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Defining Discipline

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This paper is the extended version of a report delivered by Wolfgang Coy, Professor of Informatics at the Humboldt University in Berlin, at the weekly IMFUFA Seminar in the spring 1997. The paper deals primarily with developments in computer science or 'Informatik' in Germany; the early definition of the discipline; its evolution over the last thirty years; and its perspectives in a global information society. Coy points at *Theory, Construction, and Design* as basic elements of the discipline. Deploring the lack of studies of the historical, political, and cultural dimensions of the discipline of informatics, Coy argues that informatics is still a pre-science, a science under construction, despite its opportunity to play a defining role for the technological base of the coming information society.

The paper is published in this Series as an additional input to a long lasting IMFUFA debate. The debate is on *Disciplines and Problem Orientation*, see e.g. Jens Højgaard Jensen, 'Why Interdisciplinarity', this series, no. 199/90, pp 99-103. Since problem orientation is a key-word at Roskilde University, it seemed important to Højgaard to distinguish different kinds of interdisciplinarity and to emphasize that the interdisciplinarity called for at Roskilde University results from an interplay between discipline orientation and problem orientation rather than from problem orientation alone.

Similarly, Mogens Niss pointed out in his analysis of *The Role of Disciplines in Teaching* in 'Faglighed og problemorientering', Kvan 10, 27 (August 1990), pp 81-89, that disciplines are factors which take part in creating the physical, economical, social and cultural reality: 'Disciplines are of very different characters and it is important to see their specificity. Each exists in a given form and state and if one wants to understand a discipline one has to use the entrance it provides.' When teaching, be it for good reasons directed against the straitjackets of the disciplines, 'disciplines should not be integrated away into an unstructured reality.'

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Wolfgang Coy

Defining Discipline

Introduction

This paper deals primarily with developments in computer science or ›Informatik‹ in Germany, the early definition of the discipline, its evolution over the last thirty years, and its perspectives in a global information society. Although throughout the world departments of informatics do research in more or less in the same areas as departments of *computer science, computer engineering, informatique, informatica*, or *datalogi*, and though in these field German students may develop more or less the same qualifications as students elsewhere, there are some historical peculiarities in the short history of ›Informatik‹, which I want to point out. In particular, I want to argue that the discipline of informatics is still under construction, despite its opportunity to play a defining role for the technological base of the coming information society.

As the paper relates primarily to German experiences, these peculiarities affect the translation from German into American English in a very special way, and I had to make some decisions. I will use the word *informatics* either as synonymous to the German name *Informatik*, or as generalization of the world wide field, depending on the context. Sometimes I will also use the term *computer science* to make a distinction between U.S. and German experiences. The professionals will be called *informaticians*. Readers should be able to follow these twists.

I. ›Informatik‹: Defining a New Discipline

An Academic Path to Data Processing?

Like many other technological and engineering activities building computers was forbidden by allied law in post-war Germany. Nevertheless there was some research done. Konrad Zuse developed the Plankalkül, the first programming language (earlier than John v. Neumann's and Herman Goldstine's Flow Diagrams, and nearly ten years before John Backus' first note on the Fortran project), without any access to a working computer. There was also research done in university mathematics and physics departments, like the work by Heinz Billing on magnetic drums at Werner Heisenbergs Institute in Göttingen or by Alvin Walther at the Institut für Praktische Mathematik of TH Darmstadt, and later by Hans and Robert Piloty at TH München, by N.J. Lehmann at TH Dresden, by Heinz Rutishauser and Eduard Stiefel at ETH Zürich, or by Heinz Zemanek at TH Wien.

In the sixties there were already many industrial activities. Computers were developed and built by Siemens, by AEG, by SEL, by Zuse KG and other smaller companies, and by the German subsidiary of IBM (where the acronym is cautiously expanded to ›Internationale Büro Maschinen‹). Large mainframes (mostly IBM) were used by industry, trade, financial institutes, insurance companies, and in the public sector. Technical highschools and universities founded the first computing centers and a central Deutsches Rechenzentrum was established at Darmstadt. A growing number of data processing specialists was needed. A lack of formal education, combined with high places in the hierarchy, including high salaries, raised serious concerns in the companies.

In the Bundesrepublik, much as in the U.S.A. and other European countries, a solution to these problems was seen in the academic qualification of data processing specialists. The rapidly growing field of data and information processing was to be supplemented by an academic discipline.

The first computer-related courses were developed around 1960 in the U.S.A. Three different lines emerged: *Computer Engineering*, *Computer Science* und *Information Science*. The first curriculum in *information science* seems to have been established in 1963 at the Georgia Tech (*Institute of Technology*). In 1965 the name *computer science* was generally accepted and in 1968 the first ACM *Curriculum for Computer Science* was printed.

Although decisions on university matters are the responsibility of the decentralized state governments (Länder), it was federal money that started the introduction of an academic computer science programme in West Germany. Federal research minister Gerhard Stoltenberg announced the first recommendations for academic education in data processing (Empfehlungen zur Ausbildung auf dem Gebiet der Datenverarbeitung) and started a funding programme (1. Datenverarbeitungs-Förderprogramm). In July 68 a conference on Computers and Universities was organized at the Technische Universität Berlin in cooperation with the Massachusetts Institute of Technology. In the opening speech of Minister Stoltenberg the word *Informatik* was used the first time officially for the discipline to be founded – a translation of the French word *informatique*. From 1970 to 1975 fifty working groups were funded under a Federal Research Programme (*Überregionales Forschungsprogramm* ÜRF, part of 2. *Datenverarbeitungs-Förderprogramm*). This was the start of the West German *Informatik*.

›Informatique‹: What's in a Name?

While *computer engineering* and *information science* are nearly self explanatory, the term *computer science* is somewhat puzzling. Is hardware, the computer, in the focus of that science? What then is the difference to *computer engineering*? And if information processing is in its focus: What is the difference to *information science*? And, as it is obviously different from computer engineering and information sciences, what is it all about? And why does the Association for Computer Machinery propagate a *Curriculum* of Computer Science, as ACM did in 1968 and thereafter?

Peter Naur was well aware of this lack of semantic precision, when he proposed the word *datalogi* as an alternative to computer science in a letter to the *Communications of the ACM*. His definition *›Datalogi: The discipline of data, their nature and use‹* was to be complemented by a technical subfield called *datamatik* (›that part of datalogi which deals with the processing of data by automatic means‹), a name taken from Paul Lindgreen and Per Brinch Hansen. But *datalogi* was only accepted in the kingdom of Denmark, while the U.S.A. stayed with the trinity of *computer science, computer engineering*, and *information science*. Even the modest proposal of an ACM Task force headed by Peter J. Denning to use the term *science of computing* instead of *computer science* is not widely recognized.

It seems that Philippe Dreyfus introduced the name *Informatique* from the elements *Information* and *Automatique* or *Électronique* in 1962. It was used throughout the French press. After even Le Monde printed it, the Académie Française defined it officially in 1967:»Science du traitment rationnel, notamment par machines automatiques, de l'information considerée comme le support des conaissances humaines et des communications dans les domaines technique, économique et social.«

This definition shows some peculiarities. Most interesting, it assumes that the newly defined *informatique* is already a science. Its object is the rational treatment of informations, especially with automatically working machines (i.e. computers). This science should support human knowledge and skills as well as communication. Applications of that treatment are to be found in technical, economical, and social domains. Clearly this definition looks far beyond programming and use of computers. It embeds hardware and software in a field of applications and connects it with human work and communication.

Many European languages adopted that word. Only the British usage differs somewhat as *informatics* is used in the U.K. since 1967 as synonymous to information science. But the German ›Informatik‹ made a strange twist: While it uses the French word, it sticks firmly to the American usage of *computer science* (with elements from *computer engineering*). Computing machines are seen as the base of the newly formed discipline. Neither problems nor consequences of the rational treatment, i.e. rationalization of work force, nor the communicative aspects of the new technology are themes of the academic discipline. Technical problems and their mathematical foundations form the almost exclusive discourse in ›Informatik‹, while practical applications, as well as economics and social questions are generally left out.

Wolfgang Giloi wrote 1969 in a pamphlet of the Technical University of Berlin: ›It was obvious, right from the beginning, that the notion *Informatik* had to be synonymous with *Computer Science*, i.e., it should enclose approximately that, what is understood as *Computer Science* in the U.S.A.‹

This referential definition unveils its recursive wit in the following sentence: ›The problem one had to face there, was that in the U.S.A. there is no common and general understanding what this discipline should be.‹

This *non-definition* shows clearly that the whole process of introducing the new discipline was not guided by a desire of precise definition. It was instead a matter of sciento-political cooperation between interested researchers who tried to establish an inner circle while excluding unwanted or presumably less important actors. ›Informatik‹ was exactly what the members of the founding committees and the heads of the new departments and chairs did or intended to do. And this was deeply rooted in mathematics and electronic engineering. Important applications like business data processing were left out. The whole definition process of the discipline was much more a social selection than a scientific distinction.

Politics of Choice and Exclusion

Explicit definitions of the term ›Informatik‹ were rarely given in the first years (perhaps with the notable exception of Heinz Zemanek's paper from 1971), and there was certainly no generally accepted common definition. But there is a common attitude in all definitions of the newly founded discipline: They all draw lines of distinction to the manifold of other emerging or competing sciences, like *cybernetics, semiotics, numerics and instrumental mathematics, formal logic and theory of computation, control theory, business data processing, operations research, system theory, information theory, coding theory, cryptography, game theory, semi conductor technology and (micro) electronics, memory and storage technology*, but also *process automation, communication theory,* and *bionics*. They were either excluded or thought to play only a marginal role in informatics – perhaps with the exception of formal logic and computation theory. The definition of the discipline was done primarily by exclusion. It seems that there was only one common sciento-political agreement among the founders of informatics, namely to become as independent as possible from the faculties they came from and where they found less resonance and cooperation than expected.

Of course, exclusion and distinction are understandable attitudes when something new is constructed. It was however not driven by the inner necessities of the field, but primarily by political motives without much regard for the external demands, even when these were not unreasonable. Especially the hopes and demands of the industry, the finance companies and the public sector for academically educated data processing personnel, able to cope with the actual problems of information processing (including knowledge of Cobol and OS/360), was largely ignored in the academic field. As a result academic informatics generated an *application gap* quite beyond the unavoidable difference of practice and its scientific reflection. This *application gap* was enforced by a close relation between informatics and mathematics or electrical engineering as many early informatics chairs were taken by academically trained mathematicians or engineers. Other fundamental aspects of system design and software construction like the study of organizations, team work, working conditions, psychology, economics, or application fields were generally ignored or considered to be less important. As a consequence methodological uncertainties show up wherever mathematical and logical foundations of informatics are insufficient to analyze and solve a problem, or achieve a task. It should be added, however, that the application gap was recognized by many and often mourned, but that it is still not bridged.

The definition of a discipline may be considered as an academic classification problem, considered an issue since centuries, when the structure of the medieval universities, its trivium, quadrivium, and the higher disciplines were transformed to the modern canon – mathematics, physics and theology finally being separated as disciplines. But where should informatics be placed?

After the given short account of its early years it is not surprising that this classification is seen to be controversial. Even Encyclopedia Britannica mirrors this problem: *Computer Science* belongs to *Applied Mathematics* - like *Automata Theory*. *Information Science* is a *Technological Science*. *Computer Engineering* belongs to *Electrical and Electronical Engineering,* but forms no own subfield.

In Germany, the classification of informatics differs from scientist to scientist, but also through the time in the understanding of the single scientist. Very often ›Informatik‹ is understood as an engineering science:

- *Informatik as engineering science* (F.L. Bauer proposed the term *Software Engineering* in 1968; 1974 he described ›Informatik as engineering science‹, a connection discussed by H. Zemanek already in 1971);
- *Informatik* as *Ingenieur-Geisteswissenschaft,* as well as *Geistes-Ingenieurwissenschaft* (F.L.Bauer 1974; the inherent language game is difficult to translate, because the meaning of both words is rather obscure in the paper. Perhaps the first could be translated as *engineering science of the mind* and the second as *humanistic engineering science*);
- *System technology and engineering science* (The general assemblies of the German university faculties Fakultätentag Informatik together with Fakultätentag Elektrotechnik 1991);
- *Engineering science and formal science* (Ch. Floyd 1992);
- *Engineering science and structural science* (P. Rechenberg 1991);
- and, departing from the narrow engineering aspects *Informatik as technical science* (A.L. Luft 1988).

In contrast, sometimes relations to mathematics and formal logic are stressed:

- *Formal Science* (F.L. Bauer 1985)
- *Structural Science* (C.F. v. Weizsäcker in 1971, introduced to informatics by W. Brauer in the following years)
- *Science of the formal structures of information processing* (W. Steinmüller 1993)
- *Very Large Scale Application of Logic* (E. Dijkstra 1989)
- *Intelligence formalizing technology* (W. Brauer 1996)

Some informaticians try to orient the discipline more on Scandinavian approaches, or the design-oriented approach of Terry Winograd and Fernando Flores, or look at informatics regarding its consequences to society:

- *Science of design* (›Gestaltungswissenschaft‹ – Arno Rolf 1992, following T. Winograd & F. Flores 1986)
- *Machinization of brain-work* (F. Nake since 1977)
- *Social science* (W. Steinmüller 1993)

Other connections beyond engineering and technology are proposed.

- H. Zemanek (1992) embeds informatics in more general systematic study of *abstract architecture*, while
- the book of A.L. Luft & R. Kötter (1994) is titled *Informatik: a modern knowledge technology.*
- R. Valk (1997) compares the practice of informaticians to the *practice of lawyers.*

Finally we may identify a group which tries to establish connections to philosophy:

- *›A bridge between science and humanities‹* (H. Zemanek 1992)
- *New fundamental science* (Informatik Duden 1993)
- *Fundamental science (comparable to philosophy and mathematics)* (Reinhard Wilhelm 1996)

Classification oscillates between submission and omnipotent phantasies, result of the ›radical novelty‹ (Dijkstra) and the rapid development of the discipline and its underlying technology. It is obvious that the real definition of the discipline ›Informatik‹ was chiefly done by academic practice, by teaching courses, by teaching manuals, by workshops, conferences, and research journals. It should be noted, however, that it was only occasionally influenced by practical data processing outside academic institutions. As a result informatics is generally considered to be ›theory‹ from the outside, whereas it is in fact the sum of academic practices, in which theoretical aspects are reduced to mathematical foundations.

Ironically, the newly founded German Informatik departments were so successful in excluding suspiciously looking and deviating content that they had to start with a bare minimum of lectures. The curricular plan developed by GAMM/NTG, which was adopted by nearly all faculties, filled only 18 hours per week (of a total of 80) in the first two years with genuine informatical content and only 24 hours (of a total of 72) in the second two years. If the other disciplines would have been more tolerant they could have easily included the new discipline as a specialization.

But after a short warm-up period the discipline made many further distinctions and generated a plethora of new subfields. It was in fact so successful that in 1985 it was no longer possible for the then more than 20 faculties to agree on a general scheme of practical informatics in the Bundesrepublik as demanded by the federal ›Rahmenrichtlinien‹ (frame of reference). The discipline had entered its adolescence.

II. Re-defining a Start-Up Discipline

Facing an Application Gap

Academic informatics is both technology and science, wrote Peter Rechenberg. We may try to be more specific: theory and construction. Construction as a technical heritage, related not only to science but also to craft and art. Donald Knuth' books *The Art of Computer Programming* denoted the state of the art of basic computer science (though the first three volumes did not touch programming techniques in a genuine sense), and despite many accomplishments there is still no visible *science of programming*. Theory is the other foundation of informatics, but again, though there are many theoretical results on automata theory, formal languages, complexity, algorithmic behavior, or crypto analysis, there is few research on the theoretical foundations of the discipline besides its mathematical and logical constructs. Even the development of new programming languages lacks solid theoretical foundations (again, besides mathematical and logical calculi). It remains an art or craft – sometimes with convincing results. A theory that shows limits and perspectives of informatics is still to be developed.

By its sciento-political classification and practice informatics became a technical science. But it hardly belongs to the engineering sciences. There is still a large *application gap*, or as Dijkstra names it, a gap between a *correctness problem* (how to assure the correct working of a program) and a *pleasantness problem* (how to build adequate programs and systems for people using them). Unlike some other engineering sciences, the use of computers and programs, the design of appropriate interfaces, is an integral part of the applications. Both problems are to be solved, and it seems to be impossible to separate them successfully in most applications. Informatics is responsible for both aspects and hence it may be seen as a new type of techno-scientific endeavor.

In the first decades informatics followed the tayloristic approach of complete automation. Human interaction was to be avoided and it was generally considered to be an irritating factor in a clean algorithmic process. Words like *automatic data processing, paperless office, computer integrated manufacturing, artificial intelligence*, or *intelligent agents* denote these projections, rarely weakened by notions like *tool* or *assistant*. Most of these projections are now considered as dreams of the past, but there is still a large gap between scientific research and everyday computer use. Even if many practitioners do not expect much help from academia anymore, this cannot be the future of informatics.

Wilfried Brauer reflected this development in his series of definitions of the notion ›Informatik‹, when he included applications in his definition the ›Studien- und Forschungsführer Infomatik‹ in 1989: ›*Informatik* is the science, technology, and application of machine-based processing and transfer of information. *Informatik* encloses theory, methodology, analysis and construction, application, and consequences of its use.‹ This is some noticeable contrast to his definition of 1978, when he wrote in accordance with most of his colleagues at that time: ›*Informatik* is the science of systematic information processing – especially the automatic processing by the aid of digital computers.‹

While probably most German informaticians will nowadays support his definition of 1989, Wilfried Brauer is already one step ahead. In 1996 he gave a new multi-facetted definition, reflecting new aspects like agent programs and cultural dependencies of informatics: ›*Informatik* is the (engineering) science of theoretical analysis and conceptualizing, organization and technical design as well as the concrete realization of (complex) systems that consist of (in some sense intelligent and autonomous) agents and actors, communicating with themselves and their environment, and that should be embedded as support systems for humans in our civilization.‹ Maybe the scientific community will accept this definition in the coming years, but we cannot predict how Wilfried Brauer, always ahaed of his time, will define ›Informatik‹ in the year 2001.

Despite a still existing application gap between practice and academic informatics, the young discipline made successful contributions to other sciences. *Symbolic Modeling* is an important task of informatics used in many fields. As computers may visualize dynamics, there is also an export of computerized *simulation* and scientific *visualization* from informatics to other scientific and application fields. *Recursive structures* and *complexity theory*, but also the technology of *large data bases* and *knowledge archives* are visible examples of research work done in informatics, reaching far beyond everyday technical applications. Informatics generates methodical instruments for other sciences besides computer programming. Biology, psychology, economics, social sciences, even philosophy use computerized models and simulation programs. Physics integrates models of informatics like *state diagrams* or *neural networks* that are used as an option beyond classical mathematical structures. And sometimes these models from informatics are developed further in physics, as with *spinglass models*.

Exporting theoretical as well as instrumental structures sets informatics apart form the classical engineering sciences. Therefore the notion *engineering science* looks too narrow; informatics is better classified more generally as a *technical science*.

Computer Nets are Media

The automata and machine perspective of informatics is too narrow for its future development, because it lacks a clear picture of challenges to come. If speed remains to be a main problem of computers, it became also a basic problem of informatics curricula development because of the swiftness with which development and application of computing is changing. Before the sixties, computers were mainly laboratory engines thought to be fast calculators – which they still are in some areas like simulation, weather forecast, stress analysis, molecular modeling, and others. The sixties saw the birth of real data processing complexes with large storages and archives. The IBM /360 family is now the index fossil of all main-frames that came later. This was the time of business data processing and the time when academic curricula were planned and started. With the advent of Large Scale Integration and the birth of the microprocessor in the seventies, computers were spread all over the labs and offices, and computer programs were regarded as more or less handy tools for many different applications – mainly for writing texts and for simple calculations. It was also the time of client-server architectures replacing centralized main-frames with their dumb terminals.

Networking and the mutual augmentation of communication and computer services, but also the rapid development of multi-media, changed the *tool perspective* to a *media perspective*, so that we may consider (networked) computers nowadays as *digital media*.

Networked computers allow new attitudes towards *knowledge* and towards the interplay between externally stored and internally memorized knowledge. For more than two thousand years external knowledge was mainly written knowledge (and for some ten thousand years painted knowledge). Since the fifteenth century knowledge is drawn mainly from printed work, but in the future, the *internet* will become the dominant storage and propagation medium of knowledge. Informaticians must develop and deliver storage technology, network technology, protocols, search engines, and presentation techniques, but also data models, formal definitions, concepts, and structures for this new landscape of externalized knowledge. Computer systems will become instrumental media, media of communication as well as of distribution, media of information as well as of entertainment. The main task of computer programs will no longer be automatic calculation or data processing, but acquisition, storage, and presentation of knowledge – of all kind, in any amount and in any quality.

Acquiring and using knowledge will become, much more than it already is, a technical performance based on computer technology. We take part in rapid change of the existing *global knowledge order*, to use a name introduced by the philosopher HELMUT F. SPINNER from TU Karlsruhe. Unfortunately, there is a substantial lack of a *media concept* in Informatics that reflects this accelerating development.

Understanding computers as media shows how problematic the exclusion of information sciences was in the beginning of academic informatics. Information sciences are a part of the discipline as well as computer science or computer engineering. We may well interpret informatics in the light of the coming information society as a ›knowledge technology‹, as the title of Alfred Lufts and Rudolf Kötters recently published book ›Informatik - Eine moderne Wissentechnik‹ implies.

III. Informatik: A Defining Discipline of the Information Society?

Elements of the Discipline: Theory, Construction, and *Design*

After more than thirty years of its success it may sound unreasonable if not impossible to change the direction of the discipline in a radical way, but it is beyond doubt that the success of ubiquitous computing demands adaptations of the academic education in the discipline itself (as well as in other disciplines, where computers, programs, and nets nowadays are used as basic tools). If we take Kristen Nygaard's elegant statement: *To program is to understand!* seriously, we have to consider theory and construction as the basic elements of informatics. Both aspects are well developed, though the theoretical aspects of informatics are still limited to mathematical analysis. As in other sciences theoretical analysis could be aware of its philosophical, cultural, historical, and social foundations.

Besides a broader, more conscious theoretical foundation, the practice of informatics demonstrates the necessity of a skill that was present from the beginning, but usually not recognized in its importance, namely the skill of *design* – in its broadest sense. Already in 1970 Peter Naur pointed out in a paper on project activities in education that design is an integral part of the construction process in informatics. By mathematically and formally trained computer scientists design is usually considered as a trivial task (This attitude may explain why software sometimes is rejected by users despite striking algorithmic elegance). Peter Naur quoted George Forsythe from Stanford University: ›To a modern mathematician design seems to be a second rate intellectual activity.‹ But we may have learned in the past quarter century that computer products have to follow other rules than mathematical theorems. Design is an important aspect of informatics – staring with the first programs doing more than numerical calculations. Dijkstra's *Pleasantness Problem* is a basic problem of informatics. There is no successful separation of correctness and ›pleasantness‹; they are two faces of informaticians' work.

Design may have many aspects: usability of the artifacts, structural decisions about communications, or the design of cooperative work with the aid of computers, but also design in a more traditional way, like digital typography, user interfaces, or the construction of virtual realities. Hard- and software are constructed in a series of design decisions – some by knowledgeable people in a conscious manner, others ignored, because they were not recognized as important or considered to be self-evident or to follow the ›one best way‹. But there simply is no such thing like the ›one best way‹ - only series of improvements. Education in informatics could make these decision processes more transparent and demonstrate the consequences of alternatives. Knowledge as well as training seems to be necessary.

Growing awareness of design problems is a result of the spread of computer usage. Computer nets are becoming news and entertainment media, used by people who try to perform a task and don't want to care much about the basic enabling technologies. Informatics has to reflect this development, it must consider the difficult balance between restricting and opening technical possibilities in a given environment. This holds *a forteriori* where design decisions will construct new environments, completely unknown before.

The telephone may be used as a striking example. Bell and its early successors developed a beautiful and simple interface, easily understood by users. It was even refined successfully several times, up to the introduction of push buttons. Today, however, even simple telephones are designed like the most nightmarish command line computer interfaces – promising a vast bundle of hitherto unheard of features, but often disguising even the most basic functions.

Social and Communicative Competences

Rather trivially, the management of programmer or developer teams and even the membership in such a group demands social and communicative skills well beyond that of a typical university mathematician or logician. Obviously such skills are essential for a professional career in data processing. This also holds for other technical professions, but in informatics these skills are demanded from the inner workings of the technology, if computer systems are used as work tools or media.

The essentials and pitfalls of *user interfaces* prove that competences besides technical and mathematical knowledge are asked from informaticians. To understand how people work with computers, programs, and computerized work-flow, demands a deeper understanding of work and communication processes.

This is by far not restricted to user interface design, because even negotiating for a programming or development contract already demands communicative skills (and the lack of it may be a prime reason for crashed or delayed software projects and dissatisfied customers). Students have to develop communicative competency, namely the capacity for communication and discernment to enable them to participate, as future computer professionals, in design activities and interdisciplinary discussions.

Knowledge about communicative competency is not sufficient; training and discussion is unavoidable. Peter Naur pointed out in 1970 that *student projects* are a basic way to teach a complete development cycle from first ideas, plans and descriptions to design, construction, programming, test, documentation, and turn-over. Project work allows to work in a team with all the problems and all the help and insight that arise from such a situation. Teaching professional skills and application knowledge by example is a basic advantage of project work, but in addition the social and communicative skills are trained (for both students and teachers).

The German Gesellschaft für Informatik considered communicative competencies to be so important that they included them besides technical, application related, and legal competencies in their Ethical Guidelines. The Guidelines are meanwhile confirmed in a formal voting process by their members with an overwhelming majority.

A New Order of Knowledge: Building the Information Society

Post-industrial society or *information society,* as it is called now, is no invention of Al Gore and his National and Global Information Infrastructure Initiatives, nor of the Bangemann-Report to the Council of the European Union. It may be better attributed to the sociologist Daniel Bell who wrote in 1973 *The Coming of Post-Industrial Society: A Venture in Social Forecasting.* There were other social scientists who described the fundamental change of societies exposed to computer technology already in the seventies. They were not recognized in the discipline of *Informatik*, much as the Nora/Minc-Report to the French president was not read by many informaticians. So it is only recently, under the influence of political decision makers that computer scientists and informaticians have recognized the prominent role which they could (and should) take in the coming information society.

By no means all of these global processes are simple technical developments: while global finances, global economy, and globally distributed commerce and production depend on information network technology and computers, they follow their own aims and goals, develop their own problems and questions, many of which are only vaguely related to informatics. There is at least one field that has been strongly related to informatics and computers throughout the last thirty years, but usually not appreciated very highly in the discipline: gathering, storing, archiving, and presenting digitally transformed knowledge in form of electronic documents and multi-media materials. This field generates technical challenges in abundance, from design and construction of protocols, networks, and services through storage and long-term archiving up to ubiquitous presentation and interaction over the network. This is a primary task where informatics may serve the information society.

As theoretical background of these changes we may identify the development of a new *global knowledge order*, which, in conjunction with the economic, political and juridical order, defines the conditions of the information society in the next century. To understand these developments, informaticians must finally do their homework, and try to understand the theoretical foundations of their discipline. This means to study the historical, political, and cultural dimensions of ›Informatik‹, computer science, informatique, datalogi, or howeverone chooses to call it.

As the French philosopher Michel Foucault asked in one of his last interviews: ›Do you know the difference between true science and pseudo-science? True science takes notice of its own history.‹ If we accept this formulation, we must consider informatics to be a pseudo-science, or, as this ignorance is not necessarily fixed for all time, a *pre-science* or a *science under construction*.

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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

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by: Thomas P. Branson, Gestur Olafsson and Henrik Schlichtkrull

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af: Anja Boisen, Anders Gorm Larsen, Jesper Varmer, Johannes K. Nielsen, Kit R. Hansen, Peter Bøggild 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

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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

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Vejleder: Dorthe Posselt

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by: Thomas P. Branson and Peter B. Gilkey

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- 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

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237/93 The Wedderburn principal theorem and Shukla cohomology

af: Lars Kadison

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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.

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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 Hass 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 mellemdistanceløb
Verifikation af model
af: Lise Fabricius Christensen, Helle Pilemann, Bettina Sørensen
Vejleder: Mette Olufsen

274/94 MODEL 10 - 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 sf: 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

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Vejleder: Jørgen Larsen

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Første modul fysikprojekt

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