Computer Science

International Benchmarking of Danish Computer Science

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Preface

This report is based on an international benchmarking of four Danish Computer Science programmes at, respectively, Aalborg University, University of Aarhus, University of Copenhagen, and University of Southern Denmark. The assignment is, in parallel with a separate investigation on drop-out and graduation time for Computer Science programmes, commissioned by the Danish Ministry of Science, Technology and Innovation.

The benchmarking provides an analysis of the educational quality of the programmes of the Computer Science departments. The benchmarking report summarises the current strengths and weaknesses of each department, and provides a number of recommendations intended to stimulate continuous quality improvement.

An international expert panel has, based on its collective expert knowledge, established the quality benchmark by approving a list of criteria for good quality computer science education. The benchmark has been an important part of the benchmarking process.

The expert panel and EVA expect the report to encourage development processes at the departments, and anticipate that the benchmarking report will be a useful tool in ensuring Computer Science programmes of high international standard in the future.

The benchmarking has been conducted between August 2005 and June 2006 by the Danish Evaluation Institute (EVA) in cooperation with the international expert panel.

Mads Nygård
Chairman of the international expert panel

Christian Thune
Executive Director

1 Summary

The purpose of this benchmarking is to provide an analysis of the quality of the educational programmes of the computer science departments at Aalborg University (AAU), University of Aarhus (AU), University of Copenhagen (KU), and University of Southern Denmark (SDU), and to account for their strengths and weaknesses. Based on its collective knowledge, an expert panel established the benchmark by approving a list of criteria for good quality computer science education. (See Appendix C for a full list of criteria). This report contains a list of recommendations, designed with the aim of stimulating quality improvement at the four departments.

Overall conclusions
Generally, the departments offer computer science programmes of a high educational level. Each department has given the combination of teaching and examination methods considerable thought. The main didactic principle of all departments is to provide teaching methods that support the integration of theory and practice. The departments, furthermore, succeed in incorporating research methods and results into the teaching and thereby introduce students to research processes and methods. This is most apparent at masters level where students receive more specialised education.

The four computer science departments differ in respect of size, academic or professional orientation, teaching methods and the weighting of theory and practice. Consequently, the strengths and weaknesses of each department are not identical, so different actions are appropriate to different departments.

The departments do not, however, promote the essential differences between their programmes clearly, and the student population is often insufficiently informed about programme details. The published aims of each programme often appear to be very similar and somewhat abstract, and the descriptions of required student qualifications are vague. As a consequence, students' initial perceptions of the programmes are often incorrect, which can result in dropout and long graduation times. The number of students who discontinue their bachelor and master programmes is significantly greater for computer science than for other scientific subjects.

The departments are, to a large extent, structured and run according to mainly informal procedures with widespread delegation of responsibilities. Current managerial styles reduce the capacity of the departments to undertake long-term strategic and coherent planning.

The computer science departments were evaluated in 1997, and those assessments also led to a number of recommendations. The present benchmarking process has shown that many of those recommendations have not been acted upon. Some recommendations of this report are, therefore, similar to those of the previous evaluation. The expert panel emphasises that continuous development is crucial for ensuring quality in education.

The recommendations

There are two types of recommendations from the expert panel:

- 'Must do': Recommendations that the expert panel considers that departments must follow in order to comply with the benchmark for good quality in computer science.
- 'Should do': Recommendations that the expert panel finds the departments should follow to enhance good practice.

In addition, recommendations are either:

- General: Recommendations that are relevant for all or most departments.
- Specific: Recommendations that are relevant for an individual department.

The different recommendations are presented in the report in the following way:

- Chapter 1: A summary of all general recommendations with the status of 'must do'.
- Chapter 3-12: More detailed consideration of all the recommendations, with accompanying reasons.
- Chapter 13: 'Must do' recommendations specific for each department.
- Appendix A: A further summary of all recommendations, collected and listed according to the themes of the benchmarking.

The recommendations are labelled with an individual code, X.N.M:

- X: States whether the recommendation is 'must do' (M) or 'should do' (S).
- N: States which chapter the recommendation is derived from.
- M: States the recommendation's sequence number in the chapter.

M.3.1 thus means that the recommendation has the status of 'must do' and is the first recommendation in chapter 3.

The general 'must do' recommendations

Promote programme profiles
The departments must state and promote their individual programme profiles more explicitly. *(M.3.1)*

The purpose of the recommendation is to ensure that potential students are provided with the opportunity for making informed choices as to which of the programmes is best for them.

Establish a vision
The departments must formulate, adopt and publicise a coherent vision. *(M.3.2)*

The purpose of the recommendation is to underline the importance of a vision that can be used as a yardstick for strategic actions, ensure continuous development of the programmes, and provide a common framework for the many individual actions taken at various levels of the organisations.

Adopt strategies on core areas
The departments must adopt strategies for the central aspects of the programmes. *(M.3.3)*

The purpose of the recommendation is to emphasise the importance of strategies as a tool for the continuous development of the programmes. Important areas could include: staff recruitment, graduation time, dropout, internationalisation and quality assurance.

Set clear aims and goals
The departments must elaborate on the aims of the programmes, and state the relation between the aims and the goals of the study elements more clearly. *(M.4.2)*

The purpose of the recommendation is to make it possible to use the aims as guidelines for the continuous development of the programmes, to help the students gain a coherent understanding of the programmes, and to facilitate the development of clearer programme profiles. Potential employers will, furthermore, be able to see what bachelor and master graduates ought to know.

Formulate output competences
The departments formulate, or reformulate, competence descriptions for their programmes in a systematic and easily comprehensible manner. The descriptions must be made at both programme level – as output competences in a competence profile – and at the level of the study element. The relation between the two levels must be explicitly stated. *(M.6.1)*

The purpose of the recommendation is to ensure clearly stated competence descriptions that will help both prospective students and external stakeholders understand the abilities and potentials of graduates. Furthermore, clear competence descriptions provide each student with an understanding of the relevance of the programme from a long-term perspective.

Attract a qualified and diverse student population
The departments must renew their efforts to increase the number of qualified students, especially female students. Departments should collaborate in their initiatives to promote computer science at secondary and upper secondary schools. *(M.9.1)*

The purpose of the recommendation is to attract more students and provide prospective students, particularly female students, with a correct picture of computer science. This is to ensure that student expectations match the aims and content of programmes.

Reduce dropout at the programmes
The departments must formulate and implement a strategy for reducing dropout. *(M.9.4)*

The purpose of the recommendation is to combat high dropout rates. Aspects, such as informing prospective and new students about programme details, enhancing academic integration, and improving the social environment by creating a cohort-feeling among the students must be taken into account.

Bring down the graduation time
The departments must clearly formulate an action plan for reducing graduation time. *(M.9.5)*

The purpose of the recommendation is to promote measures to avoid extended graduation times. These could include policies for assignment deadlines and thesis contracts, as well as efforts to create a cohort-feeling among students, for example with group-work and supportive student/teacher networks for students that fall behind.

Reward good teaching
The management of the departments must develop incentives for good teaching performance. This can be done by systematically rewarding good teaching and outstanding teaching qualifications through monetary means or other forms of explicit recognition. *(M.7.3)*

The purpose of the recommendation is to increase the status of teaching and to encourage staff to develop their teaching skills.

Ensure staff pedagogical training
The departments must formulate a strategy that will, over a period of time, ensure that all academic staff who teach on the programmes receive pedagogical training. *(M.8.4)*

The purpose of the recommendation is to strengthen the pedagogical qualifications of the staff, and to emphasise the importance of strong teaching skills.

Establish systematic quality assurance
The management at university, faculty and/or department level must formulate, implement and publish a formal strategy for continuous enhancement and assurance of quality in the programmes. *(M.12.1)*

The purpose of the recommendation is to strengthen the quality assurance mechanisms by formalising and systemising them in the form of a strategy. The strategy must outline the organisation of quality assurance, the allocation of responsibility for the different procedures, and the ways in which the strategy is implemented, monitored and reviewed.

Improve course evaluations
The departments must ensure that all study elements are evaluated systematically with objectively designed course questionnaires. *(M.12.2)*

The purpose of the recommendation is to ensure the effectiveness of study element evaluations, which are the main quality assurance mechanism at the departments. The evaluations must be submitted to the responsible study board or committee, and not simply to the teacher involved.

Establish clear follow-up procedures
The departments must describe how they use and follow-up on the evaluations of the study elements. *(M.12.3)*

The purpose of the recommendation is to ensure that feedback from evaluation is acted upon, and that students are informed about the consequences.

Adopt periodical evaluations of the programmes
The departments must adopt periodical evaluations of the programmes involving external parties from other academic environments and industry. *(M.12.4)*

The purpose of the recommendation is to furnish the programmes with an evaluation system that can be used to assess the consistency between programme aims, labour market requirements and graduate qualifications. This will provide input for further development of programme content and quality.

Strengthen the systematic collection of information
The departments must adopt systematic procedures for the collection and dissemination of key programme information and statistics. *(M.12.5)*

The purpose of the recommendation is to develop systematic information-gathering procedures that support management and create transparency, for the benefit of both internal and external stakeholders. Especially important issues are dropout rates, graduation time and graduate employment.

Establish a national forum
The departments must, in cooperation, establish a national forum for discussing educational issues. *(M.4.5)*

The purpose of the recommendation is to allow departments to, increase their awareness of developments in related programmes, ensure mutual coordination and inspiration, collaborate on initiatives relevant to computer science, share knowledge of good practice and generally discuss broad educational issues relevant to the programmes.

Establish formal advisory boards
Each department must establish a formal advisory board consisting of representatives from industry and other relevant external partners, for example from other computer science departments in Denmark or abroad. *(M.10.1)*

The purpose of the recommendation is to make it possible for departments to follow national and international trends in research, the labour market and student employment opportunities.

Establish procedures to gather feedback from graduates
The departments must establish better procedures to gather feedback from, and about, graduates. This includes the formation of alumni networks. *(M.10.3)*

The purpose of the recommendation is to get departments to establish contact with graduates and thereby provide an opportunity to gather feedback on competences acquired in the labour market, general information about graduate employment and suggestions for developing the programmes.

2 Introduction

This report presents the results of an international benchmarking of the Computer Science programmes at Aalborg University (AAU), University of Aarhus (AU), University of Copenhagen (KU), and University of Southern Denmark (SDU). The benchmarking was conducted by the Danish Evaluation Institute (EVA) in conjunction with an international panel of experts in Computer Science.

2.1 Purpose

The benchmarking provides an analysis of the quality of the teaching programmes of the four Computer Science departments. Furthermore, the benchmarking provides a summary of the current strengths and weaknesses of each programme, with the aim of stimulating continuous quality improvement.

The benchmarking covers the following areas:

- profile, vision and management;
- aims;
- content;
- competences;
- teaching and examination;
- academic staff;
- students and study environment;
- employment and graduate feedback;
- internationalisation;
- quality assurance.

The benchmarking includes a discussion of research activities in order to assess the relationship between research and education. The purpose was not to assess the quality of research in isolation.

In 1997, EVA (at the time The Evaluation Centre) carried out an evaluation of computer related education programmes in Denmark. That evaluation included programmes in computer engineering, computer science, computer technology and informatics. During the present benchmarking process, it appeared that a number of issues from the 1997 report were still unresolved, indicating that the departments have not followed-up on the 1997 recommendations.

The benchmarking is commissioned by The Ministry of Science, Technology and Development. The purpose of the benchmarking is also stated in the terms of reference included in Appendix G.

2.2 Benchmarking method

Benchmarking is a form of evaluation that involves systematic assessment and comparison on the basis of a benchmark, a quality norm that corresponds to so-called best practice. The application of best practice means that individual teaching programmes are measured in relation to criteria that are formulated on the basis of programmes that achieve good performance levels.

The appointment of an international expert panel establishes an external frame of reference for the benchmarking of computer science education in Denmark. It includes representatives from three European departments of computer science considered to be of the highest quality, together with one representative of the Danish labour market. Based on its collective expert knowledge, the panel established the benchmark by approving a list of criteria for good quality computer science education. (See appendix C for a full list of criteria).

This report is structured according to the benchmarking criteria, which constitute principles that the computer science departments should aspire to, and not a checklist for measuring the extent to which the specific departments fulfil each criterion.

The benchmarking criteria were used to structure the self-evaluation reports provided by the departments. During the benchmarking, it became clear that too many criteria were formulated at too great a level of detail, making it inappropriate to take account of each criterion in full detail.

Instead, the criteria act as a framework for discussion and assessment of the best practice which the benchmark contains. Appendix C describes where in the report the individual criteria are applied.

The main goal of the benchmarking has been to provide a number of recommendations. The goal is not to rank departments, nor to compare them with the experts' home departments, but rather to appraise their strengths and weaknesses based on the experts' experience of similar programmes abroad.

In short the specific tasks of the expert panel were to:
- establish a benchmark by formulating a list of criteria for good quality;
- assess the documentation provided by the computer science departments and the site visits;
- assess the programmes, based on the criteria and expert knowledge from members' home departments;
- present conclusions and recommendations.

2.3 Organisation

The members of the expert panel are:
- Professor Mads Nygård, Norwegian University of Science and Technology, Department of Computer and Information Science, Norway (chairman of the expert panel)
- Professor Richard Bird, Oxford University, Computing Laboratory, England
- Professor Sacha Krakowiak, Université Joseph Fourier, Projet Sardes, France
- Senior Research Manager Karsten Vandrup, Nokia Denmark

Further details regarding the members of the expert panel are provided in Appendix B.

The expert panel was responsible for the professional quality of the benchmarking, while EVA was responsible for the methodological quality and for writing the report, based on input from the expert panel. The project group at EVA comprised Evaluation Officer Mads Biering-Sørensen (Project Manager) and Evaluation Assistant Louise Bunnage.

The expert panel and the project group have held one-day meetings in January 2006 and in April 2006 and have, furthermore, visited each department for one day in February 2006. Further communication between members has primarily been via e-mail.

2.4 Documentation

Four types of documentation form the basis of the benchmarking. The two main types are, firstly, the self-evaluation reports provided by the four departments, including appendices, and, secondly, the site visits. The third type of documentation is a separate investigation conducted by EVA into dropout and graduation times for computer science. The final documentation consists of additional information that was generated by the departments on request from EVA during the benchmarking process.

2.4.1 Self-evaluation

Each computer science department conducted a self-evaluation, analysing the strengths and weaknesses of the bachelor and master programmes they provide. The self-evaluation process was designed to fulfil two distinct aims:

- to provide necessary documentation for the work of the expert panel in connection with the site visits and for this report;
- to motivate discussions and reflections on internal strengths and weaknesses and, thereby, stimulate further improvement of the quality of the education programmes.

The self-evaluations were carried out in accordance with a set of guidelines outlined by EVA. The questions in the guidelines were formulated in such a way that the answers would provide the expert panel with the information necessary to assess the programmes on the basis of the criteria. The information provided was mainly of a qualitative nature, though some limited quantitative data was also provided. The self-evaluation reports included references to relevant documents, including curricula details, the ECTS-catalogues, and so on. The documents were distributed to the expert panel and EVA.

The self-evaluation reports were produced by representatives from the departments' management, academic staff, students and graduates.

The reports have been a valuable instrument in the assessment of the programmes. They have been of varying sizes and detail, based on different approaches and levels of engagement from the departments. Chapter 13, Individual responses to each department, provides an assessment of the individual self-evaluation reports.

2.4.2 Site visits

The expert panel carried out a one-day site visit to each of the departments in February 2006. The purpose of these site visits was to provide the expert panel with an opportunity to investigate unclear and less substantiated sections of the self-evaluation reports. The site visits also served to validate the information provided in the self-evaluation report. Each visit comprised interviews with the self-evaluation group, management, academic staff, students and graduates. (See Appendix D for the agenda for the site visits.)

2.4.3 Investigation of dropout

In addition to the benchmarking, EVA has conducted an investigation of dropout for the computer science programmes in Denmark (Frafald på Datalogiuddannelserne, June 2006). The investigation is an independent assignment, commissioned by The Ministry of Science, Technology and Innovation, and a separate report on the findings of the investigation is published simultaneously with this benchmarking report. The investigation is based on statistical data, material gathered in a survey and interviews with, primarily, graduates and former students who ended their studies prematurely. The figures and conclusions from the investigation will be referred to mainly in chapter 9, Students and study environment. Besides the four departments participating in the benchmarking, the computer science department at Roskilde University Centre (RUC) features in the investigation of dropout. Since RUC is not participating in this benchmarking the statistics from RUC have been removed from the tables concerned.

2.4.4 Additional information from the departments

In March 2006, the departments were asked to produce additional information on a number of issues, for which the provided documentation was incomplete. The additional information included figures for admission, staff, PhDs and matters relating to internationalisation

2.5 Computer Science in Denmark

Computer science programmes in Denmark are regulated by a legal framework. The degree system is regulated by Ministerial Orders and, to some extent, the main law for the higher education in Denmark, the University Act. The aims of the computer science education programmes must be in accordance with this legal framework. In this section, the University Act and the current relevant Ministerial Order are presented.

The University Act

The University Act (act no. 403 of 28 May 2003) constitutes the main source of regulations for Danish universities. The act states, "The university shall conduct research and offer research-based education at the highest international level in the disciplines covered by the university..." (Section 2 (1))

The act, among other things, emphasises the following aspects:

- the demand for a thorough description of tasks and responsibilities, and the allocation of these between the different levels and areas of management and the different collegial boards;
- the importance of quality assurance and a clarification of the responsibility for quality assurance;
- the importance of guidance on education and job opportunities;
- the need for a documentation system, which can be a source of information to the management in connection with decision-making and establish transparency for relevant stakeholders.

The Ministerial Orders

The programmes at Danish universities are regulated by Ministerial Order 338 of 6 May 2004 concerning Bachelor and Master Programmes. If a student is admitted prior to September 2005, the programme is, however, still partly regulated by the former Ministerial Order 694 of 30 August 1993 concerning the natural science programmes at the universities. The differences between the current and former orders are of little significance in relation to this benchmarking, as both orders accentuate the same main principles. This section will, therefore, focus on the current order.

The Ministerial Order of 2004 states that the specific purpose of the bachelor programmes is to:
- introduce the student to academic disciplines in one or more subject areas, including theory and methodology, so they acquire broad academic knowledge and skills;
- provide the student with the academic knowledge and theoretical and methodological qualifications to enable them to independently identify, formulate and solve complex problems within the relevant constituent parts of the subject area(s);
- provide the student with the basic skills necessary to practise a profession;
- qualify the student to be admitted to a master programme.

And the purpose of the master programmes is to:
- enhance the academic knowledge and skills of the student and strengthen the theoretical and methodological qualifications and level of independence attained at bachelor level;
- provide the student with the opportunity to study in depth the advanced academic aspects of disciplines and methods within the subject area(s). This includes training in academic work and methodologies, which further develops the student's ability to work in a specialist professional capacity and take part in academic development work;
- qualify the student for further studies, including PhD programmes;
- qualify the student to occupy professional positions in private and public sector companies and acquire academic knowledge and insight into the natural sciences, as well as other theories and methods relevant to the programme concerned.

2.6 Content of the report

In addition to this introductory chapter 2, the report contains twelve chapters.

Chapter 1 provides a summary of the main conclusions derived from the assessment of the departments, and a list of the most important recommendations. Chapter 3 discusses the profile, vision and management of the four departments. Chapters 4 to 12 contain analyses of each of the focus areas: aims; content; competences; teaching and examination; academic staff; students and study environment; employment and graduate feedback; internationalisation and quality assurance. Lastly, chapter 13 provides individual responses to each of the four participating institutions based on the main conclusions regarding the programmes.

3 Profile, vision and management

This chapter examines the profiles and overall organisation of each programme as well as the visions of each department. These areas are not specifically delineated in the set of criteria, but proved to be important during the benchmarking process.

3.1 Profile and promotion

The computer science programmes in Denmark are different from one another. They range from theoretical and academic programmes, with few professionally oriented elements, to programmes in which both aims and content are firmly focused on preparing students for careers in industry. Consequently, each programme attracts different groups of students with different requirements.

The programmes at AU, KU and SDU are to a large extent theoretically oriented. However, there are variations between the programmes at the three departments:

- AU is a theoretically oriented computer science department, which does, however, also place emphasis on vocational skills.
- KU is oriented towards an academic career, and is only secondarily engaged in providing knowledge and skills needed for professional careers.
- SDU is theoretically oriented, with a strong mathematical focus.

AAU has programmes with strong emphasis on employability. The programmes focus on professional knowledge and competences, and involve substantial co-operation with industry. AAU emphasises that central to their philosophy of a problem-based learning approach is the ability to meet the demands of industry. A specific goal is that their graduates should be good programmers. This professional orientation combined with a problem-based learning approach ensures that AAU makes an important contribution to computer science education in Denmark.

Generally the four departments do not promote their programmes very vigorously, although there are exceptions. For example, SDU has compiled a promotion folder for prospective students, which among other things contains information about the profile of computer science at SDU, gives examples of different master theses, and describes the study environment and employment opportunities. AU has established trainee programmes in which upper secondary school pupils are introduced to computer science. The department at KU has established a service whereby staff members can, upon request, be sent to upper secondary schools to talk about computer science topics. These commendable initiatives aim to promote computer science in schools as a discipline worthy of study at university, and, only to a lesser extent, do they attempt to explain the differences between specific programmes at different institutions.

The site visits showed that the departments are aware of the need for promoting their subject in schools. On the other hand, some departments have a somewhat resigned attitude towards the lack of promotion. As some of the teachers at KU stated during the site visit, "We are scientists, not journalists." At KU they have recognised the problem and hired a part-time employee to issue press releases and initiate other promotional activities.

Currently, it is questionable whether new students and other potential stakeholders are able to distinguish between individual programmes offered by institutions based solely on detailed course descriptions in the material submitted for the benchmarking. The evaluation of the programmes in 1997 also highlighted the need for more clearly define programme profiles a recommendation that none of the departments seem to have acted upon.

The expert panel recommends that:

M.3.1 – all departments state and promote their individual programme profiles more explicitly, so that potential students have a better chance of making an informed choice as to which programme is best for them.

3.2 Vision and strategy

3.2.1 Vision

An important aspect of an education programme is a vision that unites the various groups and persons associated with it. Such a vision provides a common framework for the many individual actions taken at various levels of the organisation, and is the foundation for strategic planning.

The four departments have formulated vision statements for their departments, but only to a limited extent. This is reflected in the fact that departments seldom analyse the challenges computer science education may face in the future. At the site visit, all of the departments simply stated that their main challenges were to increase student numbers and enlarge the staff within the constraint of limited resources, and that these were issues that determined the goals for future actions.

Exceptionally, AU states its vision on the department's webpage. The vision concerns both teaching and the conduct and promotion of research, student intake and gender, workplace conditions and staff development.

KU describes in its self-evaluation report that there have been many discussions about programme profiles, and that these have resulted in an overarching educational vision. The vision affirms the department's dedication to theoretical and foundational subjects in computer science, but also emphasises the need for multidisciplinary education with focus on project work. It also expresses a desire for further collaboration with other departments at the university and to recruit more female students. However, this vision does not seem to have been formally adopted, publicised or promoted by the department.

Even though some departments have formulated broad vision statements, all departments could benefit from a more thorough examination and discussion of their visions for the educational programmes they offer.

The expert panel recommends that:

M.3.2 - all departments formulate, adopt and publicise a coherent vision that can be used as a yardstick for strategic actions to ensure continuous development of the programmes, and provide a common framework for the many individual actions taken at various levels of the organisations.

3.2.2 Strategy

In order for a vision to be effective at all levels of an organisation, it must be supplemented with strategies that are realisable through concrete goals and procedures. This viewpoint is reflected in the criteria of the benchmarking, which presuppose the existence of strategies in a range of areas, including: graduation time and dropout; recruitment of staff; internationalisation and quality assurance. Such strategies are found only rarely at the various departments.

The various programmes in computer science are, to a large extent, structured and run according to informal procedures and tacit shared knowledge. This arrangement reflects a culture that places emphasis on informal rather than formal procedures and policies. The obvious advantage of a loose structure is that a department can quickly change procedures in accordance with changing circumstances and emerging problems. However, there are also some drawbacks. First of all, many procedures are often tied to individuals rather than the organisation. Changes in staff, or in allocated areas of responsibility, mean that generated expertise and knowledge can be lost. Secondly, procedures are not carried out systematically and can appear arbitrary or particular to an individual. Thirdly, the ability to conduct coherent long-term planning is reduced, and when long-term planning is formulated, it is not always reflected in the implementation of everyday procedures.

A strategic approach means that a department tries to focus its efforts, identify main objectives and actively select actions that are seen to be necessary in both the short and medium term. The challenge is to integrate strategic plans, in which important focus areas are selected, problems are identified and central goals are formulated, with clear action plans and ways to monitor whether the measures produce the desired results.

AU provides a good example of how a coherent vision can direct the strategic initiatives and actions with regard to the development of the programmes. For example, AU's vision statement for its teaching programmes, discussed in the self-evaluation report, emphasises that the students should complete their studies in a timely manner. This has resulted in a range of initiatives, including: the replacement of a semester system with one based on quarters with the aim of giving more frequent feedback on student progress; the introduction of a core course on perspectives on computer science as part of the first year syllabus, aimed at giving students a feeling for the topics of some later courses; detailed study plans that are discussed with a member of the academic staff each semester; and the introduction of theses contracts with clear deadlines.

SDU provides the most formalised example of strategic planning. The department of mathematics and computer science at SDU is required to make a development contract with the Dean. The latest contract applies for 2004-06 and covers research, education, communication, staff policy and economics, the assessment of initiatives which have been implemented and planning for the years ahead.

The expert panel recommends that:

M.3.3 – all departments to a greater extent than hitherto formulate strategies for the central aspects of their programmes, and use these as a tool for continuous development. Important areas include: staff recruitment, graduation time, dropout, internationalisation and quality assurance.

3.3 Management and organisation

Strategic thinking places demands on management, but as a result, the management is able to create a sense of ownership and shared commitment towards the vision and the specific strategies that emerge from the vision. Preconditions for this are that all relevant groups are included in the setting of vision and strategy, that there is transparency in the decision-making process, and that the responsibilities for the implementation of the vision and the strategy are clearly defined.

The University Act prescribes two main organisational units with direct influence on the education: one of these is the study board with the Director of Studies and the other is the Head of Department. The study board comprises an equal number of representatives from the students and the academic staff. One of the main tasks of the study board is to make proposals for the study regulations (e.g. curricula). The Head of Department undertakes the day-to-day management of the department, which includes planning and allocation of tasks to specific employees. It is the responsibility of the Head of Department to ensure the quality and interaction between research and education in the department.

The organisation of the departments and study boards varies among the computer science programmes. KU and AU have departments solely for computer science. Computer science at AAU shares a department with the programmes for informatics and software engineering, while at SDU it shares a department with mathematics. Each department has established a range of formal research groups, which to a greater or lesser extent have been delegated responsibility for parts of the teaching programme.

The expert panel finds that the lack of stated visions and strategic approaches at the departments has resulted in a widespread delegation of tasks without formal procedures and clear management. One positive aspect is that individual staff members and research groups often enjoy great autonomy. However, the negative aspect is that there is no common view of the programmes or a shared vision for how the programme should develop. This is particularly evident at KU, where it seems to be a major problem. Interviews with management and teachers during the site visit at KU confirmed the impression that the organisation was somewhat fragmented and that there were widely different understandings of the basic intentions of the teaching programmes.

The fragmentation of the management at KU was also an issue commented on in the evaluation of the computer-related programmes in 1997. The 1997 evaluation group recommended KU to establish transparency in its management, and the current expert panel also stresses that the management at KU still needs to address this issue.

KU has a study board at department level, whose only task is to deal with issues concerning computer science. AAU, AU and SDU, on the other hand, have joint study boards at the faculty level. This has the effect that the study board contains both students and staff from a range of scientific disciplines, and not all have insight into the specific concerns of computer science. As a result, locating the study board at faculty level means that many of the minor decisions regarding the running of the computer science programmes are discussed and handled in other places.

AAU, AU and SDU have tried to solve this problem by establishing committees at department level. At both AU and SDU, teaching committees have been established, on which students are represented. The committees advise the study board at faculty level on educational matters and make proposals for study regulations and curricula. Even though the committees at department level seem to solve some of the problems posed by study boards at faculty level, the expert panel thinks that the solution is not optimal. It is problematic that the decision-making process, with regard to curricula, teaching and quality assurance of programmes, does not take place at departmental level.

The organisation of managerial responsibilities at AAU is more complex. At the departmental level, AAU has established an education committee that is comprised of academic staff members from the four research groups. Unlike the teaching committees at SDU and AU, there are no students on this committee. Instead there is a formal semester group comprised of students and teachers, and approved by the study board. The semester group has the task of sorting out practical matters and ensuring that there is a uniform understanding of methods and goals for the semester. It is however somewhat problematic that the teaching committee, where the discussions and decisions concerning long-term development are made, does not include representatives from the students.

The expert panel recommends that:

S.3.4 - management establishes clear procedures and increases the level of communication to ensure that central aspects regarding the programmes are discussed and acted upon in a transparent way. Decision-making bodies must be located at the appropriate level, with the participation of all relevant stakeholders, including students.

M.3.5 - KU strengthen the management to support the development of a shared vision and common framework of strategies, which can unite the various groups in the department, thereby establishing a consistent, widely accepted view of the goals and priorities for the programmes.

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4 Aims

This chapter focuses on the aims of the programmes, how they meet legal requirements, and how they are implemented. Furthermore, the aims are assessed in the context of current developments in computer science, the needs of the labour market, and the appropriate mixture of theoretical and practical elements.

4.1 Legal requirements

All of the departments have, on the basis of the Ministerial Orders, drawn up study regulations in which the programmes are described and the aims formulated and made public. The study regulations, furthermore, specify the curriculum, examinations, and the structure of each academic year.

The study regulations for the bachelor programmes came into force at AAU, KU and SDU in 2005 and at AU in 2003. The regulations for the master programmes came into force at KU in 2000, at AU in 2001, at SDU in 2003, and at AAU in 2005.

The aims of all of the study regulations reflect, and are very similar to, the descriptions in the Ministerial Order of 2004. However, there are exceptions:

- AAU does not state explicitly that one aim is to prepare students for professional occupation, in either the bachelor or master programmes;
- the aims for the master programme at KU do not state that the programme prepares for vocational occupation, although this is required;
- the aims of the bachelor programme at AU are coherent with the older Ministerial Order from 1993, but are not sufficiently elaborated in order to meet the requirements of the 2004 order.

The Ministerial Order of 2004, furthermore, sets out a range of requirements regarding programme organisation.

It is required that the bachelor programme be organised in a way that ensures the student is able to choose between different skill profiles that are relevant to a variety of professions. The study regulations in all of the education programmes make it possible to choose and combine various elements and, thereby, to acquire different skills.

All of the programmes also live up to the requirements regarding the combination of compulsory subjects, core subjects and electives. Both the bachelor and master programmes are, furthermore, constructed as complete and rounded programmes.

The expert panel recommends that:

M.4.1 - AAU, AU and KU revise the description of the aims at each programme level in order to comply with the Ministerial Order of 2004.

4.2 Formulation and operationalisation of aims

4.2.1 Bachelor programmes

The aims of the bachelor programmes at all four departments are described at programme level, and are operationalised as specific goals for each study element. At all departments the aims are of a generic and rather abstract nature very similar to the short, general purpose descriptions in the Ministerial Orders The specific goals for each study element are usually much more precise.

The interdependence between the aims at programme level and the goals for individual study elements is not clearly formulated in the study regulations.

The lack of a strong connection has the consequence that:

- the aims at the programme level are only indirectly assessable;
- the purpose of the aims as an effective steering tool in the planning of the curriculum is not obvious;
- it is difficult for the students to gain a coherent understanding of the programme, which in turn makes the choices of optional courses and pathways more difficult.

The connection between general aims and specific goals is strongest at AAU. In addition to the abstract aims at programme level, the study regulation displays elaborated goals for each study year, through the specific semester and finally, for the individual courses and projects. The elaborated formulation of aims through goals makes the programmes more transparent to the students and relevant stakeholders.

Abstract formulations of aims are in themselves a weakness. Considering merely the aims of the programmes, the four departments seem very similar. As stated in chapter 3.1, Profile and promotion, the programmes at the four departments are, however, fairly differentiated in terms of the content and the competences they offer the student. The lack of elaborated aims was also discussed in the evaluation of the programmes in 1997, where the formulation of clearer aims was recommended to make it possible to distinguish between the programmes.

The study regulation for the bachelor programme at SDU is an example of a more elaborated description of aims. While this study regulation also contains a very short and abstract statement of aims, it does include a more elaborate description of aims and content. This description touches upon the different subject areas, the possible specialisations and what constitutes the particular perspective on computer science.

The expert panel recommends that:

M.4.2 - AAU, AU and KU elaborate on the aims of their programmes, and that AU, KU and SDU state the relation between the aims at programme level and the goals of study elements more clearly. This should be done by specifying which study elements support the fulfilment of which specific aims. A clear relation between aims and goals will make it possible to use the aims as guidelines for the continuous development of the programmes, to help students gain a coherent understanding of the programmes, and to facilitate the development of clearer programme profiles. Potential employers will, furthermore, be able to see what bachelor and master graduates ought to know.

4.2.2 Master programmes

The overall aims for the master programmes are, again, very similar to the short purpose-descriptions in the Ministerial Orders.

AAU has a thoroughly defined master programme with named specialisations and clearly described aims and goals. At SDU, the main part of the master programme consists of compulsory elements with described goals.

At AU and KU, no study elements, except the master thesis, are defined in the study regulations. Instead, a range of elective courses are offered in different areas of computer science. The departments have not described available pathways or named specialisations in the field of computer science.

In AU's study regulations, it is stated that the student in connection with admission to the master programme must work out a study plan in collaboration with the department. This gives the department the opportunity to counsel the student and ensure that the outcome of the education programme is consistent with the aims.

It is laudable that the departments at KU and AU want to give their students the opportunity to specialise in different areas of computer science or to combine the discipline with other relevant disciplines. However, this requires a framework in which the different aims, possibilities and consequences of the choices are stated. Apparently, such a framework does not exist at the two departments.

The expert panel recommends that:

M.4.3 - AU and KU elaborate on the aims of their master programmes by exemplifying main pathways to ensure transparency to students and other stakeholders.

4.3 Theoretical and practical orientation

The various programme aims state, in different ways, that the students should be able to analyse and solve problems of both a theoretical and practical nature and apply knowledge and principles to develop practical applications. However, the aims do not give an indication of how the individual programmes intend to administer the combination of these two aspects.

Again, all of the programmes seem similar with regard to the balance of theoretical and practical orientation as stated in the aims. The prominent emphasis that AAU puts on the problem-based learning method is, for example, not clearly stated in the aims of its programmes. The aims state that the ability to solve problems is important, but the purpose and use of the problem-based learning approach is not elaborated.

The expert panel recommends that:

S.4.4 – the programme aims specify how the theoretical and practical orientations are achieved in the programme, thereby helping potential students to gain a coherent understanding of what the study entails. Particularly AAU should specify and explain the importance and perceived outcome of the problem-based learning approach in the aims of its programmes.

4.4 Developments and challenges in the discipline

With regard to setting the aims and goals of the education programmes, an important question is how the institutions monitor the developments and challenges within the field of computer science, both nationally and internationally.

Monitoring of national developments within the discipline

The involvement of individual staff members in research collaborations is the prevalent basis for input regarding developments and challenges within the discipline. In order to increase the quality of their information gathering, however, the departments must adopt a more systematic approach. This is emphasised by a new requirement in the Ministerial Order of 2004. Universities must, when they prepare and substantially revise curricula, ensure coordination with other universities that offer similar or related programmes. It is unclear whether the programmes are in fact subjected to this national requirement, as the departments have no formal national forums in which the management or other departmental representatives meet to discuss educational matters.

The site visits revealed that the contact between computer science departments is very limited, and knowledge of programmes at other institutions is sparse. The departments, to a large extent, see each other as competitors rather than potential sources of inspiration and knowledge of good practice. Through the benchmarking, it has become clear that the departments often share the same problems and potentially can learn much by investigating the different solutions that have been tried at different departments.

The departments participate in different educational and research collaborations. All the departments, for example, collaborate with the National Academy of Digital Interactive Entertainment and, furthermore, AAU, AU and SDU participate in the IT-Vest collaboration. BRICS is an example of a research collaboration between AAU and AU. Whether these relations give a deeper insight in the developments within the discipline is not directly assessable.

Monitoring of international development within the discipline
The discipline of computer science is highly international, and departments need to keep up to date with international developments within the subject area. Departmental monitoring of international developments occurs particularly through professional and scientific computing societies, such as the Association of Computing Machinery (ACM) or the Institute of Electrical and Electronics Engineers (IEEE). An important task for these societies is the regular formulation of curriculum guidelines for various computing-related disciplines.

The expert panel recommends that:

M.4.5 – all departments establish a national forum where the institutions can become acquainted with developments in related programmes, ensure coordination, gain inspiration, share knowledge of good practice and generally discuss broad educational matters regarding the programmes.

4.5 Needs and requirements of the labour market

Firm knowledge of the labour market, especially of the industry that participates in computer related research and development, is a prerequisite for the formulation of aims. The legal framework for the programmes clearly states that the programmes must have the dual purpose of educating towards both academic and professional practice. Inputs from industry can benefit the programmes with regard to renewal of the curriculum and insight into the research processes of industry. This is highlighted by the Ministerial Order of 2004, which states that the universities must consult industry and relevant organisations when preparing and revising curricula.

AAU, AU and SDU all stated that good relations and input from the labour market are important both in terms of the planning of the curricula, the setting of aims for the programmes and the goals for the study elements. However, the departments mostly use informal channels to obtain input. The contact of the programmes with industry is, to a large extent, based on the networks of the individual researchers. The reason why a more formal connection with industry has not been established seems to be the high level of employment. Some departments have started initiatives to support information gathering; an aspect that will be considered in more detail in chapter 10 Employment and graduate feedback.

KU emphasises the academic orientation of their programmes and does not see them as vocational. Their self-evaluation report states, "Practical or vocational orientations are not directly reflected in the aims," which though, "does not mean that practical problems do not have a place in the programme." The development of courses is often driven by the research groups, particularly at masters level. Consequently, goals evolve only as a result of academic research. At the site visit, representatives from the teachers and management doubted that industry had relevant suggestions for the development of the aims of the programme.

The expert panel finds it very problematic that the management and the staff at KU see no benefits to formal relations with industry, with regard to programme development. This negative attitude and unwillingness to discuss their programmes with the outside world were also pointed out in the 1997 evaluation. It is discouraging that this attitude persists at KU. While the expert panel acknowledges that there is no single well-defined professional profile for computer science Nevertheless by establishing relations with industry it becomes possible to ensure that programme profiles are relevant.

The expert panel recommends that:

M.4.6 - KU make serious and sustained efforts to obtain input from industry and other relevant external stakeholders and to encourage a more dynamic and open discussion of the aims and development of their programmes.

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5 Content

This chapter focuses on the content and structure of the programmes. The consistency between aims and content is assessed, as are the programme structure, the organisation of content, the progression in the programmes, and finally the balance of theoretical and practical elements.

5.1 Aims and content

The aims of the programmes must be consistent with the content offered in the study elements. The consistency of the programmes is, though, difficult to assess because of the abstract formulation of the aims, and the missing relation between aims at program level and the operationalised goals at study element level. The consistency between the goals and the content of each study element should, on the other hand, be directly assessable through the examinations at the departments.

As stated earlier in chapter 3.1 Profile and promotion, there are significant differences in the ways the departments interpret apparently similar aims in their preparation and execution of the programmes. The abstract aims make it difficult for prospective students to assess what can be expected of the content, and what demands the content poses.

It is perhaps, therefore, not surprising that the investigation of dropout on the computer science programmes (Frafald på datalogiuddannelserne) reveals that many of the admitted students display a lack of understanding of what the study in computer science entails. Misplaced expectations is a major reason for early dropout from a programme - dropout that to some extent could be countered by more detailed aims that are consistent with the content. These issues will be addressed more fully in chapter 9.2, Dropout rate and graduation time. The students' misconception of programme content only serves to accentuate the previously stated importance of elaborating aims, and relating them to goals that indicate how the aims are consistent with the content of the programme. *(See recommendation M.4.2)*.

5.2 Programme structure

The programme structure determines the time span of the courses and the frequency of examinations. The traditional programme structure followed the semester division of the academic year, but since 2003 many faculties in Denmark have changed this into the quarterly structure. A central motivation for introducing the quarterly structure was to keep in step with the students and to reduce dropout rates and graduation time.

AAU is the only institution where the semester structure is still in operation. The students and the teachers expressed satisfaction with the structure because of the long duration of group work. Problem-based learning forms the basis for coherent progression, and the benefits of implementing the quarterly structure are, therefore, not obvious. Furthermore, AAU has only minor problems with graduation time and dropout.

The quarterly structure was implemented at AU in 2003, KU in 2004 and SDU in 2005. The quarterly structure is organised in a similar way at the three departments. The academic year consists of four modules that each comprises seven weeks of teaching. Evaluations and examinations are normally placed in continuation of these seven-week periods.

Both AU and SDU appreciate the new programme structure. Under the quarterly structure, the student has more frequent exams, but the exams cover smaller parts of the syllabus. With the semester structure, the student would experience 3-4 large exams at the end of most semesters. The self-evaluation reports from AU and SDU state that the concentration of the exams was one of the main reasons that the students withdrew enrolment to exams. The faster pacing should result in a more even exam pressure with fewer withdrawals from exams. To withdraw from an exam not only prolongs the student's graduation time, but may also dissolve a study group and leave the individual student to his or her own devices, which can lead to dropout. Whether the quarterly structure has the desired effect cannot yet be concluded. The quarterly structure will be discussed further in chapter 9.2 Dropout rate and graduation time.

KU is, generally, very discontent with the new quarterly structure. The management of the department, the academic staff and the students all feel that the structure has been forced upon them. The quarterly structure is perceived as an initiative from the management of the Faculty of Science, and not as an idea that has evolved within the department itself. The exams in the middle of the semesters are generally seen as a stressful obstacle, which diminishes the outcome, especially of the theoretical subjects, because the students do not have enough time to digest the material. Furthermore, the academic staff are concerned that the students quickly become too focused on passing the exams instead of focusing on the learning process.

Which structure is the most appropriate for the realisation of the aims is not clear. The semester and quarterly structures clearly have both advantages and disadvantages, but it is possible to neutralise some of the problematic aspects of the quarterly structure through careful planning. SDU has, for example, decided that some courses should continue through two quarters, when the subject content and chosen teaching method require it. AU has given considerable thought to the way the examinations are organised. It is clear that a structure-change of such magnitude needs the support of the groups who implement it. As it seems to be an invariable demand from the faculty at KU that the programme follows the quarterly structure, the best course of action for KU must be to find measures to combat the disadvantages.

The expert panel recommends that:

S.5.1 - the managements of AU, SDU and particularly KU investigate the measures that other institutions have taken to exploit the advantages of the quarterly structure.

5.3 Organisation of content

An important aspect in assessing whether the content of the programmes is appropriate for the realisation of the aims is the division between compulsory and optional elements, and the balancing of the breadth and depth of content.

Entry to the bachelor programmes

The students at AU and KU start directly on the bachelor programme. Until 2003, all students at SDU were required to take an introductory year in science before starting computer science. In 2003, SDU established direct intake to the computer science programme, making the science year optional, and, since 2005, all students have been required to start directly with computer science. At AAU, all students start with a science year, after which the students begin a specific study area. The students choose a discipline at the beginning of the science year and select courses aimed at the chosen subject-area.

Single-subject or two-subject programmes

At all of the institutions, it is possible to take both single-subject bachelor and master programmes, and two-subject bachelor and master programmes. The student can individually decide whether to take a single- or a two-subject programme. If a single-subject programme is chosen, the students can combine optional study elements in the programmes more or less freely.

If a two-subject programme is chosen, there are more restrictions. The student must take a minor subject that comprises a self-contained package of study elements in one subject area, such as mathematics or physics. At all of the departments, the two-subject programme in computer science can also be directed towards a career as a teacher in the upper secondary education system. An education to upper secondary school teacher builds upon two-subject bachelor and master programmes, where 60 ECTS at the bachelor level and 30 ECTS at the master level are taken in the same elective. The elective qualifies the student to teach one of the upper secondary school teaching-subjects. The 210 ECTS that remain constitute the central subject, which must also be taken in an upper secondary school subject.

In the following, the descriptions of the programmes in computer science will focus on the single-subject programmes.

5.3.1 Compulsory and optional study elements in the bachelor programmes

All four bachelor programmes are described and regulated in some detail. The main aim of the bachelor programme is to introduce the student to the basic areas of the computer science subject. Many of the study elements are, therefore, compulsory. The table below shows the distribution of compulsory and optional study elements in the bachelor programmes.

Table 1
Compulsory and optional study elements in the bachelor programmes

	Compulsory core elements	Other compulsory elements	Optional elements required inside C.S.	Total ECTS required in C.S.	Free optional elements
AAU	120 ECTS[1]			120 ECTS	
AU	70 ECTS	40 ECTS[2]	25 ECTS	135 ECTS	45 ECTS
KU	60 ECTS	52.5 ECTS[2]		112.5 ECTS	67.5 ECTS
SDU	75 ECTS	60 ECTS[2]		135 ECTS	45 ECTS

Source: Study regulations
Note[1]: *Without the basis science year. It should be noted that even though the types and numbers of elements are compulsory, there is some freedom of choice between the compulsory project units and courses that the student actually follows.*
Note[2]: *With the Bachelor project and the Theory of computer science/Theory of science.*

Tables 16 to 19 in Appendix E list the specific compulsory courses of the bachelor programmes at the four departments.

The number of compulsory study elements in the bachelor programmes varies from 112.5 to 135 ECTS. KU is the most flexible bachelor programme, as it has only 112.5 ECTS of compulsory courses and unrestricted possibilities for the student to combine electives. At AAU, all of the study elements of the bachelor are compulsory.

The programmes at AU, KU and SDU follow, to a great extent, the same principles with regard to types of elements offered and the organisation of the content. The most frequent types of study element are courses based on a series of lectures. An average size of a study element at AU and SDU is 5 ECTS, and at KU 7.5 ECTS. The first year of the bachelor programmes at AU, KU and SDU consists of compulsory elements arranged in a specific order. In the second and third year, the order of the elements is loosened up, and both optional and compulsory courses are offered. However, all departments have sketched a recommended order for the elements.

At AU, KU and SDU, the departments have adopted a system of elective subject packages, where a number of study elements are assembled in packages of 30 ECTS. This is meant to ensure that the modules contain both progression and identifiable competences in a demarcated subject area. All departments offer these packages, which makes it possible for a student to tune their education with elements from both inside and outside computer science. Besides these pre-configured packages, a student can construct his or her own subject packages. These can again be comprised of optional elements in computer science or elements from other studies. At AU and SDU, individually tailored electives must be approved by the study board or the teaching committee. At KU the student can freely compose the 67.5 ECTS that remain after the compulsory elements have been taken. The students are thus not required to take the subject packages. The expert panel finds that the large number of unrestricted free electives at KU constitutes a problem. The department must provide a framework that ensures that the student receives a coherent bachelor degree with sufficient competences.

The organisation of the content at AAU is very different from the other departments. There are three basic types of study elements in the study regulations: project units, project courses and study courses. The project units are the main elements, and the students must follow one project unit every semester. The project unit weighs from 21 to 26 ECTS, out of the 30 ECTS in a semester, and consists of the following different parts: supervision, project work in groups, and a number of project courses. The project courses are an integral part of the project unit without a separate exam. The study courses on the other hand are separate elements with an exam.

The weighting of the courses in relation to the project-work in the project unit is somewhat problematic. According to the students met during the site visit, the ECTS-points allocated to the courses do not reflect the workload and time needed to complete the course satisfactorily. The project-work develops a wide range of skills, which the students find indispensable. But the strong emphasis on the project form shifts focus from some of the basic skills, especially the theoretical content of the programme. A change in the allocation of ECTS-points, so more points are given to courses, would, therefore, both reflect the time needed to take the courses and emphasise the importance of the acquired knowledge.

At AAU, the opportunity to compose an individual study programme is more restricted. In most semesters, students can choose between 3 different project units that each tone the profile of the student with regard to the study courses that need to be selected. At the site visit, both teachers and students indicated that it is actually possible to choose elements other than the mandatory study elements. The students stressed that it was a problem that information concerning these possibilities was limited.

The expert panel recommends that:

M.5.2 - KU either increases the number of compulsory elements or demands that the combination of electives taken be formally approved, to ensure that each student receives a coherent bachelor programme and achieves sufficient competences.

M.5.3 - AAU change the ECTS weighting to reflect the real amount of time necessary to complete courses in a satisfactory manner. This would also emphasise the importance of the knowledge acquired through courses.

S.5.4 - AAU more clearly state the different possibilities that students have with regard to actively selecting and combining their own study programmes. This could occur through guidance counselling or published written instructions.

5.3.2 Study elements in the master programmes

The master programmes are more loosely structured than the bachelor programmes, and normally form a framework for the student's own combination of study elements. In this way, the student can specialise in one or more areas. The master programme amounts to 120 ECTS, of which 90 ECTS must be taken within the subject area of computer science. The table on next page shows the distribution of compulsory and optional study elements in master programmes.

Table 2
Compulsory and optional elements in the master programmes

	Compulsory elements	Optional elements	Total ECTS required in C.S.
AAU	60 ECTS[1]	60 ECTS	90 ECTS
AU	30/60 ECTS[2]	60/90 ECTS	90 ECTS
KU	30/60 ECTS[2]	60/90 ECTS	90 ECTS
SDU	97.5 ECTS[3]	22.5 ECTS	90 ECTS

Source: Study regulations
Note[1]: *The master thesis amounts to 30 ECTS.*
Note[2]: *The master thesis normally weighs 30 ECTS, but an experimental thesis weighs 60 ECTS.*
Note[3]*: The master thesis amounts to 60 ECTS.*

At AU and KU, the only compulsory course is the master thesis, which is normally weighted 30 ECTS but can, as an experimental master thesis, be weighted up to 60 ECTS. The courses at master level are often derived from the research groups.

At AU, the study regulations state that a part of the admission procedure for the master programme is that the student, with guidance from the programme staff, assembles a coherent study programme of 120 ECTS, which is then submitted for approval by the department.

At KU, the study elements of the master are so called tasks that are carried out by the individual student or in a group. The research groups each offer a set of courses that the student can choose or combine according to their preference. In relation to the courses, the teacher sets one or more tasks that the student can select. It is the students themselves who must ensure that the master programme as a whole is coherent. The expert panel finds that this is not viable. The final responsibility for assuring that students receive a coherent programme belongs to the department, and the department must, therefore, establish measures to achieve this. According to students at KU, an additional problem is that the curriculum is unpredictable. It is also difficult to plan more than 6 months ahead, because of many changes to the study elements, which are often advertised late.

At SDU, 37.5 ECTS of the master is comprised of compulsory courses, besides the master thesis of 60 ECTS. That leaves only 22.5 ECTS as elective courses.

At AAU, the master programme is structured in two sections: the specialisation year and the supplementary year. The specialisation year consists of an elective subject area of 30 ECTS and the master thesis of 30 ECTS. The elective subject area is chosen from different offered specialisations in computer science. The final supplementary year is a continuation of the specialisation year, where the student works with industry-oriented applications within at least one of the following areas: transfer to an existing company; creating a new company; or industry oriented research.

The expert panel recommends that:

M.5.5 - KU establish measures to ensure that the students receive a coherent study programme at master level. This can, for example, be done by establishing content packages or by requiring that the student, as a part of the admission procedure, composes a coherent study programme that is subsequently approved. Both solutions presuppose that the department ensures that the student, to some extent, is able to predict which courses will be offered on the master programme.

5.4 Progression

AAU, AU and KU have stated progression pathways for at least the bachelor programmes, which ensure that subsequent courses build on the knowledge and competences acquired in earlier completed courses, and thus eliminate redundancy in the programme.

In the master programmes at AU and KU, progression is loosely structured. To be admitted to the master programme at AU, the student must create a study plan with progression, which is then approved by an academic staff member. In the master programme at KU, the research groups each offer a set of study elements that constitute a sequence with progression, but the issue as to whether the final combination of courses chosen contains progression is the responsibility of the individual student.

At SDU, the progression is stated in the recommended sequence for the compulsory courses, which is based on their interdependencies. During the site visit, the students expressed that there were courses in the bachelor programme where content was repeated. The catalogue of study elements shows that the prerequisites for the courses are not requirements, but recommendations. This means that students starting a course can possess very different qualifications, which might have the undesirable consequence that the course level is pitched at the lowest common denominator. It is the responsibility of the study board that there is satisfactory progression, clear demarcation of the elements, and that the curriculum is consistent and coherent both in terms of requirements and content.

The expert panel recommends that:

M.5.6 - SDU ensure progression in the programmes by setting prerequisites in the form of completed courses.

5.5 Theory and practice

The content of the programmes must cover both theoretical and practical elements. Computer science education relies on a well-established body of theoretical knowledge, which forms the core of the curriculum. On the other hand, the practical and technical aspects are rapidly evolving, and the students must, to some extent, be introduced to these.

All of the departments have a satisfactory balance of theoretical and practical elements. The departments state that the most important aspect of the balance between theory and practice is that the students are taught the principles behind the practical and technical aspects. The practical elements in the programmes are, in this way, often used as cases that exemplify more theoretical perspectives. For example, it is not the specific programming language taught which is important, but the ability to understand the principles of programming as such. All of the departments state that an important asset for the graduates is a well-founded theoretical understanding, which makes it possible to learn and quickly adapt to many practical and technical contexts and problems.

The balance of theoretical and practical elements can, to some extent, be gauged from the balance of lectures and projects, exercises, assignments and other practice-oriented activities. The courses primarily cover and present theoretical issues, while the projects and assignments focus more on practical elements and the development of vocational skills.

At AAU, there is a great amount of project work. When the study elements are summarised at both bachelor and master level, but excluding the science year, 163 ECTS are allocated to project work in the project units, 29 ECTS to project courses and 48 ECTS to study courses. That means that courses only amount to about 1/3 of the total ECTS of the programmes, and, of these 29 ECTS, the project courses are an integrated part of the project units. As stated earlier in chapter 5.3, Organisation of content, AAU should carefully consider whether the ECTS allocated to the courses reflect the study load necessary to complete the courses in a satisfactory manner *(See recommendation M.5.3)*.

At AU, KU and SDU, the main type of study element is the lecture, but almost all of the lectures are combined with some kind of practical activity. The most common is in the form of exercises, but also workshops, discussion sessions and different types of assignments are used. These practical activities amount to roughly the same time as is allocated to lectures. In the master programme the use of the project work form increases at the expense of the exercises. So, even though the profile of the programmes at AU, KU and SDU is, to a large extent, theoretical, there is a significant amount of practical work in relation to the lectures.

6 Competences

The focus of this chapter is the formulation of competences in the programmes, and whether the declared output-competences are in fact achieved. The chapter will first introduce the concept of competence and assess the formulated competences for the programmes, and whether the competence descriptions are comparable to the Danish Qualification Framework. The last part of the chapter assesses whether there is consistency between the formulated competences and the competences the students achieve.

6.1 Formulation of competences

The expert panel defines competence to be *the ability to apply knowledge and skills in relation to actual situations*. This definition stresses that the term competence not only covers academic and intellectual competences, such as the ability to connect theory with practice and analytical problem solving, but also practical competences, such as programming skills or model construction.

The competences must be formulated at two levels:

- competences achieved in the study element;
- the competence profile achieved at degree level, consisting of the main required output competences which students should have achieved upon completion of the degree.

Competences are a combination of generic and more specific abilities, and should be formulated with a broad view of possible career paths. Competence profiles should, for example, be able to encompass both academic and industrial career paths.

Programmes must formulate competence profiles for both bachelor and master levels. Competence profiles, comparable to the Danish Qualifications Framework, help to ensure that students achieve the competence level required for a bachelor and master degree.

The Danish Qualification Framework is an outcome result of the Bologna Process, which has highlighted the need for clarity and transparency in higher education in order to support mobility in Europe. The framework comprises a systematic description of the degrees of the Danish education system. Descriptions of competence profiles for education programmes are seen as an important aspect of this process.

The Danish Qualification Framework focuses on three main kinds of competences:
- *intellectual competences*, such as analytical and abstract thinking, a knowledge-seeking approach, communication skills and the ability to structure one's own learning;
- *academic and professional competences*, such as specialist competences within a specific discipline, insight into related disciplines, cross-disciplinary competences;
- *practical competences*, such as practical skills, professional ethics and responsibility.

6.1.1 Competence descriptions
The competences are described in the study regulations, but none of the departments have drawn up more detailed profiles outside the study regulations, nor do they differentiate between different kinds of competences.

The formulation of competences is not done consistently and systematically at AAU, AU and KU. The departments do not systematically distinguish between aims, content and competences in the programme descriptions. KU has, for instance, not formulated a competence profile for the master programme, although the aims of the master programme do indirectly include competence descriptions. Furthermore, at KU the competences are not explicated in the study elements, even though the goal descriptions and element content include descriptions of gained abilities and skills. Similarly, the description of competences for study elements in the bachelor programme at AU, and the bachelor and master programmes at AAU, are unclear.

The departments at AAU and KU are reluctant to use descriptions of competences. For example, KU has been working with descriptions of competences since 2004, but finds the notion difficult and the benefits unclear. Instead they refer to the knowledge students can achieve. This does not mean that the students do not gain competences, but, as KU states in the self-evaluation report, "To what extent the individual student achieves these is a matter of personality."

AAU also considers it unnecessary to spell out detailed competences for its programmes. It feels that such descriptions are superfluous, because the graduates are well-received and mobile in the labour market. However, in the study regulations and the framework provision for the Faculty of Engineering and Science, a range of competences are in fact described at programme level, for each study year and each semester, as well as at the level of the individual study elements.

This lack of enthusiasm is unfortunate, because competence descriptions bring important benefits to the planning and running of the programmes. The descriptions communicate the purpose of the programmes and, just as importantly, force the departments to reflect upon and discuss what abilities the programmes as a whole should provide the student. The departments' reluctance to make competence descriptions is especially disheartening in relation to the previously mentioned lack of clear aims in chapter 4.2 Formulation and operationalisation of aims. Both problems indicate that the staff and management, to some extent, lack a common view of the programmes as a whole.

SDU is the only department that has worked thoroughly with the formulation of competences at programme and study element level. In the study regulations for the bachelor programmes, generic and subject-related competence descriptions are stated. At the master level, aims and competence descriptions are formulated. The competences are divided into three different specialised competence profiles which are aimed towards the labour market, research and communication, respectively. However, the descriptions at SDU are not sufficiently elaborated and systemised, and the relation between the competence profile at the programme level and the competence descriptions for the elements is not explicit. Finally, the competence-descriptions are not available outside the study regulations and are, therefore, not accessible to a wide enough audience.

The expert panel recommends that:

M.6.1 - all departments formulate, or reformulate, competence descriptions for their programmes in a systematic and easily comprehensible manner. The descriptions must be made at both programme level – as output competences in a competence profile – and at the level of the study element. The relation between the two levels must be explicitly stated. Clear competence descriptions help facilitate an understanding of the abilities and potentials of graduates, from the viewpoints of both prospective students and external stakeholders, and provide the student with an understanding of the potentials and relevance of the programme in a long term perspective.

6.2 Achievement of competences

Whether the competences formulated at the level of the study element are achieved should be assessed directly through examinations. The examinations in the programmes are generally designed to assess not only the assimilation of the academic content, but also the development of competences. This aspect is dealt with more thoroughly in 7.2.2 Examination and competences.

It is more difficult to assess the achievement of the competence profiles at the programme level. The reason is that there is no stated connection between output-competences at programme level and at the level of the study element in any of the departments.

This is a problem which significantly decreases the value and reliability of the formulated competence profiles, both as guidelines for curricula planning and as useful guides to the differences between the output-competences of the programmes at the four institutions. Furthermore, it makes it difficult to assess whether the programmes attain the output-competences for degrees, as prescribed in the Danish Qualification Framework, and it complicates the comparison of the departments' degrees with computer science degrees from abroad.

One way of assessing whether the prescribed output-competences are achieved is to establish relations with graduates or employees who can provide feedback on whether the competences provided by the programme are relevant and adequate for employment. None of the departments have established such relations; an issue which will be discussed in more detail in chapter 10 Employment and graduate feedback.

It is a general view held by students and graduates at the departments that the programmes have supplied them with adequate competences. During the site visit, these parties almost unanimously stated that:

- the bachelor is a rounded programme, but that it is not seen as sufficient by employers, who prefer graduates with a master degree;
- the bachelor gives a broad competence profile with both academic and practical skills, whereas the master gives the student the possibility to further develop academic abilities. The students especially stressed that the master makes it possible for the students to mature academically, strengthen their analytical abilities, become more critical and be able to work independently. The graduates believed that employers find these skills important;
- the ability to use theoretical principles is more important than practical skills. The reason is that it is easy to learn practical skills, but difficult to acquire theoretical knowledge after the completion of the programmes.

At AU, KU and SDU, the students and graduates stated that the programmes focused on the competences required for an academic career. This was generally not seen as a problem, because both the students and graduates felt that these were the same competences sought by the labour market.

The expert panel recommends that:

M.6.2 - all departments establish ways of assessing whether the output-competences described in the competence profiles of the programmes are achieved. This should be done by showing how the competence profile is operationalised in terms of competences at study element level, the achievement of which is assessable through examinations.

7 Teaching and examination

The purpose of this chapter is to assess the teaching and examination methods at the four departments. The chapter first assesses the teaching methods in relation to didactic principles, the combination of teaching methods and the quality of the teaching. The second section assesses the examination methods in relation to didactic principles and the intended competences.

7.1 Teaching and teaching methods

7.1.1 The teaching methods and didactic principles

The self-evaluation reports show that the institutions have given the combination of teaching methods considerable thought. The main didactic principle in the departments' approaches to learning is to combine teaching forms that support the integration of theory and practice. There are two main didactic trends at the departments: lecture based learning, which is prominent at AU, KU, and SDU, and problem-based learning, which is predominant at AAU.

The lecture based model

At AU, KU and SDU, the main teaching method is the lecture. The connection between theory and practice is achieved by combining lectures with practical activities. In the master programme, this approach is increasingly supplemented by project work that is not necessarily tied to lectures. The most common practical activity in the bachelor programmes is exercises, but also workshops, discussion sessions and study cafes, where the student can work with assignments under supervision, are used. Particularly AU has experimented with an impressive range of different teaching methods, which helps sustain a dynamic learning environment.

The main benefit of the lecture is that it can cover a large amount of material. The disadvantage is that unless the lecture is carefully structured to permit student questions and discussion, it can be less motivating than other teaching forms. This is compensated for by the exercises and assignments that involve the students and ensure that they understand and are able to use the material presented in the lectures.

The lectures are given by tenured staff, while teaching assistants or PhDs often are responsible for the assignments and exercises. For the different teaching methods to work in concert, it is vital that there is a clear consistency between the two. The fact that teaching is usually carried out by two separate groups constitutes a potential problem. However, the combination of lectures and practical exercises, together with an increasing amount of individual and group project work, as the student progresses through the course, does establish a range of competences of both an academic and practical nature.

As the students progress through the bachelor programme, and especially through the master programme, the amount of project work gradually increases, which offers the students a possibility to work in groups with an independently defined problem.

The combination of teaching methods shows forethought concerning both progression in the learning process and a balance of methods that dilutes the weaknesses of the individual methods.

The problem-based method

AAU is dedicated to the didactic principle of problem-based learning. Every semester the students must participate in and complete one large project based on a problem that is identified and formulated according to the theme of the semester. To support learning in the project, the programme offers a range of courses which also include exercises. The courses can either be study courses, which require the passing of an individual exam, or project courses which are integrated in a project unit. As the students progress through the studies, the amount of ECTS allocated to the courses is reduced, and the amount allocated to the project work increases.

A major feature of the problem-based learning at AAU is that projects are carried out in groups, typically of four to seven students at bachelor level, and one to four students at master level. A supervisor is attached to the project groups, which normally hold weekly meetings. AAU assesses that the model gives the student experience in identifying and solving problems and working in groups over time. The project form also gives the student a feeling of ownership, which creates a high degree of enthusiasm that is a strong driving force in the learning process. The projects require a high degree of involvement and independence from the students. It makes it possible for the students to get in-depth knowledge in specific subjects and develop the students' analytical skills, and the ability to define and solve problems individually or in groups.

The project form often focuses on specific problems and therefore has a more narrow scope. This might be detrimental to the acquisition of a broad range of subject-related knowledge and competences. The impression is that the achieved knowledge and competences are acceptable. However, while the abilities and skills derived from the project work are easily identified, it may not be as easy to precisely characterise the academic aspects of the knowledge acquired by the students.

Use of teaching methods
It is the opinion of the expert panel that the teaching and learning methods, and the didactic principles at all of the departments, reflect and support the aims of the programmes. The explicit balance of teaching methods provides a good basis for the achievement of a broad range of competences. The emphasis on an efficient balance between the lectures and the practical assignments or, in the case of AAU, between the projects and the courses, is a strength of all of the departments. Having said this, it is important that the institutions continue to develop and try alternative teaching methods. A mix of different teaching methods helps sustain a dynamic learning environment and the achievement of a range of competences.

The expert panel recommends that:

S.7.1 - new teaching methods are continuously developed and assessed. Both the lecture-oriented approach at AU, KU and SDU and the problem-based learning approach at AAU have advantages and allow the students to develop different competences, and the programmes can benefit by adopting features from both approaches.

7.1.2 The quality of the teaching

A qualified and motivated staff is a prerequisite for good teaching. The expert panel, however, found no clear indicators at any of the four departments that a substantial part of the teaching is performed in an enthusiastic and motivating way. According to the students and graduates at all the institutions, there were some very good teachers and some equally bad teachers, but most were simply acceptable. Generally, the academic staff members seem to identify themselves as researchers rather than teachers.

It is especially important that the departments select enthusiastic and qualified teachers in the first year of the bachelor programme, where the foundation of the study is laid. The teaching staff at AU and SDU seemed dedicated to this approach. They emphasise the importance of allocating permanent staff to teach the first year courses, so students can be introduced to the tenured staff as quickly as possible and experience teaching of high academic quality. This helps ensure that the students, besides getting research-based teaching of high quality, get to meet those most involved in the academic and research environment, and this creates the feeling that their education has been given a high priority.

Many of the teachers at KU seemed to be more motivated in relation to teaching on the master programme, where the courses are based on activities in the research groups. It is a serious problem that the mandatory courses on the bachelor programme are something the staff try to avoid.

The academic staff needs to be motivated towards teaching. However, the management finds it difficult to reward teaching of high quality, and thereby develop incentives for good teaching performance. Teaching prizes have been introduced t at faculty level, which are given to exceptionally good teachers. Particularly SDU has a fine track record, as the department has received most teaching prizes at the faculty. There is a small monetary reward, but the prizes are mainly honorary.

The expert panel recommends that:

S.7.2 - the management at AAU and, especially at KU, ensures that the first year of the bachelor programme is taught by motivated and qualified academic staff members. By letting the best tenured teachers teach the first year, the students get a good start and are more likely to feel part of the academic environment.

M.7.3 - the management at all of the departments develop incentives for good teaching performance. This can be done by systematically rewarding good teaching and outstanding teaching qualifications through monetary means or other forms of explicit recognition.

7.2 Examination methods

All four departments publish details of how each particular course is examined, on their web pages. Thus, all examinations are carried out according to publicly available criteria and procedures. Students, therefore, have an opportunity to complain about an examination decision if appropriate procedures are not implemented.

7.2.1 Examination methods in relation to didactic principles and aims

All departments state that examinations are an integral part of the learning process. In this way, the institutions look upon examinations as an integral part of the didactic considerations discussed earlier in this chapter, and that the choice of examination method should reflect the goals of the study element.

Table 3 shows the examination methods used in the compulsory courses at the bachelor programmes of the 4 departments. The discussion of the examination methods is mostly based on the bachelor programme, as the master programmes are mainly composed of electives.

Table 3
Examinations on compulsory courses at the bachelor programmes

	AAU[1]	AU[2]	KU	SDU
Written exams	2	2	1	3
Oral exams	9	6	1	2
Report exams	0	4	3[3]	3
Assignments	0	0	1[4]	3[5]
Written + assignments/projects/reports	0	0	5	6
Oral based + report/project	4	0	1	2
Other	0	1[6]	0	1[7]
Not stated	0	3	2	2
Total no. exams	15	16	14	22
(in ECTS)	(120)	(90)	(112.5)	(135)

Source: Study regulations and course descriptions
Note[1]: *Science year not included.*
Note[2]: *Support courses Calculus 1+2 (10 ECTS) and Mathematical modelling 1 (10 ECTS) not included.*
Note[3]: *1 exam covers the bachelor-project and the other 2 exams require two reports to pass each exam.*
Note[4]: *Programming assignment.*
Note[5]: *1 exam is an obligatory assignments and the other 2 are programming A and B with integrated projects.*
Note[6]: *Programming project with multiple choice exam.*
Note[7]: *Calculus course with written exam, assignments and project.*

Table 3 shows that the size and number of examinations vary; the balance of oral and written examinations differs from department to department; and, finally, there are differences in the complexity of the examination methods used. These three aspects will now be considered.

Firstly, the table illustrates that KU and AAU have fewer exams per ECTS than AU and SDU. The main reasons are that AAU still has the semester structure with fewer examination periods and KU has chosen to use modules of 7.5 ECTS instead of 5 ECTS as at AU and SDU.

Secondly, the table also shows that AAU has many oral examinations, whereas KU and SDU have many written exams in the form of presence exams or reports. At AAU, all of the project-units are assessed by oral group examinations based on project reports. The project report, the oral examination and developed applications all have influence on the student's grade. AAU, furthermore, states that examination methods for the courses are chosen in order to reflect the character of the courses. This statement, however, seems contradictory when almost all courses are evaluated orally.

Thirdly, the table highlights the variation in complexity of the examinations. KU and SDU have more complex and extensive examination types than AAU and AU. At KU, most examinations comprise more than one examination method which must be completed in a satisfactory manner in order to pass. A common combination of examination methods at KU and SDU is that of a project, or assignment report during the course followed by a written examination at the end of the course. A tendency is that the study element contains both an examination during the course, e.g. an assignment or a project that evaluates the practical aspects of the course, and an exam at the end which evaluates the whole course.

The examination methods at KU and SDU seem more tailored to the teaching methods, as well as to the goals and aims of the programme, than at AAU and AU. It is a strength that the examinations clearly assess different aspects and competences of the programmes. Especially KU makes a substantial and compelling account for the rational behind the application of the different examination methods. On the other hand, the many and extensive exams can be counterproductive, as they could cause increased dropout or extended graduation time. The extensive examination activity can also cause students to be more focused on the examination rather than the learning process.

AAU and AU have few hybrid examinations with multiple examination methods. Besides the project examinations at AAU, the examination methods applied by AAU and AU are generally oral, written presence examinations or report examinations.

It has come to the expert panel's attention that the use of group examinations is currently a highly politicised topic in Denmark. The main issue is whether the students should account for the parts of the project they are responsible for. The expert panel emphasises that a combination of group work and individual work as a learning method is important, especially since the ability to work in groups emulates the way work is conducted in industry, as well as in many research environments. When group work is assessed it should be done by group examinations, just as individual work should be assessed individually. The expert panel sees no apparent reason for the students to account for their individual work in the project, as the idea behind group work is to produce a common product based on input from all group members. It is the expert panel's impression that the subsequent oral examination at AAU allows the determination of individual student outcome and, thereby, involvement in the process.

The expert panel recommends that:

S.7.4 - departments balance the use of different types of oral and written examinations. This means that AAU should include more written examinations for their courses, and that KU and SDU should extend their use of oral examinations.

S.7.5 - SDU and KU consider simplifying some of their examinations based on multiple examination methods, so that examination pressure is reduced, which could result in a decline in graduation time and dropout. This, however, should be done with care, so the positive aspects of a broad assessment of the intended outcomes are not significantly reduced.

7.2.2 Examination and competences

The self-evaluation reports show that the departments are attentive to the relation between examinations and intended competences. As stated earlier in this chapter, KU and SDU use many different examination forms which make it possible to assess both academic and practical competences. AAU and AU, on the other hand, use a narrower range of examination forms and could benefit from broadening the range of examination forms.

At master level, AU, SDU and KU increasingly use the project form, and exercises and assignments are, to a lesser degree, used as an examination method. This tendency supports the development of the student's academic competences, such as independence, analytical skills and the ability to define and solve problems individually or in groups.

AAU uses the same range of examination methods throughout the bachelor and master programmes. The combination of a written project report and a thorough oral exam seems to give a broad framework for the assessment of a range of competences. The education could, however, benefit by introducing a wider range of examination methods in the evaluation of the courses.

The expert panel recommends that:

S.7.6 - AAU and AU develop a broader range of examination methods which themselves support the achievement of different competences and, furthermore, ensure that both practical and academic competences are assessed.

8 Academic Staff

The focus of this chapter is the academic staff. The first part of the chapter assesses the relation between research and teaching, especially with the research-based teaching. The second part assesses the use of external teachers in the programmes. The third part assesses the strategies of the departments for the recruitment of academic staff, and the final part assesses the pedagogical training and qualifications of the staff.

8.1 The relation between research and teaching

All Danish university programmes must be research-based. However, there is no centrally issued definition of what actually constitutes research-based education and teaching. It is not an aim of this benchmarking to assess the research environments of the computer science education programmes in Denmark. The purpose is to assess how the research environments support the research-based teaching in the programmes.

Although the majority of the teaching must be research-based, the scope of research-based teaching varies from department to department. Research-based teaching consists of many elements that will be assessed as follows. Firstly, the research environment in relation to core subject areas in the programme is assessed. Secondly, it is examined how the ongoing research and research methods are included in the teaching. Thirdly, the extent to which the academics and researchers teach in the programme is assessed, and, finally, the size of the teaching staff is assessed in relation to the research-based teaching.

Research and core subjects

In order for the programmes to be research-based, relevant subject areas, and especially the core subjects of the programmes, must be appropriately reflected in the research groups. Table 4 provides an overview of the research groups at the four departments.

Table 4
Research groups

AAU	AU	KU	SDU
- Information Systems - Database and Programming technologies - Distributed Systems and Semantics - Machine Intelligence	- Algorithms - Complex Systems - Computer Graphics and Sound - Cryptology and Security - Human Computer Interaction - Modelling and validation of Distributed Systems - Object Oriented Software Systems - Programming Languages and Formal Models - Robotics - Scientific Calculations	- Algorithmics and Optimisation - Distributed Systems - Image Group - Semantics-based Program Analysis and Manipulation - Systems and Human-Computer Interaction	- Algorithmics - Computer Architecture and Arithmetic - Databases

Source: The self-evaluation reports and the departments web-pages

At SDU there are three research groups. Some subject areas, such as programming language, are not research topics and are, therefore, taught by teachers with a different research background. The close relation to the mathematical section of the department and the narrow research profile mean that the programme has a very mathematically oriented content, with a limited degree of computer science research in the teaching. With the current organisation structure, SDU risks becoming too mathematically oriented at the expense of important subject areas in computer science, a risk which the programme evaluation of 1997 also pointed out.

The department of KU is much bigger than SDU and has more research groups. Yet there are topics which KU state in the self-evaluation report that the department would like to be able to offer at master level. KU finds such an expansion impossible due to the size of the staff and the need to maintain sustainable research groups. As an alternative, KU has chosen to cooperate with the IT University and the Technical University of Denmark in order to increase the range of courses available. This is a positive initiative and serves as a good example of getting around issues related to the size and resources of a given department.

Research results and research methods
An important aspect of research-based teaching is that the teachers, when relevant, include research results in their teaching and introduce the students to research methods. This kind of involvement motivates the students and supplies them with an important insight into computer science in practice.

The expert panel assesses that all of the departments successfully achieve the inclusion of research results and methods in their teaching and thereby qualify students to participate in development and research processes. This is most apparent in the master programme where the teacher often lectures in his or her designated research area. The possibility to include current research and research projects in depth is obviously not the same at bachelor and master levels. Bachelor programmes consist primarily of compulsory basic subjects and must cover a broad range of issues, whereas the master programme provides ample opportunity to specialise, often in close cooperation with the established research groups.

Extent of the research-based teaching
Table 5 shows the distribution of resources among full-time and part-time positions, calculated in terms of full-time equivalents (årsværk) and displayed in percentage. The time percentages listed for the permanent staff include the research proportion of the positions, whereas the stated temporary positions do not include time for research.

Table 5
Permanent staff and temporary staff in 2005

	AAU[3]	AU	KU	SDU
Permanent staff[1] in %	85%	86%	82%	75%
(full-time equivalents)	(33,5) [4]	(32)	(28)	(8,5) [4]
Temporary staff[2] in %	15%	14%	18%	25%
(calculated in full-time equivalents)	(5.8)	(5.1)	(6.0)	(2.9)

Source: Self-evaluation reports and additional information from institutions
Note[1]: *Permanent staff includes: professors, associate professors and assistant professors.*
Note[2]: *Temporary staff includes: external associate professors, teachings assistants, instructors, guest teachers, support teaches and PhDs.*
Note[3]: *Total staff in department which covers computer science, informatics and software engineering.*
Note[4]: *AAU has part-time professor and SDU has part-time associate professor, which are included.*

A prevalent organisation form is one in which the academic staff teach the majority of the lectures, whereas the training sessions, discussion sessions and the exercises are taught and supervised by non-tenured staff, such as teaching assistants or PhDs. This use of the temporary staff makes the extent of research based teaching sufficient. SDU has a higher percentage of time allocated to temporary staff than the other departments. SDU states that all of the courses are taught by tenured staff, and SDU, therefore, follows the same organisation as the other departments. This, though, gives the staff many teaching assignments and reduces the time left for research.

Staff and research-based teaching

The number and composition of academic staff is also important in order to be able to offer an adequate amount of research-based teaching. An adequate academic staff ensures that the relevant core subjects are covered by research, and it helps to sustain a viable and dynamic research environment. In the table below, the composition of the staff is outlined.

Table 6
Composition of academic full-time staff 2005

	AAU[1]	AU	KU	SDU
Professors	4[2]	7	8	3
Associate professors	23	18	19	4[2]
Assistant professors	6	7	1	1
Post docs	0	2	1	2
Fixed-termed lecturers (amanuensis)	3	0	0	0
PhDs[3]	27	59	18	4
Other	2[4]	2[5]	0	1[6]

Source: Self-evaluation reports and additional collected information from the departments
Note[1]*: Total staff in department which cover computer science, informatics and software engineering.*
Note[2]*: Part-times positions not included: 1 professor at AAU and 1 associate professor at SDU.*
Note[3]*: The number for PhD students include all PhD's enrolled in 2005 even if the PhD ended during the year.*
Note[4]*: Full-time teaching assistants (no research obligation).*
Note[5]*: Academic researchers.*
Note[6]*: Research assistant professor.*

As table 6 shows, the size of the departments' full-time staff varies considerably. In this connection, it should be noted that the staff at AAU is attached to the programmes of Computer Science, Software Engineering and Informatics.

A research environment needs to be of a certain size and breadth in order to optimally sustain the programmes. The sizes of the staffs at AAU, AU, and KU are appropriate to sustaining a viable learning environment. The programme at SDU, on the other hand, is based on a very small research staff. As mentioned earlier, this means that not all core areas in the programmes are covered by research. The low number of staff also means that there are fewer "heads" to share the workload of the administration and planning of the programme. This issue was also discussed in the evaluation of the programmes in 1997. Even though the department has increased the number admitted students and the staff since then, the initiatives are insufficient to solve the problems.

All the departments consider an expansion of the academic staff an important goal for the coming years. During the site visits, it became clear that the staffs of the departments, especially at AU and SDU, were stretched by the many assignments.

The desire for expansion at all the departments is laudable. At SDU, though, a large expansion is a prerequisite to ensuring the quality of the programmes. The small size of the department combined with the lack of coverage of core areas in the programme, requires SDU to make a long-term plan for the development of the core areas and the size of the staff. The current development-contract between the department and the Dean is not an adequate tool for this large task.

The expert panel recommends that:

M.8.1 - SDU adopt a long-term strategy for the expansion of the academic staff in core areas of computer science. There are three immediate actions SDU can take:
- a continuing expansion of staff within computer science;
- a closer collaboration with other computing-related programmes;
- a separation from the mathematicians in the department and merge with a more computing-related department.

The expert panel estimates that it is not enough just to expand the number of staff in the current setting, and that computer science at SDU in a long-term perspective should move towards a separation from mathematics and a merger with another computing-related department.

8.2 External teachers

In order to create a dynamic academic environment, the teaching should be complemented by lectures or case studies presented by external teachers from industry or other universities.

The departments use external teachers to a varying degree. At AAU, there have been efforts to attract industry to settle in the vicinity. The closeness means that the students are able to carry out projects in collaboration with industry, and it becomes easier to obtain external guest teachers.

AU has a close connection to the Alexandra Institute, which is located in the same premises as the department. The purpose of the Alexandra Institute is to bridge the gap between the IT corporate sector, research and education. The establishment of the institute has had a great impact on the programme, and the staff of the institute are often involved in the teaching at AU.

The use of external teachers is limited at SDU and KU. SDU had altogether 6 external teachers in the bachelor and master programme in 2005. Four of these came from industry and two from other universities. At KU, the limited use of external teachers seems to be based on a lack of interest towards the involvement of industry.

The expert panel recommends that:

S.8.2 - KU and SDU extend the use of external teachers who give lectures or present cases. A more systematic use of external teachers would add important perspectives and support a dynamic academic environment.

8.3 Recruitment

Qualified teachers and researchers are a cornerstone in an education of good quality, and the recruitment process must, therefore, be given high priority.

The majority of the departments have not explicitly stated their strategy for future recruitment. However, the departments have a range of procedures and principles which are followed in the recruitment process.

AAU and AU state that they have no problems in attracting qualified academic staff for permanent positions, but AUU experiences increasing problems in attracting temporary staff. KU and SDU have experienced problems recruiting permanent staff, especially in the applied areas. The departments assess that the main reason is that it is difficult to compete with the conditions, including salary, that are offered in the industry. However, to attract qualified staff is not only a matter of economy. In order to attract more staff, the departments need to focus on improving the working environment and, thereby, making an academic career an attractive option.

International recruitment

It is a widespread Danish phenomenon that the departments appoint their own master students to PhD positions, and their own PhDs as assistant professors and so forth. This is a potential problem for the academic environment. The inclusion of staff with academic traditions from other places supplies new perspectives and ideas to the subject area, and inspiration for ways of organising the programme differently.

The departments have made some efforts to recruit staff from abroad. At AU, the recruitment of international staff was stated as a policy during the site visit. The department has had many employees from abroad, but most of the staff only stayed for a few years. At SDU, the majority of the tenured teaching staff have earned their PhDs outside Denmark.

In order to attract staff from abroad, effective advertising procedures are important. At AAU and SDU, all positions are advertised internationally. KU writes all job advertisements in English and post them on the department's and the university's website and in relevant Danish magazines. Only full professor chairs are advertised internationally.

The expert panel recommends that:

S.8.3 – all departments formulate and adopt a strategy for recruitment. The strategy should include efforts to attract staff and PhDs from other universities and abroad in order to sustain a dynamic academic research and learning environment.

8.4 Pedagogical training

To be qualified as an academic is not only a matter of research experience; teaching experience also matters. It is, therefore, important to consider how pedagogical qualifications are regarded, both in relation to recruitment and the existing tenured staff.

All of the departments consider pedagogical qualifications, or other documentation of teaching skills, an important element in the recruitment procedures. The departments have established procedures to ensure that hired teachers, especially those in permanent positions, have adequate teaching skills.

At AAU, all applicants for permanent positions are required to document pedagogical qualifications. AU has introduced so-called teaching portfolios, with descriptions of teaching experience and skills for the applicants to fill in. AU states that this has been a beneficial addition to the recruitment procedures.

KU and SDU have other procedures to ensure that teachers have the required pedagogical skills. KU report that associate professors with undocumented teaching skills are hired on a year's probation before tenure is awarded. The tenure is awarded on the basis of an evaluation of the teaching skills. At SDU, the applicants are interviewed and the prospective employee must give a seminar as the basis of an evaluation of his or her pedagogical level. In the case of lack of documentation of teaching skills, and when the hiring committee is in doubt about teaching qualifications, the teacher is hired on a trial basis to determine whether the expectations are met.

There are established pedagogical centres, at either university or faculty level, at all of the participating institutions. The main tasks of the centres are to carry out research, development and teaching in the field of didactics and education. The centres regularly offer short courses in pedagogical methods and didactics for the academic staff.

Table 7 shows the pedagogical training the staff at the computer science programmes have received.

Table 7
Pedagogical training of the academic staff[1]

	AAU[2]	AU	KU	SDU
Pedagogical course for Assistant professor	43% (14)	25% (8)	31% (9)	25% (2)
Other pedagogical training[3]	27% (9)	28% (9)	28% (8)	37,5% (3)
No pedagogical training	6% (2)	47% (15)[4]	41% (11)	37,5% (3)
Not stated	24% (8)[5]			
Total number of staff	100% (33)	100% (32)	100% (28)	100% (8)

Source: Self-evaluation reports and additional information from the departments
Note[1]*: Professors, associate professors and assistant professors. Only full-time positions.*
Note[2]*: Total staff in department which cover computer science, informatics and software engineering.*
Note[3]*: E.g. pedagogical courses and workshops for all of the staff, pedagogical training from abroad, courses in supervision, etc.*
Note[4]*: Including 2 hired as assistant professors for whom a pedagogical course was mandatory.*
Note[5]: *Including 4 hired as assistant professors for whom a pedagogical course was mandatory.*

All assistant professors in Denmark are required to take a pedagogical training course during their employment. The course consists of 120 hours of training and education in didactics, plus supervision by an experienced member of the department. Successful completion is a prerequisite for tenure.

AU has decided that all newly recruited tenured staff must have participated in pedagogical training. Table 7 shows that almost half of the staff does not have any formal pedagogical training. However, AU is aware of this weakness and admits that there is room for improvement, and that an intensified pedagogical training would benefit the department. AU, therefore, plans to implement a strategy for improving the pedagogical qualifications of all staff members.

At AAU, SDU and KU, the management encourage their teachers to attend pedagogical courses offered by the faculty to improve the quality of their teaching. At AAU, 70% of the tenured academic staff have received pedagogical training, which is the highest percentage for the four departments. At AAU, newly appointed academic staff are, furthermore, allocated a mentor who introduces the new teacher to the pedagogical paradigm at AAU. At SDU, the teachers responsible for project courses have received special training in supervising project work. However, none of the departments has formulated a strategy for improving the pedagogical qualifications of the teaching staff.

The expert panel recommends that:

M.8.4 - all departments must formulate a strategy that will, over a period of time, ensure that all academic staff who teach on the programmes receive pedagogical training.

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9 Students and study environment

The purpose of this chapter is to discuss issues related to students and the study environments of the four departments. Firstly, admission, dropout rate and graduation time will be assessed. The second part touches upon elements of study environment and counselling. The third part examines PhD studies, and the final part assesses the facilities of the departments.

9.1 Admission

The terms of admission lay down a minimum level for the skills of the new students. A certain level must be required in order to ensure the students' progress through the programme and their ability to complete in time. At the same time, the terms influence the size of the student population. In the following, different aspects of admission are assessed.

The requirements for admission to the Computer Science bachelor programmes are an upper secondary school diploma and, since September 2005, this must include mathematics at A-level. There is, otherwise, a free intake, i.e. there is no demand for a certain grade point average in order to be admitted. The table below shows the development in intake from 2001 to 2005.

Table 8
Students admitted to the bachelor programmes for Computer Science 2001-2005

		AAU	AU	KU	SDU
Students admitted	2001	45	102	208	[1]
	2002	49	109	219	[1]
	2003	35	99	204	17
	2004	22	97	161	20
	2005	36	103	88	31

Source: Self-evaluation reports and additional information from the departments
Note[1]: *Figures prior to 2003 are not available because direct intake to the programme was first established in 2003.*

Table 8 shows a significant decline in the number of admitted students at KU from 2001 to 2005. The drop in intake is alarming, and a further drop must be averted. The intake at AAU and AU has been declining since 2002, but both departments experienced an increase in intake from 2004 to 2005, whereas SDU has had a significant increase in intake since 2003. The issue of admission is thus most significant for KU.

The general attitude of the departments towards the student population is that the programmes should adapt to the academic level of the incoming students. However, a certain minimum academic level is important. In contrast to the current free intake, KU advocates an admission grade point average of 8, which is considered a medium-to-good grade. During the site visit at KU, the management presented statistics for students admitted between 1997-2000 that showed the majority of those students who were admitted with an average grade of 8 or below, did not pass any exams during the first two years ('Investigations of Study Progression in Science Education – An Anthology' (Studieforløbsundersøgelser i naturvidenskab – en antologi) in CND-KU publications no. 2003-05. Pp.19). Table 7 shows that of all the students admitted at KU in 2005, 47.7 % had a grade point average of 8 or below.

It may seem in conflict with the declining intake that KU pleads a minimum average of 8 as an admission requirement for the programme, as this will inevitably further reduce the number of students admitted. However, the statistical material from KU indicates that the number of students who complete the bachelor and master programmes would only be slightly lower following new admission requirements and the immediate consequences for intake numbers. The programme relies on funding from the Ministry, and this funding is based on the number of students who pass exams, not on the number of students admitted.

Table 9
Student admission distributed on grade point average in 2005

Grade point average	AAU	AU	KU	SDU
Below 6.6	-	2%	1%	-
6.6-7.0	8%	4%	7%	10%
7.1-7.5	11%	12%	16%	20%
7.6-8.0	28%	18%	24%	23%
8.1-8.5	19.5%	12%	18%	23%
8.6-9.0	11%	23%	16%	13%
9.1-10.0	19.5%	25%	11%	7%
Above 10.0	3%	4%	7%	4%

Source: Additional information from the departments

Although KU is the only department that advocates a minimum average grade 8, the students' low grade point average from their qualifying education is not unique to KU. Table 9 provides an overview of students admitted between 2001-2005, distributed according to their grade point average from their qualifying upper secondary school education.

At all departments, the number of students admitted in the summer intake in 2005, with a grade point average of 8 or below, is high. For example, at AAU, 47% of admitted students had an average of 8 or below, and, at SDU, the percentage was as high as 53%. AU has the lowest percentage of students with an average of 8 or below, at 36%. AAU, AU and SDU, however, stated at the site visit that the initial academic level of the students is not a primary concern, and they do not see a strong correlation between students with low grade point averages and students who fail the first year exams.

In order to obtain a good student population that pass exams, it is of course not only the students' grade point averages that matter. It is crucial that the programmes of the specific departments are promoted so that prospective students are able to make an informed choice regarding their education. A strategic and comprehensive promotion of the programmes creates a more informed and motivated student population without false expectations regarding the programme.

The investigation of dropout on the computer science programmes reveals that many of the admitted students display a lack of understanding of what the study in computer science entails. The students are often surprised by the high theoretical level of the programmes and the large workload. Besides this, there are especially two requirements which are important, but ones the new students generally are unaware of:

- An ability to understand mathematics at a high level of abstraction. Even though the students have an A-level in mathematics from upper secondary school, the level of the maths in the programme is experienced as being significantly higher than what the students have tried before.
- A basic understanding of the principles of programming. The students experience that they benefit from experience in programming, so they quickly can use the new tools that are required. Without programming experience, the student faces a heavy workload in an already fast-paced study.

Significant competences in both theoretical mathematics and practical programming thus are required, or must be achieved early in the first year. As stated in chapter 4.3 Theoretical and practical orientation, the aims do not account for this.

Wrong expectations and lack of necessary qualifications are major reasons for the early dropout from the programmes - dropout that to some extent could be countered by better information, as well as support-courses to help students in acquiring the necessary qualifications before or during the first year.

An issue connected with promotion of the programmes is the division between genders. The majority of the students are male, and the number of female students has been rapidly declining over the last five years. At KU, for example, only 14% of the students admitted in 2001 where female. In 2005, the percentage of female students had declined to 3% at KU, or 3 out of 88 admitted students.

All departments see the decline in female applicants as detrimental to the study environment and have vainly tried different initiatives to combat the trend. The departments assess that the low number of female students is primarily a consequence of a lack of communication between the departments and the Danish secondary and upper secondary schools. The lack of knowledge regarding computer science at the schools creates a false impression of the subject area, and many female students are put off.

The expert panel recommends that:

M.9.1 - all departments renew their efforts to increase the number of qualified students, especially female students. This is especially important for KU and SDU; at KU because of the alarming decline in enrolled students; and at SDU, so the department can continue to expand in order to sustain a dynamic study environment and to be able to employ more staff. All of the departments should collaborate in their initiatives to promote computer science at secondary and upper secondary schools. The initiative must strive to provide prospective students, particularly female students, with a correct picture of computer science, so that student expectations match the aims and content of the programmes.

S.9.2 - all departments inform prospective students of the significant competences in both theoretical mathematics at a high level and the practical programming the students are required to master early in the first year.

S.9.3 - KU investigates whether tightening the admission requirements to a grade point average of 8 increases the number of qualified students.

9.2 Dropout rate and graduation time

Dropout and graduation time in the Danish computer science programmes have been thoroughly examined in the EVA report, ‘Dropout at the Computer Science Programmes’ (Frafald på datalogiuddannelserne), published in Danish June 2006.

The statistics cover students admitted to bachelor or master programmes in 1998, 1999 and 2000, and students graduated in 2001, 2002 and 2003. The material, therefore, to some extent provides a historical record of the programmes. The data cannot capture the possible recent improvements made to the programmes, with regard to drop out and graduation time.

In this section, elements of the above report on dropout and graduation time are used to emphasise issues derived from the self-evaluation reports and the site visit. It is important to note that the definition of dropout in this report follows the one in the report on dropout and graduation time. Dropout is defined as an interruption of studies, whether or not this is followed by enrolment on another program. The term late dropout is, in this report, used for those who drop out after a year or more.

Dropout and graduation time are general problems in the Danish Natural Science programmes. Tables 20 and 21 in Appendix E compare the computer science programmes with those of the natural science programmes in general, in relation to dropout over the first four years of study. The number of students who discontinue their programme is considerably higher for the computer science programmes than for the remainder of the Natural Science programmes in general.

The structural mechanisms of the Danish education system can, to some extent, be contributing factors to both the long graduation time and high dropout rate. The grant system (SU) combined with free higher education, allow students to try different educations and to study for more than the prescribed number of years. In this connection, it is important to focus on the departments’ abilities to provide incentives for students to stay with computer science and to finish in a timely manner. The structural conditions cannot, though, explain why dropout is higher in the computer science programmes than for the remainder of the science programmes.

9.2.1 Dropout

The dropout rate varies significantly among the departments. Below, is an overview of the students, divided into those who are active, those who have discontinued and those who have completed the Computer Science bachelor programme at the various universities.

Table 10
Status for bachelor students in Computer Science for years 1998-2000[1]

		After 1 year	After 2 years	After 3 years	After 4 years
AAU[2]	Active	96 % (169)	84 % (147)	36 % (63)	20 % (36)
	Discontinued	-	10 % (18)	19 % (33)	20 % (36)
	Completed	-	6 % (11)	45 % (80)	59 % (104)
	Total	100 % (176)	100 % (176)	100 % (176)	100 % (176)
AU	Active	70 % (99)	47 % (66)	36 % (51)	19 % (27)
	Discontinued	30 % (42)	53 % (75)	57 % (81)	62 % (88)
	Completed	-	-	6 % (9)	18 % (26)
	Total	100 % (141)	100 % (141)	100 % (141)	100 % (141)
KU	Active	64 % (279)	40 % (175)	29 % (126)	18 % (76)
	Discontinued	35 % (150)	57 % (248)	65 % (284)	71 % (309)
	Completed	1 % (5)	3 % (11)	6 % (24)	11 % (49)
	Total	100 % (434)	100 % (434)	100 % (434)	100 % (434)
SDU[3]	Active	95 % (18)	84 % (16)	79 % (15)	47 % (9)
	Discontinued	-	-	-	-
	Completed	-	-	-	37 % (7)
	Total	100 % (19)	100 % (19)	100 % (19)	100 % (19)

Source: Dropout at the Computer Science Programmes (Frafald på datalogiuddannelser) EVA June 2006
Note[1]*: Empty cells mean that there are less than five people in the category.*
Note[2]: *First year is the science year. The dropout at the science year is not included in the table.*
Note[3]: *Some students start at the science year and some start directly at computer science or other subject which are combined with computer science. The dropout at the science year is not included. (See Appendix A in the report 'Dropout at the Computer Science Programmes' for methodological considerations (in Danish)).*

The table shows that 71% of the students admitted to computer science at KU in 1998-2000, have discontinued their studies after 4 years, compared to 62% at AU and 20% at AAU. It should be emphasised that the dropout for the science year at AAU is not included in the table. The report from EVA about dropout at the computer science programmes states that the average dropout for the science years where between 16% and 19% from 1998 to 2000.

Even though dropout thus must be considered a major issue, none of the departments has developed systematic procedures to monitor and gather feedback on the reasons for dropout, or formulated a strategy for reducing dropout.

According to the report on dropout, there are different reasons for the dropout. The report distinguishes three types of reasons:

- *individual factors* that "push" the student out of the studies;
- *institutional factors* that "push" the student out of the studies;
- *industrial factors* that "pull" the student out of the studies.

The most significant *individual factors* are, according to the report on dropout, that the students' expectations are not met and that their study-related resources are insufficient. This was confirmed by the documentation for this report.

Generally, the departments anticipate early dropout due to false expectations during the first study-year, and their primary concern is mostly the later dropout. However, as suggested in 9.1 *Admission*, high skill-levels in mathematics and programming skills are required early in the studies. In addition to wrong expectations, one reason for dropout may, therefore, be students' lack of necessary skills in mathematics and programming. This can, to some extent, be counteracted, and early dropout should therefore be given the same priority as late dropout.

AAU, for example, offers short 'turbo' support courses a month before study start in order for all students to be able to acquire the necessary skills. This is a laudable initiative, which could profitably be adopted at the other departments.

Generally, a lack of academic integration is an important issue with regard to dropout. Academic integration covers a variety of factors, such as unmatched expectations, lack of interest in the subject area, lack of qualifications, bad experiences with the project work form and the experience of a very high academic level that "pushes" the student out of the studies.

At AU, graduation time and dropout became a focus area in the revision of the curriculum in 2003. The first semester now contains more computer science courses. These courses can alleviate the situation of students later finding that their expectations of the programme are not being met, and in that way reduce late dropout.

AU and SDU suggest the quarterly structure, as a possible mechanism to reduce dropout. Frequent exams assess students' academic abilities at an earlier stage, and frequent exams can be more manageable. This can make students more confident and active throughout the year. A combination of a clear introduction to the subject area and more, smaller exams is a possible initiative to strengthen the academic integration.

The social environment also has an effect on dropout as an *institutional factor*. A feeling of being part of a cohort both motivates the students and gives them a sense of being responsible to their fellow students. Some efforts are made in this direction. At KU, organising the students into classes to some extent creates a cohort-feeling, and, at AU, reading groups have been created with older students as tutors. The impression from the interviews with students and graduates during the site visits was, however, that particularly KU lacks a good social environment. The facilities are not optimal, and the high dropout rate spoils the cohort-feeling among the students.

The programme that stands out on this point is AAU. The extensive use of problem-based learning in groups has a very positive effect on the social integration. The group work requires continuous effort on the part of its members, and creates interdependence. The student feels a responsibility to the other group members to stay and do the work, and dropout is therefore less likely.

Industrial factors are also important in relation to late dropout. Particularly at master level, students leave because of attractive job-opportunities. KU feels that such job-opportunities are a reason for late dropout. As a member of the KU-management expressed it, "We cannot compete with cash." The departments must, in fact, be able to compete with the labour market in the sense that it must be attractive for the students to complete the programmes.

The expert panel recommends that:

M.9.4 - all departments formulate and implement a strategy for reducing dropout. Aspects such as informing prospective and new students about programme details, enhancing academic integration, and improving the social environment by creating a cohort-feeling among the students must be taken into account. AU, KU and SDU, furthermore, ought to consider support courses for newly admitted first year students, prior to study start, in order to support an easier adaptation of the new students in terms of mathematics and programming skills.

9.2.2 Graduation time

Generally, the departments assess the student graduation time to be satisfactory, even though it is longer than prescribed at AU, KU and SDU. The average graduation time varies between the institutions, as illustrated in table 11 below.

Table 11
Graduation time in years for computer scientists who graduated between 2001-2003[1]

Institution	Average graduation time	25 % percentile	Median	75 % percentile
AAU	5,0 (57)	4,7	4,8	5,0
AU	6,7 (118)	5,3	5,8	7,8
KU	8,8 (109)	6,6	8,0	9,8
SDU	7,1 (15)	5,8	6,5	7,7

Source: Dropout at the Computer Science Programmes (Frafald på datalogiuddannelser) EVA June 2006
Note[1]: *The total number of study years is stated for master students who graduated from computer science in 2001-2003, and who have earlier been enrolled on the bachelor programme in computer science. Graduates that have graduated in less than four years have been excluded. (See Appendix A in the report 'Dropout at the Computer Science Programmes' for methodological considerations (in Danish)).*

Again, it should be noted that these statistics are based on somewhat historical figures and should be interpreted with some caution.

At KU, the graduation time is high, whereas the graduation time at AAU corresponds to the prescribed number of years. This difference can to some extent, as indicated during the site visits, be a reflection of the available job-opportunities. In Copenhagen, the labour market is extensive compared to Aalborg, where a limited range of jobs are available, and is thus not a prolonging factor in terms of student graduation time. However, the graduation time at AU and SDU is also higher than the prescribed number of years. The average time calculation for SDU is, however, based on a small number of graduates and should, therefore, be taken with some reservation.

AU has, as earlier stated in Chapter 3.2 Vision and strategy, expressed as a goal that the students should complete their studies in a timely manner. This has resulted in a range of initiatives, including: the adoption of a quarterly programme structure; the introduction of a core course on perspectives on computer science as part of the first year syllabus; detailed study plans that are discussed with a member of the academic staff each semester; and the introduction of thesis contracts with clear deadlines. It is not possible to assess the impact of theses initiatives yet, but they appear sound and are commendable.

The group work at AAU also has a positive effect on the graduation time. The individual student feels responsible to the group and is motivated to pass exams and to generally keep pace with the rest of the students. There are also systematic procedures that ensure that students who fail twice receive a letter and, subsequently, have to make a plan to get back on track. According to the self-evaluation report, it is a stated policy at AAU that the master thesis must be completed within a semester. These firm, but supportive initiatives are good incentives for the students to finish in a timely manner.

KU emphasises that there are firm deadlines for all project work. However, the statistics indicate that the average graduation time is more than three years longer than prescribed. In the survey conducted for the investigation of dropout, the graduates and the students at KU point to a high workload and extensive examinations.

In the evaluation of the programmes from 1997, KU was recommended to plan the programme in a way that would ensure that the students were able to graduate in the prescribed time. It is remarkable that the graduation time remains so high, and it emphasises that KU has yet to take action regarding graduation time.

SDU also states that there are deadlines for all assignments, as well as thesis contracts. The students are, furthermore, offered individual counselling sessions with a faculty member of the department during the bachelor and master programmes.

The expert panel recommends that:

M.9.5 - AU, SDU, and especially KU, clearly formulate an action plan for reducing graduation time. This could include policies for assignment deadlines and thesis contracts, as well as efforts to create a cohort-feeling among students, for example with more group-work and supportive student/teacher networks for students that fall behind.

9.3 Study environment and counselling

Study environment
The study environment has shown itself to be very important. Part of good study environment is that the student is included in the developments and changes in the discipline and has a good contact with the academic staff. All the departments have an "open door policy" that is intended to promote an informal and open dialogue between the staff and the students. The departments further emphasise the importance of other informal forums for student-staff interaction. The self-evaluation group at AAU mentions, for example, that the department's coffee room and cafeteria are common to both students and staff, which makes informal contacts and discussions possible on a daily basis. Particularly KU and SDU emphasise in their self-evaluation reports the students'

direct influence in the continuous planning of the programme. These initiatives are ways of integrating the students into the academic environment.

As previously discussed a cohort-feeling and good relations among the students make the students feel more responsible to each other, thereby decreasing the dropout rate and the graduation time. Dropout, in a sense, can create a vicious circle where dropout leads to a weak social environment which in turn leads to more dropout. A strong social environment is thus crucial for the quality of the programmes.

Student support and counselling

At university and faculty level, there is central guidance to information about studies and job-possibilities. There is, in addition, guidance from student counsellors for individual subject areas at the department or the faculty level. A large number of the study elements contain academic supervision. In addition to these possibilities, the departments have different initiatives.

At AAU, there are mechanisms to ensure that students make an action plan if they fall behind or fail courses. The students at AAU, though, emphasise even more the supporting role of student tutors, who are older students that support new students and help them with practical matters. At KU, older students are hired to assist students at bachelor level with specific tasks and exercises.

At AU, the management holds annual interviews with each student. However, during the site visit, these were seen to be more useful to the management than to the students. The management sees the interview as a way to get feedback on the students' impression of the programme and to guide the students in relation to their educational choices. At the same time, the interview functions as a way of preventing dropout and lowering the graduation time. The students find that the actual benefit of the interviews for them is limited. As one of the students expressed it, "It only took about ten minutes, and the management just wanted to hear which courses I wanted to take next year." The otherwise good initiative of individual student-staff interviews is thus not fully exploited.

An issue that was highlighted by the students during all site visits was the general lack of career counselling specifically designed for computer science students. Although it is hardly a problem for computer science graduates to find a job, the students' lack of information about the job-market and employment possibilities makes it difficult for them to make informed career choices. External initiatives, like job fairs, are welcomed at all the programmes. Events designed to establish contact between students, former students and employers, furthermore, exist at faculty level. There are some initiatives at department level, but these vary in magnitude.

AU maintains a web portal where employers are able to upload profiles and trainee offerings, and students can upload their CVs. At SDU, a career centre has been established in order to guide the students on career possibilities and contacting businesses, and to help students to write job-applications. At AAU, the department presents possibilities for an academic career at an annual meeting. However, for individual advice, the student is referred to the career counsellors at faculty level. At KU, there are no formal steps taken towards informing students about job opportunities at department level.

The expert panel recommends that:

S.9.6 - all departments actively support a sustainable social and academic environment. In order to ensure this, a cohort-feeling among the students must be enhanced. As an example, the departments can create or maintain a student tutor network and present role models in order to encourage students to continue their studies.

S.9.7 - all departments increase their effort to provide career counselling, including informing the students about events and where they can find information about job opportunities. Particularly KU needs to focus more on providing such information.

9.4 PhD studies

In order for the departments to have viable research environments, a certain number of PhDs are required.

AU and SDU have established the 4+4-model for PhD studies which means that the student enters the PhD programme after four years of study. AAU and KU use the traditional 5+3-model where the master programme is followed by the three year PhD programme.

All of the departments assess that they have plenty of qualified applicants. At all departments, the PhD positions are advertised both nationally and internally at the institution, the latter through information meetings. At AAU and AU the positions are periodically advertised internationally, due to the department's international PhD school, BRICS.

Table 12
Total number of PhD students enrolled in 2005 compared to the academic staff in 2005

	AAU[1]	AU	KU	SDU
PhDs enrolled[2]	27	59	18	4[3]
Academic staff[4]	33	32	28	8

Source: Self-evaluation reports and additional information from the departments
Note[1]: *Total staff and all PhD in department which cover computer science, informatics and software engineering.*
Note[2]: *The number for PhD students includes all PhD's enrolled in 2005, even if the PhD ended during the year.*
Note[3]: *The department, furthermore, has two PhD students occupied with didactic questions in science.*
Note[4]: *Professors, associate professors and assistant professors. Only full-time positions.*

Table 12 shows the number of PhD students enrolled at the four departments. The numbers of PhD students at KU and SDU is not particularly high.

AU is the exception, with a very strong population of PhD students. There are an average of 15 student enrolments in the PhD programme per annum, of which 5 are international. The high recruitment rate for PhD studies is a great asset for the research environment, and the department as a whole. However, many of the PhD scholarships are funded by the Dean, which is, in many ways, a fragile arrangement.

The departments state that the problem is not a lack of applicants, but a lack of PhD positions due to limited funding. All the departments find it difficult to obtain PhD funding. Apart from the limited grants from the faculty, however, there is a range of other funding possibilities, including research councils, industrial PhDs, EU framework programmes and various research foundations.

A viable PhD population is very important, and the expert panel assesses that the opportunities available are not fully exploited.

The expert panel recommends that:

M.9.8 - AAU, and especially KU and SDU, prioritise an increase in the number of PhD students and increase their efforts to attract PhD funding through all available means, including research councils, industrial PhD grants, EU framework programmes, etc. AU also has to find alternative ways of funding in order to be able to maintain its strong PhD population, as the current funding by the Dean is a fragile arrangement.

9.5 Facilities

The departments generally view satisfactory physical facilities, including IT equipment, as a prerequisite for a good study environment. The IT facilities are, in general, adequate and up to date and thus fulfil the demands of the programmes. The physical facilities at AAU, AU and SDU also constitute an adequate setting for the realisation of a sound study environment, whereas the buildings of KU are insufficient.

The differences between the buildings of the departments are striking. The facilities at AAU are reasonably new, and the department is situated in an environment with other science educations and IT-related industries. The department at AU is located in a new building, in what is called the IT City of Katrinebjerg, which houses various IT-related companies. The physical environment at SDU is adequate, but in no way extravagant.

The physical facilities at KU, though, are in a poor state and inadequate for ensuring a motivating environment. Some of the students met during the site visit stated that the facilities in themselves were a contributory factor towards the high dropout. The department states that there are no possibilities of improving the physical environment due to current cutbacks. However, the state of the buildings is unsatisfactory, and a solution to this problem should be found.

The expert panel recommends that:

S.9.9 - the management at faculty level at KU considers ways of improving the physical environment in order to ensure an attractive and motivating working and study environment.

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10 Employment and graduate feedback

The purpose of this chapter is to assess departmental initiatives regarding employment and graduate feedback. The chapter first focuses on how the departments monitor employment opportunities and developments in the labour market. Secondly, it focuses on how feedback from graduates, as well as employers and the labour market in general, is used. This includes how the employment rate is monitored and compared with other related programmes.

10.1 Employment

It is important that the departments monitor student employment opportunities and developments in the labour market, as these issues must be reflected in the continuous planning of the programme. A firm knowledge of the relevant labour market, especially that part of industry which participates in computer related research and development, is a prerequisite for the formulation of good and relevant aims. Input from industry can benefit the programmes with regard to the renewal of the curriculum and provide insight into research processes in the industry.

The departments' contact with the labour market is primarily informal and based on personal contacts of the academic staff. Informal contact can give important input in relation to the content of the specific courses and exercises. However, departments can benefit from more formal and systematic contact with industry in order to receive additional input to the planning of the programme as a whole. All departments assess that they have a good idea of the needs of the labour market. However, since this knowledge is not systematically collected, the information is rarely made available in a consistent form, and it thus becomes difficult for departments to ensure that all relevant stakeholders are heard from.

During the site visits, the departments stated that they have not prioritised formal contact with the labour market because there is no unemployment. However, the high employment rate is rooted in a general under-supply of graduates compared with the demand in the labour market, and ignores the possibility that the graduate profiles or the study profiles could be improved. There is not one, but a range of different professional profiles that are relevant for graduates with a degree in computer science. Currently, the departments are, in principle, unable to relate their programmes to these profiles. In order to be able to do that, the departments must establish a system that provides systematic knowledge from all relevant sectors of the labour market.

One way to do this is to establish a formal advisory board, with members from industry and other relevant external partners, such as representatives from other computer science departments in Denmark or abroad. This initiative was recommended in the earlier evaluation of the departments in 1997, yet not implemented at any of the departments.

There are exceptions to this general observation at the departments. AAU is situated in an environment with other science programmes and a range of IT-related industries. Furthermore their department is a member of Nouhauz, a collaboration between researchers, students and industry with an interest in the IT-subject area.

At AU, the programme is located in the IT-city Katrinebjerg and is closely connected with the Alexandra Institute that is situated alongside the department. In Katrinebjerg, students, academic staff and IT- companies are gathered under the same roof, and the Alexandra Institute serves as a formalised connection between industry and IT-research. Furthermore, AU has, in collaboration with Aarhus Business College, established an internet portal, "ProjectZone," where private companies, government institutions and students can make contacts.

At SDU, the department has appointed an Innovation Professor, with a primary function of managing the contact with industry. The role of the Innovation Professor is to formalise the department's relationship with industry, and to communicate contacts and knowledge through projects and working groups. The initiative is interesting and original. However, the initiative seems to have had only a limited success. It is the expert panel's impression that the contact with industry established by the Innovation Professor is rather narrow in focus, and that the lack of a full and thorough appreciation of the relevant labour market prevents the initiative from being as fruitful as it might be.

The expert panel recommends that:

M.10.1 - all departments establish a formal advisory board, consisting of representatives from industry and other relevant external partners, for example from other computer science departments in Denmark or abroad. The expert panel strongly emphasises the advantages of an advisory board, as this makes it possible for departments to follow national and international trends in research, the labour market and student employment opportunities, enhance mutual cooperation, as well as receive input relevant to future development of the programmes.

S.10.2 - SDU further develops the initiative of the Innovation Professor. The professor's contacts with industry must be more broadly based, and the initiative as a whole must be subject to a strategic action plan.

10.2 Graduate feedback

It is important that the departments systematically use different kinds of feedback in order to continuously develop the programmes and meet the demands of the labour market. This helps ensure a programme of high quality and, in turn, a high employment rate amongst the graduates.

None of the departments have carried out systematic investigations of the graduates' occupational choices. An often cited reason is that graduates find employment quite easily, and there has been no recognised need for further investigations.

The departments can also establish relations directly with the graduates to receive feedback. Relevant feedback is, for example, whether the graduates find the competences provided by the programme relevant and adequate in their employment. Graduates could also give the departments insight into the need for further education that the institution might provide.

AU has close relations to the alumni-network called 'Datalogi-foreningen' (the society for computer science). About 50% of the graduates of AU are members of this network. The association is described as a platform on which AU can make contact with graduates employed outside the university. Each year, the association distributes a questionnaire to all of its members about employment, salaries, workings hours, etc. This statistical information is useful, as it provides a broad picture of changes in the labour market. The information does, however, lack significant details with regard to more specific questions concerning the education programme.

AAU has an address list of graduates at department level, but it is not systematically maintained. At the university level, an alumni programme is offered as a mail and web service with general news. AAU feels that these activities have not played a central role in the formation of department policies and is an initiative that could be further developed.

KU participates in 'Dansk Selskab for Datalogi' (Danish Society for Computer Science), which is an association for people who work in practical or theoretical computer science. The network organises events and, to some extent, serves as a forum for alumni. Furthermore, The Natural Science Faculty has an alumni society open for all graduates. However, none of these networks is exploited systematically.

At SDU, there is no formalised alumni-network at department level, but the faculty launched an alumni and student society called Science Network in 2004. The idea is that the network establishes contact between students and graduates in order to provide career opportunities for students. The department regularly holds symposiums for bachelor and master graduates where current students are informed about the different career opportunities. The symposiums, to some extent, make it possible to update information on the graduates.

The expert panel recommends that:

M.10.3 - all departments establish better procedures to gather feedback from, and about, graduates. This includes the formation of alumni networks to establish contact with graduates and thereby provide an opportunity to gather feedback on competences acquired in the labour market, general information about graduate employment and suggestions for developing the programmes.

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11 Internationalisation

This chapter deals with elements of internationalisation that are important to the departments and considers the extent to which they have achieved an international profile. The focus of the chapter is to assess whether the departments have a strategy for internationalisation, the extent to which staff and students are internationally oriented, and how international the departments are in relation to language.

11.1 International profile

Strategy for internationalisation
All departments to some degree see internationalisation as an index of good quality. However, none of the departments have established a clear strategy for internationalisation. International mobility is important in order to achieve new insights and to ensure a broader recruitment base for subsequent degrees and positions. A clear strategy and a continuous effort towards internationalisation is thus a long-term investment in order to ensure international recognition.

At SDU and KU, the strategies for internationalisation at faculty level are not reflected at department level. Consequently, the goals are unclear and not subjected to systematic follow-up. However, SDU recognises the need for internationalisation through international research cooperation, recruitment of foreign researchers and student exchange.

AAU has an overall strategy for being an internationally recognised institution in terms of both research and teaching. However, this strategy is not formal and elaborated. One of the significant initiatives at AAU is that the master programme is taught in English. This strengthens the international profile and attracts more foreign students. Furthermore, it goes hand-in-hand with the demand for international mobility.

AU is also on the right track regarding internationalisation. AU has strategic focus on international recruitment of academic staff, PhD students and student exchange. It has a stated goal that half of the academic staff should be recruited internationally. The scope of courses taught in English at AU is impressive.

Student exchange

There are some structural conditions common to the departments. One example is that all the institutions have an International Office at faculty or university level. Furthermore, all departments have a varied range of international exchange agreements that facilitate the planning and funding of student exchange. This structural setting, however, is merely a framework for the actual exchanges. The focus here will, therefore, be on the programmes' own initiatives and ability to make use of the facilities available.

The departments generally have a positive attitude towards the exchange of students. Student exchange is seen as a strength in both the programme and the study environment. However, the statistics illustrate that there is still room for improvement at the operational level.

The number of students studying abroad, and foreign students studying at the departments, varies significantly between the four departments. Below is an overview of international student exchange in 2004 and 2005:

Table 13
International student exchange 2004-2005

Computer Science department	Outgoing students 2004	Incoming students 2004	Outgoing students 2005	Incoming students 2005	Total number of students summer 2005
AAU[1]	7	60	4	52	387
AU	2	19	5	17	547
KU[2]	9	3	9	3	1113
SDU	4	6	4	6	145

Source: The self-evaluation reports
Note[1]: *Total department including informatics and software engineering.*
Note[2]: *The figures from KU on outgoing and incoming students only cover students for the academic year 2004/2005, i.e. autumn 2004 and spring 2005.*

As table 13 shows, there is a general discrepancy between in- and outgoing students in the programmes. AAU and AU have few outgoing students, but a large number of incoming students. Particularly AAU has an impressive number of incoming students. The department supports the exchange of students and has a large number of agreements with other universities, mostly within the EU, which facilitates studying abroad and encourages students from other universities to study at AAU. Apparently, the latter is AAU's primary outcome. The students currently study abroad on their own initiative, and the lack of encouragement is reflected in the lower number of students who study abroad.

At AU, all courses for the master programme are advertised and delivered in English provided at least one international student enrols on the course. The department currently has no plans to pursue an international bachelor programme.

According to the self-evaluation report, KU is not concerned about the relatively low number of exchange students. However, KU realises the benefits of exchange agreements and has actively supported the faculty in establishing an agreement with a high profile computer science programme at the University of Tokyo. The International Office connected to KU offers, in addition to practical advice on student exchange, a mentor network for incoming students as well as social events and orientation days for both incoming and outgoing students. These initiatives, above all, improve the integration of international students into the programmes.

At SDU all courses for the master programme are also delivered in English provided at least one international student enrols on the course. Apart from this, student exchange is given a low priority. The department sees student exchange as a force, but has no mission or strategy towards an increased exchange activity.

International staff
International staff are generally welcomed at the departments, which to some degree is reflected in the composition of the staff. Below is an overview of the exchange of academic staff in 2004 and 2005.

Table 14
International exchange of academic staff 2004-2005

Computer Science institution	Outgoing staff 2004	Incoming staff 2004	Outgoing staff 2005	Incoming staff 2005	Total number of academic staff 2005[1]
AAU[2]	3	4	5	2	33
AU	4	9	3	10	32
KU	2	2	3	1	28
SDU	5	2	5	2	8

Source: The Self-evaluation reports and additional information from the departments
Note[1]: *Professors, associate professors and assistant professors included. Only full-time positions.*
Note[2]: *Total department, including informatics and software engineering.*

Staff exchange is generally at a reasonable level compared to the total number of staff. However, AU and KU stand out: AU because of its high number of incoming staff; and KU because of low number of staff exchanges.

AU has a high number of staff from abroad, which is consistent with AU's goal of recruiting 50% of its academic staff internationally. The department has a strong tradition of international guest lecturers. This tradition is an important step towards an international programme of high quality. However, AU has no particular policy towards staff working abroad, which is an important way of obtaining new inputs and renewing teaching approaches. This aspect of staff exchange is not an integrated part of AU's goals regarding international recruitment.

KU's low number of exchange of staff can partly be the result of the exchanges being mostly based on personal contacts, as stated in the self-evaluation report. Thus, there is no formal international network of contacts and the initiative is left to the individual staff member. This is insufficient to create a flow of staff exchange.

The expert panel recommends that:

S.11.1 - AAU, KU and SDU formulate and adopt clear strategies for internationalisation. The strategy must include goals for international exchange of students and staff. In particular, KU and SDU need to prioritise international exchange.

11.2 Language

A successful process of internationalisation implies a wide range of courses being offered in English, and this requires staff with good language skills. In order to attract and integrate foreign students, it is also important that relevant information is available in English on the programmes' website, and that formal documents are generally available in both English and Danish. The table below outlines the number of courses offered in English at the departments.

Table 15
Courses offered in English at bachelor and master levels 2005

	AAU	AU	KU	SDU
Courses offered in English	24% (8)	7% (4)	4% (3)	55% (22)
Courses offered in English on request	24% (8)	69% (42)	29 (20)	18% (7)
Courses in total (both BSc and MSC)	100% (33)	100% (61)	100% (68)	100% (40)

Source: Additional information from the departments

The number of courses taught in English varies from department to department. Generally the number of courses offered in English is satisfactory, but KU stands out. KU only has courses in English at master level, and only 23 of the 43 courses offered at master level are in English or can be given in English on request.

The availability of formal and informal information about the programmes on the websites is important in order to attract and integrate international students. On all the departments' websites, the information available in English seems at first glance to be extensive. All of the websites' main pages are either in, or can easily be changed into English. At the general information level there is also a wide range of relevant student information and links concerning events, jobs, research, etc. None of the websites, however, provide an English version of the curriculum or other formal documents important to students. AU has chosen to offer highlights of the formal framework. This is a good initiative, yet does not entirely fulfil the need for formal knowledge about the programme.

The course descriptions are not consistently available in English at the websites. AU and AAU have English descriptions for the majority of their courses. SDU has a significantly high level of English information about the courses and has a link specifically for international students, which provides these students with a better overview of the available information. At KU's website, however, the course descriptions are in Danish only, as well as the information available to prospective and newly enrolled students.

The expert panel recommends that:

S.11.2 - all departments continue to supply a wide range of courses taught in English, as this supports international exchange. KU has particular potential for improving the international profile of its programme, as the department offers fewer courses in English compared with other departments.

S.11.3 - all course descriptions, as a minimum the courses taught in English, and other relevant pieces of information, are available in English on all the departments' websites. The curricula should be translated to English and made available to international students. Particularly KU needs to improve the level of information in English on their website.

12 Quality assurance

This chapter focuses on quality assurance at the departments. The chapter will first introduce the European standards for quality assurance in higher education, which the criteria for quality assurance in this benchmarking are based on. The chapter will then assess four main activities: the strategic framework for quality assurance; evaluation of teaching; reviewing of programmes; and the gathering of documentation.

The European standards for quality assurance
Quality assurance is an important aspect of the management of the programmes. Quality assurance is the regular and systematic gathering of information on educational matters and the use of this information in order to assure and improve the quality of the programmes.

As part of the Bologna Process, the European Association for Quality Assurance in Higher Education (ENQA) in 2005 published a set of standards for quality assurance. The standards were developed in cooperation with the European University Association (EUA), the European Association of Institutions of Higher Education (EURASHE), and the National Unions of Students in Europe (ESIB) and subsequently approved by the European Ministers of Education. This initiative is a step towards the establishment of a widely shared set of foundational values, expectations and good practice in relation to quality and its assurance in European higher education.

The criteria concerning quality assurance applied in this benchmarking (see Appendix C) follow these international standards.

12.1 Strategy, policy and procedures for quality assurance

In order to ensure coherent and systematic quality assurance, a formal strategy for quality assurance is an important prerequisite. Such a strategy must be implemented through policies and procedures.

AU, KU and SDU have not formulated and implemented a strategy for quality assurance, at the university, faculty or departmental level. SDU, though, participated in an audit (i.e. an evaluation of the institution's quality assurance procedures) in 2005, conducted by EVA, and states that they are in the process of adopting an overall strategy for quality assurance based on the recommendations of that audit. KU was also audited in 2004 by an international expert panel. KU have not yet, however, adopted a strategy or implemented the recommendations of their audit.

The departments at AU, KU and SDU, therefore, generally lack systematic and formalised procedures for assuring the quality of their programmes. Only a more or less standardised course evaluation procedure exists. Instead, there is an informal culture for quality assurance which is performed on a case by case basis in reaction to emerging problems. The lack of systematic and coherent quality assurance, however, makes the information gathering process - which serves to indicate problems in the programmes - untenable. It is, therefore, difficult for both the management and relevant stakeholders to assess the quality of the programmes, and difficult for the management to plan future development initiatives. The lack of a coherent and systematic strategy for quality assurance is a major issue and must be addressed by the three departments.

AAU is the only department which has a coherent and consistent strategy for quality assurance. The Faculty of Engineering and Science has, furthermore, produced a comprehensive quality assurance handbook that describes how the strategy is implemented and the specific allocation of responsibility for quality assurance at the faculty. The work with quality assurance at AAU is impressive and serves as a good example for AU, KU and SDU.

The expert panel recommends that:

M.12.1 - the management at AU, KU and SDU, at university, faculty and/or department level, formulate, implement and publish a formal strategy for continuous enhancement and assurance of quality in the programmes. The strategy must outline the organisation of the quality assurance, the allocation of responsibility for the different procedures, and the ways in which the strategy is implemented, monitored and reviewed. The students must be included in the quality assurance processes.

12.2 Evaluation of teaching and programmes

12.2.1 Course evaluations

Evaluation of teaching is done through course evaluations carried out by students during or upon completion of courses. Course evaluations are obligatory at all of the departments, but the way the evaluations are carried out varies. The evaluations provide insights into whether the staff involved with the teaching is qualified and competent. Secondly, the evaluations are used to gather feedback from students regarding the content and design of the courses. This feedback constitutes the basis for making improvements to the curriculum.

At AAU, all students are requested to complete electronic questionnaires for each course and for the semester as a whole. Based on the questionnaires and input from teachers, an evaluation report with recommendations is prepared and sent to the study board. According to the students, the participation rate in the evaluation is low. The students consider that the main reason for this is that the electronic questionnaires take a long time to fill in, due to the many issues and courses they touch upon.

AT SDU, course evaluations are performed at the end of a course and consist of standardised questionnaires. The collected evaluations, including a statement from the department, are submitted to the study board for further discussion.

At AU, courses end with an evaluation in the form of questionnaires distributed to the students. The questionnaires follow a standard layout, but can be rephrased by the individual teacher. The answers are reviewed by the teacher and sometimes by the department's teaching committee. The lack of standardisation of the questionnaires and the fact that the evaluations are not delivered systematically to the study board or teaching committee is problematic. From 2006, the faculty is introducing a common framework for course evaluation in the form of online questionnaires generated for all courses. This is a commendable initiative which could solve the current problems.

At KU, the evaluation of teaching is carried out either as a midterm evaluation or as an evaluation at the end of the course. There is no uniform design of the course evaluation forms. It is up to the individual teacher to decide which type of evaluation he or she finds useful for the specific course. Some teachers use midterm or end-evaluations of a qualitative form, and others use end-evaluations based on pre-configured questionnaires. Feedback to the department is provided by the teacher who prepares a minute of the evaluation and forwards this to the study board. This issue was also addressed in the evaluation of 1997, where KU was given a recommendation to strengthen the use of and feedback from course evaluations. Obviously, this has not been done. The lack of formal procedures and standardisation is a serious problem, which KU must address.

All of the departments give a weak account of how the departments follow-up on the course evaluations. The study boards can, on the basis of the evaluations, appeal to the heads of departments to replace a teacher or provide pedagogical training.

According to the students, it is not always clear what the course evaluations are used for. For some, the evaluations seem a waste of time as they consider the evaluations to be rituals, mainly done for the sake of appearance. The lack of trust towards course evaluations is a significant problem which limits their effectiveness.

AAU is the only department that addresses the issue of lack of utilisation of the evaluations. The quality assurance handbook states that the study board is required to publicise a written account, which discusses the problems raised in the course evaluations and describes initiatives to solve them. However, the handbook does not give a description of the specific measures or procedures which can be initiated on the basis of the feedback from the course evaluations.

The expert panel recommends that:

M.12.2 - SDU, and especially AU and KU, ensure that all study elements are evaluated systematically with objectively designed course questionnaires. The evaluations must be submitted to the responsible study board or committee, and not simply the teacher involved to teacher. AAU must address the students' low participation rate in the semester and course evaluations.

M.12.3 - all departments describe how they use and follow-up the evaluations, and that this knowledge is disseminated to the students. The follow-up must be publicised, so students are informed about the consequences.

12.2.2 Review of the programmes

All of the departments make frequent revisions to the study programmes. The study elements can be adjusted annually, and the whole programme is normally discussed and revised every 2-3 years in order to ensure that the curriculum is coherent and up-to-date. Course evaluations and the academic staff's awareness of changes in the discipline and the related industry are important bases for the revisions.

AAU is the only department that has decided that the bachelor and master programmes must be formally evaluated every five years. In these evaluations, external collaborators from other academic environments and industry are involved. The main focus of the recurring evaluations is, firstly, to assess whether there is satisfactory consistency between the ministerial demands, the aims of the programmes, the needs of the labour market and the qualifications of the graduates. Secondly, the programme evaluation provides input to the study board on how to ensure and further develop the quality of the programmes at AAU.

AAU's decision to carry out recurring evaluations of the programme with external participation is highly commendable. The department sets the standard for good practice with regard to quality assurance - an example that the other departments should be inspired by and emulate.

The expert panel recommends that:

M.12.4 - AU, KU and SDU adopt periodical programme evaluations involving external parties from other academic environments and industry. The programme evaluations can, for example, be used to assess the consistency between: 1) the aims of the programmes; 2) labour market requirements; and 3) graduate qualifications - and thereby provide input for the further development of programme content and quality.

12.3 Collection of information

An important aspect of quality assurance is having procedures to collect and disseminate information on the running of the programme, which support the effective management and planning of the programmes. If key information on the programmes is published, it also gives various stakeholders and prospective students important information about the quality of the programmes.

It has become clear that the departments have few systematic procedures for gathering key information and statistics. Only basic statistics, such as exam activity and admission, are systematically produced. Important issues such as drop out rates, graduation time and graduate employment are, for example, are not monitored.

Some statistical information concerning the programmes is normally compiled and published at the faculty level, but this data is somewhat abstract, and it is difficult to gain a detailed understanding of specific programmes. One exception is the publication of key figures by the Faculty of Science at KU. The statistical material collected on economic, staff and study related issues is impressive. However, the material does not include data concerning dropout rates, graduation time and graduate employment.

The expert panel recommends that:

M.12.5 - all departments adopt systematic procedures for the collection and disseminate key programme information and statistics to support the management and create transparency for both internal and external stakeholders. Especially important issues are dropout rates, graduation time and graduate employment.

13 Individual responses to each department

This chapter provides each of the four participating departments with an individual response to its self-evaluation report, emphasising the strengths, weaknesses and opportunities that the expert panel found most important. The response to one department may, nevertheless, be important to other departments.

13.1 Aalborg University

The number of students studying computer science at AAU in 2005 was 156. There has been a reduction in enrolled students, from 45 in 2001 to 36 in 2005, but the number of admitted students seems to fluctuate annually.

13.1.1 The self-evaluation report

AAU has produced a self-evaluation report which adequately covers the strengths and potentials of the computer science programmes. The self-evaluation report contains a thorough discussion of teaching methods, based on the PBL approach. However, there is no real analysis of the competences achieved. In addition, the report is somewhat weak on statistics.

13.1.2 Strengths

AAU has developed programmes with a strong professional orientation, with emphasis on employability, especially through group-work that emulates the way work is conducted in industry. These programmes, therefore, make an important contribution to Danish computer science.

The problem-based learning approach succeeds in involving and motivating students, as well as creating a sense of responsibility towards fellow group members. This contributes towards student retention and is reflected in low dropout rates and short graduation times, something that could inspire other departments.

AAU is the only institution that has developed a coherent and consistent strategy for quality assurance, and has described this in a comprehensive quality assurance handbook. The work with quality assurance at AAU is impressive and constitutes a good example for other institutions.

There is an effort towards internationalisation, especially at the master level, with a flow of 30 to 40 international students per year.

13.1.3 Weaknesses and opportunities

Produce clearly stated competence profiles
The department has not found it necessary to define competences for the programmes. A clearly formulated competence profile, however, could be a strong asset, particularly in view of the professional orientation of the programmes. *(M.6.1)*

Increase student enrolment
There is a fairly small enrolment of students to the programme, which is inconsistent with the high demand for graduates in computer science. The department needs to form a strategy to increase the intake. The close collaboration with informatics and software engineering, with whom computer science share department, provides a viable study environment in spite of the low number of students. *(M.9.1*)

Increase the ECTS rating of the study courses
According to the students, the ECTS points allocated to the courses do not satisfactorily reflect the workload and time needed to complete these courses. In addition, the strong emphasis on the project teaching form removes focus from certain basic skills and, in particular, the theoretical content of the programme. A change in the ECTS allocation, so more points are given to fewer courses, would both reflect the time needed to take the courses and emphasise the importance of the acquired knowledge. *(M.5.3)*

13.2 University of Aarhus

There were 547 students studying computer science at AU in 2005, making AU the second largest programme, after KU. The number of enrolled students has been stable, approximately 100 students each year since 2001.

13.2.1 The self-evaluation report

The self-evaluation report is well written and provides a good and honest impression of programme strengths and potentials. The report is thus a good repository of ideas for continuous programme development, and gives an impression of a dynamic department ready to cope with future challenges.

13.2.2 Strengths

The department at AU has a strong population of PhD students, with an average of 15 such students enrolled per year. The high recruitment of PhDs is a great asset to both the research environment and the programmes in general.

AU emphasise the importance of allocating permanent staff to teach the first year courses. This is so that new students are introduced to tenured staff as quickly as possible, and also to ensure teaching of high academic quality. Besides this research-based teaching of high quality, new students get to meet academics central to the research environment, and feel that the programme puts their education first.

AU has as a stated policy of educating graduates in a timely manner. This has resulted in a range of initiatives. These include: the replacement of a semester system with a quarterly one, aimed at providing more frequent feedback on student progress; the introduction of a foundation course in perspectives of computer science as part of the first year syllabus, aimed at giving students a feeling for the topics of some later courses; the provision of detailed study plans that are discussed with a member of the academic staff each semester; and the introduction of theses contracts with clear deadlines.

13.2.3 Weaknesses and opportunities

Establish pathways for the master education

The master programme at AU is mainly constructed of optional elements. To ensure coherence and progression, it is part of the admission procedure to the master programme that the student, with guidance from the department, assembles a coherent study plan. This is then submitted for approval by the department. The programme could still benefit by exemplifying main pathways. This would improve transparency for students, employers and other stakeholders by showing the different specialisations and competence profiles available to students. *(M.4.3)*

Increase and systemise quality assurance

AU has no formal strategy regarding quality assurance, and generally lacks defined and systemised procedures. Course evaluations can be formulated by teachers and are neither systematically delivered to, nor analysed by the study board or teaching committee of the department. The department has not described how feedback is used. *(M.12.1, M.12.2 & M.12.3)*

13.3 University of Copenhagen

There were 1,113 students studying computer science at KU in 2005, making it the largest programme in Denmark. KU has experienced a rapid decline in enrolled students, from 206 students in 2001 to 88 students in 2005.

13.3.1 The self-evaluation report

The self-evaluation report is short and does not seem to be the result of a rewarding and thorough self-evaluation process. In the self-evaluation report KU states, that the curriculum has been updated several times over the last years: "Therefore most problems and ideas have been discussed over and over again and very little new has come to our attention during this self-evaluation." There are many cross-references in the report, which do not answer the posed questions adequately, and the assessment of department strengths and weaknesses lacks perspective. The self-evaluation report gives an overall impression of a department uncertain of its future, and somewhat reluctant to change. This is especially problematic, as KU faces serious challenges in the coming years.

13.3.2 Strengths

KU has a history as the oldest and largest computer science department in Denmark. KU seems to successfully attach students to research groups, especially in the master programme, which means that students gain insight into research processes.

KU provides a substantial and compelling account of the rationale behind its application of different examination methods. These examination methods are tailored to match the teaching methods, and it is a strength that examinations assess the different goals and competences of the programme.

13.3.3 Weaknesses and opportunities

Increase the student enrolment

The recent drop in student enrolment is alarming, especially combined with the high dropout rate. It is vital that KU makes a long-term action plan to ensure an increase in the student population, in order to create a good study environment. KU should investigate whether tightening the admission requirements to a grade point average of 8 would increases the number of qualified students. *(M.9.1 and S.9.3)*

Make clearer pathways through the programmes and increase the transparency

KU has the most flexible bachelor and master programmes of the four institutions, with few restrictions on the students' possibilities to freely select and combine study elements. KU needs to establish measures to ensure that students follow coherent study plans, which allow for progression and the attainment of sufficient competences. This could, for example, be done by establishing fixed pathways that the student could choose. Coherent and fixed pathways could also have a beneficial effect on graduation time and dropout rate. *(M.4.3 & M.5.2)*

Strengthen the management

The organisation of KU is largely decentralized, with responsibility delegated to research teams and teaching groups. This results in a somewhat fragmented department organisation, with no common overview or shared vision of the programme and its future development. The extended delegation, furthermore, reduces general management efficiency and programme quality assurance. This reduces the ability to carry out coherent long-term planning. The department needs to strengthen its management, and work towards establishing a consistent, broadly accepted view of programme goals and priorities. *(M.3.2 & M.3.5)*

Improve the course evaluations with clear follow-up

There seems, generally, to be a lack of organisation at KU in relation to quality assurance and, particularly, course evaluation. There is no uniform design for course evaluations, and student feedback is processed by the course teacher. The lack of formal procedures and standardisation is a serious problem, which KU must address. The department must ensure that all study elements are evaluated systematically with objectively designed course questionnaires, and with clearly described feedback procedures. The evaluations must be submitted to, and followed up by, the responsible study board or committee, and not the involved teacher. *(M.12.2 & M.12.3)*

Increase the number of PhD students

The present ratio of PhD students to permanent staff is too low for a research based department. The department should investigate different potential sources of funding for PhD students, including EC and industrial collaboration. *(M.9.8)*

Develop external contacts

The department generally sees few benefits to formal relations with industry with regard to programme development. The expert panel urges KU to make serious and sustained efforts to obtain input from industry and other relevant external stakeholders. The establishment of an advisory board, to include industrial representatives and senior academics from other Danish universities, would support a more dynamic and open discussion about programme development. *(M.4.6)*

13.4 University of Southern Denmark

There were 145 computer science students at SDU in 2005. Over the previous 3 years, the number of students admitted to the programme has steadily increased to 31 students in 2005. Computer science at SDU shares a department with mathematics.

13.4.1 The self-evaluation report

The self-evaluation report is extensive, with many appendices. The report reflects an honest effort towards analysing department strengths and weaknesses, and shows that the department is motivated to deal with the challenges it faces.

13.4.2 Strengths

SDU is the only department that has worked thoroughly with the formulation of competences at programme and study element levels. This substantial and well organised analysis of expected competences is encouraging, and a benefit to SDU.

The initiative of appointing an Innovation Professor, whose role is to formalise relations with industry, and to communicate contacts and knowledge through projects and working groups, is original. It shows that the department at SDU is committed to cooperating with external partners, and is ready to use resources to make this possible. However, the present range of contacts is narrow and should be extended to cover a wider range of computer scientific interests.

SDU allocates mainly permanent staff to teach the first year courses. This shows that teaching of high quality is prioritised and ensures that new students are introduced to tenured staff as quickly as possible.

13.4.3 Weaknesses and opportunities

Establish a sustainable academic environment

The expert panel does not consider that SDU currently offers adequately well-rounded computer science degrees. The programmes at SDU are based on a small research staff, which means that core subjects in the programmes are not invigorated by research. This also means that there are fewer members of staff to share the workload of planning, administrating and running the programmes. While the programmes cover the main areas of a computer science curriculum, the number of teachers at the department with experience in computer science is too small to ensure a sustained development, following the evolution of both academic requirements and labour market needs. SDU must seriously consider how to be able to correct this situation, by offering research-based teaching by computer scientists from the department in the core subjects.

SDU must, therefore, adopt a long-term strategy for extending the academic staff in core areas of computer science. The panel recommends three immediate actions:
- a continuing expansion of staff within computer science;
- a closer collaboration with other computing-related programmes;
- a separation from the mathematicians in the department and merge with a more computing-related department.

The expert panel estimates that it is not enough just to expand the number of staff in the current setting, and that computer science at SDU in a long-term perspective should move towards a separation from mathematics and a merger with another computing-related department. *(M.8.1)*

Increase student enrolment
Even though SDU has experienced a significant increase in students over the last couple of years, it is still vital that the programme continues to expand, both in terms of supporting more staff and developing a dynamic study environment. *(M.9.1)*

Assure progression
According to student responses, there are courses where content is repeated. It is important that a clear demarcation of the study elements exists, and that the curriculum is consistent and coherent in terms of requirements and content. SDU should revise the study regulations to ensure progression in the programme by requiring the completion of certain courses as prerequisites for enrolment to later courses. *(M.5.6)*

Appendix A

Recommendations

Profile, vision and management

The expert panel recommends that:

- **M.3.1** - all departments state and promote their individual programme profiles more explicitly, so that potential students have a better chance of making an informed choice as to which programme is best for them.

- **M.3.2** - all departments formulate, adopt and publicise a coherent vision that can be used as a yardstick for strategic actions to ensure continuous development of the programmes, and provide a common framework for the many individual actions taken at various levels of the organisations.

- **M.3.3** - all departments to a greater extent than hitherto formulate strategies for the central aspects of their programmes, and use these as a tool for continuous development. Important areas include: staff recruitment, graduation time, dropout, internationalisation and quality assurance.

- **S.3.4** - management establishes clear procedures and increases the level of communication to ensure that central aspects regarding the programmes are discussed and acted upon in a transparent way. Decision-making bodies must be located at the appropriate level, with the participation of all relevant stakeholders, including students.

- **M.3.5** - KU strengthen the management to support the development of a shared vision and common framework of strategies, which can unite the various groups in the department, thereby establishing a consistent, widely accepted view of the goals and priorities for the programmes.

Aims

The expert panel recommends that:

- **M.4.1** - AAU, AU and KU revise the description of the aims at each programme level in order to comply with the Ministerial Order of 2004.

- **M.4.2** - AAU, AU and KU elaborate on the aims of their programmes, and that AU, KU and SDU state the relation between the aims at programme level and the goals of study elements more clearly. This should be done by specifying which study elements support the fulfilment of which specific aims. A clear relation between aims and goals will make it possible to use the aims as guidelines for the continuous development of the programmes, to help students gain a coherent understanding of the programmes, and to facilitate the development of clearer programme profiles. Potential employers will, furthermore, be able to see what bachelor and master graduates ought to know.

- **M.4.3** - AU and KU elaborate on the aims of their master programmes by exemplifying main pathways to ensure transparency to students and other stakeholders.

- **S.4.4** – the programme aims specify how the theoretical and practical orientations are achieved in the programme, thereby helping potential students to gain a coherent understanding of what the study entails. Particularly AAU should specify and explain the importance and perceived outcome of the problem-based learning approach in the aims of its programmes.

- **M.4.5** – all departments establish a national forum where the institutions can become acquainted with developments in related programmes, ensure coordination, gain inspiration, share knowledge of good practice and generally discuss broad educational matters regarding the programmes.

- **M.4.6** - KU make serious and sustained efforts to obtain input from industry and other relevant external stakeholders and to encourage a more dynamic and open discussion of the aims and development of their programmes.

Content

The expert panel recommends that:

- **S.5.1** - the managements of AU, SDU and particularly KU investigate the measures that other institutions have taken to exploit the advantages of the quarterly structure.

- **M.5.2** - KU either increases the number of compulsory elements or demands that the combination of electives taken be formally approved, to ensure that each student receives a coherent bachelor programme and achieves sufficient competences.

- **M.5.3** - AAU change the ECTS weighting to reflect the real amount of time necessary to complete courses in a satisfactory manner. This would also emphasise the importance of the knowledge acquired through courses.

- **S.5.4** - AAU more clearly state the different possibilities that students have with regard to actively selecting and combining their own study programmes. This could occur through guidance counselling or published written instructions.

- **M.5.5** - KU establish measures to ensure that the students receive a coherent study programme at master level. This can, for example, be done by establishing content packages or by requiring that the student, as a part of the admission procedure, composes a coherent study programme that is subsequently approved. Both solutions presuppose that the department ensures that the student, to some extent, is able to predict which courses will be offered on the master programme.

- **M.5.6** - SDU ensure progression in the programmes by setting prerequisites in the form of completed courses.

Competences

The expert panel recommends that:

- **M.6.1** - all departments formulate, or reformulate, competence descriptions for their programmes in a systematic and easily comprehensible manner. The descriptions must be made at both programme level – as output competences in a competence profile – and at the level of the study element. The relation between the two levels must be explicitly stated. Clear competence descriptions help facilitate an understanding of the abilities and potentials of graduates, from the viewpoints of both prospective students and external stakeholders, and provide the student with an understanding of the potentials and relevance of the programme in a long term perspective.

- **M.6.2** - all departments establish ways of assessing whether the output-competences described in the competence profiles of the programmes are achieved. This should be done by showing how the competence profile is operationalised in terms of competences at study element level, the achievement of which is assessable through examinations.

Teaching and examination

The expert panel recommends that:

- **S.7.1** - new teaching methods are continuously developed and assessed. Both the lecture-oriented approach at AU, KU and SDU and the problem-based learning approach at AAU have advantages and allow the students to develop different competences, and the programmes can benefit by adopting features from both approaches.

- **S.7.2** - the management at AAU, SDU and, especially at KU, ensures that the first year of the bachelor programme is taught by motivated and qualified academic staff members. By letting the best tenured teachers teach the first year, the students get a good start and are more likely to feel part of the academic environment.

- **M.7.3** - the management at all of the departments develop incentives for good teaching performance. This can be done by systematically rewarding good teaching and outstanding teaching qualifications through monetary means or other forms of explicit recognition.

- **S.7.4** - departments balance the use of different types of oral and written examinations. This means that AAU should include more written examinations for their courses, and that KU and SDU should extend their use of oral examinations.

- **S.7.5** - SDU and KU consider simplifying some of their examinations based on multiple examination methods, so that examination pressure is reduced, which could result in a decline in graduation time and dropout. This, however, should be done with care, so the positive aspects of a broad assessment of the intended outcomes are not significantly reduced.

- **S.7.6** - AAU and AU develop a broader range of examination methods which themselves support the achievement of different competences and, furthermore, ensure that both practical and academic competences are assessed.

Academic staff

The expert panel recommends that:

- **M.8.1** – SDU adopt a long-term strategy for the expansion of the academic staff in core areas of computer science. There are three immediate actions SDU can take:
  - a continuing expansion of staff within computer science;
  - a closer collaboration with other computing-related programmes;
  - a separation from the mathematicians in the department and merge with a more computing-related department.

  The expert panel estimates that it is not enough just to expand the number of staff in the current setting, and that computer science at SDU in a long-term perspective should move towards a separation from mathematics and a merger with another computing-related department.

- **S.8.2** - KU and SDU extend the use of external teachers who give lectures or present cases. A more systematic use of external teachers would add important perspectives and support a dynamic academic environment.

- **S.8.3** – all departments formulate and adopt a strategy for recruitment. The strategy should include efforts to attract staff and PhDs from other universities and abroad in order to sustain a dynamic academic research and learning environment.

- **M.8.4** - all departments must formulate a strategy that will, over a period of time, ensure that all academic staff who teach on the programmes receive pedagogical training.

Students and study environment

The expert panel recommends that:

- **M.9.1** - all departments renew their efforts to increase the number of qualified students, especially female students. This is especially important for KU and SDU; at KU because of the alarming decline in enrolled students; and at SDU, so the department can continue to expand in order to sustain a dynamic study environment and to be able to employ more staff. All of the departments should collaborate in their initiatives to promote computer science at secondary and upper secondary schools. The initiative must strive to provide prospective students, particularly female students, with a correct picture of computer science, so that student expectations match the aims and content of the programmes.

- **S.9.2** - all departments inform prospective students of the significant competences in both theoretical mathematics at a high level and the practical programming the students are required to master early in the first year.

- **S.9.3** - KU investigates whether tightening the admission requirements to a grade point average of 8 increases the number of qualified students.

- **M.9.4** - all departments formulate and implement a strategy for reducing dropout. Aspects such as informing prospective and new students about programme details, enhancing academic integration, and improving the social environment by creating a cohort-feeling among the students must be taken into account. AU, KU and SDU, furthermore, ought to consider support courses for newly admitted first year students, prior to study start, in order to support an easier adaptation of the new students in terms of mathematics and programming skills.

- **M.9.5** - AU, SDU, and especially KU, clearly formulate an action plan for reducing graduation time. This could include policies for assignment deadlines and thesis contracts, as well as efforts to create a cohort-feeling among students, for example with more group-work and supportive student/teacher networks for students that fall behind.

- **S.9.6** - all departments actively support a sustainable social and academic environment. In order to ensure this, a cohort-feeling among the students must be enhanced. As an example, the departments can create or maintain a student tutor network and present role models in order to encourage students to continue their studies.

- **S.9.7** - all departments increase their effort to provide career counselling, including informing the students about events and where they can find information about job opportunities. Particularly KU needs to focus more on providing such information.

- **M.9.8** - AAU, and especially KU and SDU, prioritise an increase in the number of PhD students and increase their efforts to attract PhD funding through all available means, including research councils, industrial PhD grants, EU framework programmes, etc. AU also has to find alternative ways of funding in order to be able to maintain its strong PhD population, as the current funding by the Dean is a fragile arrangement.

- **S.9.9** - the management at faculty level at KU considers ways of improving the physical environment in order to ensure an attractive and motivating working and study environment.

Employment and graduate feedback

The expert panel recommends that:

- **M.10.1** - all departments establish a formal advisory board, consisting of representatives from industry and other relevant external partners, for example from other computer science departments in Denmark or abroad. The expert panel strongly emphasises the advantages of an advisory board, as this makes it possible for departments to follow national and international trends in research, the labour market and student employment opportunities, enhance mutual cooperation, as well as receive input relevant to future development of the programmes.

- **S.10.2** - SDU further develops the initiative of the Innovation Professor. The professor's contacts with industry must be more broadly based, and the initiative as a whole must be subject to a strategic action plan.

- **M.10.3** - all departments establish better procedures to gather feedback from, and about, graduates. This includes the formation of alumni networks to establish contact with graduates and thereby provide an opportunity to gather feedback on competences acquired in the labour market, general information about graduate employment and suggestions for developing the programmes.

Internationalisation

The expert panel recommends that:

- **S.11.1** - AAU, KU and SDU formulate and adopt clear strategies for internationalisation. The strategy must include goals for international exchange of students and staff. In particular, KU and SDU need to prioritise international exchange.

- **S.11.2** - all departments continue to supply a wide range of courses taught in English, as this supports international exchange. KU has particular potential for improving the international profile of its programme, as the department offers fewer courses in English compared with other departments.

- **S.11.3** - all course descriptions, as a minimum the courses taught in English, and other relevant pieces of information, are available in English on all the departments' websites. The curricula should be translated to English and made available to international students. Particularly KU needs to improve the level of information in English on their website.

Quality assurance

The expert panel recommends that:

- **M.12.1** - the management at AU, KU and SDU, at university, faculty and/or department level, formulate, implement and publish a formal strategy for continuous enhancement and assurance of quality in the programmes. The strategy must outline the organisation of the quality assurance, the allocation of responsibility for the different procedures, and the ways in which the strategy is implemented, monitored and reviewed. The students must be included in the quality assurance processes.

- **M.12.2** - SDU, and especially AU and KU, ensure that all study elements are evaluated systematically with objectively designed course questionnaires. The evaluations must be submitted to the responsible study board or committee, and not simply the teacher involved to teacher. AAU must address the students' low participation rate in the semester and course evaluations.

- **M.12.3** - all departments describe how they use and follow-up the evaluations, and that this knowledge is disseminated to the students. The follow-up must be publicised, so students are informed about the consequences.

- **M.12.4** - AU, KU and SDU adopt periodical programme evaluations involving external parties from other academic environments and industry. The programme evaluations can, for example, be used to assess the consistency between: 1) the aims of the programmes; 2) labour market requirements; and 3) graduate qualifications - and thereby provide input for the further development of programme content and quality.

- **M.12.5** - all departments adopt systematic procedures for the collection and disseminate key programme information and statistics to support the management and create transparency for both internal and external stakeholders. Especially important issues are dropout rates, graduation time and graduate employment.

Appendix B

Members of the expert panel

Mads Nygård (chairman of the panel)
Born in Mosjøen, Norway in 1953. He graduated in 1979 and holds a doctorate in Computer Science from NTH (the Norwegian Institute of Technology, Trondheim). From 1983 to 1997 he worked for SINTEF (the Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology, Trondheim) as Section Head, Research Manager and Principal Research Scientist in several different Information and Communication Technology departments. In 1997 he joined NTNU (the Norwegian University of Science and Technology, Trondheim) as Full Professor in the Computer and Information Science department. His main research interests are distributed systems and operating systems. His international work includes full-time work developing Information and Communication Technology education programmes in Thailand (1988), and China (1984) for the United Nations Development Programme and part time for the Organization for Economic Cooperation and Development in a task force on Road-Vehicle Communication Systems (1989-1992). He was the Organization Committee Chair for the Very Large Data Base 2005 conference. He has more than 50 international research publications and has been engaged as chairman/member of several boards, including boards of TEKNA (the Norwegian Society of Chartered Technical and Scientific Professionals).

Richard S. Bird
Richard Bird was born in London in 1943 and studied mathematics at Cambridge University. After a short period in industry, he returned to academia and obtained a PhD in computational complexity from the University of London in 1973. He was a lecturer at the Institute of Computer Science in London (1967-72), and the University of Reading (1972-83), before coming to Oxford in 1983. He is a tutorial fellow of Lincoln College, Oxford, and was made a Professor in 1991. He was Director of the Oxford Computing Laboratory from 1998 to 2003. His major research interests are in functional programming, algorithm design, and in the mathematics of program construction. He has published over 100 articles and four books, including The Algebra of Program-

ming, and An Introduction to Functional Programming using Haskell. He is the editor and main contributor to the Functional Pearls section of the Journal of Functional Programming.

Sacha Krakowiak
Born in 1937. He graduated from École Polytechnique in 1958 and obtained a doctorate in computer science from Université Pierre et Marie Curie in 1973. He has worked at INRIA from 1968 to 1973, where he was a project leader in operating systems, and prior to this at the Bassin des Carènes from 1962 to 1968, where he created and managed the Computing Centre. Since 1973, he has been a professor of Computer Science at Université Joseph Fourier, Grenoble. From 1990 to 1995, Sacha Krakowiak has been deputy head of Bull-IMAG, a joint research laboratory established by the Bull Company and the university of Grenoble, and leader of the Guide project. He is now a senior member of the Sardes project (a cooperation between the Universities of Grenoble and INRIA), concerned with distributed systems and component-based autonomous systems. He has been a member of the Scientific Board of INRIA from 1982 to 1995, and the coordinator of the French national cooperative research action on distributed systems from 1991 to 1997. He has published over 60 scientific papers and is the author or co-author of four books.

Karsten Vandrup
Born in 1966. He is Senior Research Manager in Nokia Denmark and holds a degree in Telecommunication and Electronics from the Technical University of Denmark. He is Technical Manager and Deputy Coordinator of the EU FP6 Integrated Project MAGNET1. Prior to this position, he has been Manager of Strategic Planning in the Nokia Research and Technology Access, and Global R&D Co-operation Manager in the Nokia Research and Education Policy Department at the Nokia Head Office. He is chairman of the Technology Foresight Council under the Danish Ministry of Science, Technology and Innovation, he sits on the Board of Governors at Crossroads Copenhagen, is Chairman of the Advisory Board for Center for Information and Communication Technology at the Technical University of Denmark, and is advisor for the European Commission in Technology Transfer issues and the 7th Framework Programme. He is co-writer of "The National Danish IT Research Strategy" by the Danish Ministry of Science, Technology and Innovation and a member of the Research and Education Committee of ITEK - the Danish ICT Association.

Appendix C

Set of criteria

A: Aims and organisation		Chapter
A1	The aims and organisation of the programmes (e.g. bachelor and master) are in accordance with the present legalisation;	4.1
A2	The aims of the programmes are clearly formulated and made publicly available;	4.2.1 & 4.2.2
A3	The aims are operationalised in goals, which are precise enough to allow an assessment of the extent to which they are fulfilled;	4.2.1
A4	The academic, didactic and administrative responsibility for the programmes is clearly allocated;	3.3
A5	The aims reflect the developments and challenges within the subject-area of computer science, nationally and internationally;	4.4
A6	The aims are realistic and achievable considering the nominal duration of the programmes and the initial level of the students;	9.1
A7	The aims are formulated and developed considering the needs and requirements of the labour market broadly defined (e.g. also research);	4.5
A8	The aims specify the intended mixture of theoretical and practical orientation as well as the intended balance between depth and width of the programme content.	4.3

B: Content and structure		Chapter
B1	There is consistency between aims, organisation and content of the programmes;	5.1, 5.2 & 5.3
B2	The content of the programmes is appropriate for the realization of the aims of the programmes (e.g. the combinations and prioritizations of courses and elements in relation to the balance between compulsory and optional elements and between width and depth of scope);	5.3

B3	Progression is evident in the different combinations and prioritizations of courses and elements in the programmes;	5.4
B4	The content covers both theoretical and practical elements;	5.5
B5	The programmes cover the relevant disciplines and approaches of computer science with regard to the needs and requirements of the labour market broadly defined;	6.2
B6	The programmes are updated on a regular basis in order to reflect the development of both the computer science discipline and the needs of the labour market.	4.4 & 4.5

C: Competences		**Chapter**
C1	The programmes have formulated output-competences for bachelor and master level that are comparable with the output-competences in the Danish Qualifications Framework, to ensure that students achieve the level required for a bachelor and/or master degree;	6.1.1
C2	The competences are expressed both in terms of academic contents and in terms of practical know-how;	6.1.1
C3	The competences clearly reflect academic and didactic principles and are in accordance with the awarded degree and realistic in relation to the duration of the programmes;	6.2
C4	The competences of the awarded degree (bachelor or master) are in general comparable to those required of a degree in computer science abroad;	6.2
C5	The content of the programmes offers students the opportunity to obtain competences at the level that has been formulated;	6.2
C6	The programmes qualify students to participate in and complete development processes and/or research.	8.1

D: Teaching methods		**Chapter**
D1	The teaching and learning methods reflect the aims of the programmes;	7.1.1
D2	The teaching and learning methods reflect academic and didactic principles which support the realisation of the aims of the programmes;	7.1.1
D3	The teaching and learning methods permit the achievement of the intended competences of the programmes.	7.1.1

E: Examination methods		Chapter
E1	The examination methods clearly reflect academic and didactic principles and sustain the realisation of the aims of the programmes;	7.2.1
E2	The examination methods are in accordance with the achievement of the intended competences of the programmes;	7.2.2
E3	The examination methods are coordinated across the whole programme to ensure that all of the competences and other learning outcomes are achieved.	7.2.2

F: Teaching staff and research		Chapter
F1	The composition of the teachers' academic and research qualifications reflects the aims of the programmes;	8.1
F2	The research results and methods are actively used in the teaching activities;	8.1
F3	The ongoing research is continually presented to the students thereby sustaining the learning environment of the programmes;	8.1
F4	The programmes attract qualified teachers and researchers and have a strategy which enhances recruitment of qualified staff in the future;	8.3
F5	The relevant subject-related areas of the programmes are suitably reflected in the composition of the teaching staff;	8.1
F6	The teaching is largely provided by academics and researchers who contribute to the development of the subject area;	8.1
F7	The teaching given by the regular staff is complemented by lectures or case studies presented by external persons (e.g. from the industry or other universities).	8.2

G: Admission, graduation time and dropout rate		Chapter
G1	The programmes have formulated a strategy concerning graduation time and dropout;	9.2
G2	The programmes systematically monitor graduation time and dropout rate and regularly compare these with those of related programmes to detect the effect of the strategy and possible new ways to enhance it;	9.2
G3	The terms of admission are relevant and sufficient to meet the academic requirements of the programmes;	9.1
G4	The programmes can be successfully completed within the set time.	9.2

H: Study environment and counselling		Chapter
H1	There is a sustainable academic environment at the programmes which ensure the academic dialogue between teachers and students and a good study environment;	9.2 & 9.3
H2	The organization of the study allows students to be in contact with both academic research and industrial environments, e.g. through internships in companies and research laboratories;	4.5 & 8.1
H3	The student facilities and student support ensure a good study environment;	9.3 & 9.5
H4	The student support and counselling, as well as the information given to students, are adequate for the students' progress.	9.3

I: PhD studies		Chapter
I1	The level of recruitment of PhD students is appropriate to meet the needs for research in the future.	9.4

J: Facilities		Chapter
J1	The IT-facilities are sufficient to fulfil the aims and intended competences of the programmes;	9.5
J2	The accommodation and material facilities support the development of teaching and research and are sufficient to implement the aims of the programmes.	9.5

K: Employment and graduates		Chapter
K1	The programmes systematically collect and use feedback from graduates, employers, labour market representatives and other relevant organisations in the continuing development of the programmes;	10.1 & 10.2
K2	The programmes monitor the students’ employment opportunities and the development in the labour market;	10.1
K3	The programmes monitor the employment rate of graduates and regularly compare it with those of related programmes.	10.2

L: Internationalisation		Chapter
L1	The programmes have a strategy for internationalisation;	11.1
L2	The internationalisation is reflected in the content and syllabus of the programmes;	11.2
L3	The programmes offer opportunities for students to study abroad and for teaching staff to teach and conduct research activities abroad;	11.1
L4	The programme endeavours to attract students from abroad, and to facilitate the integration of these students;	11.1 & 11.2
L5	The programmes facilitate and provide international contacts for students and teaching staff.	11.1

M: Quality assurance		Chapter
M1	The programmes have implemented the university's overall strategy for quality assurance in operational goals and procedures;	12.1
M2	The responsibility for the quality assurance mechanisms is clearly allocated at the programmes;	12.1 & 12.2.1
M3	The quality assurance mechanisms assure approval, monitoring and periodic reviews of the programmes;	12.2.2
M4	The student examinations are based on publicly available criteria, decisions and procedures that are applied consistently;	7.2
M5	Procedures are in place to obtain knowledge of whether teachers are qualified and competent to teach. The results are available for external reviews;	12.2.1
M6	The teaching is periodically and systematically evaluated. The evaluations should among other things cover mechanisms for receiving feedback from students;	12.2.1
M7	The resources available for the support of student learning are adequate and appropriate;	9.3 & 9.5
M8	The relevant information for the effective management of the programmes are collected, analysed and used;	12.3
M9	Quantitative and qualitative information on the programmes is published and is up to date, impartial and objective;	12.3
M10	There is a systematic follow-up on the evaluations of both programmes and teaching. The results of the evaluations and the plans for follow-up are available at the homepage of the university.	12.2.1 & 12.2.2

Appendix D

Agenda for the visits

6 February: Aalborg University
7 February: University of Aarhus
8 February: University of Southern Denmark
9 February: University of Copenhagen

Agenda:

09.00-09.30:	Interview with management
09.35-11.05:	Interview with self-evaluation group
11.15-12.15:	Interview with students
12.15-13.05:	Lunch
13.15-14.15:	Interview with teachers
14.25-15.25:	Interview with graduates
15.30-16.00:	Final meeting with management
16.00-16.30:	Tour of the facilities

Appendix E

Tables

Table 16
Compulsory study elements in the bachelor programme at AAU[1]

1st and 2nd semester: Science year (60 ECTS)

3rd semester (DAT1):
PU: Program development (26 ECTS)
SC: Algorithms and data structures (3 ECTS)
SC: Mini project in programming (1 ECTS)

4th semester (DAT2):
PU: Language and translation (21 ECTS)
PU: Simultaneous processes and operating systems (21)
PU: Syntax and semantics (21 ECTS)
SC: Computer and network architecture (3 ECTS)
SC: Syntax and semantics (3 ECTS)
SC: Language and compiler construction (3 ECTS)
SC: Principles of concurrency and operating systems (3)

5th semester (DAT3):
PU: Decision support systems (21 ECTS)
PU: Distributed systems - including processes, languages, data and control (21 ECTS)
PU: Programming paradigms (21 ECTS)
SC: Complexity and computability (3 ECTS)
SC: Decision support systems and machine learning (3)
SC: Programming paradigms (3 ECTS)
SC: Distributed systems (3 ECTS)

6th semester (DAT4):
PU: Database management systems (21 ECTS)
PU: Semantics and verification (21 ECTS)
PU: Software engineering (21 ECTS)
SC: Database management systems (3 ECTS)
SC: Semantics and verification (3 ECTS)
SC: Software engineering (3 ECTS)
SC: System development philosophy (3 ECTS)

Source: Self-evaluation report and study regulations
Note[1]: *PU stands for Project unit and SC stands for study courses. Project courses are integrated in the project units.*

Table 17
Compulsory study elements in the bachelor programme at AU

The obligatory core courses (70 ECTS):	Obligatory support subjects (20 ECTS):
Introduction to programming (5 ECTS)	Calculus 1 (5 ECTS)
Perspectives on computer science (5 ECTS)	Calculus 2 (5 ECTS)
Programming 2 (5 ECTS)	Mathematical modelling 1 (10 ECTS)
Usability (5 ECTS)	
Web technology (5 ECTS)	**Elective Computer Science courses:**[1]
Algorithms and data structures 1 (5 ECTS)	Compilation (10 ECTS)[2]
Algorithms and data structures 2 (5 ECTS)	Experimental system development (10 ECTS)[2]
Machine architecture (5 ECTS)	Semantics (5 ECTS)
Operative systems (5 ECTS)	Optimisation (5 ECTS)
Regularity and automation (5 ECTS)	Combinatory searching (5 ECTS)
Computability and logic (5 ECTS)	Distributed systems (5 ECTS)
Databases (5 ECTS)	Security (5 ECTS)
Software architecture (5 ECTS)	
Programming language (5 ECTS)	**Additional compulsory subjects:**
	Theory of science (5 ECTS)
	Bachelor project (minimum 10 ECTS)

Source: Self-evaluation report and Study regulations
Note[1]: *For the Computer Science line of study, elective courses equivalent to at least 25 ECTS points must be selected.*
Note[2]: *One of the courses Compilation or Experimental system development must be included.*

Table 18
Compulsory study elements in the bachelor programme at KU

The obligatory foundation course (1st year):	Obligatory supplementary subjects (2nd & 3rd year):
Algorithms and data structures (7.5 ECTS)	Data networks (7.5 ECTS)
Theory of computer science (7.5 ECTS)	Linear algebra (7.5 ECTS)
Distribution and databases (7.5 ECTS)	Compilers (7.5 ECTS)
Functional programming (7.5 ECTS)	Advanced algorithms (7.5 ECTS)
First year project (7.5 ECTS)	
Machine architecture (7.5 ECTS)	**Final part (3rd year):**
Mathematics and computability (7.5 ECTS)	Bachelor project (15 ECTS)
Object oriented programming and design (7.5 ECTS)	Theory of computer science (7.5 ECTS)
Operating systems and multi programming (7.5 ECTS)	

Source: Study regulations

Table 19
Compulsory study elements in the bachelor programme at SDU

Constituent obligatory subject elements:	**Secondary obligatory subjects:**
Programming A (5 ECTS)	Introduction to computer science (5 ECTS)
Programming B (5 ECTS)	Calculus 1(5 ECTS)
Discrete structures (5 ECTS)	Calculus 2 (5 ECTS)
Databases (5 ECTS)	Software development and testing (5 ECTS)
Internet and language based applications (5 ECTS)	Linear algebra (5 ECTS)
Machine architecture (5 ECTS)	Practical principles of application develop. (5 ECTS)
Programming language (5 ECTS)	Computability (5 ECTS)
Algorithms and data structures (10 ECTS)	Numerical analysis (5 ECTS)
Algorithms and complexity (5 ECTS)	Introduction to linear & whole-number programming (5 ECTS)
Operative systems (10 ECTS)	Bachelor project (10 ECTS)
Compiler theory (5 ECTS)	
Theory of science (5 ECTS)	
First year project (5 ECTS)	

Source: Self-evaluation report and Study regulations

Table 20
Dropout rates for the Bachelor programmes in Computer Science and the Natural Sciences in general, admitted 1998-2000

	After 1st year	After 2nd year	After 3rd year	After 4th year
Discontinued – Computer Science	**24 %**	**43 %**	**50 %**	**54 %**
Discontinued – Natural Sciences	17 %	27 %	33 %	36 %
Active – Computer Science	**75 %**	**54 %**	**34 %**	**19 %**
Active – Natural Sciences	82 %	70 %	49 %	22 %
Completed – Computer Science	**1 %**	**4 %**	**16 %**	**26 %**
Completed – Natural Sciences	1 %	3 %	18 %	42 %
Total Computer Science/ Natural Sciences	100 % (808)/(5408)	100 % (808)/(5408)	100 % (808)/(5408)	100 % (808)/(5408)

Source: Dropout at the Computer Science programmes (Frafald på datalogiuddannelser) EVA June 2006

Table 21
Dropout rates for the Master programmes in Computer Science and the Natural Sciences in general, admitted 1998-2000

	Status after 1st year	Status after 2nd year	Status after 3rd year	Status after 4th year
Discontinued – Computer Science	9 % (33)	18 % (64)	21 % (78)	25 % (91)
Discontinued – Natural Sciences	11 % (293)	14 % (369)	16 % (409)	17 % (447)
Active – Computer Science	89 % (323)	62 % (224)	44 % (159)	31 % (111)
Active – Natural Sciences	86 % (2217)	72 % (1861)	45 % (1167)	25 % (651)
Completed – Computer Science	2 % (7)	21 % (75)	35 % (126)	44 % (161)
Completed – Natural Sciences	3 % (79)	14 % (359)	39 % (1013)	56 % (1491)
Total Computer Science/ Natural Sciences	100 % (363)/ (2589)	100 % (363)/ (2589)	100 % (363)/ (2589)	100 % (363)/ (2589)

Source: Dropout at the Computer Science programmes (Frafald på datalogiuddannelser) EVA June 2006

Appendix F

Glossary

Abbreviations:

AAU:	The computer science department at Aalborg University
AU:	The computer science department at University of Århus
KU:	The computer science department at University of Copenhagen
SDU:	The computer science department at University of Southern Denmark
BSc:	Bachelor degree in science
MSc:	Master degree in science
PhD:	Doctorate degree
ECTS:	European Credit Transfer and Accumulation System
ENQA:	European Association for Quality Assurance in Higher Education

Vocabulary:

Aim (formål): The purpose of the programme.
Goal (mål): The purpose of the specific study elements, associated with the aims of the programme.
Study regulation (studieordning): Formal document that includes guidelines for the composition of study elements, examination and aims at the programme.
Curriculum (undervisningsplan): Descriptions of the study elements.
Discipline (studieretning): A field of study, for example computer science.
Department (institut): A specific organisation within a university, in charge of education and research in a discipline.
Programme (uddannelse): A number of study elements that altogether constitute a degree, for example a BSc, MSc or PhD degree.
Competence (kompetence): The ability to apply knowledge and skills in relation to actual situations.

Appendix G

Terms of reference

Aim
The Ministry of Science, Technology and Development (Ministeriet for Videnskab, Teknologi og udvikling (VTU)) has commissioned the Danish Evaluation Institute (Danmarks Evalueringsinstitut (EVA)) to plan and carry out a comparative survey of the quality of the Danish Computer Science education programmes in relation to corresponding foreign programmes that are known for their high level of quality. The evaluation shall result in a document that not only illustrates the strengths that the Danish programmes possess, but also one that identifies any quality problems the Danish programmes have in relation to their foreign counterparts.

Scope of the evaluation
The Computer Science programmes are in this connection understood to comprise the four Computer Science programmes of the University of Copenhagen, the University of Southern Denmark – Odense, Aarhus University and Aalborg University.

Method of evaluation
The proposed evaluation follows the internationally acknowledged method applied by EVA, the cornerstones of which are:

- self-assessment by the education programmes, where the programmes are given an opportunity to account for and analyse their own strengths and weaknesses. A report is produced, which constitutes a central element of the evaluation documentation material;
  external expert-groups who, by virtue of their experience of similar programmes at other locations, can contribute by placing into perspective and appraising the programmes that are under evaluation;
- institution-visits that provide the expert-group with the possibility of obtaining a first hand impression of the programmes and to raise in-depth questions concerning the self-assessment reports and other documentation material.

The evaluation will be based upon a range of predefined themes. Examples of such themes are:
- recruitment base
- entry requirements
- subjects and topics (content), profile
- research connection
- teaching forms
- testing and examination forms
- competences
- job-market (employment, relevance)
- post qualification training and further education, PhD.-programmes
- technical facilities

The range of themes is assembled by EVA and forwarded for comment and approval to VTU and any other involved institutions.

Expert group
An expert group is established comprising representatives from three institutions having a reputation for high quality. The task of the expert group is to carry out an assessment of the Danish education programmes. The assessment shall be based upon a range of common quality-criteria within the chosen themes that the expert group defines based on their own practice.

Self-assessment
The institutions will be requested to forward materials that describe and analyse the education programmes in relation to the different themes. As far as possible, existing materials should be used. New materials shall only be produced in situations where existing materials do not cover a particular theme. The themes for the self-assessment are based upon the stated criteria. The aim of the self-assessment is both to procure information to support the appraisals of the expert group as well as to provide an opportunity for internal reflection over individual practice by the participating institutions.

Visits
Based upon the self-assessment report, the expert group carries out a visit to the Danish education programmes. The visits will provide the expert group with the opportunity to obtain further clarification of the forwarded documentation and allow the group to gain a first hand impression of the institutions.

Information meeting
As an introduction to the self-evaluation process, an information meeting will be held for representatives of the Danish institutions offering Computer Science education programmes. The purpose of the meeting is to present the evaluation and the themes on which it is to be based.

Organisation and staffing
EVA appoints a project group that has the methodical and practical responsibility for the project. Evaluation Consultant, Mads Biering-Sørensen is the primary contact person in the project group. Senior Consultant Anette Dørge Jessen is responsible for the project at management level.

Under the preparation for the evaluation, EVA may contact VTU in order to discuss themes and other technical and content-related issues that are relevant in connection with the evaluation.