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PROBLEM-ORIENTATED GROUP PROJECT WORK AT ROSKILDE UNIVERSITY

WHAT IS IT, HOW IS IT PERFORMED, AND WHY ?

by

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IMFUFA = *Department of Studies in Mathematics and Physics and their Functions in Education, Research and Applications.*

PROBLEM-ORIENTATED GROUP PROJECT WORK AT ROSKILDE UNIVERSITY - WHAT IS IT, HOW IS IT PERFORMED, AND WHY ?

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Abstract

Project-organised studies at Roskilde University are presented from the view point of a foreign observer. Particular attention is paid to the Basic Studies in Science and to specialised studies in Physics. The meaning of problem-orientated project work is discussed taking into account key concepts such as interdisciplinarity and participant direction. The implementation of the project work is observed together with the roles played by staff and students. It is found that the project work is more than just a way of organising the studies and that the students develop competencies unrecognisable in most graduates from traditional universities.

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January 1997

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FOREWORD

In July 1991, whilst attending a GASAT (Gender And Science And Technology) conference in Melbourne, Australia, I heard about "problem-orientated project work" performed by groups of students, at Roskilde and Aalborg Universities, in Denmark. While the concept sounded interesting, it was difficult to grasp the full picture and implications for learning. To the uninitiated, thoughts of group work in particular, immediately raised questions concerning the integrity of both the learning and the assessment methods.

Since 1991 I have found myself increasingly frustrated with the use of traditional university teaching methods, coupled with the general lack in motivation apparent amongst many students. Furthermore, when members of the Applied Science course advisory committee (experts from industry and research groups outside my university) raised the possibility of group projects to give students experience in group dynamics within a working environment, the general response from academics was fairly negative, with mutterings of the impracticality of such methodology. So, when the opportunity for study leave arose, I decided to go and see for myself just what this Danish "project work" was.

The following report is based on six months (August 1996 - January 1997) spent at Roskilde University in the Department of Mathematics and Physics and their Function in Education, Research and Applications (IMFUFA). The written report was my way of organising the information I was gleaning during my stay. Information from personal conversations, observations, and reading (and translating where necessary) from conference papers and university handbooks. It is an attempt to explain what I came to understand by "problem-orientated project work" as practised at Roskilde University and how I saw it implemented. While it may lack rigorous statistical data to back up many claims, I hope it may act as least as an introduction to the learning and teaching that goes on at Roskilde University. The study is based on Roskilde University and pays particular attention to the education of students in the Sciences Basic Studies course (NAT-BAS) and students specializing in Physics at IMFUFA. Comparison with a similar study on mathematics education by project work at Aalborg University (Vithal et al., 1995) may serve to highlight the differences in the approach to problem-orientated project work by the two universities.

The study could not have happened without the generosity and patience of many of the staff and students at Roskilde University, particularly Karin Beyer and her colleagues in IMFUFA. To them, I wish to say thankyou, both for your time and for the opportunity to experience and appreciate your unique University.

INTRODUCTION

On the 4th of June 1970 the Danish Parliament passed an Act to establish a University at Roskilde with teaching to commence in 1972. The decision was aimed at solving the problems that had been created when the elite universities were transformed into places of mass education and was taken following a time of student unrest throughout Europe. The Danish students' movement was quite influential about this time and had established a tradition of cooperation with the government, regarding university reforms.

Roskilde Universitetscenter (RUC) was to be Denmark's fourth university. Its geographical location was chosen so that it would take the pressure of student numbers away from the centre of Copenhagen and yet still be within commuting distance for the staff and students.

An interim steering committee of six members was established by the Ministry of Education. It drew up plans for three basic educations, in Science, Humanities and Social Sciences. The aim of the basic educations was to be two years of full time study, providing the students with a broad introduction to a more specialized study in later years. There were three main principles that were to govern the basic studies. They should be **interdisciplinary**, **problem-orientated** and organised around **group project-work**.

In 1972 the first team of university lecturers was employed at Roskilde University and the first students commenced their studies in the Basic Studies units. The teaching was done concurrently with planning for the next stages in the studies, the three-year Specialized Degree Program. The institution had a "loosely defined" organisational structure and a strong and influential student body. As a "University of the student rebellion" it was seen to be "Marxist" in a political climate that was rapidly moving to the Right particularly as the approaching economic recession dampened the political enthusiasm for the expansion of the universities and the very basis for the formation of Roskilde University.

It was about this time (1974) that Aalborg Universitetscenter (AUC) was established in the northern Jutlands. Aalborg University came about from the amalgamation of five smaller educational institutions around the city of Aalborg. These were in the main, education only institutions and did not partake in research or higher degrees. It was decided that Aalborg University would also run with an introductory Basic Studies unit (one year only) followed by the specialized degree programs and that it should also teach using the **problem-orientated, group-organized** approach. However its initial teaching population was not the young idealistic academics from Copenhagen involved in the formation of Roskilde University but, in the main, older and more established academics from very traditional Engineering schools many of whom were not enamoured with the idea that they should be adopting the teaching

methods of the "Marxist" university in the south! Furthermore there were the added pressures of establishing a research base within the university and gaining international recognition. Hence the development of the two universities in the ensuing years was quite separate and influenced by widely different forces from within and outside the university. Roskilde University in particular suffered times of waning support and near collapse when " the problem with Roskilde University" became a national issue reported by the nations media. In 1976, Parliament rejected a motion to close Roskilde University, by a majority of only one vote! However by 1987 the tables had turned and it was necessary to introduce, for the first time, restricted admission rules to cope with the influx of students.

In 1996, both Roskilde University and Aalborg University continue to teach using a project organized method although the interpretation and importance of "problem orientated" seemingly differs both within and between the universities. There is no doubt now however that they are both well established universities, teaching their student population using methods that are radically different from the traditional tertiary teaching methods and instilling in the students a competence that cannot be duplicated by the traditional lecture based approach.

WHAT IS PROJECT WORK?

"Project" is a way of organising the teaching/learning. Whilst the term is used rather loosely in Australia, usually referring to some sort of special exercise that a student performs outside the confines of a normal class structure, in Denmark there has developed a distinct meaning closely related to "experiential learning." That is to say, the learning processes are dealt with as integrated aspects of an individual's total development, influenced by such things as personal history, living conditions, interests, motivation etc. " A central issue in project work is therefore the student's participation in and responsibility for all important decisions in the qualification process" (Illeris, 1992). The project has a precise limited scope and time span and implies a report-based assessment rather than a conventional, knowledge based, written exam.

During the formulation of the project model employed at Roskilde University, there were a number of key concepts identified as important to the method of learning. That is, that the project should be:

problem-orientated
participant directed
interdisciplinary
exemplary
socially relevant
group work

In any problem-based study program there is defined, a topical problem which is then used to guide the students and teacher to the essential areas of knowledge and theories. This is in direct contrast to the traditional method of teaching where the subject is defined and examples are included as illustrations. At Roskilde University, **problem-orientated** project work stresses the learning process as much as the results of the actual investigation. The learner directs the learning process. The choice of method and theory is guided by the chosen problem and often necessitates a multidisciplinary approach. The studies are **participant directed** indicating that it is the group members that collectively make the necessary decisions and take responsibility for the project. All participants are equal although they may take different functions and responsibilities. The role of the teacher is moved away from the traditional leader or expert in the subject. The result is a body of knowledge owned for the most part by the students that produced it and not borrowed from the teacher who taught it.

A key aspect of problem-orientated project work is that it is **interdisciplinary.** This is almost implied in the nature of the project, as problems of reality often do not heed traditional discipline boundaries and it is social and political realities that determine the educational content, not the structure of a discipline. At Roskilde University, interdisciplinarity means more than an introduction to the theories and methods of a discipline through a real problem. The projects bring new perspectives to the application of the theories and methods and lead to a better understanding of the role of the discipline and its contents. The realization of interdisciplinarity is furthered through the combination of two parallel but equal subjects at the superstructure level where the student may learn to think as an expert in both disciplines, and by the possibility of combining both disciplines in a project at the superstructure level.

The problem and content material chosen should be **exemplary**. That is, the chosen problem should act as a starting point in the understanding of basic structures of the problem area. By working on a genuine problem of personal interest the students should be able to generalize the insights gained from their problem towards other contexts. Originally the problems were to be restricted to those that had **social relevance** that is they should refer to social and political features of society and thereby lead to an understanding of the general issues. The importance of social and political realities has waned somewhat in recent years.

Finally, the students work their projects in **groups**. Hence the project also emphasises the skills required for teamwork as well as the demands imposed by working with others.

Figure 1 illustrates problem-orientated project work in relation to other forms of teaching. The figure is an adaptation of a didactics model by Illeris (1995). The horizontal axis represents the contents of the course, so that on the left there is convergent thinking such as is usually the case in content driven education and on the right is divergent thinking such as is obtained in true problem orientation. The vertical axis represents the way in which the learning is directed. Hence we have four sectors each representing different types of learning.

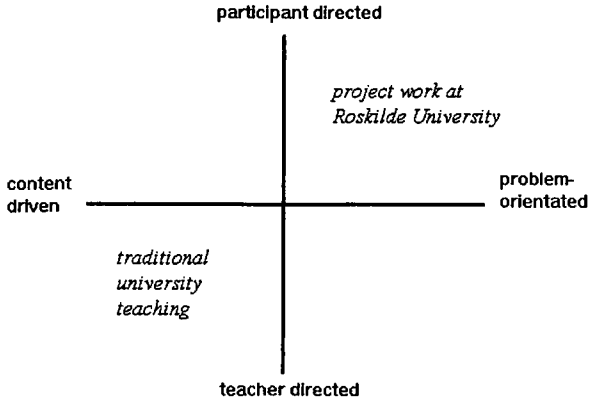

Figure 1. Diagram showing the relationship between problem-orientated project work and traditional university teaching.

In reality

Problem-orientated project work forms a major part of the teaching model at both Roskilde and Aalborg Universities. However, it has developed a very distinct flavour at each. The very nature of the degrees being taught, call for variety in objectives. In general, it would seem that Roskilde University has adopted problem-orientated project work as an educational philosophy whereas at Aalborg University it is considered more as a method of teaching towards more or less traditional goals. Even within each of the universities there are many different interpretations and emphases placed on the various aspects of project work by the various disciplines and teachers. Particularly at Aalborg University, where a majority of the science teaching is towards an engineering degree, this sometimes leads to project work more correctly represented by one or other of the two unlabelled quadrants.

That is not to imply one university is more correct than the other, but rather to caution that articles written on problem-orientated project work can be institution specific.

UNIVERSITY STRUCTURE

Roskilde University consists of approximately 6000 students, 400 academic staff and 230 technical and administrative staff, housed in approximately 30 buildings. The University resides on 35 hectares of land, only half of which actually contains the university campus, the rest is woods, marsh or agricultural land. It is situated about 5 kilometres away from the centre of the city of Roskilde (population 50,000) and 30 kilometres west of Copenhagen (population 1.4 million).

An early publication suggests that there was to be close communication between the university and the people of Roskilde. As such, there were plans to build a suburb of Roskilde (Trekroner) with space for 2000 residences within the immediate vicinity of the university with the idea of the integration of people and university with common institutions and physical buildings. To date this has not eventuated and Roskilde University stands in isolation amongst farmlands 5 kilometres outside Roskilde City. Neither does the city appear to harbour any proprietorial claims on the university and the majority of students and staff commute to the University from Copenhagen. The November issue of "RUC Nyt" suggests that there are again plans for residential development at Trekroner to be completed by the year 2010.

The University is governed by a 15-member *konsistorium* (Senate), consisting of a Rector (chairperson) and Pro-rector, (both elected from among the academic staff), four heads of department, two academic staff representatives, three student representatives, two technical/administrative staff representatives and two external members appointed by the National Research Council. The *konsistorium* makes decisions on university wide issues such as allocation of funds and the creation of new degrees.

The university is publicly funded through the national budget. It receives 290 million Danish kroners annually ($A 65 million). The library - which is funded independently as a public library receives 23 million Danish kroners ($A 5 million).

Study environment

Roskilde University was built literally from scratch. As such, the buildings were designed to take into account the specific needs of group project work. The courses are structured within units called 'houses'. Each student belongs to a house consisting of approximately 100 students, six tutors (academic staff) and a secretary. The houses also act as social units and are assigned specific physical areas, usually the floor of one building. A typical house plan is included below. The plan is intended to enable the students to work together in groups of 5 to 10 students with easy access to the tutors. In reality the physical

plan varies slightly as each new building is constructed and the numbers of students in the courses vary. In some houses the student groups must share group rooms and do this by allocating themselves particular time slots. Academics may also be teaching in more than one house during a semester and most seem to prefer to remain in offices in their 'overbygning' (specialized area), visiting their basic studies groups at prearranged times and communicating on the E-mail at other times.

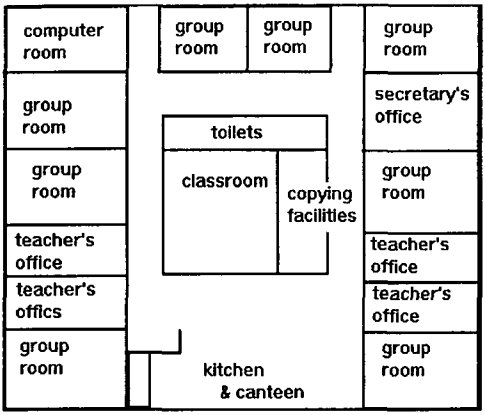

Figure 2. Typical floor plan of a house.

Study structure

Denmark has only recently (late 1980's) adopted a Bachelor/Master/Ph.D degree structure, hence the study structure was formulated on the idea that minimum study duration would be 5 - 5 ½ years for a Master's degree. Roskilde University began with the idea of a special 3-year degree to train elementary school teachers, however strong opposition from the school teachers union stifled the course before the first students were finished. Since then, the government has sought to make the tertiary education system more compatible with those of

the United States and other European countries, and has insisted on the introduction of Bachelor's degrees. Although they have now been introduced and take only 3 - 3 ½ years study time they are not particularly popular and most students still go on to complete a Master's degree.

All degree programs begin with a two-year Basic Studies course in either one of Science, Humanities or Social Sciences, followed by Specialised degree programs. The structure is illustrated on the next page. The Basic Studies courses allow the students to study within an area such as science while at the same time postponing their decision as to which area to specialise in. Note that the Master's degree is undertaken as a single subject in a few areas or, more commonly, as a combination of two subjects. This combinational option is quite popular and allows the students to follow a program of their own choice in two closely related fields (eg: Mathematics and Physics or Chemistry and Physics) or more diverse fields (eg: Physics and Philosophy or Danish and Physics).

Each program consists of semester modules and each module consists, in the main, of 50% course work and 50% project.

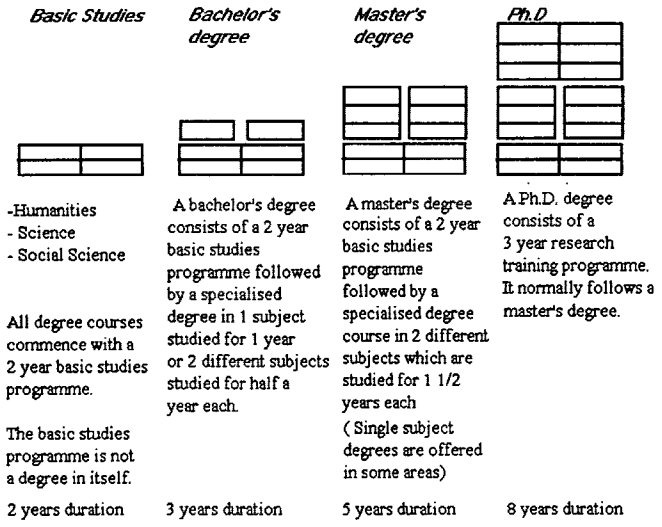

Figure 3. The degree structure at Roskilde University. Each block represents ½ year.

BASIC STUDIES IN SCIENCE (NAT-BAS)

The aim of NAT-BAS is "to enable the student to analyse and work critically and methodically, with science problems in a social context" (Beyer, 1976). However, in reality there must also be preparation for the students' further studies. Hence a second aim may also be to prepare the students to follow the studies at the superstructure. A natural consequence of the Basic Studies is a postponement in the choice of specialisation. This too is an important factor for many students.

The Basic Studies in Science takes two years. Within this time the students must complete four problem-orientated projects, one per semester. At the same time the students must follow two courses each semester. Hence the students' time is divided into 50% project work and 50% course work each semester. The courses are chosen by the individual student from an extensive list. There are suggested prerequisites for some courses and also some requirements (again suggested) for some of the specialized studies. For three of the four semesters there are project guidelines or themes. In the fourth semester the choice is free. At least one of the projects should include experimental or field work. There is no overt connection between the courses and the project work.

Each of the first three semesters is characterised by a particular theme, to which all the projects must comply. The themes are broad and are designed to ensure that the projects are **exemplary** in their dealing with three different aspects of the relationship between the Sciences and Society.

Semester 1: The interaction between Science, Technology and Society

The project should investigate the use of science in the interaction between Nature, Technology and Society. This could, for example, involve work environments, energy sources or pollution.

Example: 1996

"Hunting shot"

A group of seven students investigated the banning of the use of lead in shot. They looked at, whether there was an alternative that the timber industry, hunters and environmentalists could all accept and they asked whether the banning of lead shot was sufficient regulation in the area.

Semester 2: Models, Theories and Experiments

The project must investigate the use of theories, models and experiments in Science. This could be a computer model imitating physical or biological processes or the proving of

new theories with experiments. It is typically during this semester that students choose to fulfill the experimental requirements for their project.

Semester 3: The communication of science and its applications

The project should be in the area of the interaction between objective, content and means. In Danish the theme is written as *Formidling af naturvidenskaberne.* However, the word *formidling* does not have an adequate translation into English. It refers to the communication or dissemination of science such as occurs in educational institutions, science centres and museums, the media etc... Hence the project could involve the communication of a topic to a particular target group or the analysis of an existing communication. However, despite the title, the theme is, in fact, broader than implied by the word *formidling* . It can include an investigation into the character of scientific disciplines and/or their development or further still the history of science and the theory of knowledge and its cultural and societal consequences.

Example: 1996

"Focus on gymnasium physics teaching"

A group of six students investigated the use of practicals in physics teaching at gymnasiums (upper secondary schools). They asked the questions:

Are there discrepancies between what the pupils and what the teachers, expect the pupils to gain from the practicals?

What consequences can this have?

In the first semester the students take an outside look at Science and the role it plays in Society. They are looking at science through the eyes of an engineer. They are learning to identify the science within the problem and to distinguish it from the other, the non-science. In second semester the students take an inside look at science. They look at it through the eyes of a researcher and reflect upon the scientific structures connected with their problem. In the third semester the aim is not so clear cut. The students take a look at science through the eyes of a humanist and consider how science is communicated. It is concerned with the interface between the science, culture and the society.

Semester 4: Free choice

In the fourth semester the choice of project theme is open. It is common for students in this semester to choose to work on a topic related to or within one of the discipline areas that they intend to pursue at the superstructure.

DEVELOPMENT OF A PROJECT

The phases of a project

Illeris (1992) has identified eight phases of a project's development at Roskilde University. The phases are presented below with short (semi-revised) descriptions. Not all phases will be present in all projects, nor will the order necessarily be adhered to and some phases will occur simultaneously. Furthermore it would be unusual if some of the phases were not returned to often throughout the projects duration.

The introduction. An introduction to the project method, regulations and practical conditions. An introduction to the subject area, and to the people involved in the total process (other students, tutors, administrative staff etc...).

The choice of topic. This is usually done in conjunction with the formation of the group membership. The topic should be chosen in accordance with the principle of **exemplarity** and in most cases must follow some sort of broad specified topic area. Formation of groups should be on the basis of interests in content matter although social and work preferences are also valid considerations and often play a more significant role.

The problem formulation. In this the specific problem that the project is to deal with is precisely formulated. This is an extremely important part of the project method and may often be altered throughout the project. It is important that the group members pay attention to details in the formulation so that it can function as a statement of precisely what the group has agreed to.

The practical planning. Time planning, delegation of tasks, internal and external appointments, internal evaluations etc...

The investigation phase. The chosen problem is probed, and an understanding is sought of the problem and all its relevant theory.

The product phase. The report is produced in the most suitable medium (usually written). There is often a lot of pressure at this time because, invariably, time left is short!

The product evaluation. An internal evaluation by other students and tutors, and very often an external examination.

The post evaluation. An internal statement on the workings of both the project group and each individual member.

Identification of the project phases in NAT-BAS

Note the use of such terms as "usually", "can" and "may" are deemed necessary because for much of the project work there is no given or correct way of carrying out the tasks/phases.

The Introduction

Each semester begins with an introduction period. It is at this time that students, tutors and house secretaries are introduced to each other and to the semester themes. In the Basis program this is done in part through a SIK (Semester Introducerende Kursus = Semester Introductory Course). Participation in SIK 1, 2 and 3 equates to one of the eight courses NAT-BAS students must complete. Each of the SIK courses has an assigned responsible staff member but nevertheless may involve other house tutors and guest lecturers as well as the students. The purpose of the SIK course is to introduce and develop an understanding of the semester theme. Not only on how it can relate to various disciplines and interests but the nature in which a project can be said to be exemplary. The students may be shown examples of previous groups' projects under the same theme. It is undertaken by all students enrolled in the relevant semester. There is concurrently, a program run within the houses in which house tutors will introduce themselves and their own research interests and the house will undergo much social activity. Generally, the house tutors remain with the house for the full two years, so the students will have the same selection of supervisors for each of their 4 projects.

The introduction to the first semester is necessarily different from the other semesters. The students are being introduced not just to the semester theme and their house but to the university as a whole, to its physical structures as well as its culture and educational philosophy. Much of the introduction is the responsibility of the RUS instructors (RUS = freshman). RUS instructors are, in the main, second year students who are employed to welcome and introduce the new students to Roskilde University. For the last four or five years, this welcome has started at the main train station in Copenhagen and proceeded, in the train to Trekroner, to the university campus, where strange "happenings" occur (much along

the lines of a student run orientation week). The RUS instructors will have been working for a number of weeks before this in preparation for the orientation days. Their duties include organising the first semester groups, preparing an introductory handbook, arranging and hosting a camp at the end of the orientation period. They also prepare introductory games and exercises. Each group is assigned one or two particular RUS instructors who then become, in effect, peer supports and are also responsible for helping them through a pilot project during the RUS period. The duties of the RUS instructors are their own responsibility and staff members may advise but cannot interfere with the process. The instructors hold an evaluation and prepare a report at the close of the RUS period which can then be used by following years RUS instructors. With the presenting of the report the instructors are paid their nominal fee (of the order of $A 100 for 2-3 months work)

The RUS program includes a pilot project. The students work within their allotted group. They choose a topic from a range of articles provided. They work for a few days on formulating a problem around the topic and planning a method by which the topic could be explored and the form in which the final report will be presented. They are not expected to do the actual investigations. The house tutors act in a limited way as supervisors however they do not see much of the groups. The RUS instructors play a more important role working somewhat as supervisors, whereby they observe the way the group operates, suggests concrete ways of proceeding when a group stalls and provide positive criticism, at the end of the process, based on their observations.

The choice of topic

In semester 1, the students are in groups of between 8 to 12, as arranged by the RUS instructors prior to the start of the semester. Hence the students have no say in group membership. The group must set about deciding a topic within the semester theme. As with much of the project work, there is no true or correct way in which the topic is decided upon. The groups must decide for themselves. There is an allotted deadline for the groups to forward their chosen topic to the house secretary to allow for allocation of supervisors. Until this time a group discusses the possibilities amongst themselves and with the house tutors. They do preliminary information searches, reading articles provided or suggested by tutors and/or found in the library or newspapers. The topic is generally chosen in one of three ways. (1) A continuation of a topic followed in the pilot project (2) A topic suggested by a house tutor (3) A topic of particular interest to one (or more) of the group members.

How the groups cope during this period varies widely. On the day when topic submission to the house secretary was due, I witnessed a group weighing up the possibilities of 2 widely different topics, a second group that had done no preliminary literature search and had a host of topics they were considering and third group that had made their decision the

previous week to proceed with their pilot project topic and were already proceeding with further literature searches and deciding what authorities to approach (Note that at this point in time no supervisors had been assigned).

In the second and third semesters the choice of a topic occurs concurrently with the group formation. The students will have completed or are undergoing their relevant SIK course and will have been introduced to the semester theme. Students and house tutors will have put forward topic suggestions which may, for instance, then be displayed on a board, or presented at a seminar. The individual students then consult with the various initiators and the slowly forming groups, about the topic and the direction(s) it may take. Again the groups must submit their membership and topic to the house secretary by a certain date, together with the name of the supervisor they request. They are not guaranteed their choice of supervisor as work loads must be evenly distributed, however it is important to note that it is not just the students who must go through a selection procedure! It takes up to three weeks for the groups and topics to be finalised and the supervisors assigned. The formation of groups is supposedly on the basis of interests in content matter however it is well accepted that personal, social and work prejudices will be involved. House tutors point out that group formation can be a painful experience for many students. They must deal with possible exclusion and rejection by other students who, for some reason, do not wish to work with them. Even dealing with their own desire to exclude another individual can be difficult. It is at this point in time that students who have not pulled their weight in a previous project will find themselves censured. It is not unusual for there to be a group of "leftover students" who have been ostracised by the other groups. While this may indicate a greater propensity for such a group to fail, it is not always so and some individuals when left to fend for themselves manage to do so quite admirably while others may realise that project work is not for them and will withdraw. Nevertheless, a number of students have indicated that choosing a theme and forming a group, whilst it may have personal difficulties is also an exciting time.

In semester four the procedure is much the same except that there is no introductory SIK course and no semester theme. The choice of topic is free. Often at this point students will choose to work on a topic that involves one of their chosen disciplines at the superstructure.

It is worth noting at this stage that, just as project work is not confined to its allocated times, neither is the formation of groups. Students often discuss topics, form groups, compare notes etc... on the train to and from the university, between lecture courses, at each others residences. Students admit to forming groups and choosing topics before the start of the semester. Some then work to keeping the group closed to others.

There is no set size to the groups and after semester one the students in fact have the right to work individually, but there are a number of constraints. Firstly the number of house

tutors and group rooms and it is not unusual for 2 groups to have to share one group room by allocating themselves particular times. Secondly a group of one, two or three members must do much more individual reading and research than a group of (say) six or seven. On the other hand groups that become too large run the risk of becoming unwieldy. It is difficult to maintain an even distribution of tasks and to have adequate discussions where everyone is involved. Nevertheless the ideal size of a group often depends on just what the topic is and who the students are.

Problem formulation

Problem formulation is one of the key aspects of problem-orientated group work. Once a topic is decided a group must work out the specific problem that the project is to deal with. This can be done in the first instance by discussing what each member wants to get out of the project, and attempting to satisfy these needs. The formulation is one aspect of the project that may be revisited many times. Each time the formulation will tend to get tighter as the group works out just what it is that they are investigating. There is no limit to the number of rewrites it may undergo and the final formulation may well not occur until the writing of the report.

The planning, investigation and product phases

Each of these phases depends very much on the group and their supervisor. Some students admit to very little regulated planning. They often just dole out the tasks and work individually or in pairs for a time and then swap the task with some other group member(s). The groups have regular meetings to discuss where they are up to and where they are going and if necessary to reformulate their problem. However, although the students do admit to an improvement in their ability to work a project as they gain experience, questions asked along the lines of "Where are you at in your project at the moment?" appear to be difficult to answer for many group members. Not because they are not working but more because they are doing many and varied things and there is no set plan to the tasks. Furthermore a typical comment appears to be that even though, with each new semester, they resolve not to leave so much to the last minute, it seldom works out that way and there is a frenzy of activity towards the submission date. The production of the final document is the work of all group members. The way in which they go about this task again varies between groups. They may choose to produce a chapter each or, more likely, to work together on writing and rewriting all parts. It is important to reiterate that there is no set method of performing the necessary tasks required in planning, investigating and producing a project, it varies between groups and project topics, just as it can in the work force. The students must find a suitable method for <u>their</u> project group and are learning to be aware of the tactics they employ.

The Product Evaluation

For those with limited or no experience with group project work, one of the first questions is always in relation to assessment. How can a student be assessed when their work is part of a project produced by so many? The answer to this can vary but in the first instance should be, that it depends on what it is that you are actually interested in assessing.

At Roskilde University, the evaluation of project work takes a number of forms. There is a midsemester evaluation that is used mainly to prod the groups into gathering a certain amount of momentum and to ensure that difficulties are dealt with early in the semester, before they are too late to address. There is also a final evaluation at the close of the semester where both the project as well as the contribution of the individual students, is evaluated.

In any project evaluation the group must produce both written and oral presentations. The final written report is typically 60 -100 pages in length and is the work of all group members. The students submit the report by a specified date and it is read and assessed by their supervisor and at least one other group (the opponent group) and its supervisor.

Evaluation of the project is undertaken with a seminar presented to the opponent group and supervisor. The evaluation is based on the strengths and weaknesses of the project work, including the report, the presentation, how well the work relates to the semester themes as well as the quality of the work. "The purpose of the internal evaluation is not to grade the project, the resulting report or the individual students, but to evaluate more profoundly the project..." (Beyer 1993). The outcome is a pass or fail verdict. In the case where a project is deemed to be unsatisfactory there will be information provided to the group as to the required direction that is needed to get a pass certificate issued and usually a time by which this should be completed.

After any project evaluation there should be a post evaluation. This is a special group meeting devoted to the evaluation of the contributions and achievements made by each member, including the supervisor. In practise, the post evaluation depends very much on the supervisor and how they wish it to be undertaken.

At the completion of the semester every student is issued with a project certificate certifying that they have

1) Taken part satisfactorily in the study evaluation of the group together with the supervisor.
2) Taken part satisfactorily in all project work phases, including taking part satisfactorily in the working of the group's project report within the set time frame.
3) Taken part in an internal project evaluation in the group together with the supervisor (evaluation of problem formulation, work process and product, including reports content and conveyance value).

4) Taken part satisfactorily in the group seminar presentation.
5) Taken part satisfactorily in the group's evaluation (as an opponent group) of another group's presentation.
6) Lived up to the semester regulation requirements. This is estimated from the report and presented seminar.
The project certificate is signed by the supervisor. Each student thus must be issued with four such certificates to complete the conditions of NAT-BAS. It is possible that a project will be satisfactorily completed and hence passed that is not perhaps up to a reasonable standard. However the students will then be warned, in order that they understand the standard that will be expected of them when they undergo oral examinations (outlined below) in the second and fourth semesters.

As well as these internal assessments there are two external project assessments set up in order to satisfy doubt from both within and without the university on the rigour of project assessment. The students must face an oral examination based on their projects at the end of each year at NAT-BAS. Hence there are the first year trials and the final exam.

1st year trials: The trial after first year evaluates the individual student. This demonstrates that the student has gained the skills and the understanding that are required for first year project work. To pass this trial the student should have gained a certificate for participation in project work in the first and second semester and three course certificates. This trial is conducted by the supervisor and a second tutor (or internal examiner) within the basic education but without connection to the house. The internal examiner is suggested by the supervisor. The trial is undergone as with the exam after second year.

Second year exam: In the final oral examination the group must present their project to both their supervisor and an examiner, external to the university. The external examiner is a member of a formal board of examiners appointed by the ministry of education. Although the examiner is officially nominated by the chairperson of the external examiners board, the supervisor of the group usually suggests a suitable person and one or two alternatives. Three days prior to the exam each student is given a topic related to the project. The students attend the exam together. Each student will make a 10 minute presentation on their prescribed topic. The student will then be questioned by the examiners on their presentation. At the conclusion of the presentation the examiners will then question the whole group on aspects of the project. Students can be singled out for particular questions. The students are awarded an individual mark on a scale out of 13. Again the exact procedure depends on the particular examiners as does their ability or philosophy on awarding individual marks. A common way is for the

examiners to assess the written material and decide on a mark. They then move the mark up or down for the individual student depending on their performance at the oral exam. Some examiners believe that individual marks are too difficult to distribute and award all members of the group the same mark. There is also a belief amongst some supervisors that the students should be encouraged to work as a group and to share all information and that awarding individual marks can be counterproductive. For instance, some students may withhold information from their group in order to appear more knowledgable during the examination. Thus it may be better to ensure that the individuals mark depends on the full understanding of all members.

The role of the NAT-BAS supervisor

The role played by the supervisor is vital but by no means rigorously defined. The supervisor's task is to help the group with study related matters, to offer advice regarding reading lists and to pose critical questions concerning the groups project. The role most definitely does not include formulating the task or the project for the group or deciding what the group has to work with. Nor should the supervisor be regarded as knowing all the right answers. In other words the supervisor can guide the group but should refrain from leading it. "The main task of the supervisor is not to control the project work, but to challenge the students. It is important that the students feel they have the true responsibility for their own work. But on the other hand, no group or individual should be left totally on its/his/her own " (Beyer, 1993).

The way in which a supervisor operates in reality depends on the individual supervisor, the group, and to some extent the semester. A first semester project group for instance will usually require a certain amount of coaxing into making their own decisions, while more experienced groups are sometimes almost too busy to see their supervisor. Some students even speak of their on-the-job training of new members of staff in the role of a supervisor.

There are no hard and fast rules as to the way in which a supervisor should operate. Most supervisors at the Basic level will meet with their group periodically, say once a week, and expect an oral or written update on the group's activity. Some supervisors are more direct than others, and may end up leading their groups into making the right decision (usually in an attempt to ensure that the group gets some meaningful results). The method of supervision adopted seems to depend on the aspects of project work the supervisor believes are important and to some extent the priority they give their supervision among all their other tasks.

The houses in NAT-BAS generally hold fortnightly meetings of the house tutors where the tutors can discuss their group's progress and difficulties. These meetings it would

seem are the main method of ensuring that the task is taken seriously by all tutors, and to share ideas. They are also a possible forum for discussions on the semester themes, rules and assessment procedures to be followed by the house.

It should be noted that although there is an attempt to allocate supervisors within a certain house to groups according to their professional expertise they may well not be particularly expert in the topic chosen by their group. Nevertheless they should be expert in the methodology required by any scientist in the formulation of and research into scientific problems. This situation appears to be more endemic with first semester projects, which are overwhelmingly environmental topics even though the supervisors are from any of the sciences.

SPECIALISED STUDIES - PHYSICS

Physics consists, as do all other disciplines, of three modules, each of which is normally one half years study time. A Bachelor's degree consists of a two-year Basic study followed by a module from each of two discipline areas or two modules from one discipline. All disciplines under the combination structure have selected one of the three modules as the "Bachelor module". In physics the Bachelor module is "The broad module". A single discipline Bachelor's degree in Physics consists of the broad and the deep module.

In total the physics studies consist of the Broad, the Deep and the Specialised modules. The Broad module consists of the broad course, and a project. The Deep module consists of two deep courses, a course in practical physics and a project and the Specialised module consists of one large project (equivalent to a Master's project).

Hence the studies in physics include three projects. The project work goes on in groups, but the students have the right to work individually. The project work is again participant directed; its purpose is to train the students to formulate, analyse and solve problems concerning physics. Eventually it has the purpose of training the students in the use of relevant scientific theory and methods for work in a defined subject topic. The project work finishes with the production of a project report.

At least one of the Master's degree three projects must, in the end, involve suitable experiments.

The three project types

The projects in the Master's degree should include one of each of the following project types:

i) **Meta project (*about* physics):** The project deals with physics in its historical, social and epistemological contexts. This can be done either in a historical perspective or else in an analytical way.

Examples: 1996

"Crucial Experiments in Physics"

ie What are the crucial experiments in the history of physics?

What is meant by "crucial"?

A group of four students. The project entailed a lot of reading and the students attempted to read papers in their original language. They sought references to "crucial experiments" in many papers and analysed what it was that made the authors describe the experiments as crucial and then referred back to the original papers describing the experiment or work to

which it was crucial. The project looked at two particular examples of crucial experiments. The Michelson-Morley experiment and The Compton Effect.

ii) **Tonings project (*with* physics):** The name refers to the choice the students have in the "colour" of their project. This project is realised in one of two ways: A (the application) or F the formidling of physics. An A-tonings project should be an exemplary treatment of a problem concerning the use of physics within measurement techniques, within technology or within another science subject other than physics.
An F-tonings project should be an exemplary treatment of a problem within physics education or a corresponding problem concerning physics communication outside the education system.

Examples: 1996

A-tonings project: "Quantum effects in nanowire"

A group of four students. The project dealt with quantum effects evident when two electrical conductors are drawn (slowly) away from each other. The phenomena observed is that the contact is kept between the conductors a little longer than the uninitiated would think, as there are formed very thin connections between the conductors with a thickness in the order of nanometres. Earlier experiments have shown that the conductance in this nano-thread are quantised in whole multiples of $2e^2/h$ (where e is the electronic charge and h is Plank's constant). The original experiments were carried out with the use of a scanning tunnel microscopes (STM). A recent paper in Nature had described being able to see similar effects with a much simpler experiment. By placing two conductors in contact on a table and then simply hitting the table so the conductors swing from the contact to the non contact position and observe the conductors close to the moment of contact change.

The purpose of the project was to set up an experiment that is midway between the advanced STM experiment and the primitive "table banging experiment", such that it really does show the quantum effect, but at the same time does not need advanced equipment.

F-tonings project: "Gymnasium physics didactics and the role of experiments"

A group of 3 students. The group was interested in testing pedagogy concerning the way in which instructions, both written and oral, are expressed and to determine the effect this had on the pupils motivation and understanding. They described as traditional, instructions that did not allow for the pupils' independent views as the pupils were guided through an experiment. The group chose to investigate this by organising and carrying out a physics experiment with a gymnasium physics class. The problem formulation for the project asked questions along

the lines;

"Is there a difference in the pupils' motivation when they are given more broadly expressed instructions compared to when they are given the more traditional instructions?"

"Is there a difference in the pupils understanding of the theory behind the experiment with the various instructions?"

iii) **Internt-fagligt project (*in* physics):** The project should expose the interplay between theory and experiment in physics.

This can be done either

- with experimental work where the results interpret theory or
- with theoretical work that connects theory /model with experimental work carried out by another.

Example: 1996

"Thunderclouds charge"

A group of two students with a common interest in geophysical conditions. The project came about following the reading of an article in a physics text (O'Hanian), concerning the formation of electrical fields and thunder clouds in the atmosphere. From the article it was clear that it has not yet been possible to clarify precisely how charge build up arises in the atmosphere, which means that it is not possible to understand thunderclouds' full development.

The students began by seeking an understanding of the leading models for the build up of charge in a thundercloud with the intention of comparing the models with existing experimental observations and critically analysing each model. However it became clear that there was a new model since the original article was written. A model that supposedly surpassed the others and the group then sought to investigate this model only.

The project required the students to get a basic understanding of the electro- and fluid- dynamics and solid state physics that is used in this geophysical problem. The original formulation was "How does charge arise in the atmosphere and why are current models for the formation of thunderclouds not sufficient?" However the physics involved in understanding the problem is very complicated and the group reformulated the problem so that they were investigating the cycle of charge around the earth.

Identification of project phases in Physics

The students at the superstructure level have completed at least 4 projects at the Basic level. It is generally assumed that by this stage they can work fairly independently and there is a tendency for the project work to be more student driven and a little less supervisor driven. Like many things however this is only a tendency and depends very much on the group, the supervisor and the problem.

Introduction and choice of topic

Again there is an introductory period, though this time somewhat shorter. The new students are introduced to each other and the rest of the house at a "breakfast". Then follows a few weeks during which time, seminars and meetings are held to discuss the project themes and semester courses. The themes are no longer devoted to a particular semester and the students may choose to fulfill the thematic requirements in any order they like. Again, the house tutors present their own research interests, possible project topics that may arise from them and any other topics that they may have thought of. Students present past projects and indicate how they correspond to a particular theme and put forward topics they are interested in pursuing. Groups are formed within the space of about 2 weeks and topics are forwarded to the study board to enable the allocation of supervisors. The groups no longer necessarily consist of students from the same year level and students must take care in their topic selection that they are fulfilling their requirements.

Problem formulation

Again the formulation may well change many times over the working of the project. During 1996 the physics students organised themselves into presenting a short seminar on their various projects. The seminar was open to all physics students and staff members who wished to come, although it was dominated by the students. The aim was to present the topic that you were investigating, the problem formulation and a description of how it fitted into one of the themes. The audience could then make suggestion, argue relevant points or recommend experts that could be contacted for assistance in the topic.

Planning, investigation and product phases

This does not differ widely from what was said for NAT-BAS. The students at the superstructure level are supposedly more self aware and disciplined. There is generally less pushing of slow groups by the supervisor and very little emphasis is now placed on the evaluation of the process. There is an expectation that the students are well schooled in the working of a project and this is indeed generally the case. The students have out-of-hours

access to the department and it is common for groups to spend the last one or two weeks practically living there. Interestingly, this is not just because they may be running out of time, but in some cases because the group believes that the project will be better if they have a concentrated effort, where all members of the group can devote themselves entirely to the project and put all other interests or commitments aside.

Evaluation

Although the mid-semester evaluation is encouraged, it is left very much up to the groups to organise it themselves. This involves finding a second group and exchanging evaluations. Hence the mid semester evaluation does not always occur. However, all projects undergo a final evaluation. They are evaluated by the supervisor together with an external examiner, again from the national board of examiners, and individual marks are awarded. The evaluation is based on both the written report and the oral exam.

The role of the Physics supervisor

The role of the supervisor is now more dependent on the group and the topic they are attempting to tackle. Generally a group will still meet periodically with their supervisor, however the supervisors within the house no longer hold meetings with each other. It is assumed that the students have learnt how to do project work at the Basic level. The supervisor at the specialised level operates more in the fashion adopted by many supervisors of individual projects at any university. They are the assigned "expert" in the physics and methodology but not necessarily an expert in the particular problem advanced by the students. Their major contribution is to help the students understand the content and ensure that they are making progress. The external examiner is generally suggested by the supervisor although officially nominated by the chair of the national board of examiners for physics. Both the supervisor and the external examiner are responsible for assigning a final mark based on the written report and oral exam.

OUTCOMES

In order to evaluate a teaching method, one should obviously start with the declared aims and objectives. In the case of problem-orientated project work as performed at Roskilde University, this is not so simple. Historically it is quite clear why radical changes were introduced to the tertiary education system in Denmark. It followed the wide spread student unrest that gripped parts of Europe in the late 1960's and the concurrent huge increase in student numbers. There were calls for recognition to be given to the fact that the universities were now a place where the masses were educated and not just the elite. There was also a reaction against the overspecialisation that was seen to be occurring in traditional university education. Denmark resolved many of these grievances by deciding both to establish more universities and to give the student union a greater control of the education process. The new universities were the obvious sites for the education reforms to be established.

Less obvious is why it was decided that problem-orientated project work would be the solution. Project work was a catchword of the student movement and a small collection of educational theorists in the early 70's but there was little practical evidence of its implementation. It drew its inspirations from work by Jean Piaget on cognitive development and more particularly from the work of the German sociologist Oskar Negt on exemplary learning. It obtained a Danish flavour from the influence of Nicolaj Grundtvig and Kresten Kold who were responsible for the ideas and development of the Danish Folk High school system (Rasmussen, 1991). It occurred during a small aberration in time, when the political climate was ripe for educational experimentation, and so the establishment of the new universities was worked concurrently with the development of a coherent methodology for project work. Since these unique years the political and economic climates have changed drastically in most developed countries and it is doubtful whether there will ever again be the chance to establish a new institution at the same time as developing an untested educational philosophy.

For this report I must rely on my own observations, personal communication with staff and students and documentation written since the start of the university. However, within Denmark, Roskilde University is unusual not just because of its high proportion of project work, but also because it allows the students two years in which to decide what specialisation they will take. Reasons given for Roskilde University's unique education are therefore not relevant to the question of project work alone but concern also the delayed specialisation and the combinational Master's degree both of which contribute to the interdisciplinarity aim.

Aims and objectives

Illeris (1996) cites "...reasons of motivation and adequate qualifications..." for the educational philosophies installed at Roskilde University. This is broad enough to be used by most education institutions, and a good starting point for evaluating the outcomes.

Motivation

Most educators would agree that motivation plays a very important part in a student's learning outcome. Today, the lack of motivation perceivable among many students is a difficulty university academics constantly struggle with.

Responsibility and control are key aspects of the motivational techniques employed in project work at Roskilde University. The students are responsible for their own educational experience. They choose the problem area themselves and the problem is then used to guide them to the essential areas of knowledge and theories and the relevance of these in a wider context. They maintain a certain degree of control in all aspects of the project work, from the initial problem formulation right through to the evaluation of the work.

As a result, most students report motivation as a significant outcome from project work. "...a minimum of 50% of the student's time should be spent on project work. If you ask the students themselves they will generally indicate that they spend some 70-80% of the active time of their studies on the projects, as they usually regard the project work as more important and profitable than the other activities." (Illeris 1992). The proportion of time spent on project work, varies between the three basic studies and amongst the specialised disciplines. In the science basics studies (NAT-BAS) students generally spend 50% of their time on their project.

Nevertheless, at the Basic level it is pertinent to note that the students are in fact spending a good deal of their time on a project for which there is no mark attached. The responsibility for its completion is largely left up to themselves as is the assessment of the work, and yet they persist not only in completing it, but in ensuring that it is at a level they can be satisfied with.

At the superstructure level students often tackle projects for which they do not have the necessary content background. In the physics area, groups of students were grappling, out of choice, with concepts from thermodynamics, electrodynamics, quantum mechanics and fluid mechanics, to name but a few.

Finally a number of students stated quite categorically that they enjoyed their projects. What better motivation is there?

Adequate qualifications

Roskilde University has recognised from its inception that the university is no longer

a place for a few highly specialised and privileged students. It is a place where many students must prepare themselves for the broad spectrum of occupations in the public and private workforce. The aim of project work is to fulfil vocational objectives and not content only objectives. It has evolved out of a broader picture of the requirements of graduates and their educational needs than is often considered.

In an address to school leavers Karen Sonne Jacobsen (pro-rector) writes "...Scholarship has a variety of functions in society; important decisions in the political and social scenes depend on a background of scientific investigations; on results, reports and deliberations, and the communication of these results to the decision makers. In environmental, social and cultural questions - in all important areas we rely on expert knowledge. As such, the academically educated must play a vital role...it is important that there are academically educated people who can be neutral critics to the discipline experts. They need to be people that have the sense and outlook for the whole, of which the subject is only a part" (ruc,1996).

The students at Roskilde University are not undergoing specific professional training. They will find employment in more general applications of science such as different kinds of teaching, research, communication of science, environmental planning, mathematical modelling. In recognition of this fact the projects not only treat cases of practical applications, but also more general aspects of the sciences and their role in culture and society (Beyer, 1993).

Furthermore, given that the aim of science education is generally to develop an independent and autonomous learner, then students should not only acquire knowledge of the theories and models in science but should gain competence in how to pursue a scientific investigation. This includes, amongst other things, the ability to work as part of a team.

Roskilde University graduates are recognised as having different competencies to traditionally educated graduates and their employment prospects reflect the needs of employers for these competencies. Overall, Roskilde University graduates experience the same rate of unemployment as graduates from the other Danish universities. Hence one might say that their education is not a disadvantage compared to that of a traditionally educated graduate. An investigation into unemployment statistics that considered, not just the percentage of unemployed graduates, but also the type of graduate that the universities turn out, and weighted the disciplines according to the job opportunities, suggested that the Roskilde University graduates may even be favoured for employment.

Past graduates are unequivocal about both the competencies they have gained through project work and the subsequent holes in their education. They are valued for their ability to work in groups, the ease with which they can write reports and their ability to seek out information and take responsibility for decisions. The down side to their qualifications is

that they have usually covered less knowledge-based content in comparison to their peers from other universities.

Other, indirect consequences

Problem-orientated project work does not provide the students with a necessarily better education, but rather with a different education. Some content is replaced with other competencies such as cannot be gained through traditional educational methods: namely the ability to work in a team; to work with little assistance; to use their own initiative and investigative skills; the ability to formulate problems and critically analyse other material. On a more subtle level, the students gain an understanding of the role and function of science in society and the parts played by the theories and methods of individual disciplines. This in turn can enrich the disciplines and produce new perspectives on the relevance and application of their theories and methods.

However, the students do not appear to choose Roskilde University solely for its project work. The major reasons cited by science students were either (1) because they could delay their choice of major or (2) because they liked the social atmosphere. Both reasons have strong links to the teaching approach.

In the first case, the delay in subject choice is aided by the fact that the students may get a taste of a variety of disciplines through their projects. Roskilde is not immune from the seemingly worldwide trend away from sciences and in particular physical sciences. The falling number of enrolments in NAT-BAS is a concern as is the limited number of students who wish to pursue mathematics or physics. Nevertheless, there are many students who entered Roskilde, unsure of what they would pursue, some even who entered a non-science basic education and chose eventually to pursue Physics or Mathematics as one of their majors. The combinational degree structure allows students to study in widely different disciplines and enhances the possibility that they will pursue some of these otherwise less popular areas. At the start of the autumn semester in 1996, there were 21 new students beginning a physics degree and 82 physics students in total. As a percentage of the total number of students, this represents significant interest in an otherwise declining discipline.

In the second case, it is obvious that the physical and social structures that are primarily in place to aid project work, play an important part in instilling a particular social atmosphere about the campus. The security of the house, the use of the RUS instructors and the contact in and among the groups, all aid in producing the social climate at Roskilde University.

There is a perceivable confidence and purpose among the students attributable in the main to the control and responsibility they must take over their own education. There is a definite air about the students that they are studying because they want to learn, not merely for

the qualifications they shall gain at the end or the job prospects they bring with them.

It is well recognised within Roskilde University that the system does not suit all students. There are some that are better suited to the study techniques of the traditional university or are unable to maintain the self discipline required for project work. Such students seldom stay long at Roskilde. Nevertheless, the sorting is generally done by the students themselves. It appears to be rare for the university to need to restrict the students because of failure or unwillingness to comply particularly in regard to the project work. It is reported that the students are far tougher on themselves than any academic would dare to be.

Most of the difficulties that an outsider may imagine in the implementation of such a teaching style are questions that arise out of considering it from their own perspective. It is not possible to critically analyse the success of Roskilde University by defining boundaries relevant only to traditional universities. One must return to the basic question " What is the University attempting to achieve? "

By institutionalising project work, Roskilde University has ensured that education has a prominent profile in the definition of the university.

Critique

Roskilde University is a successful university producing reputable graduates and research. It is distinct not just in its teaching methods and ideology but because it actually has an ideology. Contrary to many traditional universities, there has been a concerted effort to develop an educational model rather than leaving the teaching to just happen. The result is a university in which staff and students have a healthy sense of belonging and of their individual responsibilities. The students are, on the whole, well motivated and their skills are sought by employers. They appear to have a clear understanding on what it means to be a graduate from Roskilde University.

Whilst the university was young, small and dominated by the staff that were originally responsible for the concept, problem-orientated project work developed at Roskilde University into a highly successful teaching/learning strategy. However past success on its own is not reason enough for continuation of an idea, particularly if it does not allow for changing populations. Furthermore, as the university expands and brings in other academics with other ideas, there is inevitably the danger of conflict. Most people, if left to themselves, will rely on their past individual experiences when forming their aims. University academics are not immune from this and new staff will often look at their own student experiences when formulating their teaching methods and objectives.

To date, many changes to the original education model at Roskilde have had the tendency to swing the structure towards more traditional teaching methods or requirements.

These can often be explained through economic if not educational reasoning or more often than not, through practical requirements. In general the changes seem to have affected the physical and study structures and left the actual project work untouched. However, there exist differences in attitude and objectives to the project work, among the academic staff. This is particularly troublesome in the basic studies, where staff from a variety of disciplines must work together as house tutors.

To some extent, the problem is illustrated by the seeming lack of definitive material from the university on just why it does what it does, (although this may be more a consequence of my limited skills in reading Danish). Furthermore, inauguration of new staff into the methodology employed is just as relevant at Roskilde University as at any other. Universities worldwide have slowly recognised that new and old academic staff need training in how to teach. At Roskilde this is just as essential. Rapid expansion in staff numbers coupled with the leaving of their training to the whim of the individual department has lead to a dichotomy in the aims and objectives, particularly at Basic level. Whilst differences of opinion are not glaringly open, unexpressed or unresolved conflicts, where people either do or do not adhere to the agreed position can be dangerous at any institution. It would be a great pity if they were allowed to fester for too long. It seems to me that Roskilde University needs to spend more time in training all staff, but particularly the new, not just how, but also why problem-orientated project work is practised. Only then can the diversity of opinions and experiences, be used constructively to retain Roskilde University's leading edge in tertiary education.

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Vithal, Renuka, Christiansen, Iben and Skovsmose, Ole "Project Work in University Mathematics Education - A Danish Experience:Aalborg University" ; Educational Studies in Mathematics 29:199 - 223, 1995

Internal Publications

"Roskilde University Centre" - author and date of publication unstated (approx late 1970's to early 1980's).

"Roskilde University Denmark", Information Office, Roskilde University, August 1996.

ruc - 1996, publication sent to schools for the information of school leavers.

NAT BAS Undervisningsåret 1996-97
NAT BAS Studievejledning
NAT BAS Studieordning af August 1996
Håndbog til Rusperioden, NATBAS

FYSIK Studievejledning af August 1996
FYSIK Studieordning af August 1996

RUC NYT (weekly campus newspaper)

Liste over tidligere udkomne tekster tilsendes gerne. Henvendelse herom kan ske til IMFUFA's sekretariat tlf. 46 75 77 11 lokal 2263

217/92 "Two papers on APPLICATIONS AND MODELLING IN THE MATHEMATICS CURRICULUM"
by: Mogens Niss

218/92 "A Three-Square Theorem"
by: Lars Kadison

219/92 "RUPNOK - stationær strømning i elastiske rør"
af: Anja Boisen, Karen Birkelund, Mette Olufsen
Vejleder: Jesper Larsen

220/92 "Automatisk diagnosticering i digitale kredsløb"
af: Bjørn Christensen, Ole Møller Nielsen
Vejleder: Stig Andur Pedersen

221/92 "A BUNDLE VALUED RADON TRANSFORM, WITH APPLICATIONS TO INVARIANT WAVE EQUATIONS"
by: Thomas P. Branson, Gestur Olafsson and Henrik Schlichtkrull

222/92 On the Representations of some Infinite Dimensional Groups and Algebras Related to Quantum Physics
by: Johnny T. Ottesen

223/92 *THE FUNCTIONAL DETERMINANT*
by: Thomas P. Branson

224/92 *UNIVERSAL AC CONDUCTIVITY OF NON-METALLIC SOLIDS AT LOW TEMPERATURES*
by: Jeppe C. Dyre

225/92 *"HATMODELLEN" Impedansspektroskopi i ultrarent en-krystallinsk silicium*
af: Anja Boisen, Anders Gorm Larsen, Jesper Varmer, Johannes K. Nielsen, Kit R. Hansen. Peter Boggild og Thomas Hougaard
Vejleder: Petr Viscor

226/92 *"METHODS AND MODELS FOR ESTIMATING THE GLOBAL CIRCULATION OF SELECTED EMISSIONS FROM ENERGY CONVERSION"*
by: Bent Sørensen

227/92 "Computersimulering og fysik"
af: Per M.Hansen, Steffen Holm, Peter Maibom, Mads K. Dall Petersen, Pernille Postgaard, Thomas B.Schrøder, Ivar P. Zeck
Vejleder: Peder Voetmann Christiansen

228/92 "Teknologi og historie"
Fire artikler af:
Mogens Niss, Jens Høyrup, Ib Thiersen, Hans Hedal

229/92 "Masser af information uden betydning"
En diskussion af informationsteorien i Tor Nørretranders' "Mærk Verden" og en skitse til et alternativ baseret på andenordens kybernetik og semiotik.
af: Søren Brier

230/92 "Vinklens tredeling - et klassisk problem"
et matematisk projekt af
Karen Birkelund, Bjørn Christensen
Vejleder: Johnny Ottesen

231A/92 "Elektrondiffusion i silicium - en matematisk model"
af: Jesper Voetmann, Karen Birkelund, Mette Olufsen, Ole Møller Nielsen
Vejledere: Johnny Ottesen, H.B.Hansen

231B/92 "Elektrondiffusion i silicium - en matematisk model" Kildetekster
af: Jesper Voetmann, Karen Birkelund, Mette Olufsen, Ole Møller Nielsen
Vejledere: Johnny Ottesen, H.B.Hansen

232/92 "Undersøgelse om den simultane opdagelse af energiens bevarelse og især om de af Mayer, Colding, Joule og Helmholtz udførte arbejder"
af: L.Arleth, G.I.Dybkjær, M.T.Østergård
Vejleder: Dorthe Posselt

233/92 "The effect of age-dependent host mortality on the dynamics of an endemic disease and
Instability in an SIR-model with age-dependent susceptibility
by: Viggo Andreasen

234/92 "THE FUNCTIONAL DETERMINANT OF A FOUR-DIMENSIONA BOUNDARY VALUE PROBLEM"
by: Thomas P. Branson and Peter B. Gilkey

235/92 OVERFLADESTRUKTUR OG POREUDVIKLING AF KOKS
- Modul 3 fysik projekt -
af: Thomas Jessen

236a/93 INTRODUKTION TIL KVANTE HALL EFFEKTEN

af: Anja Boisen, Peter Bøggild

Vejleder: Peder Voetmann Christiansen
Erland Brun Hansen

236b/93 STRØMSSAMMENBRUD AF KVANTE HALL EFFEKTEN

af: Anja Boisen, Peter Bøggild

Vejleder: Peder Voetmann Christiansen
Erland Brun Hansen

237/93 The Wedderburn principal theorem and Shukla cohomology

af: Lars Kadison

238/93 SEMIOTIK OG SYSTEMEGENSKABER (2)

Vektorbånd og tensorer

af: Peder Voetmann Christiansen

239/93 Valgsystemer - Modelbygning og analyse

Matematik 2. modul

af: Charlotte Gjerrild, Jane Hansen, Maria Hermannsson, Allan Jørgensen, Ragna Clauson-Kaas, Poul Lützen

Vejleder: Mogens Niss

240/93 Patologiske eksempler.
Om sære matematiske fisks betydning for den matematiske udvikling

af: Claus Dræby, Jørn Skov Hansen, Runa Ulsøe Johansen, Peter Meibom, Johannes Kristoffer Nielsen

Vejleder: Mogens Niss

241/93 FOTOVOLTAISK STATUSNOTAT 1

af: Bent Sørensen

242/93 Brovedligeholdelse - bevar mig vel

Analyse af Vejdirektoratets model for optimering af broreparationer

af: Linda Kyndlev, Kare Fundal, Kamma Tulinius, Ivar Zeck

Vejleder: Jesper Larsen

243/93 TANKEEKSPERIMENTER I FYSIKKEN

Et 1.modul fysikprojekt

af: Karen Birkelund, Stine Sofia Korremann

Vejleder: Dorthe Posselt

244/93 RADONTRANSFORMATIONEN og dens anvendelse i CT-scanning

Projektrapport

af: Trine Andreasen, Tine Guldager Christiansen, Nina Skov Hansen og Christine Iversen

Vejledere: Gestur Olafsson og Jesper Larsen

245a+b /93 Time-Of-Flight målinger på krystallinske halvledere
Specialerapport

af: Linda Szkotak Jensen og Lise Odgaard Gade

Vejledere: Petr Viscor og Niels Boye Olsen

246/93 HVERDAGSVIDEN OG MATEMATIK - LÆREPROCESSER I SKOLEN

af: Lena Lindenskov, Statens Humanistiske Forskningsråd, RUC, IMFUFA

247/93 UNIVERSAL LOW TEMPERATURE AC CONDUCTIVITY OF MACROSCOPICALLY DISORDERED NON-METALS

by: Jeppe C. Dyre

248/93 DIRAC OPERATORS AND MANIFOLDS WITH BOUNDARY

by: B. Booss-Bavnbek, K.P.Wojciechowski

249/93 Perspectives on Teichmüller and the Jahresbericht Addendum to Schappacher, Scholz, et al.

by: B. Booss-Bavnbek

With comments by W.Abikoff, L.Ahlfors, J.Cerf, P.J.Davis, W.Fuchs, F.P.Gardiner, J.Jost, J.-P.Kahane, R.Lohan, L.Lorch, J.Radkau and T.Söderqvist

250/93 EULER OG BOLZANO - MATEMATISK ANALYSE SET I ET VIDENSKABSTEORETISK PERSPEKTIV

Projektrapport af: Anja Juul, Lone Michelsen, Tomas Højgård Jensen

Vejleder: Stig Andur Pedersen

251/93 Genotypic Proportions in Hybrid Zones

by: Freddy Bugge Christiansen, Viggo Andreasen and Ebbe Thue Poulsen

252/93 MODELLERING AF TILFÆLDIGE FÆNOMENER

Projektrapport af: Birthe Friis, Lisbeth Helmgaard, Kristina Charlotte Jakobsen, Marina Mosbæk Johannessen, Lotte Ludvigsen, Mette Haas Nielsen

253/93 Kuglepakning

Teori og model

af: Lise Arleth, Kåre Fundal, Nils Kruse

Vejleder: Mogens Niss

254/93 Regressionsanalyse

Materiale til et statistikkursus

af: Jørgen Larsen

255/93 TID & BETINGET UAFHÆNGIGHED

af: Peter Harremoës

256/93 Determination of the Frequency Dependent Bulk Modulus of Liquids Using a Piezoelectric Spherical Shell (Preprint)

by: T. Christensen and N.B.Olsen

257/93 Modellering af dispersion i piezoelektriske keramikker

af: Pernille Postgaard, Jannik Rasmussen, Christina Specht, Mikko Østergård

Vejleder: Tage Christensen

258/93 Supplerende kursusmateriale til "Lineære strukturer fra algebra og analyse"

af: Mogens Brun Heefelt

259/93 STUDIES OF AC HOPPING CONDUCTION AT LOW TEMPERATURES

by: Jeppe C. Dyre

260/93 PARTITIONED MANIFOLDS AND INVARIANTS IN DIMENSIONS 2, 3, AND 4

by: B. Booss-Bavnbek, K.P.Wojciechowski

261/93 OPGAVESAMLING
Bredde-kursus i Fysik
Eksamensopgaver fra 1976-93

262/93 Separability and the Jones Polynomial
by: Lars Kadison

263/93 Supplerende kursusmateriale til "Lineære strukturer fra algebra og analyse" II
af: Mogens Brun Heefelt

264/93 FOTOVOLTAISK STATUSNOTAT 2
af: Bent Sørensen

265/94 SPHERICAL FUNCTIONS ON ORDERED SYMMETRIC SPACES
To Sigurdur Helgason on his sixtyfifth birthday
by: Jacques Faraut, Joachim Hilgert and Gestur Olafsson

266/94 Kommensurabilitets-oscillationer i laterale supergitre
Fysikspeciale af: Anja Boisen, Peter Bøggild, Karen Birkelund
Vejledere: Rafael Taboryski, Poul Erik Lindelof, Peder Voetmann Christiansen

267/94 Kom til kort med matematik på Eksperimentarium - Et forslag til en opstilling
af: Charlotte Gjerrild, Jane Hansen
Vejleder: Bernhelm Booss-Bavnbek

268/94 Life is like a sewer ...
Et projekt om modellering af aorta via en model for strømning i kloakrør
af: Anders Marcussen, Anne C. Nilsson, Lone Michelsen, Per M. Hansen
Vejleder: Jesper Larsen

269/94 Dimensionsanalyse en introduktion
metaprojekt, fysik
af: Tine Guldager Christiansen, Ken Andersen, Nikolaj Hermann, Jannik Rasmussen
Vejleder: Jens Højgaard Jensen

270/94 THE IMAGE OF THE ENVELOPING ALGEBRA AND IRREDUCIBILITY OF INDUCED REPRESENTATIONS OF EXPONENTIAL LIE GROUPS
by: Jacob Jacobsen

271/94 Matematikken i Fysikken.
Opdaget eller opfundet
NAT-BAS-projekt
Vejleder: Jens Højgaard Jensen

272/94 Tradition og fornyelse
Det praktiske elevarbejde i gymnasiets fysikundervisning, 1907-1988
af: Kristian Hoppe og Jeppe Guldager
Vejledning: Karin Beyer og Nils Hybel

273/94 Model for kort- og mellemdistancelob
Verifikation af model
af: Lise Fabricius Christensen, Helle Pilemann, Bettina Sørensen
Vejleder: Mette Olufsen

274/94 MODEL IO - en matematisk model af intravenøse anæstetikas farmakokinetik
3. modul matematik, forår 1994
af: Trine Andreasen, Bjørn Christensen, Christine Green, Anja Skjoldborg Hansen, Lisbeth Helmgaard
Vejledere: Viggo Andreasen & Jesper Larsen

275/94 Perspectives on Teichmüller and the Jahresbericht
2nd Edition
by: Bernhelm Booss-Bavnbek

276/94 Dispersionsmodellering
Projektrapport 1. modul
af: Gitte Andersen, Rehannah Borup, Lisbeth Friis, Per Gregersen, Kristina Vejrø
Vejleder: Bernhelm Booss-Bavnbek

277/94 PROJEKTARBEJDSPÆDAGOGIK - Om tre tolkninger af problemorienteret projektarbejde
af: Claus Flensted Behrens, Frederik Voetmann Christiansen, Jørn Skov Hansen, Thomas Thingstrup
Vejleder: Jens Højgaard Jensen

278/94 The Models Underlying the Anaesthesia Simulator Sophus
by: Mette Olufsen(Math-Tech), Finn Nielsen (RISØ National Laboratory), Per Føge Jensen (Herlev University Hospital), Stig Andur Pedersen (Roskilde University)

279/94 Description of a method of measuring the shear modulus of supercooled liquids and a comparison of their thermal and mechanical response functions.
af: Tage Christensen

280/94 A Course in Projective Geometry
by Lars Kadison and Matthias T. Kromann

281/94 Modellering af Det Cardiovaskulære System med Neural Pulskontrol
Projektrapport udarbejdet af:
Stefan Frello, Runa Ulsøe Johansen, Michael Poul Curt Hansen, Klaus Dahl Jensen
Vejleder: Viggo Andreasen

282/94 Parallelle algoritmer
af: Erwin Dan Nielsen, Jan Danielsen, Niels Bo Johansen

283/94 Grænser for tilfældighed
(en kaotisk talgenerator)

af: Erwin Dan Nielsen og Niels Bo Johansen

284/94 Det er ikke til at se det, hvis man ikke lige ve' det!
Gymnasiematematikkens begrundelsesproblem

En specialerapport af Peter Hauge Jensen
og Linda Kyndlev

Vejleder: Mogens Niss

285/94 Slow coevolution of a viral pathogen and its diploid host

by: Viggo Andreasen and
Freddy B. Christiansen

286/94 The energy master equation: A low-temperature approximation to Bässler's random walk model

by: Jeppe C. Dyre

287/94 A Statistical Mechanical Approximation for the Calculation of Time Auto-Correlation Functions

by: Jeppe C. Dyre

288/95 PROGRESS IN WIND ENERGY UTILIZATION

by: Bent Sørensen

289/95 Universal Time-Dependence of the Mean-Square Displacement in Extremely Rugged Energy Landscapes with Equal Minima

by: Jeppe C. Dyre and Jacob Jacobsen

290/95 Modellering af uregelmæssige bølger

Et 3.modul matematik projekt

af: Anders Marcussen, Anne Charlotte Nilsson, Lone Michelsen, Per Mørkegaard Hansen

Vejleder: Jesper Larsen

291/95 1st Annual Report from the project

LIFE-CYCLE ANALYSIS OF THE TOTAL DANISH ENERGY SYSTEM

an example of using methods developed for the OECD/IEA and the US/EU fuel cycle externality study

by: Bent Sørensen

292/95 Fotovoltaisk Statusnotat 3

af: Bent Sørensen

293/95 Geometridiskussionen - hvor blev den af?

af: Lotte Ludvigsen & Jens Frandsen

Vejleder: Anders Madsen

294/95 Universets udvidelse -
et metaprojekt

Af: Jesper Duelund og Birthe Friis

Vejleder: Ib Lundgaard Rasmussen

295/95 A Review of Mathematical Modeling of the Controled Cardiovascular System

By: Johnny T. Ottesen

296/95 RETIKULER den klassiske mekanik

af: Peder Voetmann Christiansen

297/95 A fluid-dynamical model of the aorta with bifurcations

by: Mette Olufsen and Johnny Ottesen

298/95 Mordet på Schrödingers kat - et metaprojekt om to fortolkninger af kvantemekanikken

af: Maria Hermannsson, Sebastian Horst, Christina Specht

Vejledere: Jeppe Dyre og Peder Voetmann Christiansen

299/95 ADAM under figenbladet - et kig på en samfundsvidenskabelig matematisk model

Et matematisk modelprojekt

af: Claus Dræby, Michael Hansen, Tomas Højgård Jensen

Vejleder: Jørgen Larsen

300/95 Scenarios for Greenhouse Warming Mitigation

by: Bent Sørensen

301/95 TOK Modellering af træers vækst under påvirkning af ozon

af: Glenn Møller-Holst, Marina Johannessen, Birthe Nielsen og Bettina Sørensen

Vejleder: Jesper Larsen

302/95 KOMPRESSORER - Analyse af en matematisk model for aksialkompressorer

Projektrapport af: Stine Bøggild, Jakob Hilmer, Pernille Postgaard

Vejleder: Viggo Andreasen

303/95 Masterlignings-modeller af Glasovergangen
Termisk-Mekanisk Relaksation
Specialerapport udarbejdet af:

Johannes K. Nielsen, Klaus Dahl Jensen

Vejledere: Jeppe C. Dyre, Jørgen Larsen

304a/95 STATISTIKNOTER Simple binomialfordelingsmodeller
af: Jørgen Larsen

304b/95 STATISTIKNOTER Simple normalfordelingsmodeller
af: Jørgen Larsen

304c/95 STATISTIKNOTER Simple Poissonfordelingsmodeller
af: Jørgen Larsen

304d/95 STATISTIKNOTER Simple multinomialfordelingsmodeller
af: Jørgen Larsen

304e/95 STATISTIKNOTER Mindre matematisk-statistisk opslagsværk indeholdende bl.a. ordforklaringer, resuméer og tabeller
af: Jørgen Larsen

305/95 The Maslov Index:
A Functional Analytical Definition
And The Spectral Flow Formula

By: B. Booss-Bavnbek, K. Furutani

306/95 Goals of mathematics teaching

Preprint of a chapter for the forth-comming International Handbook of Mathematics Education (Alan J.Bishop, ed)

By: Mogens Niss

307/95 Habit Formation and the Thirdness of Signs

Presented at the semiotic symposium

The Emergence of Codes and Intensions as a Basis of Sign Processes

By: Peder Voetmann Christiansen

308/95 Metaforer i Fysikken

af: Marianne Wilcken Bjerregaard, Frederik Voetmann Christiansen, Jørn Skov Hansen, Klaus Dahl Jensen Ole Schmidt

Vejledere: Peder Voetmann Christiansen og Petr Viscor

309/95 Tiden og Tanken
En undersøgelse af begrebsverdenen Matematik udført ved hjælp af en analogi med tid

af: Anita Stark og Randi Petersen

Vejleder: Bernhelm Booss-Bavnbek

310/96 Kursusmateriale til "Lineære strukturer fra algebra og analyse" (E1)

af: Mogens Brun Heefelt

311/96 2nd Annual Report from the project
LIFE-CYCLE ANALYSIS OF THE TOTAL DANISH ENERGY SYSTEM

by: Hélène Connor-Lajambe, Bernd Kuemmel, Stefan Krüger Nielsen, Bent Sørensen

312/96 Grassmannian and Chiral Anomaly

by: B. Booss-Bavnbek, K.P.Wojciechowski

313/96 THE IRREDUCIBILITY OF CHANCE AND
THE OPENNESS OF THE FUTURE
The Logical Function of Idealism in Peirce's Philosophy of Nature

By: Helmut Pape, University of Hannover

314/96 Feedback Regulation of Mammalian Cardiovascular System

By: Johnny T. Ottesen

315/96 a + b "Rejsen til tidens indre" - Udarbejdelse af et manuskript til en fjernsynsudsendelse + manuskript

af: Gunhild Hune og Karina Goyle

Vejledere: Peder Voetmann Christiansen og Bruno Ingemann

316/96 Plasmaoscillation i natriumklynger

Specialerapport af: Peter Meibom, Mikko Østergård

Vejledere: Jeppe Dyre & Jørn Borggreen

317/96 Poincaré og symplektiske algoritmer

af: Ulla Rasmussen

Vejleder: Anders Madsen

318/96 *Modelling the Respiratory System*

by: Tine Guldager Christiansen, Claus Dræby

Supervisors: Viggo Andreasen, Michael Danielsen

319/96 *Externality Estimation of Greenhouse Warming Impacts*

by: Bent Sørensen

320/96 Grassmannian and Boundary Contribution to the -Determinant

by: K.P.Wojciechowski et al.

321/96 Modelkompetencer - udvikling og afprøvning af et begrebsapparat

Specialerapport af: Nina Skov Hansen, Christine Iversen, Kristin Troels-Smith

Vejleder: Morten Blomhøj

322/96 OPGAVESAMLING

Bredde-Kursus i Fysik 1976 - 1996

323/96 *Structure and Dynamics of Symmetric Diblock Copolymers*

PhD Thesis

by: Christine Maria Papadakis

324/96 Non-linearity of Baroreceptor Nerves

by: Johnny T. Ottesen

325/96 Retorik eller realitet ?

Anvendelser af matematik i det danske Gymnasiums matematikundervisning i perioden 1903 - 88

Specialerapport af Helle Pilemann

Vejleder: Mogens Niss

326/96 *Bevisteori*
Eksemplificeret ved Gentzens bevis for *konsistensen af teorien om de naturlige tal*

af: Gitte Andersen, Lise Mariane Jeppesen, Klaus Frovin Jørgensen, Ivar Peter Zeck

Vejledere: Bernhelm Booss-Bavnbek og Stig Andur Pedersen

327/96 NON-LINEAR MODELLING OF INTEGRATED ENERGY SUPPLY AND DEMAND MATCHING SYSTEMS

by: Bent Sørensen

328/96 Calculating Fuel Transport Emissions

by: Bernd Kuemmel

329/96 The dynamics of cocirculating influenza strains conferring partial cross-immunity

and

A model of influenza A drift evolution

by: Viggo Andreasen, Juan Lin and Simon Levin

330/96 LONG-TERM INTEGRATION OF PHOTOVOLTAICS INTO THE GLOBAL ENERGY SYSTEM

by: Bent Sørensen

331/96 Viskøse fingre

Specialerapport af:

Vibeke Orlien og Christina Specht

Vejledere: Jacob M. Jacobsen og Jesper Larsen

332/97 ANOMAL SWELLING AF LIPIDE DOBBELTLAG

Specialerapport af:

Stine Sofia Korremann

Vejleder: Dorthe Posselt

333/97 Biodiversity Matter

an extension of methods found in the literature on monetisation of biodiversity

by: Bernd Kuemmel

334/97 LIFE-CYCLE ANALYSIS OF THE TOTAL DANISH ENERGY SYSTEM

by: Bernd Kuemmel and Bent Sørensen

335/97 Dynamics of Amorphous Solids and Viscous Liquids

by: Jeppe C. Dyre