basis of the criteria used in the IPR-EE (International Programme Review of Electrical Engineering, VSNU, 1992), which were largely derived from the criteria used by ABET (the Accreditation Board for Engineering and Technology) in the USA. Recent trends in educational science and in the teaching of physics were also taken into account. The criteria were formulated after a first round of discussions during the first plenary peer meeting and substantiated and extended during subsequent exchanges.

2.1 INTRODUCTION

2.1.1 General

What is the aim of an academic education in physics and/or technical physics?

- To engender enthusiasm for physics, basic and technological research.
- To convey a working knowledge of the main aspects of the physical world.
- To develop problem-solving abilities including the use of tools (computers, library, workshops, etc.).
- To develop communication skills (both oral and written) and to introduce students to teamwork.

What is the importance of research in physics study programmes?

First of all, to develop enthusiasm on the part of students for understanding the physical world and for the ways in which this understanding may be achieved. In some students, this will stimulate an interest in fundamental research. However, only a minority of students will have the desire and the opportunity to conduct fundamental research. The job market for physics graduates is a very broad one; it includes employment in industrial research and development as well as work in mathematical modelling and software development. Also, an increasing proportion of graduates set up their own companies or consulting bureaus. Thus, not every graduate will be required to carry out individual research projects. Nevertheless, research must be an important part of the curriculum, even for those graduates who do not want to work in academic or industrial research. Physics graduates are attractive to many employers because of their problem-solving abilities. To acquire these abilities, experience through independent work in a research field can serve as a good basis. Also, the qualities which characterise a good researcher, such as independence and creativity, are useful in a variety of professional contexts.

2.1.2 Definition of the Assessment Programme

The visiting panel shall review the curricula leading to Master´s and diploma degrees in Physics (U Duisburg, D, RUG, B, U Hanover, D), Civil Engineering in Physics (RUG, B) and Applied Physics (U Twente, NL) as well as their implementation in the practice of teaching and learning.

Physics study programmes should comprise a coherent set of courses or other educational modules that enable students to learn the basics of physics at the beginning and extend and consolidate their experience in the higher-level courses. A well balanced ratio between lectures, exercises and laboratory courses is indispensable. Autonomous work in groups should also be part of a physics education. Furthermore, input from the professional world is required. The students should acquire the ability to apply their knowledge later, both in practical applications in industry and other fields of employment and in basic and applied research.

For the Cross Border Quality Assessment, the peer group has formulated criteria that form the requirements for a study programme in physics. These are not formulated too specifically in order to allow the participating institutions their individual focuses and ideas. The criteria should be regarded as a statement of principles that can be implemented in a variety of ways rather than as a set of rigid standards. Finally, they are also intended to encourage and stimulate the development of creative novel programmes of study.

2.2 PROGRAMME CRITERIA

A curriculum has to provide breadth and depth in the entire realm of physics. Breadth means that the students should develop fundamental knowledge in several areas characteristic of various approaches to physical phenomena (micro/macro systems, microscopic and phenomenological descriptions, etc.). Depth requires the study of at least one area at an advanced level.

A programme should enable graduates to:

1) identify and solve problems in society that can be addressed with the methods developed in physics;
2) appreciate the possibilities of research in physics and carry out independent research, e.g., in a subsequent doctorate study;
3) understand the technical problems in society which confront the profession;
4) comprehend the ethical characteristics of research and professional activity in physics and its responsibility to protect public health and the environment;
5) maintain professional competence through life-long learning;
6) work in an international context.

In order to prepare the students for a graduation in Master´s and diploma degrees, the curriculum should include areas of theoretical and experimental physics, mathematics as well as other basic sciences. The minimum requirements for the course programme are:

- providing an appropriate combination of observational and experimental studies on the one hand and theoretical studies on the other;
- presenting various approaches towards describing and understanding the physical world,
- providing an appropriate combination of mathematics and other basic sciences that should be chosen primarily for their relevance to the contents of physics courses and the requirements of the graduates in their intended professional careers;
- providing a sequential development leading from simpler to more advanced and increasingly independent tasks culminating in a final thesis;

- introducing students to sources of information to be used during and after their studies, and training them to use these sources in independent study projects as a preparation for life-long learning;
- enabling the students to come into contact with areas other than physics to allow them to acquire additional knowledge and skills in various minor subjects.

The final thesis is a very important part in the curriculum. The students have to apply the knowledge and experience they have gained throughout their preceding studies. The final thesis should deal with a problem in research or industrial development. It will in general be prepared in a team of researchers led by a faculty member. In the course of the thesis the student should learn to work in a team; this should also be a preparation for a later professional career.

While the peer group favours a flexible approach to the design of the curriculum, it also recognises the need for specific coverage in each curricular area.

1) *Experimental physics*

   The teaching of experimental physics should convey the central role of observation and experiment in forming, refining and testing our theoretical concepts in a dialogue with nature. Students should learn to appreciate the approximate nature of measurements and learn to estimate and critically evaluate the sources of experimental error. They should learn to communicate effectively with supporting technicians, e.g., in machine or electronic shops.

2) *Theoretical physics*

   The teaching of theoretical physics should convey the beauty of its concepts and structures but in equal measure emphasise its foundation in observations and experiments. The students should understand the limitations in the application of models to the physical world. They should be able to derive predictions from theoretical models.

3) *Mathematics*

   The mathematical part of the curriculum should be directed primarily towards mastering and understanding the techniques used for modelling and describing physical systems and deriving predictions from mathematical models, rather than towards developing mathematics as an independent intellectual structure.

4) *Minor subjects*

   The choice of minor subjects should not be too restricted and should allow the students to develop their interests beyond physics and to acquire additional skills relevant for their intended professional career.

5) *Additional requirements*

   a) An integral part of the study programme should be work in laboratories which serves to combine elements of theory and practice. Every student must have the ability to carry out practical experiments in order to find answers to questions which are typical of physics. This is especially important for the higher levels of the programme. Furthermore, a working knowledge of safety and environmental regulations as they apply to laboratory work is indispensable.
   b) Appropriate use of computers must be an integrated part of the programme. It should include development of novel software and the efficient use of standard soft-

ware such as editors, compilers, and debugging routines in order to carry out simulations and to collect, process and analyse experimental data.

c) Physics graduates should have the ability to communicate scientific subjects, including the results of literature searches and their own work, in oral and written form. Education in communication skills should therefore be integrated into the curriculum, beginning with simpler tasks for first-year students and becoming more and more demanding from year to year. Not only the content of written work, e.g., the final thesis, is important, but also correct use of the language.

d) A general understanding of the ethical, social, economic, and safety considerations in physics practice is essential for graduates. Special courses may be provided for this purpose, but – as a minimum – it should be the task of academic staff to address such professional concerns in all courses.

e) Graduates should develop an interest and skill in communication with non-experts and in various initiatives to increase public understanding of physics (contacts with secondary schools, open days, etc.)

6) *Preparation for professional life outside the university*

It is important that the faculties/departments take trends in the job market for physics graduates into account when considering how to improve the study programme. There should be a constant influx, which means that staff should be aware of the new challenges and requirements of industry and other employers of physics graduates and try to take them into account in the curriculum. Students should be encouraged to acquire practical experience wherever possible. Inviting guest lecturers and contract teachers from professional life may also be a valuable contribution. Another important point is establishing good contact with alumni who can, for example, be invited to talks and meetings. This is not only an important source of information from professional life outside the university, but also gives students an opportunity to meet possible employers.

2.3 IMPLEMENTATION CRITERIA

2.3.1 Introduction

In order to maintain a coherent, high-level study programme that is continually adapted to present and future demands, and in order to assure high-quality teaching of individual courses, certain organisational conditions must be met.

In the following these conditions will first be outlined in general terms. They will then be dealt with in greater detail, thus providing us with a checklist for the evaluation.

2.3.2 Organisational Criteria

Within the organisation of the faculty it must be absolutely clear which person or committee is responsible for the policy, the quality and the execution of all educational matters relating to a given study programme. Should these responsibilities be divided among more than one person or committee, the structure must allow for and guarantee the necessary co-ordination. The person or committee concerned must have sufficient competence and authority to carry out what is deemed necessary, they must have the necessary resources, and must be well incorporated within the faculty government structure and the research environment.

As regards the management of the education programme, four distinct but interrelated aspects need to be considered. They are Policy, Resources, Quality as well as Information and Communication.

- Educational policy: curriculum structure in the context of the political, economic and cultural situation and in the international context, providing international contacts for students, relations with secondary education and employers; educational concepts.
- Resources: teaching staff and facilities, management and administrative staff.
- Quality of the education: quality of individual courses, coherence within the phases of the curriculum and the curriculum as a whole, a proper system of evaluation.
- Information and Communication: gathering and dissemination of information concerning educational developments in general, study progress of students, developments in secondary education, job market, etc.

2.3.2.1 Policy

The following aspects in the "Policy" category influence the quality of the study programme, such as the coherence of the content of the curriculum, and of teaching practice:

a) Is there an explicit policy concerning the profile of the education in the national and international context? Is there an internationalisation policy?
b) Is there an explicit policy concerning educational matters such as the depth and breadth of the knowledge and skills expected of graduates and the time in which students have to obtain this knowledge and these skills?
c) Is there an explicit policy concerning methods of teaching and learning?
d) Is there an explicit policy concerning resource management, including in particular a policy to maintain and develop the quality of the teaching staff?
e) Are these policies known to all persons concerned, do they have sufficient opportunity to contribute their views and has a reasonable level of consensus been reached?

2.3.2.2 Resources

The following aspects in the "Resources" category influence the quality of the organisation and implementation of the course programme. We therefore need to investigate the question of whether they have been fully taken into account in the programme management.

Academic Staff

a) The quality and dedication of staff is of paramount importance for the success of an education in physics.

The overall competence of academic staff may be judged by such factors as:

- active involvement in innovative research and the ability to convey its importance and excitement;
- the level of academic training of its members;
- the diversity of their backgrounds, which should include non-academic physics experience for at least some staff members;
- the size of teaching staff and the distribution of tasks, allowing staff members sufficient time for their professional development in research and to keep themselves informed about developments in physics and in educational science;
- experience in teaching and a willingness to use teacher training and teaching evaluations to assess and improve the quality of their teaching;
- interest in and enthusiasm for developing more effective teaching methods;
- appreciation of their work by students;
- personal interest in students' curricular and extra-curricular activities;
- availability for students (consulting hours, etc.);
- consideration of teaching performance (dedication and skills) as an important criterion in the hiring and promotion of staff;
- availability of programmes for the training of academic teachers.

b) The staff must be large enough, in terms of experience and interest, to cover all of the curricular areas of physics. Qualified teachers for the non-physics subjects in the curriculum must be available.

c) Teachers or other staff must ensure that students receive proper curricular and career advice. In addition, to a certain extent it should be possible for students to obtain help with personal problems related to their studies.

Supporting Staff

d) Staff of sufficient number and quality must be available to carry out managerial, technical and administrative tasks related to the study programme, such as the administration of study progress, working out the yearly schedule and timetable of courses, gathering and dissemination of management information, assistance with information and communication technology and maintenance of laboratory equipment and computer facilities.

Facilities

e) A physics programme can only be properly implemented if adequate facilities, including offices, classroom space and laboratories, are provided.

f) The libraries must contain subject-related and non-subject-related literature, including books, journals, and other reference material sufficiently varied and up to date for collateral reading in connection with the instructional and research programmes and later professional work. This is also important for maintaining contact with alumni.

g) Computer facilities for students and staff must be adequate to allow and encourage their use during the study. Computer equipment must be appropriate for searching information resources and for all other applications in physics, including modelling, simulation, data processing and laboratory work.

h) The laboratory facilities must reflect the requirements of the study programme; this includes appropriate up-dating and maintenance of the equipment.

2.3.2.3 Quality Evaluation

Quality plays a role on three levels: individual courses, the curriculum phases and the curriculum as a whole, with particular emphasis on the internal coherence. It includes two aspects: the quality of performance of the staff: lectures, materials, timetable, etc. and the quality of students: what they have learned in the respective parts of the curriculum. To assess whether the educational goals established by the faculty in its educational policy (see 2.3.2.1) are being achieved, regular evaluations among students, recent graduates, employers and teaching staff are necessary. Furthermore, information concerning student progress on the various levels must be available.

The person or committee responsible for the education ensures that these evaluations are carried out in the light of faculty policy and that the results of the evaluation play a role, e.g., in possible modifications in the corresponding part of the curriculum or in an improvement in the skills of staff, when necessary.

2.3.2.4 Information and Communication

The person or committee responsible for education must ensure that all those involved in the education are acquainted with the educational policy of the faculty. In order to keep all teaching staff engaged in the education, all relevant information must be disseminated among them. Regular meetings of staff must guarantee a curriculum that is coherent in terms of content, a curriculum in which there are no excessive problems as regards the connections between the various courses (and with secondary education) and where no other avoidable impediments to the progress of students exist. Regular contacts between staff and students aimed at identifying and eliminating problems with the organisation and understanding of teaching should be institutionally encouraged.

Finally, but equally importantly, it is the purpose of good communication to stimulate the commitment of all staff and students concerned in such a way that an atmosphere of enthusiasm and inspiration exists for both staff and students. This, in turn, results in surplus value for the efforts of the entire community within the faculty.

3 IMPLEMENTATION OF THE MINIMUM REQUIREMENTS

Implementation of the minimum criteria can be achieved in a number of ways. In this chapter we discuss some of the criteria in more detail, providing the reasoning that led us to these criteria more fully and discussing ways in which they might be implemented.

3.1 Formulating Aims and Objectives

The starting point for the formulation of aims and objectives should be the qualifications one wants to equip graduates with (see 2.2). Since a considerable portion of the Diploma graduates continue studying for a Ph.D. or for a doctorate in engineering, preparation for independent research, as required for preparing a doctoral thesis, should be part of the objective, if only to prevent the doctoral phase from taking excessively long. However, only a small number, even of those students who obtain a doctorate, will stay in academic life. Thus, to a large extent the desired qualifications should be determined by the requirements of occupations outside academic research.

The job market for physicists is a particularly broad one. For many positions occupied by physicists not only physicists are being sought; but for many of them applied mathematicians, computer scientists or specialised engineers are being considered as well, and such non-physicists are members of the teams in which the physicists will work. For such jobs, in various technical areas in industry, but also in banks and other financial institutions, in software development, in mathematical modelling of complex systems or in consulting, physicists are hired not primarily because of their knowledge of physics, but because of their ability to tackle complex problems in an efficient way and to apply methods learned in physics to problems originating outside physics. An increasing number of graduates also become self-employed in some of the areas listed above.

Since knowledge concerning the employment of physicists is often fragmentary, there is an urgent need for information in this area. This is true not only for information of a statistical nature, but also concerning the qualifications needed by graduates in their present occupation and the extent to which these qualifications were acquired in the course of their education. Such inquiries should be carried out by the individual physics departments in order to take into account local particularities. However, national and international comparisons are also useful, since they might give indications about possible employment opportunities missed by local graduates due to a lack of information on the part of students or employers, or due to the particular educational profile chosen by the local faculty.

The inventory of desirable qualifications thus obtained will certainly be too large and diverse to be covered by a coherent programme of reasonable length. Each faculty will thus have to make a selection, guided by the opportunities this will imply for graduates, as well as by the sort of programme that can be offered by staff or by guest lecturers. Such a choice may imply a positioning towards a more applied or a more fundamental educational profile, and it may place a greater emphasis either on providing a broad survey of physics and neighbouring fields or on a thorough mastering of experimental, theoretical and numerical methods. In addition to these “hard” qualifications, “soft” qualifications are also important. Among them are creativity, independence and the capacity for critical thinking, problem-solving abilities, the ability to work in teams which are often interdisciplinary, the ability to use libraries and other forms of information to master new fields by independent study as well as oral and written communication skills.

Finally, knowledge of economics and social sciences, to the extent that communication with the business side of a company or with customers is facilitated, will further not only a graduate's chances of employment, but also his or her future career opportunities in companies or as a self-employed consultant or entrepreneur. An awareness of the social and ethical issues connected with science and technology is also highly desirable. Again, the decision as to the amount of time spent on such subjects should be a part of the selection of educational objectives.

Taking into account the wishes and experience of physicists working in industry and of potential employers does not mean these wishes should be followed uncritically. Too heavy an emphasis on present applications might mean too little attention being paid to fields which include tomorrow's applications. Even the famous industrialist Werner von Siemens wanted science and the universities to be industry's scouts, not its servants, and managers are not necessarily more prescient than university professors. Also, the need for a coherent programme that keeps students interested needs to be considered in addition to the potential usefulness of the subjects treated. Many abilities that are useful to industry can be equally well, and sometimes better, developed by working on fundamental subjects in which university teachers are experts, as long as students also come into contact with applied subjects in other parts of their studies and become familiar with work outside the university.

It is also important to present physics not merely in the context of its practical usefulness, but also as a part of culture: it played and still plays an important role in a fascinating intellectual adventure, the quest of mankind to understand nature. Making this aspect of physics, and of science in general, better understood in society is an important task for the physics community, one that is necessary for ensuring the future of the field. Only if physics can attract enough bright students and sufficient support from society can the research effort be maintained which is vital for the development of the field and of the industrial economy that depends on its results, either directly or via engineering. To play their role in helping to promote understanding of and support for physics in society, physics graduates, especially those planning a career in teaching, should be able to appreciate the cultural role of physics and to communicate effectively about it with interested lay people.

3.2 Teaching and Learning Methods

The profile selected by the faculty will have consequences not only for the contents of the programme, but also for the blend of teaching methods chosen to implement it. In addition to attending ex-cathedra lectures, students need the opportunity to learn how to tackle problems using the methods employed in physics. The development of oral and written communication skills is vital not only in professional life but also in furthering the acceptance of physics by society at large. It requires an active involvement in physics, not just listening to lectures. To develop problem solving skills it may be advisable to confront students with problems that increase in complexity, from simple applications of material treated in lectures to projects that require a combination of knowledge and skills taught in different parts of the curriculum, supplemented by independent study. Of paramount importance in this connection is the diploma thesis, which should require independent work as well as reproducing and interpreting known scientific results. The discussion that follows may serve to put the choices in perspective; the committee hopes it might also stimulate thinking about possible innovations. A common feature is a shift of focus from what is taught by the faculty to what is learned by students.

The evolution of physics and of the professional demands on graduates present new challenges to traditional educational methods. The explosive increase in our knowledge makes exhaustive coverage by ex-cathedra lectures illusory. Moreover, many advances in our knowledge and in its use by society are interdisciplinary in nature and do not respect the logical segmentation of our courses. Also, both the speed in the increase of knowledge and the variety of professional requirements that graduates will encounter require not only a solid foundation in basic physics, but also good training in “life-long learning". Finally, lack of motivation on the part of many first-year students may be a factor in the large dropout rate, which is detrimental both to students and to the public image of the university. More active involvement of the students might lead to better motivation.

A relatively easy way to face these challenges is to train students to make extended use of textbooks and review papers in order to study subjects beyond what can be covered in the lectures. Some ex-cathedra lectures might then be limited to explaining particularly important or difficult parts of the material; the rest is to be assimilated from the literature. It should be noted that the use of information in English also constitutes important training in language skills.

A slightly less conventional approach is the organisation of "integrated exercises". Such exercises require the use of information from various ex-cathedra lectures or other courses. This interesting approach illustrates the unity of physics; it also prepares students to search for information among the material they assimilated in various lectures and combine them for the solution of problems.

A novel method which seems to be applied with some success but has been little tried out in the institutions visited is so-called "Problem Oriented Learning" (see http://www.unimaas.nl/pbl/link.htm). Going beyond the "integrated exercises" mentioned above, this method leaves more initiative to the students. It presents them with problems, preferably taken from "real life", and provides them only with some basic information they can use in order to find the information they need. Under guidance of a senior physicist, the students are left to themselves to find an approach which is not unique and which will be the personal creation of the group. This method seems to be excellent for developing creativity and also succeeds in motivating a considerable proportion of those students who would have dropped out in the more traditional approaches.

3.3 Mathematics

Since in physics nature is described using mathematical models, a physicist must be familiar with the fields of mathematics used in these descriptions. These include analysis, linear algebra, ordinary and partial differential equations and the theory of probability, as well as elements of tensor calculus and group theory. Thus, courses in mathematics must be included in the first part of any physics curriculum. Traditionally, in the first years physics students used to attend courses that were also taken by future mathematicians. This had the advantage that physicists had a solid knowledge of mathematical concepts and techniques. However, the standard of rigour necessary for mathematicians implies that a considerable amount of time is required to reach the computational techniques needed in the physics courses, especially in the more theoretical ones. This in turn meant that the first year would hardly include any physics courses and thus became very unrepresentative of the course of study as a whole. Students were not able to form a clear impression of what would come in later years and did not have a sufficient basis for deciding whether they were right in choosing physics. Also, students not interested in mathematics for its own sake were not highly motivated by such a programme.

In principle there are two strategies to avoid these problems. The first one is to offer courses specifically designed for physics students in which less emphasis is placed on rigour and where the results and computational techniques needed for physics are mastered early. The second one is to keep some of the mathematics courses attended jointly with mathematics students, in order to familiarise students with rigorous mathematics, and supplement them with courses of the type “Mathematical Methods in Physics”, in which parts of mathematics not treated in the strictly mathematical courses are presented in a less rigorous way and, moreover, introduced by treating examples from physics. An additional advantage of such a course is that the difficulties many students experience in applying the material learned in mathematics courses to physical problems are mitigated. This may be a good solution, provided the physical examples contain real physics and are not merely used as a pretext to introduce mathematical concepts. In this strategy, the common programme for mathematicians and physicists should be designed in close co-operation between physics and mathematics study boards to ensure that it is interesting to both physics and mathematics students, and that computational techniques are taught in addition to concepts and rigorous proofs.

Which solution should be chosen depends on the educational profile of the physics faculty. A knowledge of mathematics extending beyond the minimum required for understanding physics is not only useful for some areas of specialisation in fundamental physics, especially theoretical ones, but also for many applied fields, such as the modelling of complex systems or software development, in which physics graduates would then have an advantage over specialised engineers because of their more thorough mathematical knowledge and their ability to apply, and even design, methods more sophisticated than those widely used in engineering. Such areas of employment, however, almost invariably involve numerical as well as analytical work. Thus, a good preparation for them requires that the programme include numerical mathematics and computational physics, at least as electives, and sufficient training in solving problems numerically.

The choice of strategy will also depend on the personal resources and the educational profile of the local mathematics faculty; when there is a heavy emphasis on applied mathematics, a common first-year programme may be easier to arrange than with a faculty where there is more emphasis on pure mathematics and highly formal approaches.

If a faculty opts for a more technical profile, the additional technical subjects will probably only leave time to include a few courses in rigorous mathematics that go beyond teaching standard methods. Another consequence is that it becomes difficult to prepare students adequately for thesis work in more abstract sub-fields of theoretical physics, though this may be mitigated by leaving room for electives that mathematically gifted and interested students can use to acquire the required background without loss of time.

3.4 Other Sciences and Non-Technical Fields

Non-physics subjects other than mathematics typically occur in two places in a programme. In the first stage, a few hours are often reserved for non-physics subjects which are either obligatory or are to be chosen from a few alternatives. Their objective is either to broaden the education or to provide background for later obligatory courses, e.g., chemistry as part of the preparation for solid state physics or materials science. As a preparation for professional life it is also important that students come into contact with economics and law as well as with ethical issues related to their future professional activity.

In the last section of the studies there are often electives that can be or have to be taken from outside physics. Such choices are particularly useful as a preparation for an interdisciplinary thesis project or for specific career plans. Tasks in industry or in other sectors of the economy will often require graduates to work in interdisciplinary teams, typically in large companies, or to solve problems from fields other than physics, especially in small companies or when self-employed. As a preparation it is certainly useful to have been exposed to the problems, the methods and the ways of thinking of other sciences. This benefit is of course greatest when these courses are taught by lecturers who are themselves active researchers in the sciences concerned.

One of the obstacles when trying to include other disciplines in the physics curriculum, or physics courses in the curriculum of other fields, has to do with dysfunctional allocation schemes for personal and financial resources. Systems used in many universities penalise faculties who import teaching from other fields by reducing the number of positions and the amount of funds provided. Thus, a conflict is created between what may be best for the students: namely a broad curriculum taught by the most qualified teachers available, and what is best for the faculty in the short term: to maintain budget and positions by maximising the number of courses taught by one’s own faculty. Also, faculties should see to it that the quality assurance system implemented extends to imported teaching as well, so that the providing faculties have incentives to assign good teachers to these service courses and that the teachers themselves are stimulated to provide good courses.

In a good climate of co-operation between faculties, or parts of larger faculties, the problems noted above are certainly soluble, but it is up to the governing bodies on the central university level to see to it that dysfunctional incentives are removed and co-operation for the benefit of the quality of education is encouraged.

3.5 Recording Teaching Activities

As regards research performance, evaluation procedures exist in various institutions. Virtually every staff member keeps a list of research publications. The journals in which they are published give an indication of the quality of the research, as do bibliographic data such as citation analyses. Of course such data cannot be used uncritically, and in particular they cannot replace peer review when a thorough analysis is called for.

Teaching activities can also be recorded. The teaching curriculum vitae may consist of a list of teaching tasks performed, indicating the subject, the number and level of students, the width and depth of the subject, teaching methods, course material, but also teacher training courses taken, etc. Such a list is, in principle, easily standardised. The teaching curriculum vitae may also contain sections of a more theoretical nature: the reason why the course is taught the way it is taught, use of innovative teaching methods, of new media, etc. Such sections stimulate reflection and discussion and thus help to promote the necessary professional attitude towards teaching, which goes beyond the automatic application and mere optimisation of ex-cathedra presentation. All this can be recorded by the staff member himself or herself; it will be advantageous to do so under the supervision of an experienced teacher.

It is more difficult, but certainly not impossible, to include formal statements about the quality of the teaching. To make this possible, the institutions should have developed a system of evaluation of teaching in which the quality of the teaching of the individual can be clearly discerned. If statements of this kind are to be included in a teaching record, the system should allow the staff member access to the data on which they are based and the opportunity to have his or her views considered by the person or committee that issues the formal statement.

Systems for assessing the quality of teaching are as yet much less well developed than those for research, though there is some experience with assessing teaching ability in the context of “Habilitation” or promotion procedures. The results of questionnaires filled out by students can give some indications, but they can certainly not be used uncritically; at the very least they have to be supplemented by in-depth interviews of students and observation of the teaching by experienced teachers. It is to be expected that systems for assessing teaching performance will be developed and tested in the coming years. It is not yet clear whether the problems inherent in such procedures will be solved. If and when a reliable system has been developed, its results can be included in the teaching record.

The above arguments can also be reversed: the necessity or possibility of establishing a teaching record, similar to a research record, stimulates universities to educate junior staff in their teaching more explicitly than is the case now. In this sense such a procedure can be part of the human resource management of a university. The procedure contributes to the development of the necessary double qualification of academic staff members, in teaching and in research, and, as a consequence, to the quality of teaching. Finally, it will lead to a more equal weight being given to teaching and research in hiring and promotion procedures in those places where research performance is now, explicitly or implicitly, treated as more important. Also, the international mobility of teachers will be furthered by the development of standards for teaching records.

3.6 International Contacts

Students and scholars of science have been travelling to different countries for centuries to meet colleagues and discuss common problems. These meetings have generally been very fruitful and helped to develop the various disciplines. They have also been essential for consistency checks on scientific results and have prevented unnecessary overlaps. For students the opportunity to spend time in a foreign country can provide invaluable experience, both personally and scholastically.

For these reasons it is not surprising that the European Commission for instance has found it important to financially support and promote international exchanges of students and teachers between universities and schools of other kinds. The Commission has set ambitious aims with regard to the proportion of students who should have an experience of this sort. For those who nevertheless decide not to go, the fact that one can meet foreign students at one's own university compensates to a certain extent for the lack of travel experience.

Furthermore, universities should feel obliged to facilitate travel to other countries for their own students as well as visits by foreign students. With shorter stays – about four months could be considered as a minimum for fruitful exchanges – it would be difficult to demand knowledge of the local language, especially in smaller countries. Thus, as English is otherwise becoming the lingua franca of scientific exchange, especially in physics, it would be very useful to offer courses and supervision of project work in that language, at least in the later years. As knowledge of scientific terms in one's own language is also necessary, courses during the first years should be in the local language. An alternative to courses in English could be more personal tutoring of foreign students, as well as reference to textbooks in English. For the universities it is also essential that they provide help with student accommodation as well as with many other practical details.

One sometimes hears that time spent abroad lengthens the time necessary to obtain a degree for students following a normal course of studies. This need not be true if the planning is done carefully, with close contacts established to fellow co-ordinators in foreign universities. If the other university offers courses which are not available at home, one might hope for a degree of flexibility, so that changes in the course plan could be made, thus reducing the delay. For elective courses in particular it might be of great interest to find a different menu in a different university.

In summary, for young persons the benefit of spending part of their studies in a foreign country could be enormous, not only for their time at university but also for the future, where contacts established abroad may be very important. The universities have a great responsibility to promote such exchanges and thus to contribute to healthy internationalisation.

PART II

GENERAL FINDINGS

1 ORGANISATIONAL STRUCTURE

In all faculties visited, the organisational structure would seem to be adequate for the organisation and implementation of the course programme. Apart from Twente, most organisational work is done within one or more committees, the dean and the faculty council being ultimately responsible. In most cases the chairpersons of these committees have a particular task in educational matters within the faculty. Student input is guaranteed since students are members of the important committees. Most actions are undertaken by consensus. They are often prepared, advised upon and implemented by the same people; at least, there is often no clear distinction between preparation of proposals, advisory actions and implementation. For some larger special projects ad hoc (sub)committees are set up. To a variable extent the central university level has certain rights to approve or not approve actions to be taken on the faculty level.

The visiting committee did not receive any indications from the faculties that the organisational structures set up are not considered appropriate.

In Twente a different organisational structure has been put in place, in the sense that a director of education instead of a committee has been entrusted with the task of and the responsibility for proposing, preparing and implementing actions and measures that have to do with (the quality of) the education, under the overall responsibility of the dean. This structure was introduced with the 1998 law for the restructuring of the university governmental structure (MUB) in which persons instead of committees have the responsibility and the authority to decide and implement actions and measures. This is the case with research institutes as well as with institutes of education that were founded within the faculties. Thus in Twente there exists the INO, the “Institute for Physics Education”.

It is interesting to note that in the other faculties as well, signs of a structure of this kind are becoming visible. Thus in Ghent, both in the relatively large Faculty of Science and in the Faculty of Applied Sciences a director of education operates within a so-called Quality Centre. The task of this centre, and therefore of the director, is to supervise and to support. He supervises for example the quality of the study programme, of the available infrastructure and of the teaching methods applied. He provides support on various managerial and logistical aspects of education within the faculty, and thus also to the Department of Physics, where an important body is the study programme committee (OC-TN). The structure is still under development.

In Duisburg the organisational structure may change as well. In the future a larger Faculty of Science may be formed, with one dean. In this faculty there will be an Institute for Physics. This institute will have two deputy deans, one of whom is responsible for study matters.

In Hanover, a new state law on higher education plus initiatives by the central administration may change the organisational framework. In this context the establishment of a new function, a deputy dean for educational matters, is currently under discussion. Further details are not yet clear.

Generally speaking, we are thus seeing a shift in the way educational matters are handled, from committees towards an individual being ultimately responsible. In such a structure it may become clearer who can and must take initiatives. More professionalism may develop in the organisation of education and in instructional matters, and more innovative initiatives may be taken, provided one can appoint the right person, someone with the requisite competence and authority, for a sufficiently long period of time. As long as the person in charge solicits the opinions of all those involved and weighs them carefully, the tradition of decision by consensus can be preserved in a structure of this kind; it may even function more efficiently.

2 AIMS AND OBJECTIVES

In positioning themselves, the faculties visited made different choices from the spectrum of possible objectives and in the weight given to them. As stressed before, such differences are legitimate and even desirable, as long as all students are provided with representative examples of both fundamental and applied aspects of physics. In Ghent, and as of this year also in Hanover, programmes with different emphases are being offered at the same university. Twente has made an explicit choice in favour of stressing engineering aspects and preparation for outside professional life, whereas Duisburg has developed a fundamental physics programme in which applied aspects are also strongly represented.

The aims and objectives of the five faculties are all clearly stated and realistic. A general point of concern is that, except in Ghent, the actual period of study is considerably longer than the nominal one. Except for Twente, a lack of explicit preparation for professional life other than academic research was noted.

3 PROGRAMME

The aims common to the programmes of all the institutions visited was to educate physics students so that they are familiar with the basic subjects and methods of their science and train them to apply these methods to the ever-changing challenges they will meet in their professional life. The objective of developing sensitivity to social responsibility is also pursued at most places, though not always very explicitly.

The methods applied to achieve these aims range from classical lecture-based teaching to developing problem-solving skills, e.g., in the preparation of the Master's thesis. The number of lecture-linked or more general exercises requiring more or less personal involvement from the students as well as the amount of laboratory work varies from institution to institution. We shall present a comparative picture at a later stage, but in the discussion of each institution we shall refer to these criteria. We shall also mention, wherever appropriate, educational efforts aimed at developing better motivation and changing the passive, receptive attitude of most incoming students into a dynamic, more creative one.

3.1 Structure

Of the five faculties participating in the Cross Border assessment, two offer a programme in applied physics: Twente and the Faculty of Applied Sciences in Ghent. The latter offers a second cycle programme building on a first cycle common to all engineering students. The physics programme in Ghent is the only four-year programme, and many of the problems identified in the report are related to this short time. In general, the committee recommends a five-year programme, not only to cover all the necessary fields in physics, but also to allow more time for electives outside physics, as for instance in the other basic sciences and in non-technical subjects such as economics, social sciences or law. A uniform adoption of five-year programmes would also facilitate the international mobility of graduates.

3.2 Contents and Methods

The programmes in Ghent and Hanover are very broad and cover a wide range of topics, whereas Twente and Duisburg made a deliberate choice to concentrate on a small number of research fields, motivated in part by the size of their faculties. In general the variety of the field is sufficiently covered; in some cases it might even be helpful to sacrifice some breadth for the sake of more depth.

The programmes provide ample opportunities to choose between electives or minors, albeit in the case of Twente rather late in the programme. Especially in Ghent, a better connection of the laboratory courses to later professional life would be desirable.

With the exception of Twente, the predominant teaching methods are the well tried and tested traditional ones, mostly combining ex-cathedra lectures with exercises and laboratory courses. Except for Twente, demonstration experiments play a central role in the introductory lectures in experimental physics. The Faculty of Applied Physics at the University of Twente places strong emphasis on projects and practical work at the expense of traditionally organised courses. More inclusion of practical work is also recommended for the other faculties. Other very commendable aspects are the obligatory seminars in Duisburg and Hanover, where the students are trained extensively in oral and written communication skills. The laboratory courses are all very appropriate and well co-ordinated with the lectures.

Elements of problem oriented learning, as described in Part I, sec. 3.2, are present in the projects assigned to students in various stages of their studies in Twente, in various seminars, especially in Duisburg, as well as in some individual courses in Ghent. We refer to the faculty reports for further details.

3.2.1 Mathematics / Other Basic Sciences

Of the programmes assessed, Hanover has a large part of the mathematics programme common to future mathematicians and physicists; in the Ghent physics programme the entire first year is common to mathematics and physics students. Ghent Applied Sciences and Twente have specially designed courses for technical physics students. In Twente these courses later turned out to be suitable for mathematics students as well. The Ghent programme leaves the students more room to specialise in a more theoretical or mathematical direction, and in fact many of them do. This difference may be due to the fact that the student population is different: most Twente students explicitly choose applied rather than fundamental physics, whereas many Ghent students opt for engineering rather than physics because of its higher prestige. The Duisburg programme mixes both approaches; the courses are designed especially for physics students, but contain a good deal of abstract material.

Whereas in Ghent and Twente not many complaints were heard about the mathematics part of the curriculum, it appears to be a major problem area in Duisburg and Hanover. The committee was not able to pinpoint all the reasons. The closer contact between students and teachers or tutors in Ghent and Twente certainly plays a role, and perhaps differences in high school preparation as well. However, the climate for co-ordination between mathematics and physics departments also appeared better than in the German universities; a definitive judgement cannot be given, however, since the time frame of our visits did not allow us to obtain the views of mathematicians as well as of physicists.

Other basic sciences occur as minors or as electives. For further details we refer to the faculty reports.

3.2.2 Non-Technical Subjects

Within the three physics programmes, almost no attention is paid to non-technical subjects. In Duisburg, Hanover and Ghent, such courses can be taken as electives or minors, but the faculties do not really encourage their students to do so. Due also to an apparent lack of time, very few students, if any at all, take this opportunity. A noteworthy exception is the subprogramme "Physics of Traffic and Transport" in Duisburg, which stresses relevance to society: students are stimulated to view physics in a broader social context.

The two programmes in applied physics in Ghent and Twente are praiseworthy in this respect. The University of Twente in particular is undertaking considerable efforts to educate students in social sciences, philosophy, law or economics to prepare them adequately for a professional life outside the academic world. Also, the Faculty of Applied Sciences in Ghent has included mandatory courses in economics as well as in "Technology and Environment" in its curriculum.

The committee recommends to all the faculties the inclusion of non-technical courses in their programmes, as not only engineers need to have some knowledge of non-technical fields for their later professional life. The majority of graduates in all faculties assessed will work outside academic research, and the committee has the feeling that most of them are not optimally prepared.

3.2.3 Computer Skills

The teaching of computer skills is more than adequate in Duisburg and Twente, where extensive courses are given and computer exercises form an important part of the curriculum. The same cannot be said about the faculties in Ghent and Hanover. The Faculty of Physics in Hanover offers no courses in basic computer skills at all and opportunities to attend courses outside the faculty are limited. In Ghent, the situation is currently improving, since programming courses for MAPLE and Java for instance have recently been introduced. The committee considers the use of computers an important part of any physics curriculum and recommends that the faculties make clear which basic computer skills are required for the subsequent programme and ensure the availability of appropriate courses. The time needed to follow them should be taken into account in determining the study load.

3.3 Theses

In all of the programmes assessed, the thesis, which is written during the last year, is an essential part of the education offered. It requires the students to combine knowledge and skills acquired in earlier parts of their studies. It also develops and tests their capability to face and solve a complicated problem, a capability they will need in professional life, either in research or in other fields of employment (see sec. I.2.1.2). In most subjects the thesis is also a welcome initiation to teamwork. The thesis project consists of an introductory phase, in which the student has to understand the problem posed and the "state of the art", i.e., the progress made thus far towards solving it, and a research part, in which independent and novel contributions are expected. The written thesis should report on both phases. In Ghent much emphasis is laid on a clear exposition of the state of the art, often involving an extensive literature search. The other faculties place more emphasis on novel contributions by the students. In Duisburg and Hanover, the thesis has to be completed within twelve months, in Twente within nine, and in Ghent four months are assigned to it. Four months appear to be a very short time for a thesis, and the time actually taken in Ghent is considerably longer. Nevertheless, the committee was impressed by the high standard of the theses in Ghent as well as in the other faculties.

TABLE 1: HOURS PROGRAMMED FOR THE THESIS

FACULTY	U. Duisburg	U. Ghent Physics	U. Ghent Eng. Phys.	U. Hanover	U. Twente
Programmed hours for thesis	2000	600	600	2000	1440

3.4 Examinations

In all faculties except Twente, examinations, mostly oral, are set at the end of the programme phases. In Ghent, oral and written examinations are set at the end of every semester, whereas in Twente they are tied to individual courses, mostly in written form. Duisburg and Hanover set an intermediate examination after the fourth semester, the so-called "Vordiplom". The committee recommends regular examinations or tests to monitor students´ progress, preferably also very early in the programme, so that the students can decide whether they are sufficiently suited to the subject. Also, oral examinations are a good means of getting feedback from students. The emphasis on reproductive learning noted in the physics programme at Ghent University, as reflected in the examinations for several courses, is a point of concern. One praiseworthy effort towards reducing the length of studies is the introduction of a so-called "Freiversuch" in Hanover and Duisburg, namely giving students the option of sitting parts of comprehensive examinations one semester early without this having any effect should they fail.

The overall level of the examinations was very high. In the German universities, especially in the second stage, grade inflation occurs; i.e., the distribution of grades is unduly slanted towards higher grades. This is a problem which will need to be solved at a national level.

3.5 Study Load

With the possible exception of Ghent, the study load appears to be very high, an important reason for the discrepancy between actual and nominal duration of study in Twente, Hanover and Duisburg. Very little time is left for activities not included in the programme. The committee realises that no definitive solution for this problem is in sight, but notes with approval that all the faculties are aware of this problem and at least try to address it.

TABLE 2: TOTAL STUDY LOAD

	Lectures	Exercises	Laboratory courses	Total contact hours	Industrial training	Thesis	Total estimated hours (incl. individual study)
U. Duisburg	933,5	639	313,5	1886	0	2000	8815,5
U. Ghent, Physics	1097,5	642,5	365 1)	2105 2)	0	600	6505
U. Ghent, Eng. Physics	650	550	327,5 1)	1527,5 2)	0	600	5000 3)
U. Hanover	1125	315	360	1800	0	2000	8000
U. Twente	790	400	400	1590	560	1440	7870

1) Including 200 hours for the thesis
2) Plus optional courses
3) Second cycle only

Note that in this and the following tables, 45-minute lecture-units are translated into total 60 minute-hours.

TABLE 3: CONTACT HOURS SPENT ON DIFFERENT SUBJECTS [1)]

FACULTY	U. Duisburg	U. Ghent Physics	U. Ghent Eng. Phys.	U. Hanover	U. Twente
Experimental Physics	697	555	n.n.a.	607,5	795
Theoretical Physics	447	337,5	n.n.a.	382,5	142
Mathematics	274	375	52,5	202,5	289
Further obligatory subjects	0	277,5	n.n.a.	247,5	71
Electives (physics)	324	560[3)]	ca. 225	180[4)]	125
Electives (non-physics)	144	0	ca. 200	0	75
Electives (free)	222[2)]	0	0	180[5)]	93
Total Absolute Numbers	**1886**	**2105**	**1527,5**	**1800**	**1590**

1) Total contact hours: lectures, exercises, seminars, laboratory courses, projects. Hours programmed for industrial training and thesis activity are not included.

2) Not obligatory

3) Some electives (phys.) can be substituted for electives (non-phys.) for the teacher-training programme.

4) Special Subjects (Vertiefungsfach) of semesters 7 and 8; they are physics and applied physics subjects.

5) Elective Subjects (Wahlpflichtfach) of semesters 3, 4, 7 and 8. They are free within broad limits; they can be taken from applied physics, mathematics, other natural sciences and non-technical sciences as economy, law and social sciences.

n.n.a.: numbers not available

3.6 Overall Assessment

The programmes assessed all amply fulfil the minimum requirements; scope and level of courses and examinations reach European standards. In particular the level of the theses sampled was impressive.

The faculties visited all take their responsibility for education seriously. Except in Twente, students were on the whole satisfied with the quality of the teaching; in the case of Twente it was not clear whether a less satisfactory performance by the faculty or a higher level of expectations by the students compared to the other places visited was responsible.

All programmes provide a well-balanced mix of compulsory and elective courses with a broad choice of electives from various areas of physics; in view of the broad range of future fields of employment, this is a necessary feature of physics education programmes in the committee’s view.

The variety of teaching methods is satisfactory. Examples of innovative teaching were found in all departments visited, though apart from Twente traditional methods predominate. Although attention is paid to developing problem-solving abilities in all the programmes assessed, a more systematic approach, which assigns problems that require increasingly independent work on the part of students as the course of study progresses, is recommended. Also, more attention could be given to practising team work.

The integration of mathematics into the curriculum is not satisfactory in Duisburg and Hanover; in Hanover the teaching of basic computer skills is unsatisfactory.

All programmes assessed pay attention to the development of oral and written communication skills, though the means employed differ from place to place.

With the exception of Twente and to a lesser extent the Ghent engineering programme and the “Physics of Transport and Traffic” sub-programme in Duisburg, courses in social and economic sciences are not part of the obligatory curriculum, and no particular effort is being made to recommend them as free electives.

Apart from Twente, preparation for professional life outside academic research is insufficient, though to differing degrees. More efforts to bring students into contact with graduates working in various fields and with potential employers are recommended.

4 STAFF

To obtain information about the academic staff, the committee conducted separate discussions with the various groups, professors, non-professorial staff and with students. It has looked at the size of the staff, the scientific qualifications, the range of specialisation, problems of ageing and other circumstances relevant to teaching.

In all the departments assessed, the academic staff is well qualified and large enough to cover the entire range of the curriculum (Table 4). In Duisburg, however, difficulties may occur in connection with the announced staff reduction as a result of the "Qualitätspakt". The range of specialisations is diverse enough in all cases.

In Duisburg and Hanover the teaching assignments are regularly rotated, a fact which was noted with approval by the committee. The introduction of similar flexibility in Ghent and Twente might help to keep course content up to date and stimulate teaching innovations.

The overall lack or scarcity of women in senior academic positions is a problem common to all institutions visited. The faculties are clearly aware of it.
A point of concern in all departments apart from Twente is the rather bleak situation of junior staff members, especially those who wish to qualify for a university career. Usually they have limited time contracts and large teaching loads with little responsibility or independence. They have practically no promotion opportunities in their own faculties. For more specific information about the staff structure we refer to Appendix 1.

The preference shown in Ghent for members of local staff in promotions to higher level professorships can endanger the quality and diversity of the staff. However, the committee notes with approval that the proportion of local graduates among Ghent professors is decreasing.

As university budgets have shrunk, faculties have become more dependent on external sources of funds, e.g., for financing Ph.D. students and postdoctoral fellows. Senior researchers, and even junior staff preparing for applications for a faculty position elsewhere, have to spend a considerable amount of time on fund raising activities. This work has to be performed in addition to normal research and teaching duties; the committee had the impression that this fact is not given sufficient weight in determining the duties of the various categories of staff members.

Educational training courses are offered for staff members in Ghent and Twente. Formal records of teaching achievements of staff members do not exist in any of the institutions visited.

TABLE 4: ACADEMIC AND NON-ACADEMIC STAFF: NUMBER OF PERSONS AND FULL-TIME EQUIVALENTS 2000

FACULTY	NUMBER OF PERSONS AND FULL-TIME EQUIVALENTS (in brackets)						
	Full professors	Associate professors	Assistant professors	Research assistants	Others	Total academic staff	Non-academic staff
U. Duisburg	15 (15)	0	7 (7)	38 (28)	3 (0)	63 (50)	30 (27)
U. Ghent, Physics	10 (9,1)	8 (8)	26 (25,1)	16 (15)	21 (21)	81 (78,1)	n.n.a.
U. Ghent, Eng. Physics	13 (12,1)	12 (11,4)	23 (18,5)	30 (29,5)	0	78 (71,5)	77 (74,8)
U. Hanover	17 (17)	3 (3)	3 (3)	39 (32)	0	62 (55)	36 (34)
U. Twente	16 (11,1)	10 (9,7)	29 (28,7)	35 (34,1)	33 (27,9)	123 (111,5)	139 (82,6)

others: students/assistants or lecturers (industry) teaching part-time

n.n.a.: numbers not available

5. FACILITIES AND RESOURCES

The facilities and resources of all the departments are adequate and reasonably up to date. For more detailed information see the faculty reports. The most conspicuous point of criticism for all the departments has to do with the limited opening hours of their libraries.

6 STUDENTS

6.1 Attainment Level and Selection

In Ghent and Twente the faculties have been making commendable efforts to develop a data base of the skills, level and knowledge of the population of first-year students. These faculties consider the general level of education of first-year students to be quite good, whereas in Germany the level of physics and mathematics education in secondary schools is considered to be rather low. Duisburg and Hanover are attempting to compensate for this by offering pre-semester courses to all students. The committee views this as a commendable effort. A general problem is that the number of physics graduates is low at the moment all over Europe. One result is that too few physics teachers are being trained. In Flanders, the committee heard complaints that often physics in secondary schools is being taught by non-physics graduates. Similar problems were noted in Germany.

Except for the Civil Engineering in Physics programme in Ghent, where applicants must pass an entrance examination, no entrance selection takes place in the faculties assessed: every student is taken in. In Twente, selection mainly takes place during the first, propaedeutic year. Early examinations or tests could in general provide a method of selection and a means for students to find out whether they are suited for the study of physics.

6.2 Student Numbers

In general, the number of students enrolling in physics is low and has decreased markedly in the last ten years, i.e., since shortly before the period covered by Table 5. In the academic year 2000/01, however, a promising increase was noted in Germany and in the Civil Engineering in Physics programme in Ghent. The faculties are of the opinion that interest in science is waning in society generally. The faculties in Hanover, Twente and Duisburg are devoting considerable effort to advertising their programmes in secondary schools and during information days for secondary school students.

A general problem in Germany is the large number of so-called "Schein-" or "Parkstudenten", students enrolling in a programme without any intention of participating. These students are either waiting for acceptance in another programme with a numerus clausus or they just want to benefit from their student status, e.g., to obtain cheap public transport tickets ("Semesterticket"). It is therefore hard to estimate the real number of first-year students. This makes it difficult to obtain reliable data about dropout rates and study progress. Overcoming this problem is difficult due to privacy protection regulations. For a promising attempt we refer to the Hanover faculty report. The committee suggests identifying a monitor group of active students at the beginning of the first year and following their career. This is the practice, for somewhat different reasons, in Twente University.

The percentage of female students enrolling in physics is generally very low, an as yet unsolved problem with supposedly mainly cultural reasons. There is apparently still an acute lack of acceptance in society at large for women as physicists. Also, girls in secondary school and university students lack role models. In Duisburg and Hanover, efforts are being made to attract more women to the study of physics by offering summer schools for female secondary school students. In Duisburg, there was an increase in the number of female students in the last two years; it is to be hoped that this trend will continue. Twente offers special information days for female students. As yet these efforts have had no great success, however, and a solution to the problem is not in sight.

TABLE 5: STUDENT NUMBERS 1996-2000: FIRST-YEAR AND TOTAL

FACULTY	NUMBER OF FIRST-YEAR STUDENTS														
	TOTAL					FEMALE					FOREIGNERS				
	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
U. Duisburg	47	42	49	49	68	7	7	7	14	13	3	4	2	2	5
U. Ghent, Physics	45	35	37	34	29	17	13	14	11	10	0	0	0	0	0
U. Ghent, Eng. Physics	21	23	21	22	40	3	0	4	5	10	0	0	0	0	0
U. Hanover	75	80	104	83	78	27	17	29	22	27	3	5	2	2	13
U. Twente	98	101	67	81	59	6	8	6	11	7	12	8	10	16	11

FACULTY	TOTAL NUMBER OF STUDENTS														
	TOTAL					FEMALE					FOREIGNERS				
	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
U. Duisburg	284	285	263	246	260	39	42	39	35	38	14	17	19	14	20
U. Ghent, Physics	114	94	98	88	79	30	27	30	28	25	0	0	0	0	0
U. Ghent, Eng. Physics	65	66	69	63	90	6	5	6	9	19	0	0	0	0	0
U. Hanover	557	498	470	424	376	76	68	78	74	73	24	24	25	23	32
U. Twente	432	412	399	403	400	34	31	34	37	42	12	8	10	16	11

As first-year students, students enrolling for the first time are counted. The years refer to academic years, thus 1996 = 95/96. (Twente: 1996 = 96/97)

Foreign students are students of foreign nationality and a foreign qualification for admission to higher education.

6.3 Counselling

At all the faculties visited, the staff seemed to be very open to feedback and advice, but counselling is still very dependent on students´ own initiative, right from the beginning of the first year. A commendable effort is the tutoring system in place in Duisburg and for first-year students in Hanover. In Ghent, an "ombudsperson" has been appointed for general complaints; this seems to function well within the Faculty of Applied Sciences but considerably less so in the Faculty of Science, where only one "ombudsperson" has been appointed for the entire faculty, a person who is seemingly not very well known or accessible. In Twente, every student has a mentor, but the mentors do not approach the students of their own accord. An institutionalised tutoring system is generally recommended by the committee to monitor student progress on a more systematic basis. This is especially relevant for the first year of study. It is of paramount importance that problems in the transition from secondary school to university, either with course content or with adapting to unfamiliar forms of teaching and learning, be detected sufficiently early so that effective counter-measures can be taken.

6.4 Duration of Study and Completion Rates

With the noteworthy exception of Civil Engineering in Physics in Ghent, the average duration of study is considerably higher than the nominal one. Possible reasons are a very high study load which would leave little time for activities outside of the curriculum. In Germany, another major reason is the social situation of students. Most of them work part-time to cover at least part of their living expenses, as government funding and scholarships are very rare. A solution to the problem of the excessively long duration of study is not on the horizon, but the committee had the impression that in some cases solutions are not really being sought. Occasionally, students explicitly stated that they went through a phase of less motivation in second and later years, but before their thesis.

The committee wishes to emphasise that, whereas it is the responsibility of the universities to design curricula that can be finished within the nominal period of study by full-time students, the state should provide an adequate financing system.

TABLE 6: NOMINAL AND EFFECTIVE (AVERAGE) LENGTH OF STUDIES OF THE GRADUATES IN THE ACADEMIC YEAR 1999/2000

FACULTY	NOMINAL	EFFECTIVE	DISCREPANCY EFFECTIVE-NOMINAL
U. Duisburg	5,0	5,8	16%
U. Ghent, Physics	4,0	4,6	15%
U. Ghent, Eng. Physics	5,0	5,2	4%
U. Hanover	5,0	5,8	16%
U. Twente	5,0	6,0	20%

Another general problem is the high dropout rate in all of the participating faculties apart from the Civil Engineering in Physics programme in Ghent, where over 90% of students finish their studies. However, since this is only a second-cycle programme, it is difficult to compare it with the others. The committee has no data on the dropout rate in the faculty´s first cycle programme which is common to all engineers.

TABLE 7: DROP-OUT RATES AND GRADUATES IN THE 1999/2000 ACADEMIC YEAR (Completion percentages refer to the graduates in the academic year 1999/2000, drop-outs are first-year students of the previous year who did not register again.)

FACULTY	FIRST-YEAR STUDENTS	DROP-OUT AFTER ONE YEAR	COMPLETION IN NOMINAL TIME	COMPLETION WITHIN ONE MORE YEAR	COMPLETION IN LONGER TIME
U. Duisburg	49	13%	14%	41 %	45 %
U. Gent, Physics	34	50%	60%	36%	4%
U. Gent, Eng. Physics	21	n.n.a.	n.n.a.	n.n.a.	n.n.a.
U. Hannover	78	50%[1)]	15%[2)]	49%[2)]	36%[2)]
U. Twente	81	26%	8%	53%[3)]	39%[3)]

1) The quoted drop-out rate after 1 year actually contains predominantely those virtual students who never start their study.

2) Graduates for the 1998/99 academic year

3) Graduates of the former 4-year programme

n.n.a.: numbers not available

6.5 Graduates and Job Prospects

A major proportion of graduating students leave academic life and enter professional life in industry or other sectors of the economy. Columns 1, 3 and 4 in Table 8 show students leaving university after graduation. Column 2 includes students entering a doctoral programme, most of whom will also leave the university after obtaining their doctorate.

At present, job prospects for graduates in physics are generally very good and finding a job does not pose a problem. However, as experience shows, there will again be times in which the labour market for physicists is tight. To be better prepared for such times, much more emphasis should be put on preparation for professional life. While most of the programmes provide the option of choosing basic courses in economics, law and social sciences, most faculties do not encourage students to do so, with the result that such courses are poorly attended. Also, the co-ordination of such courses with the remaining programme often appears to be a problem. Further, students in general have little contact with possible employers during their studies. The situation could be improved by bringing students in contact with problems and projects originating in industry or other sectors of the economy. Such projects could also give students a better idea of the demands that may be made on them in their professional life.

While the specific training of students for professional life outside university is in general poor, it should be pointed out that several institutes in different faculties are on their way to improving the situation. Twente generally has very good contacts with industry and offers an obligatory course in communication skills to overcome students' deficiencies in this respect. One especially praiseworthy feature is an obligatory external traineeship. In Duisburg and Hanover as well as in the Ghent Faculty of Applied Sciences, various groups have close connections to industry that enable students to familiarise themselves with practical applications of physics.

To adjust the programmes to the requirements of industry and other sectors of the economy, regular evaluation among graduates, aimed at monitoring their success in professional life and looking for possible weaknesses of the programmes, should be institutionalised. Existing contacts to alumni should be used to implement this monitoring. Again, Twente has made the most progress in this direction, in part since it can use a national monitoring system for graduates. Evaluations by graduates were also part of the preparation of some self reports for the present assessment.

The committee strongly recommends that the faculties overcome the deficiencies mentioned above and take the changing demands of the labour market into account in the design of the curriculum. This might also increase the support of industry for the universities, both politically and financially.

TABLE 8: DESTINATIONS OF GRADUATES (PERCENTAGES)

FACULTY	INDUSTRY	UNIVERSITY/ RESEARCH	CIVIL SERVICE	OTHERS	TOTAL	PERIOD COVERED
U. Duisburg	45%	41%	14%	0	191	1993-1999
U. Ghent, Physics	41%	38%	10%	11%	73	1987-1997
U. Ghent, Eng. Physics	n.n.a.	n.n.a.	n.n.a.	n.n.a.	n.n.a.	n.n.a.
U. Hanover	34%	55%	9%	1%	91[1)]	1995-1999
U. Twente	38%	40%	6%	16%	110	1996-1998

1) During the evaluation process 240 graduates, whose addresses were known, out of a total of 306 during the calendar years 1995-1999 could be asked about their destination; 91 answered.

n.n.a.: numbers not available

7 EXTERNAL RELATIONS

7.1 Industry and Other Sectors of the Economy

Twente and several institutes in Duisburg, Hanover and Ghent Applied Sciences have close contacts with industry, but in other institutes and faculties much more should be done in this respect. In particular, some institutes in the Ghent Faculty of Science and in Hanover apparently see no need or opportunity to co-operate with institutions outside academic life in their research projects and curriculum design. A lack of co-operation with non-academic institutions is seen most often in theoretically oriented institutes, though Duisburg is a clear exception. Theoretical physics, and the methods developed in it, play an important role in many relevant fields of employment for graduates, so these institutes should also look for external collaborations. Students, regardless of their preference for experimental or theoretical physics, should have the opportunity for practical work outside the university and obtain academic credit for it. Guest lecturers from industry could also inform students about possible applications of their knowledge and skills. Close contact to alumni could be helpful in adjusting the programme to the requirements of professional life outside academic research.

7.2 International

In Ghent, Hanover and Twente, many students spend some time abroad, though in Twente this is primarily for their external traineeship. In Duisburg and Twente, studying at a foreign university is not really encouraged, as the faculties are of the opinion that it would always result in a serious loss of time. The examples of Ghent and Hanover show that this is merely a question of co-ordination, which is also in line with the experience of several of the peers. More effort towards alerting the students to the opportunity to study abroad are recommended.

Twente, Duisburg and Hanover provide very good support to students from abroad: courses are sometimes taught in English or bilingually to enable students who have not yet mastered the native language to participate.

In Ghent, the main problem lies in the very strict language laws of Flanders, where all the courses have to be taught in Dutch. The opportunities available to obtain assistance in English, especially in the second half of the curriculum and in initiation to research, should be better advertised.

8 INTERNAL QUALITY ASSESSMENT AND MANAGEMENT

In Ghent and Twente, a very good and effective system of quality assessment is institutionalised. In Twente, in the questionnaires somewhat more emphasis should be put on the quality and effectiveness of the efforts made by individual teachers. The system of response groups for courses is considered good practice by the committee (see the faculty report). In the German faculties visited, systematic quality assessment is almost non-existent, though efforts by individual teachers are relatively common. In Duisburg, a regular evaluation is to be installed with the upcoming restructuring of the university. The committee recommends a regular and systematic monitoring and assessment of teaching efforts and of the quality of the education. Its objective should be to identify factors that influence the effectiveness of teaching and learning and the motivation of students, The results should be used to adjust the programme and the teaching. The faculties should investigate the reasons for dropout and the views of graduates and potential employers on the weight to be given to the various objectives of a physics education and to the degree to which these objectives are achieved. A regular evaluation and a systematic recording of teaching activities of individual staff members could also be beneficial to the career prospects of junior staff (see also chapter 4 and Appendix 1).

PART III

FACULTY REPORTS

DEPARTMENT OF PHYSICS AT THE "GERHARD-MERCATOR-UNIVERSITÄT DUISBURG", DUISBURG, GERMANY
Date of Visit: 2/3 November 2000

1 ORGANISATIONAL STRUCTURE

The University of Duisburg was founded in 1972 as a comprehensive university ("Gesamthochschule"). In 1980 it was renamed “Universität-Gesamthochschule Duisburg" and in 1994 “Gerhard-Mercator-Universität-Gesamthochschule Duisburg“. It is divided into 10 faculties. The total number of students is about 14,300, of whom around 380 are enrolled in the Department of Physics.

The Department of Physics is one of ten departments of the university. It has a strong position in the University of Duisburg, especially in research. There is appreciable concern because of the low number of students. As of April 1, 2000, the department itself is responsible for the development of curricula, which, however, have to be approved by the rector.

The University of Duisburg is responsible for its own administration, while remaining legally under the control of the state and the Minister of Science in North Rhine Westphalia. Its central bodies are the rectorate ("Rektorat"), consisting of a rector ("Rektor/in"), pro-rectors ("Prorektor/in") and the chancellor ("Kanzler/in"); the council ("Konvent"), the senate ("Senat") and standing committees. Senate and council include representatives of the different status groups - professors, scientific associates, technical and administrative staff, and students - with a majority of professors. Each status group elects its representatives every other year, with the exception of the students, who are elected once a year. The rector is head of the university and its external representative. Along with the pro-rectors, he/she is elected by the council. A chancellor, who is elected by the senate, attends to day-to-day administrative and legal affairs. The pro-rectors are in charge of a) research, b) studies and c) planning and finance. The senate decides on all central university issues. The faculty deans participate in the meetings of the senate, but only as non-voting advisers.

The department is governed by the departmental council ("Fachbereichsrat"), consisting of nine professors, one of whom is elected dean of the department ("Dekan/in"), three students, two scientific assistants and one representative of the non-academic staff. The departmental council decides on all faculty issues, but it may delegate certain issues to dedicated committees.

The department is divided into five sub-units:

1. Theoretical Physics
2. Applied Physics
3. Low Temperature Physics
4. Solid State Physics
5. Didactics of Physics

The departmental council elects a committee for the diploma study programme (“Diplomprüfungsausschuss.”), consisting of four professors, one member of the non-professorial teaching staff and two students. It proposes changes to the study regulations and the curriculum (“Studienordnung”). It also decides on the recognition of academic credits that students have obtained at other universities, and on the placement of students who join the Duisburg study programme at an advanced stage. It nominates the two referees for each diploma thesis and ensures that the duration of the thesis project complies with the examination regulations. Two central university offices are of importance: the examination office (“Prüfungsamt”) makes sure that the examinations comply with the regulations; it registers the corresponding exams, collects the protocols and issues the graduation documents. The foreign students’ office decides on the admission of foreign students to the study programme, while their placement is decided by the committee for the diploma study programme.

Important, but more informal deliberations within the group of all the professors take place in the Chamber of Professors (“Professorenrunde”). It is the impression of the visiting committee that most decisions in the faculty are prepared in this “Professorenrunde”. Furthermore, this institution plays a major role in the co-ordination of the course contents.

The responsibilities for the infrastructure related to the study programme are assigned to the sub-units:

- computer laboratory and physics library to the sub-unit Theoretical Physics;
- collection of demonstration experiments and machine workshop to the Laboratory of Applied Physics;
- basic laboratory course to the Laboratory for Low Temperature Physics;
- advanced laboratory course to the Laboratory for Solid State Physics.

The university is on the verge of a major restructuring in which the number of faculties will be reduced to five. This is closely related to the so-called “Qualitätspakt” in North Rhine Westphalia and is the result of a legal obligation by the universities to reduce personnel. However, one needs to ensure that this does not affect the attractiveness of the university for students. The loss of teacher training programmes for example would be especially harmful in view of the role physics teachers can play in maintaining contacts between the university and the community.

The organisational structure may change as well. Within a larger Faculty of Science (with a single dean) there will be an Institute for Physics, which will probably have two deputy deans. One of these will be responsible for study matters. There is thus a shift from committees being responsible for study matters towards persons being ultimately responsible. The visiting committee considers this a good development, since there is more clarity as to who is responsible, who can and must take initiatives. Furthermore, more professionalism may develop in the organisational and teaching aspects of education.

2 AIMS AND OBJECTIVES

The aims of the Physics programme at the University of Duisburg are formulated as follows:

(1) *Broad and solid education in experimental and theoretical physics meeting national and international standards.*

(2) *High ranking, research oriented education.*

(3) *Continuous adjustment of the study programme to new knowledge in physics and to the demands of the job market for physicists.*

(4) *Competitive position within the international academic education market. (self-report, p. 2)*

The aims are clearly formulated and appropriate. They also appear to be realistic: the actual duration of studies is among the lowest in Germany.

3 PROGRAMME

3.1 Structure

As of the academic year 1999/2000, the faculty itself and not the university senate is responsible for the curriculum. Still, eventual modifications have to comply with the "Eckdatenverordnung" of North Rhine Westphalia and thus can be of limited scope only.

Formerly, two different programmes coexisted: D I and D II. D I was a university course focused on physics engineering and had a nominal length of 3.5 years. Although the graduates of this programme readily found employment in the region, their prospects in the rest of Germany were less good, since no comparable programme existed elsewhere. This programme is therefore being terminated.

The D II programme first offers a common basic stage of two years ("Grundstudium"), followed by an examination ("Vordiplom"). This is followed by a second stage of three years in which the student has to choose between two sub-programmes: "Physics" and "Physics of Transport and Traffic". In both sub-programmes quite a number of elective courses can be chosen.

The second stage of three years is devoted to extending the introduction to the fundamentals of physics to an introduction to the principal local research areas, to specialisation and finally, in the last year, to research work for a diploma thesis ("Diplomarbeit").

For incoming students who only have a polytechnic entrance qualification ("Fachhochschulreife"), special pre-semester courses are compulsory in physics, mathematics and English. These can be taken by regular students as well.

3.2 Contents and Methods

The first stage of study is devoted to the fundamentals of physics, mathematics and the use of computers. In the third and fourth semester a basic laboratory course, closely related to the experimental physics course, has to be attended. For every experiment in the laboratory course a report has to be written. The committee was satisfied with the co-ordination within this part of the programme and with the reports required. Though somewhat lengthy, they teach the students to express themselves in a clear and structured way.

The third year includes more advanced theoretical physics courses and in addition focuses on two research areas important in Duisburg, condensed matter physics and physics of complex systems. It includes courses on solid state physics, statistical physics and modern measurement methods. The fourth year is devoted to an advanced laboratory course, to electives and to seminars. This year prepares students for the thesis project in the fifth year. Students have to prepare a seminar talk and hand in a written account of it. These seminars require a rather extensive literature search in the library and/or on the internet. The committee considered this to be a very effective contribution to developing communication skills. They found, however, that teamwork was the exception rather than the rule, and recommend it be stimulated more. The experiments in the advanced laboratory course made a good impression.

A large number of textbooks, German as well as English, are recommended. The level of the exercises is high and meets the standards of the other physics departments assessed.

For some subjects there are written tests ("Klausur") and the contents of the lectures also form the subject of the final examination ("Diplomprüfung") in experimental and theoretical physics as well as in the field of specialisation ("Vertiefungsfach") and a non-physics minor (“Wahlfach”).

The peers noted the emphasis given to solid state physics ("Structure of Matter"), especially in the "Physics" sub-programme. 112.5 contact hours are devoted to this subject, about twice as much as in the other universities visited. A large range of electives is offered in solid state physics as well.

In the "Traffic and Transport" sub-programme, courses in modelling, simulations, logistics and traffic economics have to be taken. The students are brought into close contact to up-to-date problems, which has a positive effect on motivation.

Every student has to choose from a variety of minors. In general, chemistry, mathematics, electrical or mechanical engineering, or computer science are chosen. 360 hours of study are programmed for these compulsory minors and an additional 222 hours are programmed for free electives. There are no tests in these elective courses but their contents can be part of the final examination.

The teaching methods are somewhat traditional: ex-cathedra lectures, combined with exercises closely connected to the lectures. The seminars in the fourth year have, however, the specific objective of inducing creative individual work. This objective could be pursued more in the other years of the curriculum as well.

The programme is somewhat limited with respect to the electives that are offered; this is the consequence of a deliberate choice to concentrate on a limited number of research fields in which the faculty can produce internationally competitive research. The intended new chair in biophysics should improve the attractiveness of the programme in this respect as well. With this proviso, the programme is quite coherent and varied; there is, in particular, a strong effort to develop oral and written communication skills, and the seminar talks provide a good example of this. More incentive to be creative and take initiative would nevertheless be welcome, possibly in the form of more project work in the earlier stages of the programme.

Early contacts to research groups, which are already present to a considerable extent, should be promoted further. They typically provide strong motivation for students and allow them to place the material they encounter in the basic courses into a broader perspective.

TABLE 1: PROGRAMME (without a total of 222 programmed hours for free electives)

Semester 1 of Diploma Study Programme in Physics

No.	Course Unit	A	B	C	D
1	Experimental Physics I	48	24	0	180
2	Theoreticum I[1)]	24	24	0	120
3	Mathematics for Physic Students I	48	24	0	180
4	Mathematics for Physics Students IIa	24	12	0	90
5	Obligatory Minor (e.g. Chemistry)	48	24	0	180
6	**Sum**	**192**	**108**	**0**	**750**
7	**Sum total**	**1050**			

Semester 2 of Diploma Study Programme in Physics

No.	Course Unit	A	B	C	D
1	Experimental Physics II	42	21	0	160
2	Theoreticum II[1)]	21	21	0	105
3	Data Processing in Physics	21	21	0	105
4	Mathematics for Physics Students IIb	21	10,5	0	80
5	Mathematics for Physics Students III	42	21	0	160
6	**Sum**	**147**	**94,5**	**0**	**610**
7	**Sum total**	**851,5**			

Semester 3 of Diploma Study Programme in Physics

No.	Course Unit	A	B	C	D
1	Experimental Physics III	48	24	0	180
2	Basic Lab. Course I	0	24	48	180
3	Theoretical Physics I	48	24	12	210
4	Mathematics for Physicists IV	48	24	0	180
5	**Sum**	**144**	**96**	**60**	**750**
6	**Sum total**	**1050**			

Semester 4 of Diploma Study Programme in Physics

No.	Course Unit	A	B	C	D
1	Experimental Physics IV	42	21	0	160
2	Basic Lab. Course II	0	21	42	160
3	Theoretical Physics II	42	21	10,5	185
4	**Sum**	**84**	**63**	**52,5**	**505**
5	**Sum total**	**704,5**			

Sub-Programme "Physics"

Semester 5 of Diploma Study Programme in Physics

No.	Course Unit	A	B	C	D
1	Theoretical Physics III	48	24	12	210
2	Structure of Matter I	36	24	0	170
3	Measuring Techniques	24	36	0	130
4	Obligatory Minor	48	24	0	180
5	**Sum**	**156**	**108**	**12**	**690**
6	**Sum total**	**966**			

Semester 6 of Diploma Study Programme in Physics

No.	Course Unit	A	B	C	D
1	Theoretical Physics IV	42	21	10,5	185
2	Structure of Matter II	31,5	21	0	150
3	Computer Simulation	21	0	31,5	110
4	Special Course in Physics	21	21	0	110
5	**Sum**	**115,5**	**63**	**42**	**555**
6	**Sum total**	**775,5**			

Semester 7 of Diploma Study Programme in Physics

No.	Course Unit	A	B	C	D
1	Theoretical Physics V or Structure of Matter III	48	24	12	210
2	Advanced Lab. Course I	0	24	72	240
3	Special Course in Physics	24	24	0	126
4	Seminar	22	24	2	120
5	**Sum**	**94**	**96**	**86**	**696**
6	**Sum total**	**972**			

Semester 8 of Diploma Study Programme in Physics

No.	Course Unit	A	B	C	D
1	Advanced Lab. Course II	0	21	63	210
2	Special Course in Physics	21	21	0	110
3	**Sum**	**21**	**42**	**63**	**320**
4	**Sum total**	**446**			

Sub-Programme "Traffic and Transport"

Semester 5 of Diploma Study Programme in Physics of Traffic and Transport

No.	Course Unit	A	B	C	D
1	Structure of Matter I	36	24	0	170
2	Traffic Economics / Logistics	48	24	12	210
3	Discrete Math. / Optimisation	48	24	12	210
4	Obligatory Minor	48	24	12	210
5	**Sum**	**180**	**96**	**36**	**800**
6	**Sum total**	**1112**			

Semester 6 of Diploma Study Programme in Physics of Traffic and Transport

No.	Course Unit	A	B	C	D
1	Theoretical Physics III B	42	21	10,5	185
2	Computer Simulation	21	0	31,5	110
3	Modelling I	21	0	31,5	110
4	Logistics	42	21	0	160
5	**Sum**	**126**	**42**	**73,5**	**565**
6	**Sum total**	**808,5**			

Semester 7 of Diploma Study Programme in Physics of Traffic and Transport

No.	Course Unit	A	B	C	D
1	Theoretical Physics IV B	48	24	12	210
2	Modelling II	24	36	0	130
3	Adv. Laboratory Course	0	0	48	120
4	Special Courses in Physics	24	12	0	94,5
5	**Sum**	**96**	**72**	**60**	**554,5**
6	**Sum total**	**782,5**			

Semester 8 of Diploma Study Programme in Physics of Traffic and Transport

No.	Course Unit	A	B	C	D
1	Adv. Laboratory Course	0	0	42	105
2	Special Courses in Physics	42	42	0	220
3	Seminar	20	20	2	110
4	**Sum**	**62**	**62**	**44**	**435**
5	**Sum total**	**603**			

A: contact hours: lectures

B: contact hours: exercises

C: contact hours: other supervised study activity (laboratory courses)

D: hours of study time for personal assimilation of course material. (About 30% of D during the semester breaks)

1) Mathematical Methods in Physics

3.2.1 Mathematics / Other Basic Sciences

25 study points are reserved for mathematical subjects during the first three semesters. The courses are taught by mathematicians specifically for physics students and adapted - in principle - to their wishes and needs. Though the committee did not have the opportunity to talk with the mathematics professors in charge of these courses, complaints heard by the committee suggest that the quality of these service lectures should be improved. It is also hoped that the formation of a common faculty for mathematics, physics and chemistry may be helpful in finding a solution to this problem.

There is an obligatory non-physics minor in both stages ("Grundstudium" and "Hauptstudium") that can be chosen from science, engineering or, with the permission of the study board, from other fields. In the sub-programme Physics of Transport and Traffic, only parts of computer science can be taken without such permission.

3.2.2 Non-Technical Subjects

Non-technical courses, e.g., in social sciences or economics, are mainly covered by the free electives, but since these are not compulsory and are not necessarily relevant for the examination (unless they form a full minor), it was obvious that very few students take this option. Choosing one of the non-technical subjects as the obligatory minor can be a major organisational problem, since the programmes of the relevant faculties are not co-ordinated with the programme in physics. Although enough of these courses seem to be provided to meet the actual demand, the committee is of the opinion that students have to be shown the importance of these subjects for their professional life. More insight into the way an economist thinks for instance would be highly recommendable. A systematic survey amongst the alumni could show the importance of this objective. Compulsory examinations for the free electives would certainly increase the interest in these subjects, but are impossible due to the "Eckdatenverordnung". The faculties should look for other ways to encourage participation in such courses and to provide academic credit for them.

An exception in this respect is the sub-programme Physics of Traffic and Transport, which is exemplary in its inherent relevance to economics and every-day life. More tie-ins of this kind could probably be established in the Physics sub-programme as well.

3.2.3 Computer Skills

Attention towards computer skills is adequate, and basic courses in data processing and regular computer exercises are an important part of the curriculum. Computer problems are integrated into the theoretical physics courses. Also, every student gets an e-mail account and a connection to the Internet.

3.3 Theses

The thesis, to be written in the fifth year, has to be real research work and can be written in English as well as in German. The level of those examples which the committee was able to see was high, both with regard to scholarship, i.e., the description of what is known about the topic treated, and with regard to the originality of the work contained.

3.4 Examinations

The level of the examinations is generally very high. Grade inflation is a problem, especially in the "Hauptstudium", but this is not specific to Duisburg - it is general for the whole of Germany and Duisburg feels that as a small university it cannot take the lead in improving the situation. Both the intermediate and the final examinations consist of four different oral tests.

3.5 Study Load

The study load appears to be very high, especially in the first stage. Not much time is left for activities not included in the programme such as project work outside the university or free electives in non-technical faculties. Most of the semester breaks are devoted to individual study and preparing for written tests. A total of roughly 8,850 hours is estimated as the real time spent on studies in the programmed five years.

3.6 Overall Assessment

The programme offered by the Duisburg faculty is of very high quality; it offers a good survey of the various fields of physics and provides a good introduction to the various methods used in physics. The smaller range of electives, due to the small size of the faculty as well as the concentration on a few research fields in which the research effort can remain internationally competitive, is compensated for by the greater amount of personal attention students can obtain at a smaller university. The range of electives might be broadened by introducing an exchange of lecturers with smaller neighbouring universities that have complementary specialisations. In addition, the planned introduction of an additional research focus, e.g., in biophysics, will certainly lead to a more attractive programme, and the appointments needed for it should be made promptly.

The programme is well balanced between fundamental and applied topics; the special programme in Physics of Traffic and Transport, unique both nationally and internationally, is a good example of an education that combines a broad and solid introduction into a range of physical fields and methods with special attention to an interesting scientific field of considerable social relevance.

The variety of teaching methods offered is satisfactory, though traditional methods predominate. The integration of numerical exercises into the theory courses is exemplary. The attention given in the seminar to the level of written and oral expression, as well as to the training of students to carry out literature searches and searches of other sources of information is commendable; more encouragement of team work in this connection is recommended, however. The theses studied by members of the committee provided a balanced combination of independent research work and a “scholarly” report on the scientific state of the art. Somewhat more systematic attention to the development of problem solving skills in various earlier stages of the programme is recommended, however. An unusually large group of students is introduced early to the various research groups as student assistants ("studentische Hilfskräfte"). It would be advisable to introduce additional larger, quite openly formulated problems or small projects in which knowledge and skills from various courses should be combined; these could partly replace more conventional exercises.

The content of the mathematics programme appears to be well co-ordinated with the physics department, but some complaints were heard concerning the quality of teaching in these courses.

Courses in non-physics subjects can be taken as electives, but are not often chosen. In general too little systematic attention is paid to the preparation of students for later professional life outside the university. The good contacts which the various research groups have to graduates and potential employers could be used more effectively to provide information to students about possible future careers and about the knowledge and skills, inside of physics and outside, that could give them a starting advantage there.

A commendable special feature is the effort made to enable students starting in the summer semester to enter the programme with minimum loss of time.

In summary, in spite of considerable handicaps, Duisburg offers an attractive programme that would well deserve a professional and self-confident presentation to potential students, both from the immediate vicinity and from further afield.

4. STAFF

The faculty staff fall into four major categories:

* Full professors (C4)
* Full professors (C3)
* Private lecturers
* Research assistants

A typical academic career in Germany is described in Appendix 1.

TABLE 2: ACADEMIC AND NON-ACADEMIC STAFF

NUMBER OF PERSONS AND FULL-TIME EQUIVALENTS (in brackets)						
Full professors C4	Full professors C3	Private lecturers	Research assistants	Others	Total academic staff	Non-academic staff
15 (15)	0	7 (7)	38 (28)	3 (0)	63 (50)	30 (27)

others: students/assistants or lecturers (industry) teaching part-time

The staff in general is somewhat on the small side, which is also reflected in the curriculum. Within these constraints, however, the staff is able to cover all the programmed areas. The size of the staff is also going to decrease in the course of the “Qualitätspakt”: three professorial positions will not be filled again. It is worth noting that there are plans on the university level for a new, interdisciplinary chair in biophysics. No complaints were heard about the general qualifications of the staff.

The number of female professors is zero, which is not uncommon, but still undesirable: female (Ph.D.) students lack a role model.

It was noted approvingly by the committee that teaching assignments are regularly rotated. The idea that students should get to know every professor is also very commendable, but more co-ordination might be needed to achieve it, since in students’ experience it is certainly possible to stay with one professor through the various stages of, for instance, "Experimental Physics I-IV".

Although high-ranking research-orientated education is one of the basic objectives of the study programme, attempts are being made to give more weight to the staff’s teaching record, especially when hiring new staff members. However, no record of teaching activities exists and the existence of academic training centres ("Hochschuldidaktische Zentren") in North Rhine Westphalia is not well known or held in high esteem among the academic staff. More openness to these attempts at improving academic education may be helpful.

Another point of concern is career opportunities for junior staff members. Promotion in general is not possible; to obtain a better position staff members have to change to another university. A permanent position is seldom reached below the age of 40; all junior staff positions are limited, mostly to five years. Again this is a political problem and cannot be solved by single universities. The German academic system makes it hard to give teaching responsibilities to junior staff members, apart from holding exercise classes and laboratory courses under the supervision of professors. However, the Duisburg faculty directs considerable effort towards exploiting these possibilities by giving assignments to junior staff in which they can gain teaching experience and develop their teaching abilities under appropriate supervision. On a positive note, the committee had the impression that the research assistants who are working on their doctoral thesis or their "Habilitation" are very well looked after by their supervisors in a traditional, but well-tried and effective master/apprentice relationship.

5 FACILITIES AND RESOURCES

The facilities available to staff and students alike are more than adequate and up-to-date. Enough computers are available to students and the library is very well equipped; the only criticism has to do with the very restricted opening hours of the library.

6 STUDENTS

6.1 Attainment Level and Selection

According to the staff, the general level of physics and mathematics taught in secondary schools ("Gymnasien") is considered very low, making the transition very hard for most of the students. It is the opinion of the visiting committee that the faculty should consider this as a given situation and adapt to it, as long as secondary school education is not improved. To help incoming students, the faculty recommends that all of them take the pre-semester courses, which are obligatory only for students with an advanced technical-school certificate.

No selection is made, and every applicant has to be taken. In general, the first semester is a good filter, but earlier examinations or tests would enable students to find out even earlier whether they are suited to the study of physics.

6.2 Student Numbers

The number of students enrolling in physics at the University of Duisburg has remained fairly constant, with a notable peak in 2000. Still, the department is a very small one, with about 40-50 first-year students a year. Entrance is possible every semester, and special arrangements are now being made for students entering in the summer semester. Whether the number of enrolments really reflects the actual student number is unclear, since a significant percentage have to be counted as so-called “Schein-“ or “Parkstudenten”, which means that either they are waiting to be accepted for another degree course with a low numerus clausus, or they just want to benefit, for example from the student public transport pass. No real data exist with regard to this problem.

The trend in the proportion of female students is fairly positive; at a figure of 17% it is considerably higher than the average for Germany. No real cases of discrimination were reported; women are treated equally and a Summer University for women has met with a very positive response. Also, child-care facilities are available for students.

As reasons for coming to Duisburg, geographical reasons (the nearness of the university) are most frequently mentioned; the small size of the department and university is also mentioned, a factor which apparently makes it less anonymous than bigger universities in the vicinity. To attract students, the department offers students in the 12th grade the option of attending a laboratory course or going on an excursion organised by the department, an apparently quite effective strategy. The topic of Traffic and Transport attracts students from all over Germany and from abroad, and the programme is widely advertised.

TABLE 3: STUDENT NUMBERS 1996-2000: FIRST-YEAR AND TOTAL

NUMBER OF FIRST-YEAR STUDENTS														
TOTAL					FEMALE					FOREIGNERS				
1996	1997	1998	1999	2000	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
47	42	49	49	68	7	7	7	14	13	3	4	2	2	5

TOTAL NUMBER OF STUDENTS														
TOTAL					FEMALE					FOREIGNERS				
1996	1997	1998	1999	2000	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
284	285	263	246	260	39	42	39	35	38	14	17	19	14	20

As first-year students, students enrolling for the first time are counted. The years refer to academic years, thus 1996 = 95/96.

Foreign students are students of foreign nationality and a foreign qualification for admission to higher education.

6.3 Counselling

A tutoring system for students in the first stage existed for a period, which was financed by the government. It was staffed by student assistants on a part-time basis. Now, the faculty is trying to finance the tutors on its own and to implement a tutoring system for higher years as well. Nearly all the first-semester students took part in the tutoring, but no monitoring system exists. The official departmental advisory service is offered by the head of the committee for the study programme. This seems to function well.

The teaching staff appears to be very open to feedback and advice. However, counselling is still largely dependent on the students' initiative. For some students at the beginning of the first year it may be difficult to adapt quickly enough to the level of independence and initiative that is necessary to finish the first semester successfully.

6.4 Duration of Study and Completion Rates

The actual duration of study is among the lowest in Germany. It is still above the nominal one; the reasons, however, seem to have more to do with students pursuing activities outside their actual course of study including earning money to cover living expenses, and less to do with deficiencies in teaching, counselling or the curriculum. Many students in Germany finance their studies in part by means of part-time jobs; very few receive a grant from the government ("Bafög"), which in the past few years also comes in the form of an interest-bearing loan. Efforts to further reduce the actual duration of study are being made, e.g., by introducing the extensive tutoring, which started three years ago.

Also, the dropout rates are considerable, especially in the first semester, but agree with the typical values at German universities. One of the reasons seems to be problems with the mathematics course. Another common exit point is directly after the intermediate exam, when many students leave for other universities to specialise in fields not offered in Duisburg. Since, with the exception of the Traffic and Transport sub-programme and the Advanced Study Programme (see 7.2), almost no students change to Duisburg from other universities. This is a major problem for the faculty, though it may be an unavoidable one for small-sized universities.

TABLE 4: DROP-OUT RATES AND GRADUATES IN THE 1999/2000 ACADEMIC YEAR

FIRST-YEAR STUDENTS	DROP-OUT AFTER ONE YEAR	COMPLETION IN NOMINAL TIME	COMPLETION WITHIN ONE MORE YEAR	COMPLETION IN LONGER TIME
49	13%	14%	41 %	45 %

Completion percentages refer to the graduates in the academic year 1999/2000, drop-outs are first-year students of the previous year who did not register again.

6.5 Graduates / Job Prospects

At the moment the situation in the job market is very good for physicists in industry and other sectors of the economy, so finding initial employment is not a real problem for graduates. However, more preparation for professional life is desirable, since during their studies students have little contact with possible employers. Also, more attention should be given to the development of social skills. To adjust the programme better to the requirements of business and industry, a regular evaluation among graduates should be institutionalised. Contacts with alumni which exist on a personal or group basis should be used systematically to obtain information that could be used to adapt the programme to the requirements of professional life.

7 EXTERNAL RELATIONS

7.1 Industry and Other Sectors of the Economy

In general, the faculty has very good contacts with industry and other sectors of the economy. A good example, which is by no means the only one, is the Traffic and Transport subprogramme, which works closely with industry and local authorities. A company connected with this research field is being set up. A number of other companies were set up by Duisburg graduates from various other fields.

7.2 International

Few students from Duisburg go abroad, and the committee gained the impression that this is also not much encouraged by the faculty. The committee strongly disagrees with the opinion that study time abroad must result in a considerable delay in completing the course of study. Whether the students lose time is mostly a matter of organisation, and the faculty should devote some effort to this. Internationalisation could actually be used as a positive point in advertising the faculty and getting rid of the persistent provincial image of the university. The present participation in international student exchange programmes such as ERASMUS is unsatisfactory. In discussing a possible loss of time one should also remember the added value of acquiring experience, both scientifically and personally, in a foreign environment.

Excellent support is given to foreign students coming to Duisburg, mostly as part of a newly implemented Advanced Study Programme (ASP). The main contacts are to the University of Ulyanovsk in Russia, but several other universities responded positively to the ASP. Several attempts have been made to teach courses bilingually (English/German) or entirely in English. These have been well received by students, with the possible exception of the Russian visitors who mostly do not speak English sufficiently well. As a matter of fact, one of the reasons for their coming to Duisburg was to improve their proficiency in German.

8 INTERNAL QUALITY ASSESSMENT AND MANAGMENT

No institutionalised system of quality assessment exists. Some of the professors have their courses evaluated on a voluntary basis, but the data are not made available either to students or to the faculty. Thus, students' opinion of the various courses and the way they are taught is only known on an informal level, if at all. In the course of the preparation of the self-study report, an evaluation of the physics education in Duisburg was carried out using questionnaires for students. Useful information was gathered, although the response was only 16.4%. The "Professorenrunde" and the study programme committee watch over the overall coherence in the curriculum. It remained unclear how the opinion of students enters into this process, apart from their being represented in the programme committee.

The absence of a regular assessment system does not make for an atmosphere in which it is normal for teachers to try and improve their teaching by, for instance, doing dedicated teacher training courses. No formal record of the teaching merits of the staff is kept, so it appears that the assessments do not have any real consequences for their career either. A record of this kind would be particularly useful in the German academic career system, where permanent positions can only be obtained at a university different from the one where the "Habilitation" degree has been obtained.

A general evaluation of education is to be installed in the course of the university restructuring. The committee recommends that the faculty evaluate the Duisburg physics education on a regular basis among graduates and employers. Data protection laws should not be a real obstacle.

Student progress is monitored each semester on the level of exams and tests, using data from the central administration of the university.

The faculty is experiencing a significant student dropout rate, especially at the beginning of the first year. This is in large part attributed to the phenomenon of "Scheinstudenten": students who have enrolled without any real intention to study physics. Those who do not re-register at the university are counted as dropouts. This procedure makes it difficult for the faculty to obtain information concerning the reasons why students drop out, whether they continue their study elsewhere, and if so, where. This information would certainly be useful.

9 SUMMARY OF WEAK AND STRONG POINTS; MAIN RECOMMENDATIONS

In general, the physics programme in Duisburg left a good impression. One weak point, however, is its marketing; the department has a good programme but does not advertise its achievements clearly and self-confidently enough. The regular media presence of the Traffic and Transport sub-programme is a good example of successful marketing, and perhaps other parts of the department could learn from it. Involving a professional marketing expert is recommended.

The difficult basic conditions in North Rhine Westphalia as embodied in the “Qualitätspakt” or the “Eckdatenverordnung” are another problem. The committee gained the impression that the level of trust between the universities and the ministry responsible is particularly low in North Rhine Westphalia. Within these constraints, the department has found good solutions; the concentration on a few fields of research is a necessity, and for such a small faculty, the spectrum is about as broad as is feasible. Other problems to be solved mainly on the government level are the career possibilities for junior staff and the overall lack of training in teaching methodology for academic teachers, although more efforts could be made by the faculty as well.

The innovative Traffic and Transport sub-programme is a good example of problem-orientated learning and industrial contacts, and the planned chair for biophysics is also a step towards modernising the physics programme.

More attention to developing problem-solving skills during the course of study would be desirable, as well as even better preparation for the requirements of professional life outside university. The majority of graduates do not stay in research, so better preparation for professional life is desirable. Today, almost every graduate finds employment, but there is no guarantee it will stay that way. Closer contact with industry in the form of work experience or projects based on real-life problems might also help students in their decision as to which direction to take. Courses in economics and social sciences are also highly recommended. A systematic evaluation among graduates would provide a basis for adapting and improving the programme.

Another concern is that so few students go abroad for part of their studies. Experience gained in other countries are very valuable in terms of personality development as well as for later professional life. The internationalisation efforts are very good as far as foreign students are concerned, but the number of outgoing students should be considerably higher.

With regard to quality assurance, a systematic evaluation of the courses and programme phases and of teaching activities should be established.

FACULTY OF SCIENCE (PHYSICS) AT THE "UNIVERSITEIT GENT" (RUG); GHENT, FLANDERS
Date of Visit: 17/18 October 2000

1 ORGANISATIONAL STRUCTURE

Ghent State University (RUG) was founded in 1817. The federalisation of the Belgian state had important repercussions for Ghent University. The Decree of June 12, 1991 concerning the universities in the Flemish Community had a substantial (positive) influence upon the autonomy of the university. The RUG is divided into eleven faculties. It is funded by the Flemish Ministry of Education. About 23,300 students are registered, 92 of them in the field of Physics.

The university is governed by a president (rector) and a vice-president (vice-rector) who are elected for a period of four years by all the professors. Its main governing body is the board of directors, which consists of the rector and vice-rector, representatives of the independent academic staff (= professors), representatives of the supporting academic staff, representatives of the administrative and technical personnel, student representatives, representatives from outside the university (representing employers' and employees' organisations, and representing the Flemish parliament), the academic and the logistics manager, the government commissioner, a financial delegate and the secretary. In total, it consists of 33 members (in 2000-2001). This body takes all the crucial decisions for the university and meets roughly once a month.

The executive committee consists of a smaller number of members than the board of directors; it deals with daily matters of university government and meets somewhat more often than the board of directors.

On the central level an advisory council for education gives advice to the board of directors, which takes the ultimate decision in matters concerning education.

The education in physics is organised within the Faculty of Science. In this faculty, a number of other study programmes from the sciences and mathematics are organised. At the faculty level there is a faculty council, chaired by the dean of the faculty. The council consists of the full professors, representatives of lecturers and of scientific personnel, and (depending on the faculty) six student members (a total of 104 members). All decisions are made by the faculty council. The dean is responsible for the implementation of the decisions of the council. The faculty council has set up advisory committees such as the education boards (for physics: OCN, "opleidingscommissie natuurkunde"), and the committee on examinations, and decides on the assignment of teaching tasks. In addition, the faculty council advises the university board of directors, e.g., on the course structure of the study programmes of the faculty and on the employment and promotion of academic personnel.

A relatively new function within the Faculty of Science is that of director of education. The director of education operates on the level of the faculty within the so-called "Quality Centre" ("Kwaliteitscel"). The director is the head of this centre, he is supported by a logistics manager and is appointed for a period of two years. Every education board within the faculty is represented in the quality centre; three members come from the supporting teaching staff and three from the students. The tasks of the quality centre for education are: monitoring the quality of the study programme and the available infrastructure, monitoring the teaching methods used and teaching-related matters. Furthermore, it has a number of executive tasks: it supports the production of programme prospectuses and of the study guide; it prepares and carries through the evaluation of education by students and co-ordinates the reactions to it; it supports the departments in preparing for external evaluations of education and in reacting to them.

Education is thus primarily organised by the faculties, acting on the advice of the education boards (OC: "opleidingscommissies") of the various disciplines. The OCN ("opleidingscommissie natuurkunde") consists of eighteen persons: nine from the independent academic personnel (ZAP), three from the supporting academic personnel (AAP) and six students (second year and higher). The OCN has both executive and advisory tasks. The executive tasks are the design and fine-tuning of the study programmes and the organisation of the education in physics. The primary task of the education board is to advise the faculty on the development and adjustment of the course programme. Another important advisory task is to propose the annual teaching assignments.

Theoretically, all decisions are taken by the board of directors on the central level of the university and the faculty makes proposals to them. In practice, the university employs a decentralised style of administration, where considerable autonomy is in practice given to the faculties and departments. Departments are smaller units of professors, assistants and administrative personnel, responsible for the practical implementation of teaching. The visiting committee had the impression that most important topics concerning the physics education are decided by consensus. (About half of the professors are members of the OCN). The decentralised system of decision-making, with its mixture of executive and advisory tasks for the several committees and centres, may appear chaotic to the outsider, but it works well apparently.

The faculty is in a phase of rapid change. It is interesting to observe that the faculty is searching for a structure in which the practical implementation of the quality assurance of education is effective and efficient. The function of the director of education represents a move from committees being responsible for study matters in the direction of individuals being ultimately responsible. The visiting committee sees this as a positive development since it becomes clearer who is responsible, who can and must take initiatives. Furthermore, more professionalism may develop in the organisational and teaching aspects of education. One may argue that such a function at the level of the physics study programme, in which all the executive tasks of the OCN, and some of those of the quality centre, are located, may also be effective and efficient.

Within the Faculty of Science, the following departments are concerned with the physics programme:

1. Mathematical Physics and Astronomy
2. Solid State Sciences
3. Subatomic and Radiation Physics
4. Applied Physics (from the Faculty of Applied Sciences)
5. Physics for Biomedical Sciences (an interfaculty study group)

The mathematics courses are supervised by the mathematics education board.

The departments do not have any formal authority in educational matters. They serve as home base for the teachers and for the second cycle advanced laboratory courses. Also, the final year thesis project takes place in the departments. Every department has a library and computer facilities, both accessible to students.

2 AIMS AND OBJECTIVES

The objectives for physics at the Faculty of Science are formulated as follows:

1) *A physics student must receive a thorough training in the foundation subjects of physics and a sound training in maths.*
2) *In this basic training the emphasis must be placed on the general principles and methods of physics which can be applied to concrete physical problems by means of precise and analytical thinking. Of particular importance here are the identification of important physical parameters, the estimation of scale and the ability to arrive at a physical-mathematical model by abstracting from these elements.*
3) *It is necessary to instil in the student the essential importance of precise experiments and their role both in formulating and testing a physical theory.*
4) *In addition to a thorough basic training the student must be able to acquire skills in the principal fields of study of physics and to delve deeper into a number of specialisations. In this way he or she must be able to acquire a good overview of contemporary physics. Close links between the courses and scientific research in the laboratory are of great importance in this respect.*
5) *With this solid grounding in the fundamentals of physics and the experience acquired in a specialist field of study of physics, the physics graduate should be ready to move to a specialisation level within a reasonable amount of time. This could be in the form of scientific research at a scientific institute or research and development in industry. His abstraction and analytical thinking skills must also enable the physics student to work in wide-ranging sectors of society. Finally, if he opts for teacher training, he must be able to communicate an enthusiasm for physics and the physics-based way of thinking to the next generation of students in secondary education.*

   (Self-report, p.3)

The aims are clearly stated and realistic, and appear attainable in the time available. However, aims and objectives clearly targeted at the requirements of a career outside research in physics should be emphasised more strongly. Also the systematic development of problem-solving abilities does not appear as a guiding principle, though it appears in the objectives of some individual courses.

3 PROGRAMME

3.1 Structure

The physics programme of the Faculty of Science at Ghent University is the only four-year programme assessed in the Cross Border Evaluation. It is divided into two years of a first cycle (leading to a diploma) and two years of a second cycle, terminating in the preparation and defence of a thesis; this cycle also leads to a diploma.

The first year is taught jointly with mathematics, which allows students to postpone their choice between these two fields. This is considered a positive point but also has as a negative consequence the fact that the mathematics lectures may contain more abstract material than is really required for future physicists.

There is currently a discussion about increasing the length of the first cycle to three years, after which a European Bachelor Degree in the sense of the Bologna declaration may be awarded.

The total programme encompasses 240 study points (ECTS, i.e., 6.500 hours of study), of which only 22 study points are associated with the preparation of the Master's thesis. In view of the requirements for the Master's thesis (and of the high quality achieved), this amount seems to underestimate considerably the effective time required. An adjustment to the real situation should be considered.

3.2 Contents and Methods

Overall, the programme design is reasonably good. The first two years provide a basic introduction to physics and to the methods used in it. In the second cycle the students can choose a "theoretical" or an "experimental" orientation, with elective courses adapted to this orientation. This approach mixes directionality and personal choice; the committee considers it very positive.

The laboratory exercises are well co-ordinated with the lectures, but their overall weighting seems rather small. Their organisation, moreover, is somewhat more prescriptive than appropriate for academic learning and the faculty could try to promote better motivation and more creativity. The committee also noted that the final-year laboratory courses are insufficiently tuned to later professional life.

The co-ordination of the (experimental) general physics and theoretical courses, which often deal with the same phenomena, could be improved. Students should realise that they learn two complementary approaches to the same reality. This remark having been made, the level of both types of lectures is high and fulfils international requirements.

Nuclear and particle physics are well covered. This is also the case for solid state physics. The corresponding solid-state laboratory courses are inspiring and bring students into contact with laboratory equipment to be used in their future Master's theses. Extensive textbook-like syllabi exist, but more references to supplementary literature as well as to modern applications and experimental methods might be helpful. The level of the written examination questions is high and meets the requirements achieved in leading physics departments.

Questions that can be answered by reproducing verbatim part of the text of the syllabus appear less appropriate, however.

As to the methods of education, the programme reviewed here is rather traditional and, with some exceptions, lecture- and reproduction-orientated. The introduction of approaches requiring more creativity, the use of diverse source materials and the introduction of problems requiring a combination of concepts and techniques encountered in various lectures would be advisable. The committee has noted that an interesting project was carried out in recent years to make use of modern ICT equipment and techniques for education.

TABLE 1: PROGRAMME

First Year First Cycle

No.	Course Unit	A	B	C	D
1	Analysis I	37,5	22,5	0	136
2	Analysis II	37,5	30	0	156,5
3	Linear Algebra and Analytical Geometry I	30	15	0	95
4	Linear Algebra and Analytical Geometry II	30	30	0	108
5	Differential Geometry I	15	15	0	82
6	General Physics I	30	15	30	121
7	General Physics II	60	15	0	177
8	Theoretical Mechanics I	30	15	0	95
9	Programming	30	30	0	108
10	Philosophy	22,5	0	0	61,5
11	**Total**	**322,5**	**187,5**	**30**	**1140**
12	**Sum Total**	**1680**			

Second Year First Cycle

No.	Course Unit	A	B	C	D
1	Analysis III	30	22,5	0	115,5
2	Theoretical Mechanics II	30	15	0	95
3	Electromagnetism	22,5	15	0	102,5
4	Astronomy	30	15	0	95
5	Quantum Mechanics	22,5	15	0	102,5
6	General Physics III	30	15	0	95
7	General Physics IV	30	15	37,5	113,5
8	Statistics	30	15	0	95
9	Numerical Analysis	30	22,5	0	115,5
10	Chemistry	37,5	15	0	115,5
11	Crystallography I	22,5	22,5	0	90
12	**Total**	**315**	**187,5**	**37,5**	**1140**
13	**Sum Total**	**1680**			

First Year Second Cycle

No.	Course Unit	A	B	C	D
1	Mathematical Methods in Physics	22,5	37,5	0	105
2	Non-relativistic quantum mechanics and Principles of Relativistic Quantum	40	20	0	140
3	Relativity Theory and Conventional Fields	30	15	0	105
4	Statistical Physics	22,5	15	0	82,5
5	Symmetry Groups	15	15	0	60
6	Subatomic Physics	22,5	15	15	97,5
7	Basic Terms of Solid State Physics	22,5	15	15	97,5
8	Atomic and Molecular Physics	30	7,5	15	112,5
9	Electrical and Magnetic Material Properties	15	7,5	15	67,5
10	Option Courses	60	30	0	210
11	**Total**	**280**	**177,5**	**60**	**1077,5**
12	**Sum Total**	**1595**			

Second Year Second Cycle

No.	Course Unit	A	B	C	D
1	Option Courses	180	90	0	680
2	Dissertation	0	0	200	400
3	**Sum Total**	**1550**			

A: contact hours: lectures

B: contact hours: exercises

C: contact hours: other supervised study activity (laboratory courses)

D: hours of study time for personal assimilation of course material

3.2.1 Mathematics / Other Basic Sciences

We already mentioned the risks and benefits of a first year common to mathematics and physics students. One of the important advantages is, however, that the level of the mathematics courses is certainly sufficient for physicists.

The other basic sciences, natural or humanities, are not well represented in the curriculum. When an increase in the study volume of the first cycle allows it (cf. above), this situation should be remedied. Student who are training as secondary-school teachers will also have to teach natural sciences other than physics, and so some introduction to the basics of these topics would be welcome.

3.2.2 Non-Technical Subjects

Apart from the obligatory philosophy course, there is a total lack of non-technical subjects such as social sciences and ethics; this is one of the major deficiencies of the physics programme. The committee regards the ability to place the subject in a broader societal context as being very important. Also, courses in economics would be helpful for students as a preparation for professional life. This deficiency might also be due to the lack of time; non-technical courses could well be included in a five-year programme.

3.2.3 Computer Skills

The attention paid to computer skills has been very low until recently. Now, programming courses in Java and MAPLE are being offered. Still more attention could be devoted to this. Computers are widely used to search the literature on the web and in experimental work.

3.3 Theses

The thesis is an important part of the second year of the second cycle, and the time available to complete it is about four months. It has to be written in “correct Dutch”, the only exception being those written by ERASMUS students. It has to include an extensive literature search and the development of new, independent ideas. The committee was in general very much impressed by the level of the theses, especially considering the short time in which they have to be completed, but suggests giving more weight to novel personal contributions by students.

3.4 Examinations

Examinations are held every semester to test students’ knowledge of the course material covered during that semester. There is a strong emphasis on reproduction, and many students seem to learn syllabi word for word, which may produce little understanding of the scientific content.

3.5 Study Load

As stipulated in the University decree of June 12, 1991 and the decision of the Flemish Executive of June 3, 1992, every study year must contain between 1500 and 1800 hours of study. According to a survey among the students, the study load is realistic and well balanced between the different years.

3.6 Overall Assessment

The Ghent physics programme is the only one among the universities visited that has a four-year course of studies, not only nominally, but to a large extent in reality as well. In spite of these constraints the programme offers a good and solid introduction to the various fields of physics and the methods used in them. The attention given to oral and especially written communication skills is commendable and the committee members who were able to sample some thesis work were impressed by the quality of the work produced by students from this point of view as well.

One weak point is the small amount of attention devoted to applied subjects. This concerns not so much the opportunities for choosing electives from applied subjects; rather, the committee had the impression that it is not made sufficiently clear to students that applied research can be as intellectually challenging and satisfying as fundamental research.

The variety of teaching methods is on the whole satisfactory, and the committee saw good examples of integration of lectures, exercises and contact with up to date research, as well as an example where work in interdisciplinary teams was explicitly stimulated. However, traditional teaching methods predominate and the almost complete lack of rotation in course assignments is not conducive to stimulating innovations in content and teaching methods.

In general, there is strong emphasis on assimilating and reproducing known physical knowledge and somewhat too little effort devoted to developing problem-solving skills. This is true even for the thesis project, though the committee saw some good examples of original contributions, and the short amount of time allowed for the thesis certainly plays a role.

Apart from a philosophy course in the first year, no courses outside science are included in the programme. Also, hardly any attention is given to preparing students for professional life outside university. This in the view of the committee is a clear responsibility of the faculty. It is not enough to organise occasional excursions to companies; rather, students should be given opportunities to meet on campus with graduates working outside university and encouraged to use these opportunities. Also, the additional qualifications that might help them in their future career should be pointed out and possibilities to acquire them should be provided.

Many of the weaknesses pointed out above are related to the constraints of a four-year programme. Some of them could be mitigated even within those constraints. However, an extension of the programme to five years, which may be possible in the course of the coming restructuring of university studies, might lead to a more complete education, provided the extra time is devoted to the development of problem-solving skills and to supplementing the programme with non-scientific subjects, rather than to an extension of the amount of basically reproductive learning and of the time devoted to it.

4 STAFF

The academic staff falls into the following categories:

Professorial staff:
- Full (ordinary) professor
- Professor
- Senior lecturer
- Lecturer

Non-professorial staff:
- Assistant
- Temporary teaching and scientific employee

A typical academic career in Flanders is described in Appendix 1.

TABLE 2: ACADEMIC AND NON-ACADEMIC STAFF

NUMBER OF PERSONS AND FULL-TIME EQUIVALENTS (in brackets)						
ZAP Full professors	ZAP Professors	ZAP Lecturers/ senior lecturers	AAP/ATP Assistants/ student assistants	Others (AP/ visiting lecturers)	Total academic staff	Non-academic staff
10 (9,1)	8 (8)	26 (25,1)	16 (15)	21 (21)	81 (78,1)	n.n.a.

others: students/assistants or lecturers (industry) teaching part-time
n.n.a.: numbers not available

The staff is well qualified and large enough to cover the entire range of the curriculum. Also, the range of specialisations among the academic staff is broad. The committee has the impression that staff members take their responsibilities in education very seriously and are well prepared for their assigned courses.

One concern is the high average age of the permanent staff. Due to retirements the average age will drop considerably in the next five to ten years. However, too abrupt a change will cause problems and as yet little effort is being made to ensure a smooth transition. Also, the lack of rotation in course assignments might not be of help to stimulate innovation in course content and teaching concepts. More flexibility in this respect would be desirable in the view of the committee.

Educational training courses for professors are given. Participation is optional. Education is supervised by the education board (OCN) and the director of education (see Ch. 1). They intervene if a professor is teaching too much or too little. Generally speaking, the teaching commitment becomes more important for promotion in the course of the academic career. Attention towards education is generally good and increasing.

The committee considers the involvement of the non-professorial staff in education unsatisfactory. Very little responsibility is given to them; they mainly assist their professors in laboratories and exercises. By law, they have to direct at least 50% of their efforts towards research. All of the junior staff members are hired on a short-term basis, either for four or six years during their Ph.D. or post-doctoral research, payment being dependent on scholarships. Their teaching load is considerable (16h/week as compared to 6h/week for professorial staff) and spread out over the entire faculty, and includes service courses for non-physicists. No real organisation among the junior staff exists. Career prospects are rather bleak; few get a job in the university afterwards, and their teaching skills are neither trained nor recorded. Generally, more responsibility and independence should be given to this group of staff members.

5 FACILITIES AND RESOURCES

The facilities are in general quite good and the laboratories are currently being updated, thus solving the problem of ageing equipment. The main problem of the faculty is the scattering of institutes over the entire town, which often leads to a lot of travelling around between courses.

Enough computers are available for students, who all get a free e-mail account when they start university. The laboratories are accessible after hours, but the opening hours of the library are strictly nine to five. More flexibility in that direction would make individual work much easier. No rooms for individual or group work are available, but whether a real need for them exists is not apparent.

The faculties of Science and of Applied Sciences co-operate well in educational matters and can make use of one another's resources, when necessary, without any problems. The general budget is low, but the faculty seems to make good use of it.

6 STUDENTS

6.1 Attainment Level and Selection

The general level of education among first-year students is considered good, although it was mentioned that the teachers of the first courses face a continuous struggle to get the students to work on their own. One problem that has arisen in the last years is that the number of physics secondary-school teachers is in decline, and thus physics in secondary schools is sometimes taught by non-physics graduates. There is no entrance selection, and university education in Flanders is generally free. Selection mainly takes place at the end of the first year. As entrance is only possible at the beginning of the academic year, no early selection in combination with a re-direction of the students is possible. This is clearly a disadvantage for those students who should be advised to discontinue their physics studies. Transfer to non-university courses of higher education appears to be possible with less loss of time, however.

6.2 Student numbers

The general number of physics students in Flanders is rather low. It seems to be difficult to convey the attractiveness of physics to secondary-school students. A slow increase has been noted over the last few years, however.

The percentage of female students is very low, which is probably a reflection of the general problem in society. To increase the number of female physics students is a slow and difficult process, as considerable prejudice still exists. Until five years ago, secondary education was split into girls' schools and boys' schools. A split of this kind is sometimes suggested as a way to increase the number of female physics students. The experience in Flanders does not support this assumption.

TABLE 3: STUDENT NUMBERS 1996-2000: FIRST-YEAR AND TOTAL

NUMBER OF FIRST-YEAR STUDENTS														
TOTAL					FEMALE					FOREIGNERS				
1996	1997	1998	1999	2000	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
45	35	37	34	29	17	13	14	11	10	0	0	0	0	0

TOTAL NUMBER OF STUDENTS														
TOTAL					FEMALE					FOREIGNERS				
1996	1997	1998	1999	2000	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
114	94	98	88	79	30	27	30	28	25	0	0	0	0	0

As first-year students, students enrolling for the first time are counted. The years refer to academic years, thus 1996 = 95/96.

Foreign students are students of foreign nationality and a foreign qualification for admission to higher education.

6.3 Counselling

Student counselling is mainly dependent on the initiative of students. No tutoring system exists and weak students are not approached by staff members. Due to the small number of students, contact between staff and students is very good and the teachers are very accessible and inclined to help. The general trend is that students are quite willing to approach their professors for advice, much less so the teaching assistants. The introduction of a tutoring system, especially at the beginning of the first year, could help students early on with their adaptation to the university way of teaching and learning and assist them to decide in time whether to proceed with their studies or not. The central university “Student Advisory Centre” is probably not very well suited for this task, since it is too far away from the students’ daily study activities.

The possibility of arranging an “individually tailored annual programme” is a good way to find an efficient study programme for delayed students, so that delay is kept to a minimum and the loss of a full year can be avoided. Within the Faculty of Science, one adviser (“ombudsman”) is assigned, mainly for general complaints about staff and curriculum, but not many students seem to be aware of this service.

6.4 Duration of Study and Completion Rates

In general, it is feasible to finish the programme in the nominal time (four years) and slightly more than half of the number of graduates do so (see Table 4). The average length of study is about 4.6 years. One point of concern to the committee is the high dropout rate (over 50%). The faculty attribute this to the quality of the incoming students: many students interested in studying physics first take the entrance examination of the Faculty of Applied Sciences. If they pass it, they enrol there and later often enter the Civil Engineering in Physics programme; if they fail they enrol in the physics programme. However, since the Physics and Civil Engineering in Physics programmes supposedly require comparable abilities, their chances of succeeding in physics are not very good either. The committee thinks it is important to find out whether this hypothesis is true.

TABLE 4: DROP-OUT RATES AND GRADUATES IN THE 1999/2000 ACADEMIC YEAR

FIRST-YEAR STUDENTS	DROP-OUT AFTER ONE YEAR	COMPLETION IN NOMINAL TIME	COMPLETION WITHIN ONE MORE YEAR	COMPLETION IN LONGER TIME
34	50%	60%	36%	4%

Completion percentages refer to the graduates in the academic year 1999/2000, drop-outs are first-year students of the previous year who did not register again.

6.5 Graduates / Job Prospects

The job prospects of graduates are very good, but in general graduates are insufficiently prepared for professional life in industry and business. During their course of study, they have little contact with the economic world, and what little there is, is organised by students. The faculty itself provides no information about possible employers. External project work is not encouraged and the course contents have little relation to the needs of professional life outside the university. Evaluations among graduates should be carried out regularly to monitor their success in the job market and identify possible weaknesses of the programme.

7 EXTERNAL RELATIONS

7.1 Industry and Other Sectors of the Economy

Only very few contacts with industry or other sectors of the economy appear to exist. No external part-time lecturers are employed for physics. Students are not encouraged to gain experience outside university, and graduation projects and laboratory courses are not tuned to the requirements of industry. Students do get a job very easily due to the present situation on the labour market, but there is no discernible effort being made to prepare students for jobs other than academic research or secondary-school teaching. No record of the initial employment of graduates and of their success in professional life exists.

The committee had the impression that many members of the faculty are very comfortably settled in academic life, and that there are virtually no research collaborations either with non-physics faculties, in particular with the Faculty of Applied Sciences, or with non-academic institutions. In view of role played by research in a physics education (see sec. I.2.1.1) it is important that students come into contact with both industrial and fundamental research, as well as with interdisciplinary and international projects; the participation of Ghent physics institutes in collaborations with foreign universities and international research institutes is comparable to that found in the other faculties visited.

Existing contacts with alumni, particularly alumni working in industry, should also be used to help implement a systematic evaluation of the study programme among graduates to obtain information which could be used to adapt the programme to the requirements of business and industry.

7.2 International

Of the students enrolled in physics 15 % go abroad for a period of time during their studies. They are given ample support and the courses taken in a foreign university are fully recognised. The stay abroad, both for students and lecturers, is often administered as part of the ERASMUS/SOCRATES programmes.

The number of outgoing students is, however, out of balance with the very few foreign students who come to Ghent. Recently, a number of students came from Eastern Europe, but the committee thinks it important that students from Western European countries come to Ghent as well; this is particularly important for a university that attracts almost all of its students from Flanders. The main reason for the absence of foreign students seems to be the strict language laws in Flanders, which state that all courses have to be taught in Dutch. The opportunities for giving some courses in English, thus making the RUG more attractive to students from abroad, are therefore very limited. Foreign students come to Ghent mainly to take part in research projects, where they can use English. Students enrolling in regular courses are expected to learn Dutch, though pedagogical assistance in English is provided. Exchange in Physics appears to be less lively than in Civil Engineering in Physics, however.

The committee suggests that the RUG might try to be more flexible. One way would be to provide translations of exercises and let some examinations be taken in English. This is already practised to some extent, but is insufficiently known to foreign students who might be interested in studying in Ghent. Fundamental changes with respect to the language regulations could well be initiated at the university, but would of course need approval on the governmental level.

8 INTERNAL QUALITY ASSESSMENT AND MANAGMENT

At Ghent University the central university authorities set rules for the faculties on how to conduct the internal quality control. The internal quality assurance system appears to work well. Every course is evaluated once every three years by means of questionnaires which have been designed with the involvement of students. The results, with reactions from the teachers, are reported unfiltered to the study programme committee (OCN). Co-ordination of the contents of the course units takes place in the OCN. Evaluations of the entire programme are carried out as the need arises, for instance on the occasion of a visitation. This form of internally organised quality control is organised institutionally.

The faculty has appointed a member of staff ("ombudsperson") to deal with student criticisms, usually of an individual nature. This person is not consulted very often; in fact few students know about him.

It is very unusual for junior staff members to have participated in any formal teacher training. The teaching assistants learn to teach “on the job”.

One weak point is that there is little evaluation among graduates; more evaluation would be helpful in adjusting the programme to the requirements of industry and other potential employers.

The results of the evaluation definitely have consequences for the promotion of the teaching staff. No formal record of the teaching merits of the supporting teaching staff is kept; a formal record would, however, be of use in their further academic career.

The faculty keeps a record of the extent of the level of preparation of incoming students, i.e. of the number of hours taken in secondary school in the various science subjects. Students’ progress is reported on the basis of the results of the first-year and final examinations, although examinations are held after each semester. Also, the progress of students is monitored quite systematically in the exercise sessions, in which they can be asked to solve problems and defend their solutions in front of their fellow students. Although this might be a good practice for immediate feedback, it is unclear how the faculty manages to identify obstacles for individual students during their studies in time.

9 SUMMARY OF WEAK AND STRONG POINTS; MAIN RECOMMENDATIONS

In general, the physics programme in the Faculty of Science left a good impression; it certainly fulfils the minimum requirements. The academic level of the graduates, as reflected in the theses, was rated highly, especially given the constraints of a four-year programme. Another positive point is the small difference between average and nominal duration of study.

Many of the shortcomings noted are due to this time constraint and could be solved by adding another year to the first cycle. Our main point of concern is a lack of interest on the part of many members of the faculty in applications of physics and in its relationship to business and industry and to society at large. The differences between pure and applied physics, and hence between physicists and engineers, are overrated.

More contacts with the Faculty of Applied Sciences, extending beyond purely educational matters, would have a positive effect on the quality of the education offered in physics. A system of evaluation among graduates should be implemented and used for adapting the programme to the requirements of professional life.
Making the RUG more attractive for foreign students is hampered by legal and political circumstances; the university can make some contributions, however, and the committee encourages it to do so.

One very positive point is the strong dedication to education. The implementation of the curriculum is evaluated regularly and adjusted to the needs of the students. More responsibility for the junior staff would be desirable, and even more effort could be made to train university teachers adequately. Rotation of course assignments among staff members could lead to more flexibility and innovation. The students are very well looked after, a fact which is made easier by their relatively small number, but the establishment of a tutoring system could improve the effectiveness of the counselling.

The large distances between the various lecture theatres and laboratories represent a general structural problem; the opening hours of the library are quite limited.

FACULTY OF APPLIED SCIENCES (CIVIL ENGINEERING IN PHYSICS) AT THE "UNIVERSITEIT GENT" (RUG), GHENT, FLANDERS
Date of Visit: 17/18 October 2000

1 ORGANISATIONAL STRUCTURE

Ghent State University (RUG) was founded in 1817. The federalisation of the Belgian state had important repercussions on Ghent University. The Decree of June 12, 1991, concerning the universities in the Flemish Community, had a substantial (positive) influence upon the autonomy of the university. The RUG is divided into eleven faculties. It is funded by the Flemish Ministry of Education. About 23,300 students are registered, 90 of them in the second cycle education in Civil Engineering in Physics. The Faculty of Applied Sciences was founded in 1835.

The university is governed by a president (rector) and a vice-president (vice-rector) who are elected for a period of four years by all the professors in all the faculty councils. Its main governing body is the board of directors, which consists of the rector and vice-rector, representatives of the independent academic staff (= professors), representatives of the supporting academic staff, representatives of the administrative and technical personnel, student representatives, representatives from outside the university (representing employers' and employees' organisations, and representing the Flemish parliament), the academic and the logistic manager, the government commissioner, a financial delegate and the secretary; in total, it consists of 33 members (in 2000 - 2001). This body takes all crucial decisions for the university and meets approximately every month.

The executive committee consists of a smaller number of members than the board of directors, deals with daily matters of university government and meets somewhat more often than the board of directors.

A director of education operates on the level of the faculty within the so-called "Quality Centre" ("Kwaliteitscel"). The director is the head of this centre, he is supported by a logistics manager and is appointed for a period of two years. Every education board within the faculty is represented in the quality centre, three members come from for the supporting teaching staff and three from the students. The tasks of the quality centre for education are: supervision of the quality of the study programme and of the available infrastructure, of the teaching methods used, of teaching-related matters. Furthermore, it has a number of executive tasks: it supports the production of programme prospectuses and of the study guide; it prepares and carries through the evaluation of education by students and co-ordinates the reactions to it; it supports the departments in preparing for external evaluations of education and in reacting to them.

On the central level an advisory council for education gives advice to the board of directors, which takes the ultimate decision in matters concerning the education. It meets about 10 times a year.

The education in Civil Engineering in Physics is organised within the Faculty of Applied Sciences, with a large input from the physics department of the Faculty of Science. In the Faculty of Applied Sciences a number of other engineering study programmes are organised. At the faculty level there is a faculty council, chaired by the dean of the faculty. The council consists of the full professors, professors, representatives of the lecturers and senior lecturers, representatives of the scientific personnel, and (depending on the faculty) six student members. All decisions are made by the faculty council. The dean is responsible for the implementation of the decisions of the council. The faculty council has founded advisory committees such as the education boards (for engineering in physics: OCN: "Opleidingscommissie Natuurkunde"), and the committee on examinations, and decides on the assignment of the teaching tasks. In addition, the faculty council advises the university board of directors, e.g., on the course structure of the study programmes of the faculty and on the employment and promotion of academic personnel.

Education in Ghent is thus primarily organised by the faculties, acting on advice from the education boards (OC: "Opleidingscommissies") of the various disciplines. The OCN ("opleidingscommissie Natuurkunde") consists of eighteen persons: nine from the independent academic personnel (ZAP), three from the supporting academic personnel (AAP) and six students (third year and higher). The OCN has both executive and advisory tasks. It controls the programme and the content of the course units, it deals with complaints and questions formulated by student representatives, and it decides whether choices made by students can be approved.

In theory, all decisions are taken by the board of directors on the central university level and the faculty makes proposals to it. In practice, the university employs a decentralised style of decision-making, where much autonomy is left to the faculties and departments. Departments are smaller units of professors, assistants and administrative personnel responsible for the practical implementation of the teaching. The visiting committee had the impression that most important topics are decided by consensus. The decentralised system of decision-making, with its mix of executive and advisory tasks for the several committees and centres, may appear chaotic to the outsider, but seems to work well.

2 AIMS AND OBJECTIVES

The main objectives of the Civil Engineering in Physics course are formulated as follows:

> *The objective of the Civil Engineering in Physics programme is to combine the basic concepts of an engineering education with the essence of a physics education in order to deliver an engineer capable of carrying out and guiding technical-scientific research at universities, research institutes and industry. This wide scope in two domains makes the Engineer in Physics well suited for taking up management positions.*
>
> *The basic concepts in the engineering course focus on analysis, design and the optimisation of existing and new systems, products, machines, appliances, devices, materials, etc. Artefacts designed and manufactured by man are usually more structured than what is found in nature. It is essential for the engineer to carry out the "necessary" simplifications to arrive at sufficiently simple "system descriptions" (from rules of thumb to expert systems), which can be used for new or improved designs. A system designed by man will operate correctly if it is designed correctly. It is characteristic of an engineering course that great importance is attached to problem-solving exercises in which theory is applied, making use of solution-oriented functional approaches.*
>
> *For his part, the physicist tries to find order in existing nature. In a physics course, the reductionist approach is central. In this, experiments and mathematical models are aimed at reducing physical phenomena to their essential components in order to discover the applicable laws of physics. In comparison to the engineering sciences, the physicist has a much more philosophical approach. Nevertheless, this requires a rigorous attitude, and the speculative element, which also exists, is controlled by the requirement that a physical theory must pass the test of experiments.*
> *(Self-report, p.3)*

The attainment targets are stated as follows:

- *For the first cycle degree: mathematics, chemistry and physics must be sufficiently mastered for their use in the second cycle degree. There should be an adequate insight into the various technical disciplines to make an informed choice.*
- *With regard to the general section of the physics course: the basic techniques of physics, the main areas of application of physics and technical system theory must be sufficiently mastered to allow for further studies. The basic philosophy of both scientific and technical thinking must be taught by ensuring that half of the course is taught by the Science Faculty and half by the Applied Science Faculty.*
- *With regards to the options and the thesis: an understanding of the required level for doing research and proving this in the thesis. The subject itself may be chosen at random from the research fields of the laboratories concerned, and is less important in itself, provided that our basic idea is followed as closely as possible: to achieve a balance by immersing oneself both in scientific philosophy and in technical philosophy.*
- *For the optional subjects, the students must be left completely free (for 15 study points) to choose either socio-economic, ethical or language subjects so that the student learns to take responsibility for himself or herself.*

The aims and objectives are clearly stated and attainable in the time available. They represent a good balance between fundamentals and applications. A stronger emphasis on problem solving capacity would be desirable.

3 PROGRAMME

3.1 Structure

The physics programme of the Faculty of Applied Sciences at the Ghent University is divided into two years for a first cycle (leading to a diploma) and three years for a second cycle terminating in the preparation and defence of a thesis, after which a diploma is also awarded. The first two years are common to all engineering students and a decision to specialise in Civil Engineering in Physics is taken at the end of this period. It should be noted that professors of the Faculty of Science are also involved in lecturing in the second cycle.

Civil Engineering in Physics at Ghent University is the only programme participating in the Cross Border Evaluation which requires an entrance examination from its students. This clearly improves the success rate in the subsequent first-year examinations.

The total programme encompasses 300 study points (ECTS, i.e. about 6,600 hours of study) of which only 20 study points are associated with the preparation of the Master's thesis. Though this is already an increase over earlier practice, this figure appears to underestimate the effective time required considerably in view of the requirements of the Master's theses (and of the high quality achieved). A further adjustment to the realities of the situation should be considered.

3.2 Contents and Methods

Overall, the programme design is good. In the first cycle, the students obtain a broad introduction to the engineering sciences in general, with a good basis in mathematics and physics. Quite deliberately, no choice between specialisations is made as yet, which is considered quite positive. In the second cycle, students who choose to enrol in Civil Engineering in Physics benefit from a double focus on the basic aspects and on the technical applications of physics. This double focus is also reflected in the sharing of teaching responsibilities between professors of the Faculty of Science and the Faculty of Applied Sciences.

The laboratory exercises are well co-ordinated with the lectures. Efforts are made to develop problem-solving skills, but the organisation of the exercises still remains more prescriptive than appropriate for academic learning and the faculty should try and promote even better motivation and more creativity. The committee also notes the good tie-in with industrial applications furthered by Master's thesis projects carried out in collaboration with industry.

The faculty should improve the co-ordination of the (experimental) general physics and theoretical physics courses, which often deal with the same phenomena. Students should realise that they learn two complementary approaches to the same reality. This remark having been made, the level of both type of lectures is high and meets the necessary requirements.

Nuclear and particle physics are well covered as electives. This is also the case for solid state physics. The corresponding solid state laboratory courses are inspiring and bring students into contact with laboratory equipment such as will be used for their future Master's theses, also preparing them in some instances for work in industry. Extensive textbook-like syllabi exist, but some further references to supplementary literature and to modern applications and experimental methods might be helpful. The level of written examination questions is high and meets the requirements realised in other leading physics departments.

As to the methods of education, the programme we review here is still rather traditional and, with some exceptions, lecture- and reproduction-orientated. The introduction of approaches requiring more creativity, the use of diverse source materials and the assignments of problems requiring a combination of concepts and techniques encountered in various courses should be considered.

TABLE 1: PROGRAMME

First Semester of the First Course (BN1)

No.	Course Unit	A	B	C	D
1	Applied Mathematics	22,5	30	0	57,5
2	Fields, energy, forces	45	60	0	65
3	Symmetry Groups	15	15	0	50
4	Statistical Physics	33,8	25	5	46,2
5	Quantum Mechanics I	33,8	15	0	36,2
6	Advanced Physics	60	40	0	70
7	Semiconductors	22,5	30	0	27,5
7	**Total**	**232,6**	**215**	**5**	**352,4**
8	**Sum Total**	**805**			

Second Semester of the First Course (BN1)

No.	Course Unit	A	B	C	D
1	Subatomic Physics	22,5	15	15	87,5
2	Basic Concepts in Solid State Physics	22,5	15	15	87,5
3	Atomic and Molecular Physics	30	7,5	15	87,5
4	Quantum Mechanics II	33,8	15	0	66,2
5	Electronic Systems and Instrumentation	45	0	30	65
6	Crystallography	22,5	30	0	27,5
7	Physics Technology	22,5	0	30	57,5
8	**Total**	**198,8**	**82,5**	**105**	**478,7**
9	**Sum Total**	**865**			

First Semester of the Second Course (BN2)

No.	Course Unit	A	B	C	D
1	Dynamics of Electrical Systems	45	60	0	65
2	Heat Transfer in Electronics	22,5	30	0	57,5
3	Electromagnetic Radiation and Special Relativity Theory	45	18	42	65
4	Physical Chemistry OR Theoretical Mechanics III	30	15	0	95
5	Optional Subjects	275			
6	**Sum Total**	**865**			

Second Semester of the Second Course (BN2)

No.	Course Unit	A	B	C	D
1	The Electrical Properties of Materials	22,5	30	0	57,5
2	Physical Metallurgy	45	45	15	65
3	Control Engineering	45	60	0	65
4	Plasma Physics I	22,5	15	0	42,5
5	Optional Subjects	275			
6	**Sum Total**	**805**			

Third Course (BN3), 1st and 2nd Semester

No.	Course Unit	A	B	C	D
1	Optional Subjects	650			
2	Free Electives from the RUG Programme	430			
3	Thesis	600			
4	**Sum Total**	**1680**			

A: annual contact hours: lectures

B: annual contact hours: exercises

C: annual contact hours: other supervised study activity (laboratory courses)

D: annual hours of study time for personal assimilation of course material

3.2.1 Mathematics / Other Basic Sciences

Mathematics is well integrated into the programme, with good emphasis on applied mathematics.

The sciences other then physics are not well represented in the curriculum. An introduction to other basic sciences may be useful in view of the multifaceted applications students may encounter in their professional life.

3.2.2 Non-Technical Subjects

The social, economical and environmental responsibility of engineers is touched upon in the curriculum of the first cycle in two mandatory courses ("Introduction to Economics" and "Technology and Environment"). This introduction could be pursued in the second cycle, possibly in the form of seminars on current problems in this area. In the last year of the second cycle, fifteen study points are reserved for optional courses outside the faculty. The students are encouraged to choose courses in social sciences and many of them do so, but in general they are left to choose freely. Other options favoured by the students are languages, economics and ethics. This attention to non-technical subjects is commendable.

3.2.3 Computer Skills

The attention paid to computer skills has been very low until recently. Now, programming courses in Java and Maple and MATLAB are being offered. Still more attention could be devoted to this. Computers are widely used to search the literature on the web and during experimental work.

3.3 Theses

The thesis is an important part of the last year of the second cycle. It has to be written in “correct Dutch”, and has to include an extensive literature search and the development of new, independent ideas. Many of the thesis projects are suggested by industry. The committee was in general very much impressed by the level of the theses, especially considering the short time in which they have to be completed. Presumably, however, the actual time is considerably longer than the assigned 600 hours.

3.4 Examinations

Examinations are held every semester to test students' knowledge of the course material covered during that semester. They are given in written and oral form. For several course units, different kinds of small examinations are used.

3.5 Study Load

As stipulated in the University decree of June 12, 1991 and the decision of the Flemish Executive of June 3, 1992, every study year must encompass between 1500 and 1800 hours of study. According to a survey amongst students, the study load is realistic and well balanced between the different study years.

3.6 Overall Assessment

The combination of the two-year introduction to engineering and the three-year physics programme meets the stated goal of combining a thorough engineering education with a good education in physics. It amply meets the minimum criteria for a physics education as formulated by the committee. The later part of the course allows for a broad choice of optional courses, and provides the opportunity for a specialisation either in more technological or in a more basic physical direction. Since students in the course of their studies meet colleagues both from mathematics and basic sciences and from more specialised engineering, they are well prepared for working in interdisciplinary teams.

The variety in teaching methods is on the whole satisfactory, and the committee saw good examples of integration of lectures, exercises and contact with up to date research, as well as an example where teamwork in interdisciplinary teams was explicitly stimulated. However, traditional teaching methods predominate and the almost complete lack of rotation in course assignments is not conducive to stimulating innovative teaching methods.

The inclusion of projects, especially in the physics technology course, helps in systematically developing students' problem-solving abilities. Also, the use of practical problems originating in industry helps preparing them for future professional work outside university. This preparation might be improved by stimulating discussions between students and graduates working in industry, also beyond this specific course. Somewhat more attention could also be paid to the development of problem-solving abilities in the "regular" physics courses as well, where there is often too much emphasis on assimilating and reproducing known physical knowledge.

In the first two years there are non-scientific courses, but there are no further ones in the second cycle. This may be related to the decision of the OCN not to provide an option for business studies, since at the moment virtually no graduates find jobs in research management as opposed to in research and development proper. Nevertheless, a few additional business courses could be included, or at least the faculty could stimulate students to choose some of their free electives from the socio-economic field. Such courses might help some of them obtain positions in research in which they are given responsibility for leading smaller research or development projects, or start their own companies or consulting bureaux. An increasing number of them will do so, at least if Flanders follows the trend which is already perceptible in many other European countries.

4 STAFF

The academic staff falls into the following categories:

Professorial staff

- Full (ordinary) professor
- Professor
- Senior lecturer
- Lecturer
- Guest lecturer

Non-professorial staff

- Assistant
- Temporary teaching and scientific employee

A typical academic career in Flanders is described in Appendix 1.

TABLE 2: ACADEMIC AND NON-ACADEMIC STAFF

NUMBER OF PERSONS AND FULL-TIME EQUIVALENTS (in brackets)						
ZAP Full professors	ZAP Professors	ZAP Lecturers/ senior lecturers	AAP/ATP Assistants/ student assistants	Others (AP/ visiting lecturers)	Total academic staff	Non-academic staff
13 (12,1)	12 (11,4)	23 (18,5)	30 (29,5)	0	78 (71,5)	77 (74,8)

others: students/assistants or lecturers (industry) teaching part-time

The staff is well qualified and large enough to cover the entire range of the curriculum. Also, the range of specialisations among the academic staff is broad. The committee has the impression that staff members take their responsibilities in education very seriously and are well prepared for their assigned courses.

One concern is the high average age of the permanent staff. Due to retirements the average age will drop considerably in the next five to ten years. In the past two or three years a number of new young permanent staff members have joined the departments, and in this way an abrupt change has been avoided. The lack of rotation in course assignments may not be helpful in stimulating innovations in course content and teaching concepts. More flexibility in this respect would be desirable.

Educational training courses for professors are provided; participation is optional. Education is supervised by the education board (OCN) and the director of education (see Ch. 1). They intervene if a professor is teaching too much or too little. Generally speaking, a professor’s teaching commitment becomes more important for promotion in the course of his or her academic career. Attention to education is generally good and increasing.

The committee considers the involvement of the non-professorial staff in education unsatisfactory. Very little responsibility is given to them; they mainly assist their professors in laboratory courses and exercises. By law, they have to direct at least 50% of their efforts towards research. All of the junior-staff members are hired on a short-term basis, either for four or six years during their Ph.D. or post-doctoral research, payment being dependent on scholarships. Their teaching load is considerable and spread out over the entire faculty, and includes service courses for non-physicists. No real organisation among the junior staff exists. Career prospects are rather bleak; few get a job at university afterwards, and their teaching skills are neither trained nor recorded. Generally, more responsibility and independence should be given to this group of staff members.

5 FACILITIES AND RESOURCES

The facilities are generally quite good and the laboratories are currently being updated, thus solving the problem of ageing equipment. The main problem of the faculty is the scattering of institutes over the whole town, which sometimes leads to a lot of travelling around between courses.

There are enough computers available for students, who all get a free e-mail account when they start university. The laboratories are accessible after hours, but the opening hours of the library are strictly nine to five. More flexibility in that direction would make individual work much easier. No rooms for individual or group work are available, but whether a real need for them exists is not apparent.

The Faculties of Science and of Applied Sciences co-operate well in educational matters and can make use of one another's resources, when necessary, without any problems. The general budget is low, but the faculty seems to make good use of it.

6 STUDENTS

6.1 Attainment Level and Selection

The first-year students in the Faculty of Applied Sciences have to pass an entrance examination. The Civil Engineering in Physics education is a second cycle education. This implies that those who enrol in this programme have successfully passed two selection procedures, so the attainment level of the students can be considered to be at least adequate.

6.2 Student Numbers

The number of physics students in Flanders is generally very low. It seems to be difficult to convey the attractiveness of physics to secondary-school students. This is also a problem for the Civil Engineering in Physics programme. The average number of students entering this second cycle programme amounts to slightly more than twenty a year for the last ten years, making up 5 - 10% of the students in the Faculty of Applied Sciences. The number of students entering the second cycle programme may be increasing, and this year there are 40 first-year students, making 15% of the students in the Faculty of Applied Sciences.

The percentage of female students is very low, which appears to be a reflection of a general problem in society. To increase the number of female physics students is a slow and difficult process, as much prejudice still exists. Until five years ago, some of the secondary education was split between girls' schools and boys' schools. A split of this kind is sometimes suggested as a way to increase the number of female physics students. However, this assumption is not supported by the experience in Flanders.

TABLE 3: STUDENT NUMBERS 1996-2000: FIRST-YEAR AND TOTAL

NUMBER OF FIRST-YEAR STUDENTS														
TOTAL					FEMALE					FOREIGNERS				
1996	1997	1998	1999	2000	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
21	23	21	22	40	3	0	4	5	10	0	0	0	0	0

TOTAL NUMBER OF STUDENTS														
TOTAL					FEMALE					FOREIGNERS				
1996	1997	1998	1999	2000	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
65	66	69	63	90	6	5	6	9	19	0	0	0	0	0

As first-year students, students enrolling for the first time are counted. The years refer to academic years, thus 1996 = 95/96.

Foreign students are students of foreign nationality and a foreign qualification for admission to higher education.

6.3 Counselling

Student counselling is mainly dependent on the initiative of students. No tutoring system exists. Due to the small number of students, contact between staff and students is very good, however, and the teachers are very accessible and inclined to help. The general trend is that students are quite willing to go to their professors for advice. For general complaints about staff and curriculum, an adviser ("ombudsman") is assigned. This system seems to be quite efficient, as the ombudsman is very accessible and complaints usually have an effect.

6.4 Duration of Study and Completion Rate

In general, it appears to be feasible to finish the programme in the nominal time of five years and most graduates do so (see Table 4). The average length of study for those who graduate amounts to 5.13 years. About 90% of the students enrolled in the Civil Engineering in Physics programme do finish it. These figures are considered very good by the faculty; the committee agrees.

TABLE 4: DROP-OUT RATES AND GRADUATES IN THE 1999/2000 ACADEMIC YEAR

FIRST-YEAR STUDENTS	DROP-OUT AFTER ONE YEAR	COMPLETION IN NOMINAL TIME	COMPLETION WITHIN ONE MORE YEAR	COMPLETION IN LONGER TIME
21	n.n.a.	n.n.a.	n.n.a.	n.n.a.

Completion percentages refer to the graduates in the academic year 1999/2000, drop-outs are first-year students of the previous year who did not register again.

n.n.a.: numbers not available

6.5 Graduates / Job Prospects

The job prospects of graduates are generally very good at present. However, more emphasis should be put on preparation for professional life in business and industry in the course of the programme in order to provide good job prospects, also for times when the job market for physics engineers is tighter.

7 EXTERNAL RELATIONS

7.1 Industry and Other Sectors of the Economy

More contacts with industry would be desirable. Even though there are such contacts, the faculty provides little information about possible employers. The graduation project can be done in collaboration with industry, but more opportunities for project work preparing for professional life outside of the university could be provided. The faculty employs several part-time lecturers from industry. The degree is still not very well known in Flanders; more publicity could improve this situation.

Systematic evaluation among graduates should be carried out to obtain information that could be used to adapt the programme to the requirements of business and industry. Existing contacts with alumni, in particular alumni working in industry, should be used for the purpose of devising an evaluation system of this kind.

7.2 International

Of the students enrolled in physics 15% go abroad for some time during their studies. They are given ample support and the courses taken in a foreign university are fully recognised. The stay abroad, both for students and lecturers, is often administered as part of the ERASMUS/SOCRATES programmes.

The number of out-going students is, however, not offset by the very few foreign students coming to Ghent. The main reason seems to be the strict language laws in Flanders, which state that all courses have to be taught in Dutch. Though significant pedagogical assistance is provided, the opportunity to give some courses in English, thus making the RUG more attractive to students from abroad, is thus very limited. Students come to Ghent primarily to take part in research projects where they can use English. Foreign students enrolling in regular courses are expected to learn Dutch.

The committee suggests that the RUG might try to be flexible. One way would be to provide translations of exercises and let some examinations be taken in English, and make this practice known to possible applicants whose Dutch is not yet sufficient. Fundamental changes with respect to the language regulations could well be initiated at the university but would of course need approval on the governmental level.

8 INTERNAL QUALITY ASSESSMENT AND MANAGMENT

At Ghent University the central university authorities set rules for the faculties on how to conduct the internal quality control. The faculty distinguishes three elements: the quality of the lecturers, control and feedback in the OCN, and feedback from the students.

The internal quality assurance system seems to work well. Co-ordination of the contents of the course units takes place in the OCN. The students fill in evaluation forms which include questions that examine the educational quality of the syllabus, lecturers, exercises and laboratory courses. Furthermore, there are questions about the examinations. The lecturers are informed about the scores in this evaluation and are invited to react. The results of the teaching evaluation are definitely taken into account in appointments and promotions. No formal record of the teaching merits of the supporting teaching staff is kept; a formal record would, however, be of use in their further academic career. It is very unusual for junior staff members to take part in any formal teacher training. The teaching assistants learn how to teach “on the job”.

Six students are members of the OCN, so more in-depth discussions among staff and students concerning the outcome of the evaluation can and do take place in the OCN.

The faculty has appointed two members of staff ("ombudspersons") to deal with student criticism, usually of an individual nature. This system works properly.

The only weak point is that little evaluation among graduates exists; this could be helpful in adjusting the programme to the requirements of industry and other potential employers.

The intake of students takes place after the first cycle degree in engineering. Students have to pass an entrance examination before enrolling in the Faculty of Engineering. Student progress is monitored at the level of the final examination. On the other hand, there is a tradition in engineering studies aimed at maintaining discipline and recording the progress of students. With the introduction of the semester system, the system of testing has evolved into a permanent system of evaluation of the compulsory curriculum. Although this might be a good procedure for immediate feedback, it is unclear how the faculty manages to identify obstacles for individual students during their studies in time.

9 SUMMARY OF WEAK AND STRONG POINTS; MAIN RECOMMENDATIONS

The general impression of the Civil Engineering in Physics programme was quite positive, and it certainly meets the minimum requirements. The comparatively high proportion of practical work and the emphasis on problem solving were noteworthy, and the high scientific level of graduates as reflected in their theses clearly demonstrates the programme's high standard.

However, systematic evaluation among graduates and alumni should be carried out to enable the programme to be even better adapted to the requirements of professional life.

More efforts towards internationalisation could be made, but the problem of making the RUG more attractive for foreign students is, on account of the legal and political circumstances, only to a small extent in the hands of the university.

Contact with industry is established by means of guest lecturers as well as by exploiting the option of graduation projects inspired by problems arising in industry. Similarly inspired courses or projects could be offered in earlier study phases; the "Physical Technology" course already provides a good example. Also, efforts should be made to make the Civil Engineering in Physics degree more widely known.

One very positive point is the strong dedication to education. The implementation of the curriculum is evaluated regularly and adjusted to the needs of students. More responsibility for the junior staff would be desirable, and still more efforts could be made to train university teachers adequately. Rotation in course assignment among the staff members could lead to more flexibility and innovation. The students are very well looked after, a fact which is made easier by their relatively small number, but the establishment of a tutoring system could further improve the effectiveness of the counselling.

The large distances between the various lecture theatres and laboratories represent a general structural problem; the opening hours of the library are quite limited.

FACULTY OF PHYSICS AT THE "UNIVERSITÄT HANNOVER", HANOVER, GERMANY
Date of Visit: 7/8 November 2000

1 ORGANISATIONAL STRUCTURE

The University of Hanover was founded in 1831 as a higher vocational school. In 1879 it was upgraded to a “Royal College of Technology” and in 1968 to a “Technical University” ("Technische Universität"). In 1978 it was renamed "Universität Hannover". Today the University of Hanover is divided into 16 faculties with more than 160 institutes. The number of students is about 28,000, making it the largest university in Lower Saxony. Physics began in Hanover in 1853. Currently 515 students are registered in the physics programmes.

The University of Hanover is responsible for its own administration, while remaining legally under control of the state and the Minister of Science and Culture in Lower Saxony. Its central bodies are the president ("Präsident/in"), the council ("Konzil"), the senate ("Senat") and standing committees. All the governing bodies include representatives of the different status groups - professors, scientific associates, technical and administrative staff, and students - with a majority for professors. Each status group elects its representatives for two years, with the exception of the students, who elect their representatives for one year. The president is head of the university and its external representative. Along with two vice-presidents ("Vizepräsident/in"), he/she is elected by the council. A chancellor ("Kanzler/in") is elected by the senate, and attends to day-to-day administrative and legal affairs. He/she is also in charge of the budget. The senate decides on all central university issues.

The administrative structure of the Faculty of Physics has two layers. It follows the general university regulations of the state of Lower Saxony. The faculty is governed by the faculty council ("Fachbereichsrat"). Its meetings are conducted by the dean ("Dekan/in"), who is elected by the faculty council from the group of professors and represents the faculty within the university and to the general public. The dean is supported by a faculty manager. The faculty council decides on all faculty issues, but it may delegate certain issues to special committees.

The faculty is organised into five institutes, each divided into several groups or sections. Each institute is managed by a director. The institutes are:

1. Institute of Theoretical Physics
2. Institute of Solid State Physics
3. Institute of Atomic and Molecular Physics
4. Institute of Quantum Optics
5. Institute of Meteorology and Climatology

Associated with the Faculty of Physics are a Centre for Radiation Protection and Radio-Ecology, a Laser Centre and an Institute for Solar Energy Research. A Max Planck Institute for Gravitational Physics will soon be established. At the moment, the university is in a phase of restructuring. In the context of the so-called “Innovationsoffensive”, the university is trying to concentrate on promising subjects in order to establish “centres of excellence”. An interfaculty Centre for Nanoelectronics has been established and a wider Centre for Quantum- and Nanoengineering is in the planning stage.

In the organisation of the education the following committees play a role:
1. Committee for Diploma Examinations
2. Committee for Study Programmes
3. Committee for Advanced Laboratory Courses
4. Temporary Committees

In these committees all the status groups are represented, again with a majority for the professors. The students are organised in a:

5. Faculty Student Council

There is one student council for the two faculties of Physics and of Mathematics and Computer Science. This council is responsible for matters concerning students of the two faculties; it provides contributions from the students' point of view in problems concerning study programmes, examinations and social life.

Important, but more informal deliberations within the group of all professors take place in the "Professorenrunde". It is the impression of the visiting committee that most decisions in the faculty are prepared in this "Professorenrunde".

The responsibilities for some general services required for teaching and for several courses are assigned to the various institutes.

The structure of the faculty may change as a consequence of a new Law for Higher Education, and of initiatives by the central university administration. The establishment of a new function, a deputy dean for educational matters ("Studiendekan/in") is recommended in this connection. Thus a shift from committees being responsible for study matters towards individuals being ultimately responsible is envisaged. The committee thinks this is a good development, since it becomes clearer who is responsible, and who can and must take initiatives. Furthermore, more professionalism may develop in the organisational and teaching aspects of education. Care must be taken, however, to ensure that all the teachers stay involved with the curriculum and its implementation, and that their views, as well as those of students, are given due weight.

2 AIMS AND OBJECTIVES

The aims and objectives of the Faculty of Physics at Hanover University are formulated as follows:

The objectives of the study programme are:

During the training, physics students have to acquire broad knowledge of experimental and theoretical physics as well as fundamental knowledge of mathematics. Deep understanding of scientific concepts and the ability to develop further academically are most important. students have to become familiar with the wide spectrum of scientific techniques. The research-oriented diploma thesis is the concluding part of their training; it gives them the maturity to carry out scientific work independently. The training of physicists is not geared to specialisation; it is meant to provide professional flexibility.

The aims of the academic training are:

- *The training provides the ability for later professional employment.*
- *The training lays the foundation for further professional growth as a physicist.*
- *The training lays the foundation for possible advanced studies, e.g., for doctoral research.*

The study programme is meant to form personalities who are able to think and work independently and creatively and who are able to participate in interdisciplinary co-operation. (self-report, p.14/15)

The aims and objectives are clearly stated. They appear realistic; the actual duration of study is among the lower ones in Germany, though still significantly higher than the nominal one. Among the measures taken towards further reducing the study time is the incorporation of the "Freiversuch" into the examination system (see sec. 3.4) and its promotion by the faculty. The objectives appear directed mainly towards employment in research, which does not correspond to the actual employment of a large proportion of graduates.

In the course of preparing the self-report, the Hanover faculty also questioned staff, students and graduates about the objectives of the study programme. The results were reported as follows:

The aim of members of the teaching staff is that their students should acquire competence in analysing and solving complex problems, discover the analogies of questions in different fields, learn to work independently and creatively on theoretical and experimental problems, and learn to exploit the use of computers in those scientific problems. They are of the clear opinion that they support the students in their academic growth by their teaching in a very positive and fruitful way. The majority of students agrees with the aims of the study programmes and wants to learn the skills necessary to acquire the defined competence. In the view of graduates, employers value the academic versatility of physics graduates most.

This statement, especially by the teaching staff, shows a greater awareness of the necessary “soft” qualifications than the official statement of programme objectives.

3 PROGRAMME

3.1 Structure

The responsibility for curriculum design lies with the faculty's Committee for Study Programmes. Decisions are taken by the Faculty Council, advised by the Committee. In some matters, approval by the University or the Ministry is required.

Formally, the physics programme is divided into two phases, the basic “Grundstudium” and the advanced “Hauptstudium”, separated by an intermediate examination after the fourth semester ("Vordiplom"). On a thematic level, the programme is structured into (1) the study of the basic elements of physics, (2) the advanced study of selected topics and (3) research for the diploma thesis, the latter to be carried out in the fifth year. This structure is not entirely tied to the formal division into "Grundstudium" and "Hauptstudium".

A new programme of Technical Physics was introduced in the winter semester 2000/01; it is not evaluated in this assessment.

3.2 Contents and Methods

During the first two semesters, the basis for the mathematics needed for the physics programme is laid, with two purely mathematical courses. A course Mathematical Methods in Physics ("Rechenmethoden der Physik"), combines mathematical techniques and their use in physical subjects.[4] During the first stage, the entire four-part course on experimental physics is taught, as well as the basics of theoretical physics and laboratory work. About 90 contact hours are reserved for electives ("Wahlpflichtfächer"). During the third year, students are introduced to the four major fields of research conducted at the University of Hanover, atomic and molecular physics, solid state physics, nuclear and particle physics and quantum optics. The fourth year then covers at least two special subjects: the "Vertiefungsfach", in which a subject from one of the five institutes is studied in more depth, and an elective (“Wahlpflichtfach”) from applied physics or other science and engineering fields. Students have to take two seminars in which they also improve their communication skills. Again, 90 hours are reserved for electives outside of physics. The fifth year is mainly devoted to the thesis.

In the course of the seminars, oral presentations have to be held, and a literature search is required. Apart from the seminars, the main form of teaching is lectures with closely related exercises. The laboratory courses are devoted to concentrated practical work, on which extensive reports have to be written. The committee was not given sufficient justification for the large number of small experiments that students have to carry out in the Introductory Laboratory Course, but noted with approval that efforts are under way to install larger scale, more freely conducted and more extended experiments.

As electives, chemistry, computer science, mathematics, fields of applied physics such as meteorology or biophysics, and a wide range of engineering subjects can be chosen. Other subjects may be chosen with the permission of the Committee for Diploma Examination ("Diplomprüfungsausschuss").

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4 See: Physik mit Bleistift, Hermann Schulz, Harri Deutsch Verlag, Thun, 1999 (3rd Ed.)

A programme in meteorology is also offered by the faculty; it was not assessed by us. The first phase ("Grundstudium") is common to physics and meteorology.

Note that in Germany the academic year is split into two uneven parts. The lecture period of the winter semester has 16 weeks; the lecture period of the summer semester has 14 weeks. The odd numbered semesters are winter semesters, the even-numbered semesters are summer semesters. The study burden of students is counted in weekly contact hours, each contact hour consisting of 45 minutes. For the sake of a transparent comparison, the study burden is translated in this table into total 60-minute hours; for the sake of simplicity, each semester is taken to have a 15-week lecture period in the average.

TABLE 1: PROGRAMME

1. Semester (WS)

No.	Course Unit	A	B	C	D
1	Physics with Experiments I	45	0	0	n.n.a.
2	Mathematical Methods in Physics I	22,5	22,5	0	n.n.a.
3	Linear Algebra	45	22,5	0	n.n.a.
4	Analysis I	45	22,5	0	n.n.a.
5	**Total**	**157,5**	**67,5**	**0**	**525**
6	**Sum Total**	**750**			

2. Semester (SS)

No.	Course Unit	A	B	C	D
1	Physics with Experiments II	45	22,5	0	n.n.a.
2	Mathematical Methods in Physics I	45	22,5	0	n.n.a.
3	Introductory Lab Course I	0	0	45	n.n.a.
4	Analysis II	45	22,5	0	n.n.a.
5	**Total**	**135**	**67,5**	**45**	**577,5**
6	**Sum Total**	**825**			

3. Semester (WS)

No.	Course Unit	A	B	C	D
1	Physics with Experiments III	45	22,5	0	n.n.a.
2	Theoretical Physics I (Classical Physics)[1)]	45	22,5	0	n.n.a.
3	Introductory Lab Course II	0	0	45	n.n.a.
4	Elective Subject	45	0	0	n.n.a.
5	**Total**	**135**	**45**	**45**	**525**
6	**Sum Total**	**750**			

4. Semester (SS)

No.	Course Unit	A	B	C	D
1	Physics with Experiments IV	45	22,5	0	n.n.a.
2	Theoretical Physics II (Quantum Theory I)	45	22,5	0	n.n.a.
3	Proseminar	22,5	0	0	n.n.a.
4	Elective Subject	45	0	0	n.n.a.
5	**Total**	**157,5**	**45**		**472,5**
6	**Sum Total**	**675**			

5. Semester (WS)

No.	Course Unit	A	B	C	D
1	Introduction to Atomic& Molecular Physics	33,75	11,25	0	n.n.a.
2	Introduction to Solid State Physics	33,75	11,25	0	n.n.a.
3	Theoretical Physics III(Statistical Physics)	45	22,5	0	n.n.a.
4	Advanced Lab Course I	0	0	135	n.n.a.
5	**Total**	**112,5**	**45**	**135**	**682,5**
6	**Sum Total**	**975**			

6. Semester (SS)

No.	Course Unit	A	B	C	D
1	Introduction to Nuclear & Particle Physics	33,75	11,25	0	n.n.a.
2	Introduction to Quantum Optics	33,75	11,25	0	n.n.a.
3	Theoretical Physics IV(Quantum Theory II)	45	22,5	0	n.n.a.
4	Advanced Lab Course II	0	0	135	n.n.a.
5	**Total**	**112,5**	**45**	**135**	**682,5**
6	**Sum Total**	**975**			

7. Semester (WS)

No.	Course Unit	A	B	C	D
1	Special Subjects	90	0	0	n.n.a.
2	Seminar	22,5	0	0	n.n.a.
3	Elective Subject	45	0	0	n.n.a.
4	Colloquium	[22,5][1)]	0	0	n.n.a.
5	**Total**	**157,5**	**0**	**0**	**367,5**
6	**Sum Total**	**525**[2)]			

8. Semester (SS)

No.	Course Unit	A	B	C	D
1	Special Subjects	90	0	0	n.n.a.
2	Seminar	22,5	0	0	n.n.a.
3	Elective Subject	45	0	0	n.n.a.
4	Colloquium	[22,5][1)]	0	0	n.n.a.
5	**Total**	**157,5**	**0**	**0**	**367,5**
6	**Sum Total**	**525**[2)]			

A: contact hours: lectures

B: contact hours: exercises

C: contact hours: other supervised study activity (laboratory courses)

D: hours of study time for personal assimilation of course material

1) Not obligatory and therefore not included in total hours

2) Students usually take more than the required mandatory courses for their own orientation towards the diploma thesis.

n.n.a.: numbers not available

3.2.1 Mathematics / Other Basic Sciences

Mathematics is concentrated entirely in the first year, as in many German universities. It consists of courses taught by the Faculty of Mathematics and Computer Science which are attended by future physicists and mathematicians alike. The impression obtained by the committee is that these courses are insufficiently tuned to the special requirements of physics students and that better co-ordination with the physics curriculum is urgently required. The faculty reported that these issues are being discussed, and stresses the good climate of co-operation with the Faculty of Mathematics and Computer Science.

The concentration of all mathematics, and of “Mathematical Methods in Physics”, into the first year leaves too little room for general and experimental areas of physics. The committee recommends that the faculty study the possibilities for improvement, which could be achieved even with quite modest adjustments and with a redistribution of courses over the semesters.

The other basic sciences are covered by the electives. These can also be chosen from engineering fields or, in the second stage, from sub-fields of applied physics.

3.2.2 Non-Technical Subjects

With the permission of the Study Board, subjects from the fields of economics, social sciences or law may be taken as electives, but relatively few students take this opportunity, possibly since it is not really encouraged by faculty members; the committee considers this a deficiency in the education received by many students. It appears that students are insufficiently aware of the importance of these subjects for their professional life in industry and other sectors of the economy. The concentration on sciences conveys too narrow a view of science and its relevance to society.

A greater interest in broadening the horizons of students would be desirable. In the new Technical Physics programme, obligatory courses in patent law and economics are included. The committee hopes these and related courses will attract the attention of physics students as well.

3.2.3 Computer Skills

No courses on basic computer skills are offered in the physics curriculum. The opportunities to compensate for this by taking part in the activities of the regional computer centre for Lower Saxony (RRZN) are limited, as the relevant courses are only offered during the semester and are not co-ordinated with the physics timetable. In each of the theoretical physics courses one computer-based problem has to be solved during the course of study, in the form of an extended homework problem. Much more emphasis should be devoted to information technology. The faculty should specify the computer skills it expects students to have and give them the opportunity to acquire them. In addition, several computer-based projects or exercises should be included in the curriculum.

3.3 Study Load

According to the self-report of the university, students “regard their workload as a heavy one”. For some students the remedy for excessively heavy loads was to work in groups, whereas other students think this method is not suitable for efficient learning.

3.4 Examinations

Two comprehensive examinations are held during the course of study, the intermediate “Vordiplom”, after two years, and the final “Hauptdiplom”. The intermediate examination covers the subjects of experimental and theoretical physics, mathematics, and the elective subject. The final examination covers experimental and theoretical physics, the elective subject and the special subject (see sec. 3.1). The final examination is divided into two parts, the first to be taken before, the second after the diploma thesis, which itself is also a part of the final examination. The second part is devoted to the special subject which is mostly closely related to the thesis project. In each of the two comprehensive examinations, a so-called “Freiversuch” is possible, an attempt to pass some parts of an examination one semester early without any further consequences in case of failure. The “Freiversuch” is an attempt to shorten the duration of study; first results are encouraging. Grade inflation in the comprehensive examination “Hauptdiplom” is a problem, as in all of Germany, but the faculty feels it cannot address the problem on its own; a concerted effort of all German physics faculties is required.

3.5 Theses

The thesis is supposed to be written during the fifth year and has to be handed in within twelve months after starting it. Work on the thesis is divided into a three-month breaking-in phase and a nine-month research period. For their research, students are integrated into a research group, supervised by a professor from the Faculty of Physics. The students should work independently on a problem. An appreciable number of theses are written in the context of collaborative projects, e.g., with the Faculty of Biology and with engineering faculties.

3.6 Overall Assessment

The programme offered is of high quality and amply fulfils the minimum requirements. The major areas of physics are well covered, though special care is needed to ensure that parts of the classical areas of theoretical physics (mechanics and especially electromagnetism) not included in Theoretical Physics I are covered in other parts of the curriculum. The relative weight of obligatory and elective physics courses and the choice of electives offered are adequate, though more electives in the field of computational physics within the “Vertiefungsfächer” would be advisable in order to practise the efficient and effective use of the computer as a research tool in physics.

Though traditional methods predominate, the variation in teaching method is satisfactory. However, the committee recommends a more systematic development of problem-solving skills, with a development from traditional exercises towards more openly formulated problems or small projects culminating in the thesis project. Good examples already contained in the programme are the advanced laboratory course and also the numerical problems in the theory courses. Much attention is paid to developing oral and written communication skills. The emphasis on seminars is a strong point of the Hanover programme, though the seminars, or some of them, could be better used for developing teamwork and broader literature searches. The amount of attention given to written reports in the introductory laboratory courses appears quite large in view of the heavy course load of students and the other objectives that these courses should be aiming at.

In the mathematics courses, which are common to mathematicians and physicists, too little attention appears to be paid to the needs of physics. Some of the problems thus caused are mitigated by the Mathematical Methods in Physics course, but as a consequence there is too much emphasis on mathematical and theoretical subjects in the first year and too little attention paid to experimental and general physics. This leads to a first year that is insufficiently representative of the programme as a whole and does not give the students sufficient guidance in deciding early enough whether they made the right choice in starting a physics education.

Another shortcoming is the lack of a programming course offered at times when it can be taken by first-year physics students. Thus the computer skills among students are quite uneven, which is a major obstacle to a better training in the various uses of computers in solving problems in physics.

There is a broad offering of courses for non-physical electives ("Wahlpflichtfächer") in science and engineering. Electives in social and economic fields can also be chosen, but they are taken by relatively few students. This may be due in part to the lack of attention paid to acquainting the students with their possible future fields of employment. In the view of the committee, the faculty has a responsibility for arranging exchanges of views between students, graduates and potential employers to help students prepare for their later professional life and to encourage them to acquire desirable additional qualifications. The attention to non-physics subjects in the new technical physics programme (not a subject of the present evaluation) is commendable, and the commission hopes some of the courses offered there will also be taken by students in the regular physics programme.

The committee considers the introduction of the “Freiversuch” and the use made of it as a development that may contribute to a better distribution of the examination load over time and contribute to a shortening of the duration of study.

4 STAFF

The personnel of the faculty of physics falls into three categories: professors, scientific staff and technical/administrative staff. The academic personnel is mainly divided into the following sub-categories:

- Full professors (C4)
- Full professors (C3)
- University lecturers/research assistants (C2)
- Permanent scientific personnel ("Akademischer Rat")
- Research assistants (C1, A13-15, BAT IIa)

A typical academic career in Germany is described in Appendix 1.

TABLE 2: ACADEMIC AND NON-ACADEMIC STAFF

NUMBER OF PERSONS AND FULL-TIME EQUIVALENTS (in brackets)						
Full professors C4/C3	Associate professors[1)]	Assistant professors [2)]	Research assistants[3)]	Others	Total academic staff	Non-academic staff
17 (17)	3 (3)	3 (3)	39 (32)	0	62 (55)	36 (34)

1) all academic staff with a "Habilitation" in permanent positions besides C4- and C3-professors
2) all academic staff with a "Habilitation" in temporary positions
3) all academic staff without a "Habilitation" in permanent and temporary positions

The faculty is medium-sized, but the number of staff members is sufficient to cover all the programmed areas of the curriculum. With the founding of a Max Planck Institute, some teaching capacity for astrophysics will be obtained. On the other hand, the faculty is going to lose three professorial positions by 2003. Most of the loss will be in theoretical physics; in addition, a position that was moved to theoretical physics to establish the research focus of quantum optics will return to the experimental side. This will lead to a better balance between experimental and theoretical physicists, though at a lower overall figure. The committee recommends filling one of the next vacancies in theoretical physics with someone specialising in a more applied and/or computational sub-field of one of the existing research focuses, so as to extend the number of electives and student projects that may be offered in those areas.

The number of female professors is zero, which is not uncommon, but still undesirable: the female students and assistants lack a role model. A female professor in the Institute of Biophysics of the Faculty of Biology, however, regularly teaches electives for physicists and supervises interdisciplinary diploma theses written by physics students.

Professors are expected to spend eight hours a week on teaching and 25% of their time on administrative duties. According to the faculty, research activities are usually carried out in the semester breaks. In the hiring of new staff members, students' opinion of the applicant's teaching skills plays an important role, but the sample lecture is the only means of assessing these (apart from personal inquiries): In Germany, no formal records of educational activities are maintained. Educational Training Centres ("Hochschuldidaktische Zentren") are in general not well known and educational research is not held in high esteem. This is also the case in Hanover. More attention to university teaching methodology nation-wide would be desirable, but the faculties themselves can also encourage their teaching staff to take courses in university teaching. More openness towards this subject could be helpful.

One positive point is the regular rotation of teaching assignments to avoid staleness in the individual courses and to allow students to get to know almost every staff member.

One general problem in Germany is the bleak career prospects of the junior staff and the lack of teaching responsibility given to them. Promotion is in general not possible within a given university; instead, staff members have to apply for a position at another university to improve their status. Permanent positions are seldom reached before the age of 40. More varied teaching assignments and the introduction of a teaching record might help improve the situation.

5 FACILITIES AND RESOURCES

The facilities made a very good impression on the peers; the faculty library is very well equipped and accessible 24 hours a day for members of the faculty. They can also use the university's main and technical reference library, which reaches an impressively high standard. One point of concern is that very few students appear to make use of the library. More tasks should be assigned to them for which it is necessary to work with literature. The laboratory equipment is quite up-to-date. Two computer pools are accessible to the students, a CIP pool (CIP: "Computer-Investitions-Programm", computer investment programme) and a CAD (Computer Aided Design) pool.

In the introductory laboratory courses, students can choose from a large number of small-scale experiments which appear well maintained, but not very modern. The committee noted with approval that efforts are under way to install larger scale, more freely conducted and more extended experiments.

Apart from a general shortage of office and laboratory space, there is a clear shortage of small seminar rooms for up to twenty people. In addition, the Faculty of Physics has the disadvantage of being distributed over four buildings that are rather far apart.

6 STUDENTS

6.1 Attainment Level and Selection

No explicit information was available about the general attainment level of the incoming students, but the impression is that the previous knowledge of physics and mathematics was so low that pre-study mathematics and pre-study physics courses are useful for the majority of students. It seems that incoming students are not yet accustomed to the necessary attitude of academic freedom, which requires taking responsibility for their own education and learning. The committee feels that the faculty should consider this as a given situation and adapt to it, as long as secondary-school education is not improved on this point. No selection is made; all applicants must be accepted by law.

6.2 Student Numbers

As stated before, the Faculty of Physics at Hanover University is medium-sized with an average of about 80 incoming students per year. The real number of students is hard to estimate, since a considerable percentage is enrolled as so-called “Schein-“ or “Parkstudenten”, which means that either they are waiting for acceptance in another field of study with a low numerus clausus, or they just want to benefit from the general social advantages of student status. The faculty has recently initiated the setting up of a database of active students and plans to contact them regularly. The initiative should result in better data on study progress, on the reasons for delay, and on the extent to which these can and should be influenced by the faculty. The committee strongly approves this initiative.

The total number of students is slowly decreasing, which is considered by the faculty as a general problem in society, as the interest in sciences is waning. At the moment, the number of students is well below the number of available places. Still, the decrease is not as severe as the German average. To improve the situation, the faculty offers the option of continuing education for teachers in secondary schools. It helps with projects in schools, and pupils come for projects to institutes. The aim is to improve the physics education in secondary schools and thus to stabilise and increase student numbers. A considerable amount of effort is put into organising information days ("Hochschul-Informations-Tage"), where university students give interested secondary-school students a guided tour. These publicity efforts, especially in schools, should be continued and extended.

The percentage of female students is very low, as in most physics faculties in northern and western Europe. The universities still have problems attracting women to the study of physics. The faculty is trying to raise the number of female students by various means such as the organisation of summer academies for girls in secondary schools; this is having some success in the graduate programme, but has not had any impact on the normal study programme so far.

TABLE 3: STUDENT NUMBERS 1996-2000: FIRST-YEAR AND TOTAL

NUMBER OF FIRST-YEAR STUDENTS														
TOTAL					FEMALE					FOREIGNERS				
1996	1997	1998	1999	2000	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
75	80	104	83	78	27	17	29	22	27	3	5	2	2	13

TOTAL NUMBER OF STUDENTS														
TOTAL					FEMALE					FOREIGNERS				
1996	1997	1998	1999	2000	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
557	498	470	424	376	76	68	78	74	73	24	24	25	23	32

As first-year students, students enrolling for the first time are counted. The years refer to academic years, thus 1996 = 95/96.

Foreign students are students of foreign nationality and a foreign qualification for admission to higher education.

6.3 Counselling

Advice is openly offered by all staff members, but its use remains strongly dependent on students' initiative in the spirit of "academic freedom". All lecturers have consultation hours, and counselling in the second phase ("Hauptstudium") is mainly established through close contact to a research group. No real system of counselling and feedback is institutionalised, but students seem to be satisfied with the current arrangements. For first-year students there exists a tutoring system that helps them adapt to "academic freedom" and the university environment.

6.4 Duration of Study and Completion Rates

A problem most physics faculties in Germany have in common is the long study time. Most students need longer than the nominal 5 years. Most of the delay takes place in the "Hauptstudium", whereas most dropouts occur in the "Grundstudium". Especially some of the advanced courses are experienced as very difficult, and the students are dependent on the certificates if they want to finish in time.

A major reason for delay is also the social situation of students in Germany; very few receive funding from the government ("Bafög"), so virtually all of them have to work to cover part of their living expenses. The committee gained the impression that the faculty does not really give high priority to reducing the duration of study considerably, because they see a student's time at the university as a period of maturing and character building. The initiative mentioned under 6.2 should be helpful, however.

TABLE 4: DROP-OUT RATES AND GRADUATES IN THE 1999/2000 ACADEMIC YEAR

FIRST-YEAR STUDENTS	DROP-OUT AFTER ONE YEAR	COMPLETION IN NOMINAL TIME	COMPLETION WITHIN ONE MORE YEAR	COMPLETION IN LONGER TIME
78	50%[1)]	15%[1)]	49%[1)]	36%[1)]

1) Graduates for the 1998/99 academic year

Completion percentages refer to the graduates in the academic year 1999/2000, drop-outs are first-year students of the previous year who did not register again.

6.5 Graduates / Job Prospects

The job prospects of graduates are very good at the moment, but there is no guarantee that it will stay that way. The committee is of the opinion that more efforts should be made to put students in touch with possible employers and to improve their social skills.

To adjust the programme better to the needs of professional life outside university, regular evaluation among graduates should be institutionalised, i.e., the type of inquiry carried out for the self-report should be repeated regularly. Existing contacts with alumni could be used to optimise the design of the questionnaire for the purpose of providing a basis for taking the requirements of business and industry into account in the programme design.

7 EXTERNAL RELATIONS

7.1 Industry and other Sectors of the Economy

Much more could be done to promote relations to industry and other sectors of the economy. A number of members of the faculty and of the associated institutes have built up good contacts with industry and are using them for the benefit of their students, e.g., by offering them industry-related project work. In other institutes, contacts with industry and other sectors of the economy are rare or absent, in part since their research areas make such contacts less obvious. The committee feels that those institutes should also try to bring their students into contact with possible applications of the methods developed in research, i.e. by inviting guests who work in applied fields or by dealing with industrial and other applications of physics in courses and seminars. Project work based on real-life problems, or stays in research or development institutions outside university, are still quite rare, in part as a consequence of the heavy study load. Ways of granting academic credit for such activities should be explored.

Close contact to alumni is also desirable to provide information about the demands of the job market. A development in the right direction is the “Firmen-Kontaktmesse”, where representatives from industry come to the university to exchange information. Some additional activities in this direction were noted; the committee recommends they be continued and intensified.

7.2 International

The faculty of physics in Hanover is at the forefront of internationalisation in Germany. About 10% of the students go abroad for their studies, mostly for a year, and they are given very good support. Recognition of credits from other universities poses no problem, and usually the time spent abroad does not lead to a considerable delay.

Generally speaking, good support is also given to foreign students coming to Hanover. Courses are held in English to enable students who do not speak German fluently enough to follow them. Within the SOCRATES/ERASMUS institutional contract with the European Commission there are as many as 22 bilateral agreements in physics with foreign universities. However, an essential problem in the exchange programme is the fact that the university cannot provide all foreign students with accommodation. The committee considers that this fact unnecessarily creates a very serious additional burden for the Faculty of Physics which should as soon as possible be taken over by the central authorities of the university.

8 INTERNAL QUALITY ASSESSMENT AND MANAGMENT

No institutionalised system for regular quality assessment of courses, of curriculum phases and of the curriculum as a whole exists, although in the past a more formal grading of lectures was performed occasionally. In the course of the preparation of the self-study report an evaluation of the physics education in Hanover by means of questionnaires for students, graduates and teaching staff was carried out. Useful information was gathered.

The opinion of students concerning the various courses and the way they are taught is only known, if at all, on an informal level. Some lecturers monitor student progress in their course and the adequacy of their teaching methods by means of individual questionnaires or discussions. What is done with the results is not clear. In such a situation, staff members may well rate their teaching performance more highly than the students do. Furthermore, the absence of a regular assessment system does not make for an atmosphere in which it is normal for teachers to try and improve their teaching performance by, for instance, doing dedicated teacher-training courses.

No formal record of the teaching merits of the individual members of the staff is kept, so it appears that the assessments have no real consequences for their careers either. Such a record would be particularly useful in the German academic career system, where permanent positions can only be obtained at a university different from the one where the “Habilitation” degree has been obtained.

The faculty is experiencing a high dropout rate, especially at the beginning of the first year. This is for a large part attributed to the phenomenon of “Scheinstudenten”, students who have enrolled without any real intention of studying physics. This makes it difficult to monitor students’ progress rates meaningfully in the first year. Student progress is monitored by examinations and tests and, sometimes, within individual courses. However, possible obstacles in the curriculum on the course level do not appear to be identified in this manner. The monitoring of the total duration of study of students in the past has apparently led to modifications in the curriculum. The initiative mentioned in the first paragraph of sec. 6.2 should also be helpful in this respect.

The committee encourages the faculty to proceed in the direction of a systematic assessment procedure and a systematic collection of data on student progress.

9 SUMMARY OF WEAK AND STRONG POINTS; MAIN RECOMMENDATIONS

The physics programme in Hanover is on a high level. The faculty traditionally has a strong position within the University of Hanover and thus could avoid even more debilitating cuts as a consequence of the "Innovations-Offensive". The committee also formed the impression that the current evaluation produced an awareness of some problems that are now being dealt with. What is especially impressive are the very good facilities and resources of the faculty, which in some cases are used too little by students.

Another strong point is the level of internationalisation and the support given to incoming and outgoing students alike.

As to the programme, better co-ordination with the Faculty of Mathematics and Computer Science appears to be needed. The training in computer skills is well below standard. Mandatory courses in economics, law or social sciences would improve the preparation for the job market and the awareness of the social problems connected with physics and technology.

In addition, more contact to possible employers and to alumni would give students a better impression of the requirements of business and industry. More project work inspired by problems in industry and more opportunities to do external practical work would also be desirable. The job market for physics students is very diverse, and the faculty should not concentrate on educating students mainly for research. In this context, systematic evaluation among graduates should be carried out as a basis for adapting the programme to the requirements of business and industry.
Whether the faculty has the means to reduce the length of study is unclear; no real solutions have been found and perhaps they are not being sought too strenuously. The "Freiversuch" is a step in the right direction.

The efforts to establish early contacts between secondary-school students and university physics, some of them directed specifically at female students, as well as the efforts to assist secondary schools in improving science education are considered highly commendable and may contribute to halting and reverting the decrease in the number of incoming students.

The informal counselling system seems to function well, but monitoring of students would be desirable in order to develop an awareness of problems that emerge during the course of study and of the reasons for students dropping out. To that end, extending the institutionalised tutoring system is recommended.

More openness towards education research and training in teaching methodology is desirable. The need for skilled teachers does not end when a student moves from secondary school to university. Teaching in general should be given more weight compared to research, if not on a national basis then certainly on the faculty level. Experiments with new teaching methods, using new media, are also recommended.

Attention to oral and written communication is more than adequate; the seminars are a praiseworthy example.

COMMENTS BY THE FACULTY

The Faculty of Physics at the University of Hanover appreciates the large effort put by the peer committee into this *Cross Border Quality Assessment of Physics Teaching*. The future development of physics education at the University of Hanover will benefit from our self-understanding in the internal review procedure leading to the self-report as well as from the findings and comments of the peer committee. However, the whole assessment procedure would have been more effective and the report could have reflected our study programme more adequately, if the evaluation procedure had included a final discussion of the committee with members of the faculty.

We appreciate that the report mentions the important role which the field of physics plays in human culture.

The aims and objectives of an academic study programme of physics are summarised by the committee consistently with our own understanding. We see, as the committee does, the necessity for making choices in curriculum design: We position our curriculum towards a fundamental educational profile. Our study programme is meant to form personalities who are able to think scientifically, to work independently and creatively and to participate in team efforts and in interdisciplinary co-operations. We emphasise more the training of the potential of students for further academic growth after the study than the teaching of specialised qualifications which graduates are trusted to acquire with some ease in a given employment situation. In contrast, the committee seems to focus more on the short-term needs of prospective employers; we do not believe that this attitude is beneficial for our students in the long-term perspective.

Structural changes of the curriculum require a complex legal process. Furthermore, our curriculum has to remain compatible with the corresponding ones at other German universities. On those grounds, we shall leave the current legal framework of our curriculum untouched. We shall also preserve the current role of the diploma thesis; it adds the aspect of research training to the curriculum, to be judged by its own standards. Nevertheless, the recommendations of the committee are taken to improve possible weaknesses of the curriculum for the benefit of students as follows:

- The content of the first-year mathematics courses will be discussed with the Faculty of Mathematics and Computer Science which teaches them.
- The introductory lab courses will get improved within the limitations of the existing financial and man-power resources.
- In the amended study information for students, special recommendations on non-physics electives will be included and the need for acquiring language abilities and programming skills will be emphasised.
- The experience with the new study programme *Technical Physics* may create additional changes in the assessed curriculum.

A curriculum has to have a sensible formal structure; but its success depends strongly on the co-operation of the people involved, of those who teach and of those who learn. Our curriculum is based on academic freedom. Hence, both teachers and students share the responsibility to accomplish its goal. Teachers have to be competent for their assignment. They are expected to be dedicated to the area of teaching and research they represent, and they are expected to care for the benefit of students. Students are expected to be motivated, willing to make independent and self-responsible decisions when adapting the flexibility of the curriculum to their own interests and needs. However, academic freedom does not mean that students are left alone with the problems of their study; they get guidance whenever needed or necessary.

FACULTY OF APPLIED PHYSICS AT THE "UNIVERSITEIT TWENTE", ENSCHEDE, THE NETHERLANDS
Date of Visit: 19/20 October 2000

1. ORGANISATIONAL STRUCTURE

The University of Twente (UT) was founded in 1961 as a university of technology. It is divided into ten faculties. The total number of students is approximately 6000, of whom 6 - 7% (about 400) are in the Faculty of Applied Physics.

A 1997 Act of Parliament changed the governing structure of Dutch universities, enabling the UT to effect substantive changes. The new law - “Modernising University Governance Structure” (MUB) - abolished the collective decision-making bodies that emerged in the early 1970s, replacing them with a system of “individual responsibility” and advisory bodies. Under the old system, the university council and executive board formed the highest budgetary and decision-making authority in the university. The council has been abolished, so the highest university authority is now an external board of trustees. The five-person board approves the budget, articulates strategic policy for the university, and appoints members of the executive board. The trustees are appointed by, and accountable to the minister for the overall governance of the institution.

Authority within the university rests with the executive board, comprised of a chair, vice-chair, and the rector magnificus. The chair is responsible for overall co-ordination, strategy and personnel policy, the rector for education and research, and the vice-chair for financial affairs, infrastructure and operational matters. The rector is appointed from among the university professors, while the two other members are usually outside appointments. The executive board appoints the faculty deans, with input from the members of each faculty. A faculty dean assumes full responsibility as the top functional executive of that unit. Deans are accountable to the executive board and can be removed by the board for unsatisfactory performance.

The executive board and the deans together form the university management team (MT), an advisory body that deals with major strategic issues. The MT meets every three to four weeks, depending on the issues at hand. Major decisions by the executive board are only taken after consultation in the MT.

There are participatory governing structures for personnel and students, notably the central personnel council and central student council, which may call a common central meeting on issues of mutual concern. The two councils have different legal roles and responsibilities, but they basically play an advisory role. This is in stark contrast to the past, when central and constituent-level councils operated as joint (and often conflicting) decision-making bodies.

The Faculty of Applied Physics has 11 chairs:

1. Systems and Control Engineering
2. Biophysical Techniques
3. Optical Techniques
4. Laser Physics
5. Low Temperature Physics
6. Solid State Physics
7. Computational Materials Science
8. Integrated Optical Microsystems
9. Rheology
10. Heat Transfer and Fluid Dynamics
11. Computational Dispersion Rheology

After the MUB came into effect, the Faculty of Applied Physics organised its education as follows:

The education is organised within the Faculty Institute for Physics Education (INO), led by a director of education. The dean appoints this director of education after the approval of the university executive board, for a period of five years. The dean delegates his tasks and authority concerning the organisation of the education, and his responsibilities concerning the execution of the education to this director of education. The director of education thus operates under the responsibility of and in close co-operation with the dean.

The tasks of the director are administration and organisation of education, and the execution of the curriculum in agreement with the education and examination regulations of the faculty (OER). Furthermore, he is in charge of the Institute for Physics Education and he co-ordinates the teaching assignments of all the staff of the faculty. He is responsible for the budget allocated for education. The director of education is responsible for all technical matters in the education (timetable, facilities) and for the recruitment of incoming students, the provision of information to secondary-school students and to university students and for the counselling of students. He advises the dean on the OER, on the system of internal quality assessment, on the results of external quality assessments and on the developments in physics that may be relevant to education. He evaluates the quality of the teaching performance of the staff members, except the professors, and reports on this to the relevant chair holders. He is a member of the committees for the hiring and appointment of new academic personnel.

Members of the INO are the professors and all the staff involved in teaching, the teaching supporting personnel and the student assistants. The dean sets up a management team (OMT), which is guided by the director of education. One member of the OMT is a student.

The director of education establishes a periodic evaluation committee (PEC). This committee is composed of one student adviser, the faculty educational expert and three students, nominated by the SOTN: the student consulting group. The SOTN is an official body within the faculty that organises for example students' participation in committees and councils. The PEC reports to the director of education, after having asked for the reaction of the teachers involved.

The educational advisory committee (“Opleidingscommissie”) consists of eight members: four staff members and four students. Its main task is to advise the dean and the director of education on all matters concerning education. Its existence and composition is prescribed by law.

The professors deliberate within the official chamber of professors, chaired by the dean. The director of education is a member of this chamber.

The establishment of the function of director of education, with responsibility for the organisation, execution and quality assessment of the education at Twente University is considered by the committee a good development. In this structure it is clear who is responsible and who can and must take initiatives. Furthermore, more professionalism may develop in the organisational and teaching aspects of education. The director of education has the important task of enthusiastically involving his or her staff members in all matters concerning education. For this purpose, he or she must possess the necessary authority and competence in educational and organisational matters to take full advantage of this structure.

The committee has noted, however, that a relatively large number of committees and functionaries have been established and have some authority in the organisation and assessment of the education. This large number does, of course, entail the risk that the responsibilities are only subtly different for the various actors and therefore give rise to unnecessary ambiguity. The committee therefore advises the faculty to give more authority, on behalf of the dean, to the director of education, so that he/she can arrange a simple, efficient and effective management structure for the INO, within a general framework given by the faculty. For this to be effective, the director must indeed be given the necessary authority.

2 AIMS AND OBJECTIVES

The Faculty of Applied Physics formulates its aims as follows:

Main goal of the programme is to educate physics engineers who achieve, in context and at academic level, the following competences:

- *the ability to conduct scientific research with the emphasis on applications*
- *the ability to develop measurement methods and instrumentation within physics and other disciplines*
- *the ability to model physical systems and instrumentation for industrial applications*
- *the ability to conduct fundamental research*

The Applied Physics educational programme prepares students to develop both scientific and design skills. The programme is thus aimed at acquiring knowledge of the basic theories of physics and mathematics, a more thorough knowledge of one or more professional fields within physics, knowledge of technology and design and practical skills in working with measuring instruments and experimental techniques. The study programme also includes courses in the fields of philosophy and social sciences. These are intended to provide the student with insight into the coherence between the various fields in science and the relationship between science and society. Although a certain measure of specialisation is called for, the educational programme is first of all intended to educate engineers who can operate competently, creatively and successfully in a large number of areas. (self-report, p.4)

The aims and objectives are clearly stated. They imply a strong orientation towards a career in industry and contain additional qualifications beyond physics and engineering that can be useful for such a career. The faculty positions its programme towards the applied and engineering end of the spectrum of possible qualifications.

Though there is not much experience yet with the new five-year programme (the first few students just finished), there is some doubt as to whether it can be completed in the allotted time by students of average talent and diligence. It should be pointed out, however, that Twente spends a considerable amount of effort on collecting data on study progress and causes for delay, as well as on measures that may improve the situation.

If one takes for granted the fact that different students have different interests and skills and also different wishes as regards the knowledge and skills they want to acquire, it is understandable that there are students (and staff members) who are dissatisfied with the programme: some consider it too applied and others not technical enough, etc. The lack of motivation expressed by some students in their second and third year may also be an indication of this. In part this is unavoidable. However, the faculty might consider allowing for more flexibility in the programme, and not expect all "educated engineers" to "operate competently, creatively and successfully" in the same "large number of areas" immediately after graduation.

3 PROGRAMME

3.1 Structure

The Applied Physics programme is currently undergoing changes following the general philosophy of the university. Starting with the 1995/96 academic year, a five-year programme has been introduced. The programme contains 210 study points, i.e. about 8400 hours of study. It is divided into a propaedeutic first year (P-phase), a second phase in the second and third year (D1/D2) and the final phase in the fourth and fifth year (D3/D4). Moreover, in the academic year 1999/2000, a major/minor system was introduced with 21 study points reserved for the minor, an elective subject outside physics and physical technology.

The implementation of a Bachelor/Master system in the sense of the Bologna declaration is currently under discussion and a gradual transition towards it is under way. One of the issues is the place of the minor in the Bachelor/Master system. Should it be placed in the Bachelor or in the Master phase? It is the opinion of the committee that a rigid standpoint in this discussion is not in the interest of students nor of the faculty. Some flexibility might be incorporated here. For students who remain in Twente after the Bachelor phase, the place of the minor is not very important. For students who wish to continue with a Master's programme at another university, the type of programme they intend to follow and the knowledge and skills expected of them there could be the deciding factor; similar considerations could be applied to students coming to Twente with a Bachelor degree from elsewhere. For students who leave university after the Bachelor phase, their interests and the qualifications sought could be decisive.

3.2 Contents and Methods

The committee was impressed by several projects produced at the end of the P-phase, based mostly, but not exclusively, on knowledge from secondary-school physics. These introduce students to the methodology of experimentation, teamwork, data management and communication. It is considered a positive point that projects are also assigned in the second and third year, where they serve to integrate students' physical and technical knowledge and where students are trained in a number of skills such as communication, information gathering and presentation.

In the year D2, all the physics courses are either lectures or laboratory courses. The committee recommends the introduction of exercises in this part of the programme as well.

The faculty decided to concentrate on three major fields of physics pursued in Twente: materials science, fluids and optics. There is an effort to cover these three areas very thoroughly. It might be useful however to reduce the range of topics somewhat and deal with some subjects in more depth, using a variety of approaches and teaching techniques. Students could then be given some choice in the areas they wish to emphasise.

The overall balance between ex-cathedra lectures and exercises/laboratory courses designed towards developing problem-solving skills is considered by the committee to be reasonably good. The option of taking elective courses is postponed to the fourth and fifth years. The committee recommends the introduction of some electives (possibly from limited and coordinated alternatives) even earlier, to increase the motivation of the students.

The committee also noted with approval that for all courses textbooks in English are recommended and are used as guidelines.

The committee recommends increasing the number of exercises devoted to quantum mechanics, which is indispensable for the understanding of modern solid state physics, a discipline of enormous technological importance and one which is also prominent in the Twente research effort. The ten hours of exercises actually offered are probably insufficient to familiarise all but the brightest students with the concepts and methods needed in modern solid state physics. The committee notes, however, that some theoretical methods usually introduced in courses on quantum mechanics or electromagnetism are dealt with in Twente in other courses, such as "Technical Transport Theory".

Of the three areas of concentration the committee could only consider "materials science" in more detail. There is a good introductory course on solid state physics offered in the third year (3 study points, i.e., about 120 hours). This course is followed by an engineering course in materials science (2.5 study points). This feature, still not common in European physics programmes, is appreciated by the committee, as it provides an introduction to a nowadays well established interdisciplinary research field touching upon physics, chemistry and engineering. Later on in the curriculum an extraordinarily large choice of elective courses is offered, connected with the widespread research activities of the solid state physics and low temperature physics chairs.

Finally, the peers stress the importance of the external traineeship, a mandatory part of the fifth-year programme, in which students gather experience useful for professional life in industry over a period of three months.

TABLE 1: PROGRAMME

1st Year of Study Programme

No.	Course Unit	A	B	C	D	E
1	Introd. Mechanics.	15	25	0	40	0
2	Introduct. Heat & Thermodyn.	15	25	0	60	0
3	Dynamics	25	50	0	105	0
4	Electricity & Magnetism	35	50	0	95	0
5	Designing in Engineering Physics	5	25	0	20	30
6	Calculus I	20	25	0	55	0
7	Linear Structures	25	25	0	70	0
8	Calculus II	20	25	0	75	0
9	Analysis A	20	30	0	50	0
10	Maple	0	0	20	20	0
11	Practical course	10	10	140	140	0
12	Propaedeutic project	0	0	0	0	120
13	Phil. & Soc.Sciences	50	0	0	110	0
14	**total**	**240**	**290**	**160**	**840**	**150**
15	**sum total**			**1680**		

2nd Year of Study Programme

No.	Course Unit	A	B	C	D	E
1	Phys. Modeling & Control Eng.	10	35	25	70	0
2	Introd. Optics	25	20	25	90	0
3	Thermodynamics	20	20	0	80	0
4	Intr. Quantummech.	20	10	0	90	0
5	Transport Phenomena 1	25	25	0	70	0
6	Classical Mechanics	15	15	0	70	0
7	Analysis B	0	25	0	55	0
8	Linear Analysis	15	15	0	50	0
9	Analysis C	10	10	0	40	0
10	Computer Programming Java	0	10	25	65	0
11	Applied Instrumentation	5	25	30	60	0
12	Practical course Optics	0	0	50	30	0
13	Practical course Simulation	0	0	50	30	0
14	D1-project	0	0	0	0	120
15	Communication skills	10	0	0	50	40
16	Phil. & Soc. Sciences	25	0	0	75	0
17	**total**	**180**	**210**	**205**	**925**	**160**
18	**sum total**			**1680**		

3rd Year of Study Programme

No.	Course Unit	A	B	C	D	E
1	Applied Quantummechanics	45	0	0	75	0
2	Statistical Physics	25	0	0	75	0
3	Intr. Solid State Phys.	45	0	0	75	0
4	Electromagnetic Fields & Waves	45	0	0	75	0
5	Physical Signal Analysis	20	0	0	60	40
6	Materials Science	40	0	0	50	10
7	Transport Phenomena 2	40	0	0	50	10
8	Technical Optics	20	0	0	40	40
9	Partial Differential Equations	25	25	0	70	0
10	Numerical Methods	20	10	20	50	0
11	Pract. Digital Methods	0	0	50	50	0
12	Pract. Computer Instrumentation	0	0	35	45	0
13	Pract.Signal Treatment	0	0	35	45	0
14	D2-project	0	0	0	0	120
15	Information acquirement	20	0	0	40	40
16	Phil. & Soc. Sciences	25	0	0	75	0
17	**total**	**370**	**35**	**140**	**875**	**260**
18	**sum total**			**1680**		

4/5th Year of Study Programme

No.	Course Unit	A	B	C	D	E
1	Subjects related to Thesis work	est. 80	0	30	180	30
2	Electives Physical	est. 40	0	0	120	0
3	Electives Technical (incl. Phys.)	est. 40	0	0	120	0
4	Electives (free choice)	est. 100	0	0	280	100
5	Multidisciplinary Design Project	0	0	0	0	240
6	Industrial training	0	0	0	0	560
7	Thesis work	0	0	0	0	1440
8	**total**	**260**	**0**	**30**	**700**	**2370**
9	**sum total**			**3360**		

A: contact hours: lectures

B: contact hours: exercises

C: contact hours: other supervised study activity (laboratory courses)

D: hours of study time for personal assimilation of course material

E: project

Note: In this table, sessions of 45 minutes are counted as one hour.

3.2.1 Mathematics / Other Basic Sciences

25 study points are reserved for mathematical subjects during the first three years. The peers were satisfied both with the amount and the quality of the introduction to this important tool for physics engineering.

The interdisciplinary subject "Materials Science" is the subject of an obligatory course; other basic sciences can be taken as electives. The committee is satisfied with the faculty's attention for interdisciplinary subjects and the built-in possibility to study other basic sciences.

3.2.2 Non-Technical Subjects

Every student has to take 14 study points in philosophy and social sciences. This strong emphasis on non-technical subjects is in accordance with the general philosophy of the university. However, some doubts were raised as to the quality of these courses, which are often not very challenging for the students.

3.2.3 Computer Skills

The teaching of computer skills is given a high rating by the committee.

3.3 Theses

The thesis is a written report on the graduation project. It is worth 36 study points and is extended over a time span of 9 months in the 5-year programme. The examples shown were at the forefront of science as to their research content, whereas the description and critical discussion of what is known about the subject seems to have been given less attention.

3.4 Examinations

Oral examinations are quite rare in the first years, which the committee considers a weak point. They are a good means of getting feedback from students and they provide the opportunity to discuss topics that cannot be sufficiently covered by a written examination. The committee therefore advises the faculty to introduce oral examinations for a few subjects in the first years.

Examinations are held regularly during the course of study, but not at the end of the programme. This is typical of Dutch universities and deviates from the situation in the other faculties in the Cross Border Assessment. The faculty may consider the option of organising comprehensive oral examinations for a group of courses.

3.5 Study Load

The total study time is estimated to be roughly 8400 hours, of which 3340 are intended for individual study. A detailed list of the distribution between different items is given in Table 1.

3.6 Overall Assessment

The programme is coherent and well-designed, with considerable emphasis on applied subjects and the development of problem-solving abilities and design skills. Much attention is paid to project work in teams and to non-scientific subjects of relevance to future professional work. This means that the core curriculum in physics is reduced appreciably compared to the other universities visited, but not to an extent that the minimum requirements are endangered. The choices made in designing the curriculum imply that the programme is less attractive to students interested mainly in fundamental physics, and a number of them leave to continue their studies at universities with a more fundamental physics curriculum.

Though the choice of profile by the faculty is a legitimate one, of clear relevance to the segment of the job market graduates are being prepared for, some questions remain as to the specific choices embodied in its implementation in the curriculum. In view of the broad scope of the fields of physics and the related engineering disciplines, and the limited time available, one must rely on the ability of students to acquire knowledge about fields not covered by the curriculum through independent study after they graduate; in fact searching the literature and other sources of information to help solve specific problems is explicitly practised in some of the projects, and of course in connection with the thesis work. However, the criterion “easily learned after graduation or in the graduation project” could be given even more weight in the selection of obligatory courses. In the view of the committee it would be advisable to select somewhat fewer subjects and deal with those in somewhat more depth, tackling them using a variety of approaches and teaching methods, including exercises and laboratory courses. This might also mitigate the problem that many students experience the programme in the second and third year as insufficiently intellectually challenging.

Of particular concern is the small amount of time devoted to quantum mechanics, especially in exercises. The obligatory programme in quantum mechanics makes it very hard for students to arrive in subsequent electives at a good understanding of modern concepts in the physics of the solid state, an area for which quantum mechanics is becoming even more important as the miniaturisation of electronic devices proceeds apace.

The students are provided with good information about employment prospects and the expectations of future employers. In this and other aspects the programme offered by the faculty is well supplemented by the very active students’ association “Arago”, which receives a lot of support from the university.

The critical remarks above should not detract from the very positive overall impression the committee obtained. The adjustments suggested might take the form of somewhat more choice between fundamental and technological subjects in the third year; this might appeal more to some of the students who are now less satisfied, or even leave, and thus contribute to a somewhat more diverse body of students without unduly influencing the “recognisability of educational profile” the faculty is aiming for.

4 STAFF

The academic staff falls into four main categories:

- full professors ("hoogleraren")
- associate professors ("universitaire hoofddocenten")
- assistant professors ("universitaire docenten")
- research assistants or Ph.D. students ("assistenten in opleiding / onderzoekers in opleiding")

A typical academic career in the Netherlands is described in Appendix 1.

TABLE 2: ACADEMIC AND NON-ACADEMIC STAFF

NUMBER OF PERSONS AND FULL-TIME EQUIVALENTS (in brackets)						
HL	UHD	UD	AIO/OIO	Other academic staff	Total academic staff	Non-academic staff
16 (11,1)	10 (9,7)	29 (28,7)	35 (34,1)	33 (27,9)	123 (111,5)	139 (82,6)

Other academic staff includes lecturers (industry) teaching part time.

The qualifications of the academic staff are more than adequate, and the staff is large and diverse enough to cover all areas of the physics curriculum. However, attention needs to be paid to ensuring that a sufficient number of theoretical physicists active in research will be available to teach theoretical courses in the future as well. The diversity of the staff is a positive point, as several of them have backgrounds in industry or worked previously as secondary-school teachers.

The staff is also in a period of transition. New, young professors have been appointed who are forming new research groups, and in the course of so-called “human resource management” older staff members are encouraged to retire early. This rejuvenation of the staff is proceeding very smoothly and is paving the way for curricular innovations.

All the staff members are involved in teaching, but full professors do not teach in the first year. The committee considers this a weakness. To motivate students it is necessary to convince them that the subjects taught in the first year are related to active areas of research and are not just dead subjects, finished decades or even centuries ago. Active researchers, especially senior ones with a broad overview of their field, are uniquely qualified to convey such an impression. Another problem is that course assignments are not regularly rotated: staff members often teach the same course for many years. The committee noted with approval that this once extremely rigid system is changing, albeit slowly.

All the academic staff can be trained regularly in educational skills by the “Dinkel” Institute and teaching skills are given considerable weight in the appointment and promotion of staff members, together with research and management skills. Records are being kept of the participation in the courses organised by the Dinkel Institute. This could be the beginning of the introduction of official records for every individual staff member which contain data concerning the teaching tasks carried out, their quality, reflection on them, etc. Such a record could be helpful for their career prospects, especially if they wish to move to another university.

The junior staff is involved in teaching and research to an equal extent. They are supervised by professors in their separate research groups. The junior staff meets regularly and discusses possible improvements of teaching methods. The director of education is a member of all the appointment committees.

The committee noted with approval that on December 1, 2000 a female professor was appointed (in the field of biomagnetism). This is considered important: the female (Ph.D.) students have a role model.

5 FACILITIES AND RESOURCES

The facilities and resources of the faculty are more than adequate and up-to-date. The only point of criticism is that neither the library nor the computer facilities are accessible after hours. The lack of rooms for individual or group work was noted, but apparently there is no need for them. A combined bar and computer room is run in the basement by the students´ association ”Arago”.

6 STUDENTS

6.1 Attainment Level and Selection

The general attainment level of students registering in Applied Physics is very good, as shown by the marks in secondary school for physics and mathematics. There is no entrance selection for Dutch universities. Selection takes place during the propaedeutic first year (P-phase). When students wish to or have to drop out, it is advantageous for them to leave before February 1 of the first year.

6.2 Student Numbers

As can be seen in Table 3, the number of first-year students is in decline. The reasons for this are unclear. The university holds open days for secondary school students to advertise its faculties, and students find these very helpful in deciding on Twente as a university.

The number of female students remains very low. As yet, no solution to this mainly cultural problem has been found. There are special open days for female secondary-school students, hosted by female students. Also, secondary schools are undergoing changes. By introducing more project work, physics and other sciences should be made more attractive for female students as well.

As reasons for choosing Twente to study at, besides it being the nearest, students mention the atmosphere of the campus, which they were able to experience at first hand during the open days, the university's good name and the emphasis on social sciences and philosophy. Also, few universities offer applied physics. Apparently, the first choice was for applied physics and the second one for a particular university. The fact that students have easy access to teachers was also mentioned. None of the students, however, claimed to have chosen Twente because of its high scientific standards. More of the publicity could be devoted to this aspect.

TABLE 3: STUDENT NUMBERS 1996-2000: FIRST-YEAR AND TOTAL

NUMBER OF FIRST-YEAR STUDENTS														
TOTAL					FEMALE					FOREIGNERS				
1996	1997	1998	1999	2000	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
98	101	67	81	59	6	8	6	11	7	12	8	10	16	11

TOTAL NUMBER OF STUDENTS														
TOTAL					FEMALE					FOREIGNERS				
1996	1997	1998	1999	2000	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
432	412	399	403	400	34	31	34	37	42	12	8	10	16	11

As first-year students, students enrolling for the first time are counted. The years refer to academic years, thus 1996 = 96/97.

Foreign students are students of foreign nationality and a foreign qualification for admission to higher education.

6.3 Counselling and Feedback

The student counselling system is very effective, though mostly dependent on students' own initiative. Every student has a tutor or mentor with whom he or she should have regular contact. The mentor is informed about all the examination marks of his/her students. One staff member has the particular task of co-ordinating the mentors' activities.

In general the teaching staff are very accessible to students. They are also very open to feedback and questions. For each course, a so-called response group exists in which some students discuss the course together with the teacher. This seems to work quite well.

6.4 Duration of Study and Completion Rates

The overall length of study is a point of concern. For the five-year programme, no reliable data as to the real length is available, since only three students have graduated from that programme so far, these being the only ones who finished their studies within the nominal period. The high dropout rates (around 50%) and the considerable delay in the D1/D2-phase - and to a lesser extent the P-phase - point to the conclusion that the average duration of study will be six years at least (see Table 4). In the second and third year, students tend to spend less time than assumed in the programme on their studies and the overall motivation appears low. Making these years more interesting to students proves to be difficult but is considered important.

A comparison of the dropout rates of Twente with those of the other faculties in the Cross Border Assessment is difficult because of the considerable uncertainties in the numbers of the other faculties. A dropout rate of 25-30% in the first year does not seem unreasonable, but the additional 20-25 who drop out during the later years give reason for concern. It became clear that a few of them continue a physics education somewhere else, for instance because they want to study physics in a more fundamental direction.

It is clear that the length of study of a relatively large number of students is too long according to the faculty's own criteria and those of the government in the Netherlands. However, the experience with the new five-year curriculum is only limited.

An excessively long duration of study is clearly not in the interest of the student, but the committee realises that the means that the faculty has to influence the length of study are limited, at least if one expects students to take responsibility for the way they organise their studies. The faculty must and can take care, however, to avoid unnecessary obstacles in the curriculum and its organisation. For instance, the level of the examinations must be adapted to the level of the courses and their organisation must be adequate. It is the impression of the committee that the faculty is working hard on these points. A second important point is probably more difficult: the faculty must take care to provide an inspiring learning environment so that the motivation of students remains high. Some students in the second and third year expressed their low motivation; therefore the committee thinks that improvement is possible in this aspect, for instance by allowing for more flexibility in the curriculum.

A lowering of the level of the contents of the courses beyond a certain minimum is not in the interest of students, not even of those who would not drop out as a result of this lowering. Furthermore, lowering the level is not expected to result in a significant reduction of the length of study.

TABLE 4: DROP-OUT RATES AND GRADUATES IN THE 1999/2000 ACADEMIC YEAR

FIRST-YEAR STUDENTS	DROP-OUT AFTER ONE YEAR	COMPLETION IN NOMINAL TIME	COMPLETION WITHIN ONE MORE YEAR	COMPLETION IN LONGER TIME
81	26%	8%	53%[1)]	39%[1)]

1) Graduates of the former 4-year programme

Completion percentages refer to the graduates in the academic year 1999/2000, drop-outs are first-year students of the previous year who did not register again.

6.5 Graduates / Job Prospects

Graduates are highly qualified academically as well as for the job market. They thus have few problems finding employment. Furthermore, it appears that this qualification will also mean an advantage in times when the job market is tighter than today. In general, preparation for professional life is good, especially since every student has to undergo an external traineeship. Evaluations among graduates have been carried out on a national level to monitor their success in the job market and possible weaknesses of the programmes. Information obtained from alumni is taken into consideration for improving the programme. Meetings on campus with graduates and potential employers are organised regularly, in particular by the Students' Association. This association also organises excursions in the Netherlands and abroad, financed in part by small projects done by students for industry. The university newspaper regularly provides students with information about possible employers.

7 EXTERNAL RELATIONS

7.1 Industry and Other Sectors of the Economy

Every full-time professor is expected to have connections with industry for the funding of research projects. Several part-time lecturers from industry are employed and some full-time staff members have worked in industry before. All students have to gather experience in professional life, and the graduation project can be done outside university, under the supervision of a professor. Even though many links with industry exist, the situation could still be improved. In particular, too few of the students' projects are designed for or inspired by the requirements of industry. It might also be conceivable to have smaller external projects during the course of the study in addition to the obligatory external traineeship.

7.2 International

The number of students going abroad during their studies is very high, but mostly as part of an external traineeship in a foreign country. Very few students go to a foreign university to study or to do their graduation project. These latter possibilities are not encouraged by the faculty members, who are of the opinion that this would always mean a delay in students' studies due to different curricula in foreign universities. The committee does not consider this to be true in general and would wish the faculty to give more encouragement to students to study abroad. Recognition of credits from other countries should not be a problem. However, the great interest in doing an external traineeship abroad and the participation, though limited, in the ERASMUS/SOCRATES programmes are noteworthy and a good sign that students appreciate spending some time outside the Netherlands. Another positive point is that some excellent students are given the opportunity to take part in international summer schools, which the university pays the costs of. To qualify, students should have passed all the examinations of the first three years within the allotted time; this is true for about 10% of the students. Twente University itself regularly hosts international summer schools and symposia.

Due to language problems, few students from abroad study Applied Physics in Twente. Foreign students mainly come to Twente to participate in a research project. The faculty lends all possible support to students from abroad, and there is a current debate on whether the entire D3/D4-phase should be taught in English, which would be a big step towards internationalising Twente University and making it more attractive to foreigners. More and more courses are given in English, thus facilitating the eventual implementation of the Bachelor/Master system, as suggested in the Bologna declaration. In Twente the Master's thesis is often written in English, and the Ph.D. thesis always is. This made a good impression on the committee.

8 INTERNAL QUALITY ASSESSMENT AND MANAGEMENT

Course and curriculum assessments are among the strong points of the faculty. A special committee within the faculty has been charged with carrying out an evaluation system with regular assessments of the courses using questionnaires (the Periodical Evaluation Committee: PEC). Furthermore, the faculty has appointed an educational expert. The results of the evaluation are made available to the director of education and the study programme committee after consulting the teacher involved if appropriate. In these questionnaires there is considerable emphasis on questions concerning the demands on the students. Less emphasis is put on the performance of the staff. For instance, questions as to whether the course or curriculum phase was inspiring were notably absent. Recently, response groups consisting of a relatively small number of students have been established to assess the courses in greater detail.

It is not clear whether the assessments using the questionnaires have many real consequences for the quality of the teaching of the courses and of the programme phases. It is our impression that adjustment of the courses ensues more as a consequence of personal conversations and of the response groups.

In Twente, opportunities to take a dedicated teacher-training course are amply available. No formal record of the teaching merits of the staff is kept, so it seems that the assessments have no real consequences for their career either.

The visiting committee recommends that the faculty continue the assessment of the adequacy of its education and of its study programme as a whole with surveys among graduates at different intervals after their graduation (W.O. monitor).

The faculty puts a lot of effort into the monitoring of the study progress of students, in relation to their past performance and in relation to the time they spend on their studies. To this end, information concerning the quality of the student intake and the results of all (preliminary) examinations are monitored. In this way a lot of useful information is obtained. However, the targeted success rate of 85% for the monitor groups of (preliminary) examinations in the second year and later may involve the risk that the level of courses and examinations decreases, whereas there may be reasons for a lower success rate other than excessively high requirements. For instance, it became clear that many students go through a phase of lower motivation during their second and third year (see also our remarks in ch. 3).

9 SUMMARY OF WEAK AND STRONG POINTS; MAIN RECOMMENDATIONS

In general, the Applied Physics programme at Twente University made a good impression on the committee. Many of the problems mentioned above are currently being dealt with and the prospects for the faculty are very good.

The programme certainly meets the minimum requirements set for physics, and the formulated aims are sufficiently taken into account, but the duration of study is still too long and the completion rate too low. More flexibility in the second and third year might help, but an overall solution is not yet in sight.

The national system of evaluation among graduates forms a basis for adapting the programme to the requirements of professional life.

The emphasis on practical work is exemplary and the external traineeship offers ample opportunities to come into contact with professional life early on in the programme. More international experience could be provided by encouraging students to do part of their study abroad. The mandatory courses in social sciences and philosophy are a strong positive point.

The staff is large enough to cover all the subjects and is sufficiently trained. Twente University is at the forefront of educational research and curriculum design, and the training in teaching methods is exemplary. The consideration given to teaching abilities is increasing, and staff members are no longer appointed for their research skills only. The Dinkel Institute, the INO and departments for education research and technology provide a good infrastructure for maintaining and improving the quality of education. Regular rotation in the teaching assignments would be desirable and full professors should also teach in the first year.

Students are encouraged to work independently. Their academic and technical level is good. The problem of motivating the students in the second and third year, however, remains to be solved. The counselling system appears to work quite well.

Attention is paid to making the programme more attractive to foreign students, and the present problems are being dealt with.

The quality control system is extensive, but not optimally designed for improving the quality of teaching or of the curriculum structure. A revised questionnaire for students as well as for graduates could further that objective. Teaching records should be established to be used in applications for new jobs, especially by junior staff members.

PART IV

APPENDICES

APPENDIX1: TYPICAL ACADEMIC CAREERS

Note: Since career prospects for junior staff are a major concern and national systems differ appreciably and may not be known in other countries, the committee thought it useful to sketch typical career paths for the countries involved.

1. A Typical Academic Career for a Physicist in Germany

Depending on the school system (in Germany the federal states ("Bundesländer") are responsible for cultural and educational matters), German children change from primary to secondary school at the age of ten or twelve. They leave secondary school around the age of 19 by passing an examination ("Abitur"), which qualifies them for university entrance. Some of them have to serve in the army or do community service as an alternative to military service, which takes about one year. A university education in physics takes five to six years and is finished roughly at the age of 24 to 26.

About half of graduates continue as Ph.D. students ("Doktoranden"), often at the same university. The doctoral degree ("Dr. rer. nat.") is obtained after a period of about three to five years, at the age of 27 to 31. The Ph.D. time is spent completely on research work. There are no further obligatory lectures; in general it is merely research seminars or colloquia that are attended. Usually, Ph.D. students teach exercises or laboratory courses, or support students working on their Diploma thesis.

After the Ph.D. there are various options. Some graduates leave university; others stay for a limited time, either as an assistant in a temporary university position or as a research associate ("Wissenschaftlicher Mitarbeiter") supported from external sources ("Drittmittel"). Such positions are limited to five years. Some also go abroad for a post-doctoral period.

The next step in a university career is the preparation for a further examination, the "Habilitation", which takes approximately four to seven years. The decision to go down this path can be made immediately after the Ph.D. project; in practice, however, it is made after roughly two years of research activities. At such a time the candidate is not yet too old to enter professional life, whereas starting a “Habilitation” procedure means a practically irreversible choice for a university career. During the qualification period the research work has to be intensified. It is usually arranged with a professor, but it should become more and more independent and includes applying for one’s own projects supported from external sources. In addition to the continuation of exercises or laboratory courses, training for academic teaching starts, e.g., by giving special lectures or taking over parts of the lectures of a professor. For this qualification period, a few special temporary positions (limited to a maximum of six years) are available, as well as special grants ("Habilitationsstipendien"). Very often candidates just hold regular assistant positions. For the final examination a thesis ("Habilitationsschrift") containing published research has to be written and two talks are required, a research oriented one and one on a subject different from one’s own research field, which is also judged from the point of view of teaching performance. Teaching skills are also assessed by a committee including students. After passing the “Habilitation” one can obtain the title "Privatdozent" (private lecturer), which, however, is not connected with a university position. It involves the right to hold lectures and to supervise theses. Only very few special positions exist for private lecturers, again with a time limit of six years.

Private lecturers are qualified for professorships. Their age after the habilitation is roughly 33 to 39. The only way to become a full professor, however, is to apply at another university and receive a call. Only full professors hold permanent positions, nowadays up to the retiring age of 65. Only a small proportion of "private lecturers" find a research position in an institute outside university (e.g., a Max Planck Institute) and continue to lecture at their home university.

2. A Typical Academic Career for a Physicist in Flanders

In Flanders, the average child enters secondary school at the age of twelve and leaves it six years later. At the age of 18 he/she can commence a course of academic study in physics. In order to study civil engineering on physics, one needs to pass an entrance examination. At the age of 22 to 24 one has graduated and obtained the degree of physics (four years of study) or civil engineering in physics (five years of study).

About half of the graduates enter the job market outside the academic field. The other half stay at – mostly their own – university. Some have special Ph.D. grants (four years), some are university assistants for six years and some have other types of contracts. As a rule these people have a task in education: they are involved in the exercises, supervise practical work,… On the other hand they have enough time for their own Ph.D. research and can get their degree within the four or six year period of their contract.

Postdoctoral fellows can stay at the university: they can enjoy externally funded grants or become a “doctor-assistent”. This possibility is created to avoid Ph.D. holders having to leave university.

The faculty board decides on vacancies in the professorate. Once the vacancy is made public, post-doctoral fellows can apply for the position. As a rule, one starts the professorship at the level of "docent". A "docent" is active in research and education and forms part of a department ("vakgroep"). This organisational unit includes professors, assistants and administrative personnel who are all involved with closely related subjects (e.g., solid state sciences).

After at least two years (but often more) one can be promoted to "hoofddocent". Tasks are similar but more responsibility in research and experience in education is expected.

Theoretically after being "hoofddocent" for two years, one could be promoted to "hoogleraar". Still more proof of excellence in research and education is required. The ultimate promotion is to "gewoon hoogleraar". Opportunities for promotion depend on the situation of the entire faculty.

There is no substantial difference between professors of the various degrees (from "docent" to "gewoon hoogleraar"). They all work independently and organise their teaching, research, applying for grants,… autonomously.

Very often the entire academic career is spent at the same university (from 18 to 65).

3. A Typical Academic Career for a Physicist in the Netherlands

A Dutch child leaves primary school around the age of twelve, and leaves secondary school at around 18. It takes five to six years to finish a university education in physics; this occurs roughly at the age of 23 to 24. Among graduates it is well known that a Ph.D. is a prerequisite for a scientific career. About half of graduates become Ph.D. students, to a large part at their own university. The number of Ph.D. students originating from Dutch universities has started to fall, both absolutely and in relative terms. Usually the doctoral degree is obtained after a period of four years, so at an age of 27 to 28.

During the Ph.D. most of the time can be spent on research. About 10% of the time is devoted to teaching tasks; mostly assistance with exercise or laboratory courses. Ph.D. students also obtain an advanced education in their research field, mostly in the form of summer or winter schools or of dedicated lectures.

Post-doctoral fellows in a Dutch university are usually assigned to do research, rarely to teach; mixed assignments do not often occur. They usually do not have the obligation to obtain research grants, although doing so sometimes helps to extend their post-doctoral position somewhat. However, for the past few years Dutch law no longer allows a temporary limited-time contract to be extended beyond five years without offering a permanent position.

After the Ph.D., physicists in the Netherlands are advised to leave university. Some take a job in industry (Philips, OCE, Shell...), some go abroad for a post-doctoral period, some leave fundamental or applied scientific research in physics, to go into consultancy for instance. A minority become secondary school teachers. Only rarely do they find a permanent university position at this stage in their career.

After two to four years of post-doctoral work, preferably abroad, or in a few cases after research in industry for two to four years, they may apply for a permanent position at a Dutch university. They then become "universitair docent" ("assistant professor"), a few of them "universitair hoofddocent" ("associate professor"). Their age is then 32 to 35 years. Both types of position typically involve research as well as teaching in a ratio of about 60% to 40%. They do not imply the right to supervise theses ("jus promovendi"). Both have to arrange their work with a professor, but a "hoofddocent" is more independent and may in fact already operate very much on his/her own. The arrangement between a professor and a "(hoofd)docent" as a rule mainly concerns research; in teaching there often is more independence, although the professor still retains some responsibility. A typical situation is that a professor (a chair) co-operates with one "hoofddocent" and one "docent". Management tasks and applying for research grants become more important over the years. Success in these activities is extremely important for one’s career. Promotion from docent to "hoofddocent" can take place at the same faculty. It occurs often, but not automatically. One can remain "(hoofd)docent" until retirement, which is usually not considered an unsuccessful career.

One can become a full professor by applying for a vacant professorship elsewhere. It is strongly discouraged for a faculty to appoint one of its own staff members to a chair, but it occasionally happens. If a "hoofddocent" is judged to have the stature to become a professor (is "professorable"), he/she is sometimes appointed without a vacant chair being available. Another possibility is to become a part-time professor at an other university. Another main route to becoming a professor is after a longer period of about 10 years in industry, e.g., Philips Research or Shell Research.

APPENDIX 2: AGENDA OF A TYPICAL SITE VISIT

Proposal for the Agenda of the Site Visit at the University of Duisburg 02 – 03/10/00

Eve

until 18.00 Arrival of the peers

18.00 **Preliminary discussion of the peer group**
Main topics: Analysis of the self-report, topics of the meetings

Afterwards: dinner

First day

09.00 **First meeting in the department/faculty: Dean, working group for the evaluation, directions of the institutes**
Main topics: Results of the internal evaluation, study and teaching in the subject, staff development, co-operations, developmental perspectives, equipment, management of teaching, communication and co-ordination within the faculty/department

10.00 **Dialogue with the members of the study board, examination board and the departmental advisory service**
Main topics: Curriculum, organisation of study and teaching management (day to day management), schedule of studies, contents and methods of teaching, counselling of students, organisation of examinations, success of study, quality assurance, internationalisation

10.45 Break

11.00 **Discussion with the responsible women's representative**
Main topics: Support for female junior scientific staff in teaching and study

11.30 **Meeting with students from different study periods and the departmental student organisation**
Main topics: Participation in the evaluation, aims and goals of the courses of study, curriculum, organisation and schedule of study, examinations, counselling of students, working conditions, study abroad

12.45 Lunch break and internal discussion of the peer group

13.45 **Meeting with non-professorial teaching staff (including graduate academic assistants engaged in teaching and contract teachers)**
Main topics: Contacts to professors and students, involvement in teaching and examinations, opportunities to obtain a further scientific qualification

14.45 **Meeting with professors**

Main topics: Teaching and management of teaching, contents and methods of teaching, interdisciplinary activities, internationalisation, examinations, communication and co-ordination, planning of the course of study, staff development, quality assurance

16.15 Break

16.30 Tour through the faculty/department

End at about 17.30

20.00 Dinner (peer group)

Second day

09.00 **One-to-one conversations of the peers with faculty/department or direction members**
This should be the opportunity to talk to members of the faculty, the direction and the administration. Topics from the first day can be gone into in depth, further questions can be asked and supplementary information can be discussed.

10.00 **Open hour**
This is the opportunity for all of those who want to talk with the peer group.

10.45 Transfer of the peer group from the faculty/department to the direction

11.00 **Meeting with the direction of the university**
Main topics: Developmental planning of the university, position of the subject to be assessed in the context of the entire university, the direction's opinion on profile and development perspectives of the subject, expectations linked with the evaluation of this subject

11.30 Transfer of the peer group from the direction to the faculty/department

11.45 Internal meeting of the peers to prepare the final meeting; lunch break

15.00 **Final meeting of the peer group with all interested discussion partners from the faculty/department and the direction**

End at about 15.30

APPENDIX 3: THE CHECKLIST

Checklist for a Comparative Analysis of the Physics / Civil Engineering in Physics Programmes

The information outlined in this list is intended to reflect a range of background and performance characteristics relating to physics/civil engineering in physics. The range of characteristics is not comprehensive and the information provided below must be interpreted in conjunction with other relevant and qualitative background information.

The purpose of this list is to provide basic information for a comparative analysis of physics/civil engineering in physics and a tool for the committee.

The checklist is based on the IPR-EE report and the "Minimum Requirements for Master´s and Diploma Study Programmes in Physics".

I. AIMS AND OBJECTIVES

1. Are the aims and objectives clearly stated?
2. Are the formulated aims and objectives realistic and achievable, considering constraints such as the nominal duration of the study and the initial level of students?
3. Are the formulated aims and objectives a good mixture of scientific orientation and practical orientation?
4. Do the formulated aims and objectives satisfy the minimum requirements?

II. THE PROGRAMME

1. Is the programme offered by the faculty coherent?
2. Does the programme enable graduates to identify and solve problems in society that can be addressed with the methods developed in physics?
3. Does the programme enable graduates to appreciate the possibilities of research in physics and to carry out independent research, e.g., in a subsequent doctoral study?
4. Is there a good balance between essentially reproductive learning and the development of problem-solving skills in the various phases of the curriculum?
5. Does the programme develop the ability to maintain professional competence through life-long learning?
6. Does the programme offer enough opportunities to work in an international context?
7. Are the requirements in mathematics adequate?
8. Is the mathematics programme well co-ordinated with the physics programme and adapted to the needs of physics students?
9. Are the requirements for the other basic sciences satisfactorily translated into the programme?

10. Is sufficient attention paid in the curriculum to non-technical subjects?
11. Are the laboratory experiences of the students satisfactory?
12. Are the students trained adequately in the use of computers?
13. Are the students trained adequately in the use of libraries and other sources of information (e.g., databases, Internet)?
14. Is the attention to written communication skills satisfactory?
15. Is the attention to oral communication satisfactory?
16. Is the range of optional subjects satisfactory?
17. Is the balance between core curriculum and electives satisfactory?
18. Are the students trained sufficiently in combining knowledge and skills taught in different courses for the purpose of solving problems?
19. Is the content of the programme up-to-date and regularly adapted to new developments?
20. Do programme and examination system enable the students to decide at a sufficiently early stage whether their choice to study physics is in line with their capabilities and interests?
21. Does the programme show the importance of industrial projects to a sufficient degree?
22. Is the course material (books, etc.) used in the programme up-to-date?
23. Is the level of the examinations satisfactory?
24. Do the examinations reflect the aims of the courses?
25. Can the majority of students finish the course of study in the nominal time?
26. Is the preparation for professional life outside university satisfactory?
27. Does the programme produce understanding of the socially-related problems which confront the profession?
28. Does the programme enable graduates to comprehend the ethical characteristics of research and professional activity in physics and the responsibility to protect public health and the environment?

III. THE FACULTY AND THE STAFF

1. Are the faculty's procedures for curriculum design adequate?
2. Are the faculty's procedures for examinations adequate?
3. Do the staff have sufficient interest in and understanding for the difficulties of students in mastering the contents of the courses?
4. Are the teaching methods sufficiently varied and are innovative teaching methods used to a sufficient extent?
5. Are the competence/qualifications of the academic staff satisfactory?

6. Is the current range of specialisations among the academic staff satisfactory (i.e., not too narrow and not too broad)?
7. Is the size of the academic staff large enough to cover all of the curricular areas of physics?
8. Is the balance between research and teaching responsibilities of the academic staff satisfactory?
9. Are course assignments rotated regularly among qualified staff members?
10. Are the career possibilities for junior staff satisfactory?
11. Are dedication to and skills in teaching given sufficient weight in the hiring and promotion of staff?
12. Are the arrangements for the training of academic teachers and for the development of teaching skills satisfactory?

IV. FACILITIES AND RESOURCES

1. Are the student teaching and laboratory areas adequate?
2. Is the equipment used predominantly for teaching purposes on the whole adequate?
3. Do students have the opportunity to work with modern research equipment?
4. Are the library resources available to staff and students adequate?
5. Are the computer facilities available to staff and students adequate?
6. Do the laboratory facilities reflect the requirements of the physics programme to a sufficient extent?
7. Are the facilities available to staff and students accessible after hours?

V. THE STUDENTS

1. Is the preliminary education of first-year students adequate?
2. Is the selection of students (if any) adequate?
3. Is the counselling system for students with unsatisfactory progress in their studies adequate?
4. Are students offered help with difficulties in individual courses?
5. Is there sufficient feedback between students and teachers in individual courses?
6. Is information supplied about job opportunities for graduates?
7. Do the graduates get a job very easily?

VI. EXTERNAL RELATIONS

1. Are the nature and level of the interaction between the faculty and industry and other potential employers satisfactory?
2. Are the nature and level of the interaction between the faculty and other faculties/departments of physics satisfactory?
3. Are the nature and level of the international contacts satisfactory?
4. Is there adequate participation in international programmes (e.g., ESPRIT, COMMETT, ERASMUS)?

VII. INTERNAL QUALITY ASSESSMENT AND MANAGEMENT

1. Does the faculty maintain a formal and systematic record of students' progress?
2. Does the faculty maintain a formal and systematic record of the initial employment of graduates?
3. Does the faculty have a good evaluation system, including evaluation by students?
4. Do evaluation results have consequences for the curriculum?
5. Do evaluation results have consequences for course contents, teaching methods and course assignments?
6. Does a good climate for regular quality assurance exist?

VIII. SUMMARY

1. Is the formulation of the aims and objectives and the transformation into the curriculum satisfactory?
2. Is the programme satisfactory and does it satisfy the minimum requirements?
3. Do size and qualifications of the staff satisfy the minimum requirements?
4. Do the qualifications of graduates satisfy the minimum requirements?
5. Are the external relations satisfactory?
5. Are the internal quality assessment and management procedures satisfactory?

APPENDIX 4: BIOGRAPHIES OF THE PEERS

Prof. em. Dr. Jules Deutsch

Born 1931 in Budapest (Hungary); 1961 Ph.D. in Physics at Université Catholique de Louvain, Belgium; 1961 - 62 Research Associate at Lawrence Berkeley Laboratory; 1961 - 64 Research Associate Institut Interuniversitaire des Sciences Nucléaires, Belgium; 1964 - 66 Assistant Professor at Université Catholique de Louvain; 1966 - 69 Associate Professor ibid.; 1967 - 68 Visiting Scientist CERN, Geneva, Switzerland; 1969 - 96 Professor at Université Catholique de Louvain; 1974 - 77 head of Nuclear Physics Department ibid.; 1977 - 80 Head of Physics Department ibid.; 1986 - 91 Member of the Academic Council ibid.; 1987 - 88 Member of the Executive Committee, ibid.; 1986 - 89 co-editor Zeitschrift für Physik; since 1996 Professor emeritus.

Prof. Dr. Frans H.P.M. Habraken

Born 1951, Netherlands; studied experimental physics at Utrecht University; 1980 Ph.D. on surface chemistry at Utrecht University; 1980 - 82 Research at Philips Research Labs Eindhoven; 1982 - 92 staff member of experimental physics groups, Utrecht University; 1989 - 92 chair on Physics of Chemistry of Surfaces and Thin Films, ibid.; 1992 - 2000 full professor for Education in Physics, ibid.; 1992 - 1998 (Vice)-President of Netherlands Vacuum Society (NEVAC); 1996 - 2000 scientific director of Julius Institute; 1996 - 98 chairman of Utrecht University Advisory Committee on the Quality of Education; since 1998 European editor of the journal "Applied Surface Science"; since 2001 full professor of Interface Physics and scientific director of Debye Research Institute, Utrecht University.

Prof. Dr. Klaus Lüders

Born 1936 in Cologne, Germany; 1962 Diploma in Physics at University of Karlsruhe; 1965 Ph.D. ibid.; 1965 - 72 Assistant and Assistant Professor at Free University of Berlin; 1972 Habilitation in Experimental Physics, ibid.; Since 1972 Professor of Experimental Physics ibid.; 1978 - 86 head of the Cryogenics Group in the German Physical Society.

Research visits at: Kyushu University, Fukuoka, Japan (1974/75, 1977); Jet Propulsion Laboratory, Pasadena, USA (1980); University of Basel, Switzerland (1986, 1995); MPI for Chemical Physics of Solid Matter, Dresden, Germany (1999); IFW, Institute for Metallic Materials, ibid. (2000).

Prof. em. Dr. Gunnar Tibell

Born 1930 in Glava, Sweden; 1952 B.Sc. at University of Alabama, USA; 1958 - 61 CERN Fellow and Research Associate; 1963 Ph.D. on "Investigations of Nuclear Structure and Interaction Symmetries with High Energy Protons" at Uppsala University, Sweden; 1971 - 72 visiting professor at University of Maryland, USA, as Zorn Fellow of the Sweden America Foundation; 1975 - 79 CERN Senior Physicist; 1982 - 95 professor of High Energy Physics at Uppsala University; 1989 - 95 President of the Swedish Physical Society; President of the Executive Committee of International Young Physicists' Tournament. since 1998; Prof. emeritus since 1995.

Prof. Dr. Urbaan M. Titulaer

Born 1941 in Venlo, Netherlands; 1958 - 65 study of physics at Utrecht University; 1964 - 73 Assistant at the Institute of Theoretical Physics, ibid.; 1965 Research Associate at Harvard University, USA; 1973 Ph.D. at Utrecht University.; 1973 - 75 Postdoctoral Fellow at Massachusetts Institute of Technology, USA; 1975 - 84 Assistant/Senior Assistant at the Technical University of Aachen, Germany; 1978 Habilitation ibid.; 1980 temporary full professor at Essen University, Germany; 1980 - 81 Senior Research Associate at Massachusetts Institute of Technology; Since 1984 full professor of theoretical physics at Johannes-Kepler-University Linz, Austria; 1985, 1997 Guest professor at Tokyo Institute of Technology, Japan; 1991 - 94 president/Vice-president of the Austrian Physical Society; 1993 - 96 Dean of the Faculty of Natural and Technical Sciences; Member of the University Senate since 1994.

Dr. Udo Weigelt

Born 1963 in Dachau, Germany; 1989 Diploma in Physics, Technical University of Munich, Germany; 1992 Ph.D. in Physics at the Ludwig Maximilian University of Munich; 1989-92 Research Fellow at the Max Planck Institute for Physics and Astrophysics; 1993-96 patent attorney trainee; Since 1996 European patent attorney and since 1997 German patent attorney and European trademark attorney; Since 2000 partner in the law firm of Grünecker, Kinkeldey, Stockmair & Schwanhäusser in Munich; Chairman of the Board of Industry and Economy of the German Physical Society; Member of the Applied Physics and Physics in Industry Interdivisional Group at the European Physical Society.

APPENDIX 5: PARTICIPATING EVALUATION AGENCIES

1. Zentrale Evaluations- und Akkreditierungsagentur Hannover (ZEvA), Germany

The Central Evaluation and Accreditation Agency Hanover (ZEvA) is a joint venture of the universities in the state of Lower Saxony. It was founded in 1995 as the Central Evaluation Agency according to a decision of the "Landeshochschulkonferenz Niedersachsen" (LHK) and is financed by the state government.

The universities and polytechnics of Lower Saxony have taken on quality assurance in education as a strategic task in order to give form to their autonomy and responsibility in the course of a state-wide evaluation of specific fields.

ZEvA's primary task is to ensure and improve the quality of education in the universities of Lower Saxony. To accomplish this, a state-wide systematic and periodic evaluation is being implemented. ZEvA organises and co-ordinates the individual evaluation procedures. It informs and supports all the participants within the universities in internal and external analyses and assessments of academic education in Lower Saxony.

Another task of ZEvA is to develop evaluation procedures further by co-operating in a national and international context.

In 2000, after establishing an independent section for accreditation, ZEvA was renamed "Zentrale Evaluations- und Akkreditierungsagentur" in accordance with a decision by the LHK in 1999. The aim of accreditation is to contribute to safeguarding the quality of higher education by setting minimum standards. The accreditation section co-ordinates and executes these procedures.

The development of higher education policy towards more autonomy, responsibility and the development of individual profiles, as well as the introduction of appraised study programmes with internationally comparable degrees, require new efforts in quality assurance from the universities.

More information about ZEvA can be found on http://www.zeva.uni-hannover.de

2. De Vereniging van Universiteiten VSNU, Netherlands

The VSNU, or Association of Universities in the Netherlands, is an organisation that represents the interests of fourteen Dutch universities. The principal goal of the VSNU is to strengthen the position of university education and research in society. For this purpose:

- the VSNU represents the interests of the universities vis-à-vis political, governmental and community organisations;
- the VSNU is an employers' organisation that negotiates with the government and with employees' organisations regarding working conditions of university employees;
- the VSNU develops activities to provide services to its members.

The VSNU is managed by a Board of Directors consisting of the chairmen of the Boards of the fourteen universities. The VSNU maintains a service office, managed by a director, with approximately fifty employees.

All of the universities are responsible for the quality of their own teaching and research. In addition to this internal quality control, the fourteen members of the VSNU are also involved in a system of external quality control: periodic evaluations of the teaching and research by experts from outside the institution. This external quality control is organised by the VSNU and complements the internal quality control. The purposes of quality control are to monitor quality, to improve quality, to report on teaching and research and to inform the 'outside' world.

So-called review committees, set up by the VSNU, screen all similar study programmes and similar research programmes at all of the Dutch universities, make a public report of their findings and submit recommendations. In short, they perform the following four tasks: evaluate, advise, inform and (to a lesser extent) compare.

As organiser of the evaluations, the VSNU sets up a review committee after consultation with specialists in the field. It provides the committee with a secretary, monitors the procedures to guarantee that they follow the protocol, and draws up the final report.

Each study programme is evaluated by a committee once every six years and each research programme is evaluated once every five years. In this way, the universities are stimulated to maintain, and wherever possible or necessary increase, the quality of their teaching and research (and the process on which it is based). The requested and unsolicited recommendations are, however, never binding. The institutions themselves are responsible for the nature and content of whatever action is undertaken.

More information about VSNU can be found on http://www.vsnu.nl

3. De Vlaamse Interuniversitaire Raad (Flemish Inter-University Council, VL.I.R.), Belgium

The Vlaamse Interuniversitaire Raad (Flemish Inter-University Council, VL.I.R.) was founded in 1976 as a result of a decree of the Flemish Parliament following an initiative taken by the Flemish rectors. The Council consists of members representing the Flemish Universities. They are: Katholieke Universiteit Leuven (Catholic University of Leuven), Limburgs Universitair Centrum (Limburg University Centre), Katholieke Universiteit Brussel (Catholic University of Brussels), Universiteit Antwerpen (University of Antwerp), Universiteit Gent (Ghent University) and Vrije Universiteit Brussel (Free University of Brussels).

The VL.I.R. promotes dialogue and co-operation among the Flemish universities, and between the Flemish universities and the respective authorities. It is a forum for consultation between the universities and their administrations. In addition, it advises the authorities on their policy on university education and scientific research. Furthermore, it provides services to the Flemish universities in matters such as quality assessment. It supports the universities in their individual efforts concerning quality assessment in order to contribute to qualitatively outstanding university education and scientific research.

The Council may establish working groups for specific purposes such as university administration and management (including personnel policy and finance), university education, quality assessment, co-operation with developing countries, etc. These working groups meet when necessary.

The VL.I.R. encourages the Flemish universities to act on an international level. The VL.I.R. supports co-operation between universities in Flanders and in developing countries; the participation of Flemish universities in European and international higher education and research programmes; co-operation between European rectors' conferences.

More information about VL.I.R. can be found on http://www.vlir.be

4. Geschäftsstelle Evaluation der Landesrektorenkonferenz der Universitäten Nordrhein - Westfalen (GEU), Germany

Established in 1997 to support the universities in all evaluation procedures, the "Evaluation Office for North Rhine Westphalian Universities" (GEU) works under the auspices of the rectors' conference of the 15 North Rhine Westphalian universities.

In 1996 the rectors' conference set up a team of representatives, the so-called "Arbeitsgruppe Evaluation“, with each university sending one representative. From 1997 to 1999 the GEU supported this working group in the development of a concept for the evaluation of teaching, learning and research in higher education. The results have been published in the following brochures: "Empfehlung zur Evaluation von Studium und Lehre an Nordrhein - Westfälischen Universitäten" (1997), "Gegenstandskatalog für den internen Evaluationsbericht: Lehre und Studium" (1999) and "Empfehlung zur Evaluation von Forschung und Lehre an Nordrhein - Westfälischen Universitäten" (2000).

One aim of the GEU is to support the Universities of North Rhine Westphalia in their use of evaluation methods as instruments for quality assurance and improvement. Thus the GEU also offers service to the Universities in NRW. It is involved in the following tasks:

- Consultation and support of universities and departments regarding the implementation of evaluation methods
- Co-ordination and organisation of peer reviews
- Preparation of working material, guidelines, checklists, questionnaires

Up to this point the GEU has co-ordinated the evaluation of the Social Science programmes at the Universities of Bochum, Duisburg and Münster, the evaluation of Physics at the University of Duisburg, which is part of an international evaluation of the Universities of Twente, Ghent, Hanover and Duisburg, and the internal evaluation of Pedagogy and Psychology at the University of Essen. The evaluation of the teacher training courses at the University of Duisburg is in process.