

Blekinge Institute of Technology
Licentiate Dissertation Series No 4/02
ISSN 1650-2140
ISBN 91-7295-014-5

Challenging Canon: the Gender Question in Computer Science

Christina Björkman



**Department of Human Work Science and Media Technology
Division of Technoscience Studies
Blekinge Institute of Technology
Sweden**

BLEKINGE INSTITUTE OF TECHNOLOGY

Blekinge Institute of Technology, situated on the southeast coast of Sweden, started in 1989 and in 1999 gained the right to run Ph.D programmes in technology.

Research programmes have been started in the following areas:

- Human work science with focus on IT
- Computer science
- Computer systems technology
- Design and digital media
- **Technoscience Studies**
- Software engineering
- Telecommunications
- Applied signal processing

Research studies are carried out in all faculties and about a third of the annual budget is dedicated to research.

Blekinge Institute of Technology

S-371 79 Karlskrona, Sweden

<http://www.bth.se>

Jacket illustration: Corbis StockMarket/SCANPIX

© 2002 Christina Björkman

Department of Work Science and Media Technology, Division of Technoscience Studies

Publisher: Blekinge Institute of Technology

Printed by Kaserstryckeriet, Karlskrona, Sweden 2002

ISBN 91-7295-014-5

Challenging Canon:
the Gender Question in Computer Science

Christina Björkman

Abstract

The gender question in computer science is often presented as: “Why are there so few women in computer science and what can be done about that?” This question usually focuses on women. Sometimes ‘men’ or ‘gender’ enter the discussions. However, it is not common that the second part of the sentence - computer science - is considered.

The papers in this thesis challenge, in different ways, how the gender question is usually perceived and discussed within the community of computer scientists, and where solutions are looked for.

The approach taken is to move focus from women/gender to the discipline of computer science itself. This means the question is raised towards a more general level, towards “the science question”, discussing the discipline, its paradigms and knowledge processes.

Theories and methodologies from gender research, used within computer science, offer new possibilities to develop broader and more complex understandings of “the gender question in computer science”.

Acknowledgements

I wish to express my deepest gratitude to my supervisor Lena Trojer, for inviting me to join the group of Technoscience Studies, and for continuously supporting me in the work with this thesis.

Pirjo Elovaara has taken time to read and give me very valuable feedback on my papers. I have received much support and inspiration from her, Peter Ekdahl, Annelie Ekelin and Jan Björkman. I also thank everyone at the Department of Work Science and Media Technology for being so friendly and supportive.

Annika Lundmark, Uppsala university, gave me the opportunity to work with project Q+, and has supported me ever since then, for which I am very happy.

I want to thank colleagues and friends at my oldest 'home-department': Computer Systems at Uppsala University, as well as at the Computer Science Education Programme. My thoughts go especially to Linda.

Another 'home' is the new engineering education "Systems in technology and society". I am grateful to Jörgen Nissen for helping me with my duties these last months, and for valuable research discussions.

I have felt strong support from friends and colleagues at yet another 'home-department': the Department of Computer Engineering, Mälardalen University. This department also provided financial support in the beginning of my doctoral studies.

Finally, I want to express my heartfelt gratitude to my husband. Mats, you have helped me with everything in this process: the application that provided the funding, reading my papers, cooking my food, and never failing to support and encourage me.

This work has been funded in part by the Swedish Research Council for Engineering Sciences/The Swedish Research Council.

Contents

Introduction	1
Overview of the thesis	1
The Gender Question in Computer Science	1
Challenging Canon	2
“The Long and Winding Road”	3
The Gender Question and the Science Question: Making Connections	8
Computer Science and its Paradigmatic Basis	10
Gender Research within Technical Disciplines	11
Gender Research Challenges within Computer Science	14
Brief Summary of the Papers	17
Conclusions and Future Work	17
References	19
Paper I	21
EXPLORING THE PIPELINE	
Towards an Understanding of the Male Dominated Computing Culture and its Influence on Women	
Paper II	35
A Project for First-year Female Students of Computer Science	
Paper III	45
Women and Computer Science	
Paper IV	75
Computer Science and its Paradigmatic Basis – Broadening Understandings through Gender Research from Within	
Paper V	95
Computer Science, Gender and Knowledge: Readings from Partial Perspectives	

Introduction

Overview of the thesis

A thesis is, like every other text, a story. This particular thesis tells my story, the story of my research life up till now. In the introduction I will give a background to this story, and relate the papers to it. I will present my research questions in the context of the road I have travelled so far, and introduce the papers in this context.

The thesis consists of five papers, written during an extended period of time. There is a connection between the papers, although not linear.

I have written this thesis as a computer scientist *and* gender researcher. My main focus is within the discipline where I have long worked – computer science. Thus, my goal and hope is that most of this thesis shall be understandable, and interesting, to those members of the community of computer scientists who are interested in the gender question in CS, as well as to gender researchers within technical disciplines.

The introduction starts with a presentation of the theme and research question for the thesis. In order to put the papers and my research in context, I describe my background and the road I have travelled so far. I then discuss some more general issues concerning my research, in the transition from one focus to another, including a presentation of gender research within technical disciplines. Finally, I will discuss issues concerning what I call “gender research challenges within computer science”. What happens when gender research is brought into CS? What advantages does it give, and what are the problems?

The Gender Question in Computer Science

The thesis revolves around what I call “the gender question in computer science”. This is the common denominator for all the papers in the thesis.

There are two parts in this sentence. Firstly: “computer science”. I use the term “computer science” (which I will abbreviate CS) in a broad sense, to include software engineering and most of computer engineering.

Secondly: “the gender question”. Within CS it is common to talk about “women and computer science”, thus implying a focus on *women* in relation to the discipline. I choose to use the word “gender” in order to de-emphasise this focus on women, and instead focusing on issues of *gender*. This means that both men and women are included, and the socially constructed gender is emphasised over the biological sex.

The phrasing I have chosen: “The Gender Question in Computer Science”, is a paraphrase of what is termed “the Woman Question in Science”, discussed by the

feminist¹ philosopher Sandra Harding. By this, she means: “What is to be done about the situation of women in science?” (Harding 1986, p. 9). She argues for a shift from “the woman question”, focusing women, and towards what she calls “the science question”, i.e. a shift of focus towards science itself, its theories, methods and knowledge processes. As will become obvious later in this thesis, I argue for the same shift of focus for gender research within computer science.

The gender question in computer science is often presented as: “Why are there so few women in computer science and what can be done about that?”, sometimes with the addition: “Why did the number of women decrease during the 1980’s and why is there no sign of increase, in spite of many different efforts and actions?” The question usually focuses on women. Sometimes ‘men’ or ‘gender’ enter the discussions. However, it is not common that the second part of the sentence – computer science - is considered.

The picture on the front cover is taken from the January 1995 issue of Communications of the ACM². This issue had as a main theme ”Women in Computing³”. I find the picture very interesting: the woman in the picture has all the standard ‘feminine attributes’, there is no doubt that she is a ‘real woman’. What does this signal? That a ‘real woman’ can be a computer scientist? But there are many doubts as to whether the work she is performing is what a ‘real’ computer scientist would do. The picture raises many questions about how the issue of gender and CS is perceived. I cannot help but wonder why this picture was chosen, and whether those who chose it were aware of the signals it could send.

Challenging Canon

The first part of the title of the thesis is “Challenging Canon”. That is what every paper in the thesis does, although in different ways. They challenge how “the gender question” is usually perceived and discussed within the community of computer scientists, and where solutions are looked for. The papers point to different ways of discussing the issue, moving focus away from women and towards the discipline of computer science itself.

Paper I puts focus more on men, and on the culture of CS (and of academia).

The second paper starts in the experiences of a number of women within CS education, and tries to open the discussion for other issues than those of women.

¹ I use the term ‘gender research’, which is the most commonly used term in Sweden. However, many researchers, mainly from Anglo-Saxon countries, use the term ‘feminist research’.

² ACM, the Association of Computing Machinery, is one of the largest international professional organisations within CS.

³ ‘Computing’ here is essentially synonymous to how I use ‘computer science’.

Paper III is an overview and discussion of how the problem of female under-representation within CS has been perceived.

The fourth paper argues for a shift of focus, towards the discipline itself.

Paper V contains a closer analysis of two texts on “women and CS” (one of the texts is Paper I). The aim is to gain a more complex understanding of how the issue is perceived as well as how science and knowledge are viewed.

I will discuss and present the papers further on in the introduction, in the context where they have been written.

“The Long and Winding Road”

In this section, I will describe my background, work and experiences, and put my research and the first three papers in context. The intent is to show how my perspective on the issue of women in CS has developed.

My background

I am an engineer. My undergraduate education was at an Institute of Technology, and my academic degree is MSc in Engineering Physics. My training as an engineer, with its main focus on problem solving, is deeply rooted within me. For over 17 years, I have worked as a lecturer in computer science (more specifically computer systems). I have taught classes mainly within programming, computer architecture and operating systems. I have also had experiences from other types of work, as study counsellor, director of undergraduate studies and programme director for a computer science education programme⁴. All this time, I have been used to belong to a very small minority of women, first in the education, later in my profession. I probably saw myself as ‘one of the boys’.

As a study counsellor and programme director, I participated in information meetings for prospective students. I used to encourage women to come to computer science, and I would always claim that there was no need at all to have prior knowledge of computers and programming. On the contrary, they would do better if they were not ‘computer nerds’. I truly believed what I said. I would later learn, after my experiences working with female students, that I had given a false picture of the education. I had talked about what I wanted to see and believe, not about the reality the students faced. At that time, I was very much a part of the problem, and did not have the ability, probably neither the will, to see it. I have to admit that not only did I ignore to problematise the situation with few women in CS, but my attitude also had some elitist traits about it. I wanted only the best students (did I actually believe that most women did not fit into CS??).

⁴ I have described my different ‘positions’, and the experiences they gave me, in Paper V.

For many years, to be a woman in an almost totally male environment had not bothered me.

After around 6-7 years as a lecturer, I went through what I have later learnt is a very common development or 'crisis' among women in male-dominated areas. During this time, I came to question my suitability for the profession I had chosen. There are only a few ways out of such a crisis: quit your job and go to a less male-dominated area; repress your thoughts and feelings and work harder at conforming; or become a feminist. I chose the latter. Quite soon after this I started (almost reluctantly at first) to take an active interest in the situation for female students. For a number of years, I was engaged in different projects targeting female students, working both with attracting and retaining women.

Project DVQ⁵ and Paper I

The initial approach to the problem of low female participation within CS, is very often to believe that the problem can be solved by more information. I was no exception to this. However, I realised quite soon, that no matter how important these efforts were, they would not mean an increase in the number of women in CS. In the fall of 1995, the current programme director for the computer science education programme and myself, took the initiative to a project targeting the 'culture' of the education. Within this project, two Master level students in psychology/women's studies were engaged to do "a study of the CS programme from a gender perspective" (Björkman et al 1997, p.1). This project resulted in Paper I in my thesis. The paper reports on and discusses findings from parts of the study. Focus in the paper is on the male dominated culture within computer science, and its influence on women. With this paper, we wanted to spread our results and ideas about the problem of few women in CS. We wanted to promote change, to bring new approaches, to make the community consider issues such as culture, which so far had seldom been on the agenda.

This project and article became an important part in my transition from mainly being a lecturer and study counsellor, towards working with projects for women. I became enthusiastic about the new approaches and knowledge this project gave me. It became a starting point for my further work, and promoted an interest in more complex issues, such as structural (e.g. the structure and content of the education programme) and cultural issues.

In Paper V I analyse this article, and discuss how I see it now.

⁵ DVQ is a pun in Swedish, DV is the Swedish acronym corresponding to CS, and Q is the first letter in an (old-fashioned) word for woman.

A project with gender segregated teaching⁶

In the spring of 1998 I was given the chance to do a small experiment within a class on computer architecture I was teaching. Part of that class contains assembly programming, which I taught in small groups. In this case, I made one group with all the women (10 students out of approx. 60), and a reference group of 10 men. The men were chosen based on a survey in order to make both groups as similar as possible. My intention was to see if I could learn something from an all-female group, that I could bring to my teaching in mixed groups, where the women are a small minority. The classes were observed by an independent person (a Master Level student in education).

The results from this project are presented in Björkman (1999). These were totally unexpected, and mainly characterised by the women's strong negative reactions. They saw this gender segregated teaching as implying that they needed special treatment, something they found offensive. What I learnt from the project was for one thing more about my own role as a teacher, how I unconsciously acted differently in the groups. The other thing the results made me realise, was how extremely delicate the issue of special treatment for women is, even if it is done with the best intent of improving their situation and supporting them.

Project Q+ and Paper II

The experiences from the project described above, led to thoughts of a project aiming at gaining a better understanding of the situation for the female students at the computer science education programme. The idea was to support the women by starting in their own ideas and expressed needs. The project, which was called Q+, mainly targeted the first year female students. I was given the opportunity to work part-time with this project during the academic year 1998/1999⁷. The project gave me a large empirical material, both quantitative (e.g. questionnaires) and qualitative (e.g. interviews, informal observations and conversations).

Paper II in my thesis is a short summary of the project and its results.

Working with this project offered me the chance to fully take a stand for female students. I was invited to look into their lives as students, to share some of their experiences and learn about the conflicts they lived in. What I was allowed to share was often deeply upsetting, and very eye-opening. For the first time, I realised that the picture I had given prospective students, for example emphasising that no prior programming experience was needed, had been false. Furthermore, realising the

⁶ The project was financed within the national NOT-project. This is a project for attracting young people to natural science and engineering, jointly run by the National Agency for Higher Education and the National Agency for Education.

⁷ The project was initiated and to a large extent financed by the development and evaluation unit at Uppsala university, where I was employed as the project leader. The project is reported in Björkman (2000).

conflicts, and the often very pressing and demanding conditions these women lived under, made me gain whole new perspectives. Change and transformation became increasingly important for me, and frustration over lack of change grew.

During my work with this project, I gradually grew into questioning the common approaches to the problems women face within computer science. I developed an interest for exploring the complexity of the issue, and I started to think around paradigms and knowledge within the discipline. The experiences lead to asking other questions, to an interest for the invisible and taken for granted: the discipline of computer science. I argue in the conclusions in the project report for more radical approaches: “We need, in my opinion, to ask questions that go deep into the issues of both computer science as a discipline, how the discipline is formed, pictured and mirrored in education, and the cultures that exist around it” (Björkman 2000, p. 57).

Through all this time, I often experienced great frustration, the frustration of seeing problems but not having the tools to deal with them. How can these tools be obtained, and where?

Looking for tools

When I approached the issues of women in CS, I first did it with all the enthusiasm for “solving a problem” that the engineer has been trained in. This approach did not work!

As an engineer, I am trained in mathematics, and how mathematics is used to model ‘real world phenomena’. I am trained in delimiting a problem, making it as simple as possible, and then applying the simplest solution. This is an approach where logical and abstract thinking is emphasised. Within CS this training continues, in the use of algorithmic approaches to problem solving. This tends to encourage linear thinking about problems. I believe many of the approaches we, as computer scientists, try for solving the problem of low female participation, tend to look like algorithms. But, as I have experienced myself, there is no simple algorithm to be found.

What I aim at here is that my education and professional life had trained me in a certain way of thinking and approaching problems. Both mathematics, modelling, and algorithms build on the idea of being able to describe what we are interested in, that is, their method is one of simplification. This is often connected with beauty: the simpler a mathematical formula or an algorithm, the higher it is valued, as bearer of beauty and truth (Trojer 1995b). But the lived realities seldom lend themselves to simplifications, and they most certainly are not beautiful. Mathematics is indeed a wonderful language, and it is in a sense universal. It can be used for modelling many situations and phenomena. But maybe it is one of our follies to believe too strongly in the mathematical/algorithmic method, because many aspects of many problems cannot be accounted for by these approaches. Still, we can have and gain valid and relevant knowledge about these problems.

Through experience, I came to realise that my training had not given me any tools that could be useful for approaching the problem of female under-representation within CS. The way I used to approach problems did not work. (And by the way, maybe it just is not a problem that can be ‘solved’, but that is another story).

This was when I turned my attention towards gender research, in order to look for tools to gain a more complex understanding of the problem. Or maybe I should say that at a bend in the road, I “bumped into” Lena Trojer and the interdisciplinary IT and gender research group at Blekinge Institute of Technology (the group is now called “Technoscience Studies”), and was invited to become a doctoral student within the group, which I am very happy about.

Finding the tools!

The story, and the road, took another turn. At this point, it becomes much more difficult to try to describe my ‘road’, and work, in some linear way. The road by now goes back and forth, sometimes crosses itself, goes in spirals or takes leaps. It involves the simultaneous awareness and integration of theories, knowledge and experience from both CS and gender research.

I will start by presenting my project and research questions, and defer discussing what gender research within technical disciplines can be until later. Hopefully, the description of my own research will also give a picture of this type of gender research. I find it important to focus my own research and the questions they involve, how I use gender research for being able to do that work.

I came to gender research with my knowledge and experiences from computer science, and from the projects I described above, as well as with my questions. Gender research can shed new light from unexpected angles on this knowledge, experience and questions, making it possible for me to move between positions and see many different images and stories, thus approaching more complex understandings. My tools for analysis come from gender research, and I use them for looking at the discipline of computer science. When I bring these tools into CS, they can be seen as becoming part of the discipline (if they are accepted, see the discussion under Gender Research Challenges within Computer Science below). At the same time as they are incorporated, they also change and develop.

“[Gender research] is an interdisciplinary “project” situated in a cross-section of a very rare kind. It is an epistemological⁸ project and as such it spans over the borders between all the disciplines. Gender research works in quite an informal manner and can be applied wherever you need it. You can pick and choose according to your own preferences, and you contribute to its ongoing development by participating in activities like writing, discussing, networking, lecturing and so forth” (Trojer 1998).

⁸ See p. 12 for an explanation of epistemology.

Thus, theories and methodologies from gender research give me opportunities to reflect my earlier work, including knowledge and experience gained both as a lecturer and in different projects. Gender research gives me space for experimenting and exploring, and opens possibilities for new approaches. Its ways of doing research, of asking questions and using theory, are rich resources to be used within computer science.

Paper III

Paper III is written within this context. The paper is a survey of (parts of) what has been written about women and CS within different areas. Focus is on how the issue is perceived and discussed among computer scientists, social scientists, interdisciplinary groups, and also how gender researchers within computer science have approached the issue. I contrast the different approaches with each other, identifying problems and limitations with most approaches used so far. Paper III can be seen as what is commonly called a “state-of-the-art” paper, though including problematisings and critique of earlier research and approaches. In this paper, I attempt to establish a basis of how the results from earlier work can be interpreted in a broader, more complex way, using theories and methodologies from gender research.

The Gender Question and the Science Question: Making Connections

Turning the question around

During my work with project Q+, I had started to think about paradigms and knowledge within CS. The results and experiences from this project, for example noting the female students’ reactions to the discipline (which resulted in many of them dropping out), led me to conclude that the problem is much more complex than most approaches seem to recognise.

What seems to be lacking in many discussions, is deliberation of the ‘nature’ of *the discipline itself*, i.e. computer science and its knowledge processes. Thus, the issue of female under-representation within the discipline takes us right into the heart and core of CS paradigms and understandings. How these are formed, mediated and mirrored, e.g. in education, is a large, but so far mostly overlooked, part of the complex problem of low female participation in CS.

Thus, in approaching “the gender question in computer science”, my attempt is to move focus from gender to the second part of the sentence: computer science. This means the question is raised towards a more general level, towards “the science question”, discussing the discipline, its paradigms and knowledge processes.

How issues of equality can lead to questions concerning paradigms and knowledge might not be self-evident. Since this is the heart of my work, I will expound on how

this road looks for me, to put it in the terminology of Sandra Harding⁹: how I connect “the woman/gender question” and “the science question”.

I will try to explain this by using a picture¹⁰:

Let us imagine CS as a big, black, opaque box. Besides it stands a person, wanting to get inside the box, to be part of the community, and the discipline. S/he is small compared to the box. The question then becomes: “How to get into the black box”, or “how to find the key and unlock the clubhouse?”¹¹. The mutually constituting character of CS and computer scientists is hidden, and the question becomes one of uni-lateral adaptation on the part of the person who wants to become part of CS. S/he must accept existing norms, values, paradigms etc. The persons who do find their way inside might thrive, but usually they want to maintain and reproduce the black box. If you are allowed into the club, you are likely to want to keep it the way it is since you are proud to be an ‘insider’, which also renders a certain power. This creates the image of CS as existing on its own, independent of people, as being something ‘whole and pure’, while the task of the person is to understand this ‘whole and pure’. By focusing on the “gender question”, on the person beside the box, power and existing structures within the box stay untouched. This approach can be seen as requiring everything outside the box to change, but not the box - the discipline - itself. Traditional projects around the “gender question” take this approach, i.e. to strengthen women and help them to find their way into the box, to find the key to the “clubhouse”. At the same time these approaches often maintain and even strengthen the black box itself.

I want to turn this around, to put the spotlight on the black box, and not accept this image of the ‘whole and pure’. The box simply is not a bit interesting without people, since it is people who build, maintain and change it. The aim is to diminish this big black box, to open it, make the walls transparent, show that there are many cracks or openings in what has been seen as opaque and tightly sealed. Then it will be possible to see what is inside the box, and to start an interaction with its contents from the outside. In this picture, the person on the outside is an active subject, interrogating and perhaps even negotiating with the no longer box-like CS. Instead of a box we might obtain a much more interesting and also changeable shape.

“If emancipation means adapting to the standards, the measures, the values of a society that for centuries has been male-dominated, accepting unquestioningly the same material and symbolic values as the dominant group, then emancipation is not enough. [...] Putting women in, allowing them a few odd seats in the previously segregated clubs, is not enough. What is needed is for the newcomers to be able and to be entitled to redefine the rules of the game so as to make a difference and make that difference felt concretely” (Braidotti 1994 p. 242).

⁹ See page 2 above.

¹⁰ I am grateful to Peter Ekdahl and Pirjo Elovaara for inspiring me to the explanations below.

¹¹ The concept of “unlocking the clubhouse” is taken from Margolis, Jane, Fisher, Allan 2002: *Unlocking the clubhouse*, MIT Press. See paper III for a discussion.

One way of understanding this, is that the gender question is the problem identification, but it is *not* the research question that leads to possible solutions: "...what is useful in diagnosing a problem, is not necessarily a useable reaction on its consequences" (Trojer 1999, p. 101). The question changes character, from being the topic of discussion it becomes the *motive* for discussion and research.

I argue for a focus on computer science, on "the science question". However, I do not mean to leave "the gender question": "it is sometimes necessary to return to research that is centred on experience and knowledge specific for women, that is, to a women's perspective, since processes of change are helical rather than rectilinear" (Mörtberg 1999, p. 50). Thus, I see this by no means as a linear process. Both questions, "the gender question" and "the science question", are inside each other, intertwined and connected. That is why I try to refuse to go into dichotomies, but want to keep seemingly incompatible issues together, and to see all the fruitfulness in contradictions and paradoxes. "It is in the ambivalences and contradictions that the potentials for a steady radicalisation – a steady transgressing – lies" (Gulbrandsen 1995, VI: p. 22).

Computer Science and its Paradigmatic Basis

Even if the gender question has been my starting point, and remains my main driving force, there are also other motives for researching CS knowledge foundations, and for wanting change, renewal and development. These interests and motives have grown over time.

Computer Science is usually seen as growing out of and combining other disciplines: "Computing¹² sits at the crossroads among the central processes of applied mathematics, science and engineering" (Denning et al 1989 p.11). Thus, it is in a sense interdisciplinary, however only within rather closely related fields; as well as it has its own special features. It is also a somewhat particular discipline, given many 'myths' that seem to surround CS and its culture (e.g. the hacker culture). This particularity, as well as the internal conflicts that arise from the differing views in the three 'parent disciplines', makes a study and analysis of CS especially interesting.

CS, as one of the core areas within information technology, strongly influences development of technology and thus also society. As a field of knowledge and technology, CS holds a dominant position. Because of this dominant position, there is a need for it to be a broad and multifaceted discipline with many angles of approach. I strongly believe that we need a broader and more complex understanding of the fundamental knowledge processes within Computer Science. This will give possibilities to better understand and interpret the role CS has in today's technical development, and how it influences and interacts with the directions of knowledge production and research. It is important to develop

¹² See the footnote on page 2.

discussions around directions of knowledge production, risk issues, accountability, responsible and sustainable development. In a society becoming more and more dependent on research and technology, these issues are increasingly essential. Equally important as a broadly defined discipline is to have a broad representation of developers of knowledge and technology within CS:

“We need more computer scientists whose passions are art, language, literature, education, entertainment, psychology, biology, music, history, or political science. We need them because computers have an impact on all areas in our world. We need people with passion and vision from every area to drive the development of computer technology as well as the applications”
(Maria Klawe, president of the ACM, 2001).

Paper IV

In paper IV, Lena Trojer and I develop the issues discussed above. In pointing to some concepts and fundamental paradigms that exist within computer science, we argue the need for research that examines these paradigms and the knowledge foundations of the discipline. It is our belief that this is necessary in order to effect real improvements in recruitment to the area. We discuss how gender research from within CS enables us to develop broader and more complex understandings and interpretations of the discipline. If paper III is a state-of-the-art paper, providing a basis for my work, paper IV marks the start of what I see as my project, and which I will develop further in my research after the licentiate thesis.

Gender Research within Technical Disciplines

Gender research represents many theoretical and methodological approaches. I will here very briefly talk about it as I study and practice it within technical faculty¹³. The location is here important, since gender research means quite different things within different disciplines. Gender research has two general focuses: sex/gender on the one hand, and science itself on the other. Gender research within technical faculty mainly concentrates on the second of these. In the section “The Gender Question in Computer Science” above, I referred to Sandra Harding who argued for a shift of focus towards science itself, its theories, methods and knowledge processes. This is the path mostly taken by gender research within technical disciplines. This type of gender research studies the bases of the disciplines, and what kinds of understandings that are represented in the knowledge production. In addition, it formulates other kinds of understandings. The emphasis on *transformation* as the prime goal for gender research is essential. In that sense it is a so-called ‘science-critical’ discipline. It has developed from issues around women, to realising and focusing on problems concerning how science is constructed and practiced. Frustration over problems encountered in transformatory work, has led to focusing

¹³ Paper IV contains a presentation of gender research within technical disciplines, as well as examples of gender research within computer science. See also Trojer 2002 and Mörtberg 2000.

knowledge processes within science and asking questions such as “what knowledge is valid and why?” and “who has the preferential right of interpretation and why?” In addition, I want to point to inter-disciplinarity as one of the fundamental prerequisites for gender research within technical disciplines (Trojer 1995a, 1998).

As noted above, gender research offers possibilities to ask *why* things are the way they are:

“The power of feminist analysis is to move from the experience of being a non-user, an outcast or a castaway, to the analysis of the fact of McDonald’s (and by extension, many other technologies) – and implicitly to the fact that it might have been otherwise, there is nothing necessary or inevitable about the presence of such franchises. We can bring a stranger’s eye to such experiences.”¹⁴

There is thus nothing necessary or inevitable about the way CS is constructed!

An important foundation for me is *epistemology*¹⁵ – issues such as what is knowledge, how can knowledge be gained, who can have knowledge, and what are valid claims for knowledge: “concepts of knowers, the world to be known and the process of knowing” (Harding 1986, p. 140). Questions such as these have for a long time been central for gender research within technical disciplines (see e.g. Harding 1986, 1991). Sandra Harding points out (Harding 1987) that methodology and epistemology are intertwined with what we do and why we do it, and this is one of my starting points: the awareness of epistemology as underlying all research and knowledge production.

Thus, I need to consider my own epistemological starting points, not only the epistemology that I am interested in, that of CS. In this, I have turned to (among others) Donna Haraway, and especially her concepts of *situated knowledge* and *partial perspectives* (Haraway 1991). She emphasises the importance of at the same time producing knowledge and critically looking at one’s own knowledge production, i.e. the importance of reflexivity (Haraway 1991 p. 187):

“So, I think my problem and ‘our’ problem is to have simultaneously an account of radical historical contingency for all knowledge claims and knowing subjects, a critical practice for recognizing our own ‘semiotic technologies’ and a no-nonsense commitment to faithful accounts of a ‘real’ world...”

Reflexivity is thus a central concept. Elisabeth Gulbrandsen writes about the necessity to develop what she calls a “transformatory competence”. (Gulbrandsen 1995). In developing such a competence, reflexivity is central: “Reflexivity must become part and parcel of knowledge producing processes, suffice it no longer to engage in reflexivity only after the work is done” (*Ibid*, VIII: p. 86). We must realise that we are ourselves, as researchers, part of the problem and not only of the solution. Being part of the problem is a resource for transformative work.

¹⁴ Star, Susan Leigh, 1991: “Power, technology and the phenomenon of conventions: on being allergic to onions” p.38, in Law (ed): *Essays on power, technology and domination*. Routledge.

¹⁵ Swedish National Encyclopaedia defines epistemology as ‘the theory of knowledge’.

At this point, I want to make a reflection on equality issues and gender research and their relation. Lena Trojer comments on the need to separate equality issues and gender research, they are not the same thing: “Equality issues have principally been about equal representation of women and men, and equal prerequisites (salary, promotion and so on) [...] Gender research on the other hand, means development of special scientific competences...” (Trojer 2002 p. 3). On the surface, the problem of low female participation in CS might appear simply to be a problem of equality. However, I would argue that it is not quite that simple. When we follow the track of attempts to increase the number of women within CS, and if we are frustrated with the poor results, we will find that one area has scarcely been touched upon so far: that of the discipline itself. Focus then becomes “the science question”. If we are seriously committed to a project of change in its deepest sense, following a thread of questions will lead us to more complex questions about the discipline of CS and its knowledge processes. However, engaging in such a project from within CS is a dangerous task, since leaving “the woman question” can expose and thus also challenge power and existing structures.

Paper V

This paper is a continuation of paper III at the same time as it is a discussion of epistemological and methodological issues. I have analysed two texts on women and computer science. One of them is an article that has gained quite a lot of attention within the community of computer scientists, an article adopting a traditional approach. The other article is paper I in this thesis. My aim is to gain a broader and more complex understanding of how “the gender question” is perceived in these texts, and to connect the issues of equality and epistemology. In paper V, I try to combine my ‘old’ knowledge and experience from computer science, with the new tools that I have gained through gender research. The combination of knowledge and experience from both areas can give rise to unexpected results. Since I build upon and discuss theory from gender research in this article, I realise that it is probably written more for the community of gender researchers within technical disciplines, than for those computer scientists who have not yet met gender research. However, I hope the analyses themselves can be interesting for the latter.

Gender Research Challenges within Computer Science¹⁶

Change!

My project is transformative, my goal is to work for change within my own discipline. I feel encouraged in this by Elisabeth Gulbrandsen: “It is limited what you understand if you do not try to change. And – it is not necessary that you know in advance precisely what you want” (Gulbrandsen 1995, VI: p. 20). “The gender question” is my personal point of departure, and I want to keep it alive in my mind and not lose sight of it altogether. Just as I want to keep it alive, I want to problematise and bring up more complex issues than the simplistic ones of “men” and “women”.

In attempting change, it is for me of vital importance to do this from within computer science. I take my tools from gender research within technical disciplines, and I use them within computer science. “If you are a gender researcher and engineer, the location within technical disciplines is of fundamental importance in order for a research transformative and research policy work to become possible” (Trojer 1995a, p. 113). In my research, inter-disciplinary discussions and sometimes also co-operation with gender researchers from other disciplines, is vital.

Crossing or confusing boundaries?

What does it entail when I insist on not *leaving* computer science but to use methodologies and theory from gender research within CS? Concretely: what are the difficulties and possibilities that arise from mixing computer science and gender research, when actively bringing something new and ‘different’ into CS, something that breaks with traditional views within the discipline?

CS is commonly seen as building on science, mathematics and engineering (see above). Even though there certainly exist conflicts between different ‘schools’ within CS (for example between theory and practice, between mathematics and engineering), the epistemology which they all build on is positivism¹⁷. Gender research within technical disciplines then differs in a fundamental way, by its different epistemological basis. This type of gender research problematises the positivist knowledge tradition, for example the objectivity paradigm (Trojer 2002).

¹⁶This is a paraphrase of the title of Trojer (1995a). This title reads, in translation: “Technoscientific challenges within gender research”.

¹⁷ I use a simple definition of positivism: “By ‘positivism’ is meant the idea of science as neutral and objective” (Gulbrandsen 1995, VI: p. 20).

Consequences for the person doing the journey

Doing the journey from engineer to gender researcher entails the turning up-side down of my epistemological basis. It is a long and on-going process of ‘de-learning’ and ‘re-learning’ (Trojer 1998), which is not painless. When it comes to theory and methodology, the concepts can differ considerably from those I have learnt in my training and working practice, where theory is often used as the opposite of practice, thus simplifying both as well as creating a dichotomy.

Yet another difference can be seen in traditions of writing articles, and the use of language.

In my practice within CS, I use words sparsely, and basically to convey what is seen as ‘facts’. Apart from words, mathematical expressions and algorithms expressed in some ‘pseudo-language’ are often used. I had a clarifying experience in a discussion with gender researcher Susan Leigh Star (social scientist), who has participated in projects within CS. She talked about her difficulties at first to read articles written by computer scientists: they used very few words and did not define their terminology. Thus for her the texts were hard to understand. However, she realised that an article within computer science often *points to* the artefact, which is residing outside of the paper (e.g. a computer program, measurements, proofs, calculations etc), while a paper within social science *is* the artefact. I had the same (though opposite) problem, when first reading theoretical texts within gender research, written by researchers from social science or the humanities.

Crossing boundaries, taking on new approaches to knowledge and research, can give rise to internal conflicts between ‘identities’. It also entails having to explain oneself: to explain to computer scientists what gender research is, and why it can belong within CS; and to explain to gender researchers with a background in different disciplines than my own, how I think as an engineer and computer scientist. However, I look upon these as challenges and possibilities – as important components of inter-disciplinarity.

There are many places to find comfort when transgressing boundaries. One is Rosi Braidotti's metaphor of the nomad (Braidotti 1994). The nomad is constantly in transition, it “stands for movable diversity” (*Ibid*, p. 14). “Nomadism, therefore, is not fluidity without borders but rather an acute awareness of the nonfixity of boundaries. It is the intense desire to go on trespassing, transgressing.” (*Ibid*. p 36). “A nomadic subject avoids fixed categories and classifications. A nomad transgresses boundaries. For me, a nomad represents both an opportunity — boundaries are not unchangeable — and a challenge – not to be bound by boundaries but question them instead” (Elovaara 2001, p. 7). I recognise myself in these descriptions, to be in motion and to cross boundaries, or rather not to accept some arbitrary boundaries that set the rules for what can be regarded as ‘correct’ within a discipline.

Crossing boundaries also creates many opportunities:

“To be in the chasm in between categories and refuse the safe can point to other understandings than the dominating ones” (Mörtberg 1997, p. 11).

“Crossing boundaries also creates opportunities for finding yourself between different positions and it allows one to stand outside temporarily” (Elovaara 2001, p. 6).

Consequences for the ‘receiving’ discipline

Crossing boundaries, bringing new approaches into a discipline, also entails problems for the ‘receiving’ discipline, in my case CS. From a traditional point of view from inside CS, gender research can be seen as a special discipline, not belonging within CS. There can be many reasons for this. One can be the different epistemologies (see above). Another reason can be lack of knowledge, or misunderstanding, as to what gender research within technical disciplines is.

Will my research be accepted within CS? And can I communicate it to ‘ordinary’ computer scientists? Is it too new, strange, difficult, perhaps turning the world upside down within computer science? It could easily be rejected as being irrelevant, since it does not conform to existing scientific norms within the discipline.

Is it possible to become a translator, a guide? As I wrote above, gender research can easily be seen as a different world from within CS (and computer science might, in turn, be seen as another world by gender researchers from other disciplines). To me, these are not two worlds, they meet. Gender research is an interdisciplinary field, which can be very useful when integrated into CS. But the questions around openness and being communicable remain. Is it possible to write for two partly different audiences? As I said above, I want to reach and communicate into the community of computer scientists, but I also hope that my work, in its aim at looking at “the science question” will be of interest for gender research within other disciplines.

The challenge!

Gender research, as it is practiced within technical disciplines, is a research transformative force. The challenge is to make gender research understandable within, and integrated into, computer science. However, it is vital that gender research does not conform, that it does not lose its important function as a ‘salt’.

Gender research can be difficult and ‘dangerous’. It is a force that can shake not only our professional grounds, it extends beyond that. It shakes our world view, and can thus give rise to fear, not least for the person doing the research. Doing gender research within computer science has some features that can not be neglected: it is mentally and emotionally demanding at the same time as being extremely rewarding. Both CS and gender research are, apart from being areas of knowledge and research, modes of thinking about the world. Therefore, it can be trying and hard to let CS and gender research not only meet, but also clash, to let them engage in disturbing discussions. However, this is exactly the point where new ideas and opportunities are born. It not only demands a lot from CS to let this work in, it also demands a lot of

us as both computer scientists and gender researchers to do this work. If we want to contribute to a process of transformation, we need to go into this, to engage in discussions and negotiations about the nature of knowledge, discussions over which we have no control.

Currently, my research community is gender research within technical faculty, while my community of practice is mainly within CS. I see this as important, and very rewarding, to be able to do both at the same time. This gives better possibilities for integration. But when will we have a gender research group not only within technical faculty, but directly within a department of computer science?

Brief Summary of the Papers

Paper I was written during an interdisciplinary project in 1996/1997. I wrote the abstract, introduction and conclusions, and participated actively in reading, discussing and working with the whole text. My part in this paper is very much characterised by problem solving, by ‘doing’.

Paper II summarises a project during 1998/1999, where I followed closely a group of female students during their first year within computer science. This paper is also rather action-oriented.

Paper III is a study of how the problem with female under-representation is perceived within different groups. This paper is characterised by problem identification and problematising. It is written in order to obtain a basis of the approaches taken so far.

Paper IV argues the need for focusing on research on computer science and its paradigms, instead of focusing women. Thus, it points to my future research. I wrote most of the sections Computer Science and its Paradigmatic Basis, and Gender Research within Computer Science, while Lena Trojer and I co-operated on the introduction and conclusions.

Paper V is in a sense a parallel track after paper III. In this paper I analyse two different articles on the topic of “women and CS”, including my own (Paper I). My aim is to gain a broader and more complex understanding of how the problem is perceived, and to connect the issues of equality and epistemology.

Conclusions and Future Work

Through this thesis work, and my research up till now, I have gained an understanding how gender research can be used for analysing “the gender question in computer science” and for approaching more complex issues than usually discussed within CS. Interpretation of earlier work (both my own work, and the work of others) has resulted in understandings of the problems and limitations with

most approaches used so far. A foundation has been established for how results from earlier work can be interpreted in a broader and more complex view using theories and methodologies from gender research.

A first step has been taken to turn focus in “the gender question in computer science”, from the first part of the sentence and towards the discipline of computer science, its paradigms and knowledge processes.

In my future work, I will concentrate on “the science question”, the paradigmatic basis and knowledge foundation within CS, and how this is formed and mediated within education and research. I will continue to use theories and methodologies from gender research within the discipline of CS. The aim of this work is to develop new, broader and more complex understandings and interpretations of CS, and what it means to “know CS”.

References

- Björkman, Christina, Christoff, Ivan, Palm, Fredrik, Vallin, Anna, 1997: "Exploring the Pipeline, towards an understanding of the male dominated computing culture and its influence on women". In Lander and Adam (eds) *Women in Computing*, Intellect Books.
- Björkman, Christina, 1999: "Varför väljer kvinnor inte datavetenskap och hur kan vi stötta dem som gör det?" In *Kvinnor och matematik*, konferensrapport Uppsala universitet april 1999. Matematiska institutionen, Uppsala university 2001.
- Björkman, Christina, 2000: *Projekt Q+ - med och för kvinnliga studenter i datavetenskap*. Arbetsrapport 6, Development and Evaluation unit, Uppsala university.
- Braidotti, Rosi, 1994: *Nomadic subjects, embodiment and sexual difference in contemporary feminist theory*. Columbia University Press, New York.
- Denning, Peter, Comer, Douglas, Gries, David, Mulder, Michael, Tucker, Allen, Turner, Joe, Young, Paul, 1989: "Computing as a Discipline". In *Communications of the ACM*, vol 32 no 1 p.9-23.
- Elovaara, Pirjo, 2001: *Heterogeneous hybrids. Information technology in texts and practices*. Lic. Dissertation series No 01/01, Dept of Human Work Science and Media Technology, Division IT and Gender Research, Blekinge Institute of Technology.
- Gulbrandsen, Elisabeth, 1995: *The reality of our fictions. Notes towards accountability in (techno)science*. Licentiate thesis, Division of gender and technology, Luleå University of technology.
- Haraway, Donna, 1991: *Simians, Cyborgs and women, The reinvention of Nature*. Free Association Books, London.
- Harding, Sandra, 1986: *The science question in feminism*, Cornell University Press.
- Harding, Sandra, 1987: *Feminism and Methodology*, Indiana University Press.
- Harding, Sandra, 1991: *Whose Science? Whose Knowledge?* Cornell University Press.
- Klawe, Maria, 2001: "Refreshing the nerds". In *Communications of the ACM*, vol 44, no 7, p. 67-68.
- Mörtberg, Christina, 1997, "Det beror på att man är kvinna...", *Gränsvandrerstekar formas och formar informationsteknologi*. Ph.D dissertation 1997:12, Luleå University of Technology.
- Mörtberg, Christina, 1999: "Technoscientific challenges in feminism". In *NORA (Nordic Journal of Women's Studies)* Volume 7, Issue 1, 1999.

- Mörtberg, Christina, 2000: "Teknikvetenskap och genusforskning". In Trojer (ed): *Genusforskningens relevans*, Rapport från forskningsrådets expertgrupp för genusforskningens integrering, Stockholm.
- Trojer, Lena, 1995a: "Teknikvetenskapliga utmaningar inom kvinnoforskningen". In *Viljan att veta och viljan att förstå, kön, makt och den kvinnovetenskapliga utmaningen i högre utbildning*, SOU 1995:11, Utbildningsdepartementet, Sweden.
- Trojer, Lena, 1995b: "Rena och orena fakta, reflektioner kring naturvetenskaplig/teknisk kunskapsproduktion i ett könsteoretiskt perspektiv". In *Häftet för kritiska studier*, 1995 no 4.
- Trojer, Lena, 1998: "Gender research – an interdisciplinary challenge". Lecture at the conference *The theory and practice of Interdisciplinary Work*, Stockholm, June 1998.
- Trojer, Lena, 1999: *Kompetens för ledarskap inom forskningsorganisationer – en kvinnlig forskarskola för förändring vid teknisk fakultet*. Division of gender and technology, Luleå University of Technology.
- Trojer, Lena, 2002: *Genusforskning inom teknikvetenskap – en drivbänk för forskningsförändring*. Högskoleverkets skriftserie om genusforskning. National Agency for Higher Education, Sweden.

Paper I

This article is published in Lander and Adam (eds), *Women into Computing*. Intellect Books, 1997. The article is reprinted with permission from the publisher.

EXPLORING THE PIPELINE

Towards an Understanding of the Male Dominated Computing Culture and its Influence on Women

Christina Björkman, Ivan Christoff, Fredrik Palm, Anna Vallin

Abstract

We present a project aiming at making the Computer Science Program at Uppsala university in Sweden more attractive to women. The main goal of the project is to find explanations for the low number of female students attending the program, and to identify possible solutions to this problem. We focus on the prevailing culture of the program. In the first phase of the project, the program is analyzed from a gender perspective. A study, based on questionnaires and interviews, is carried out. The study will be completed during Spring 1997. The questionnaires have been analyzed and the results from these are presented in this paper.

1. Introduction

The Computer Science Program (CSP) at Uppsala university, Sweden, was initiated in 1981. It is a four-year program, leading to an MSc degree. 60 students are admitted every year, the total number of students actively studying at the program being approximately 240. During the 1980's the percentage of female students applying to the program gradually decreased, and levelled off at approximately 10%. It remained at this low level during the first half of the 1990's. This seems to be a common situation in many western countries. (In the fall of 1996, the number of women beginners increased to 18%. It remains to be seen whether this is a trend or just a temporary fluctuation.)

In order to thoroughly analyze and improve the situation we initiated a project in Spring 1996. Our goal is to make the CSP more attractive to female students. The goals are both *quantitative* (to increase the number of female students), and *qualitative* (to create a computing culture that is more "female-friendly"). We believe that these two goals are strongly connected, since a different computing culture could attract more women, while more women in computing would hopefully lead to positive changes in the existing culture.

The main focus of the project is the culture, norms and attitudes among students and faculty. We seek to establish how the male dominated computing culture affects both male and female students. If we can understand what norms and attitudes dominate, and why, we believe we can find reasons for the imbalance between female and male students. We realize that these are complex issues, which most likely interact with issues such as curriculum design and teaching methods.

The project consists of several phases: the first phase is a study of the CSP from a gender perspective. The results from this study will provide a basis for the second phase, which will focus on determining the necessary changes that should be made in order to improve the situation. These changes will then be implemented and the results evaluated.

2. Obstacles for Women in Academia

There are many different obstacles for women both in the academic world as such, and in the field of computing.

Drawing on the work of Paula Caplan [3], three main obstacles for women can be identified in the academic world. The *unwritten rules*, whose function is to conserve the traditional power structures, create difficulties for women (and other minorities) through blocking important information about how the system works, which individuals have the most influence (power) and what subjects have the highest status in the specific culture.

“The most powerful mechanism here is the wearing down of the individual woman through the dominant maleness of the environment, combined with the *paucity of clear, concrete rules* she could use to combat it...” (p. 45; our emphasis).

Furthermore, there exists a set of *myths* about the nature of the academic world. These myths contain views of academia as a democratic, objective, fair and open community, and of the role of women in this community. They also deal with the female essence: how a woman should act and how she should not act in order to be accepted, what women are like and what they are not. These myths are far from consistent, but still determine how the behavior of the individual woman is assessed by her male colleagues. A woman often finds herself stuck in certain dilemmas. This leads to the third obstacle, namely the presence of *catch-22 situations*. These are closely interwoven with myths about the female nature. On the one hand women are expected to behave in a warm, caring and essentially “female” way to be socially accepted, while on the other hand, in order to reach success in their academic career they have to behave in a way typical for prominent individuals in their environment. So, if a woman chooses a career instead of raising children, she risks to be viewed as “masculine” and not be socially accepted, but if she acts like a “typical” woman, her chances of having a successful career are small [3, 6].

The negative effect of stereotypes in the computing culture (as in society in general) seems to be yet another critical obstacle for women. For extended discussions of the influence of gender stereotyping within the computing culture see [1, 4, 8, 10, 11].

Other problems facing women are: sexism (overt or not), lack of role models and mentors, lack of support from parents and teachers in pursuing a career in computing. Equality in the field of computing cannot be viewed as an isolated problem.

3. Study of the CSP from a Gender Perspective

The first phase of the project is a study of the program from a gender perspective. Here, we focus primarily on how students perceive the specific culture at the CSP, their own place in it and how they view problems of equality in computing. It seems relevant to examine how male and female students experience and relate to values of the dominant culture. Is it for example easier for male than for female students to accept and internalize these values? Are there differences in the identification with the role of “the computer scientist”? In more general terms, do women’s and men’s different experiences and the promotion of male experience over female experience, serve the exclusion of women in computer science?

Taking a gender perspective, we’re acknowledging the power dominance of men in the field of computing. This power can partly be viewed as exercised through the overwhelming emphasis on male interests. Thus, skills and subjects considered most important in computer science today are closely linked to traditionally masculine interests in western society. At the same time as attracting men in large numbers to the field, this emphasis excludes traditional female fields of interest. Femininity is often equaled with technical and technological incompetence. But this power dominance is not to be seen as rigid in any deterministic sense. Rather it is an ever ongoing process where certain values and interests constantly are discredited in favor of others. It can be viewed as a constant struggle where the social constructions of computing, technology and masculinity are both resisted and defended. Computer science cannot be seen as an unquestioned and rigid male entity. Although the male domination seems almost completely stable, keeping it so is a process which demands a high amount of flexibility. This flexibility allows the dominant culture to resist competing interests in a much more local and effective way. Ignored and subjected values and perspectives can therefore both actively and indirectly be resisted.

Through analyzing the discourse in which students express their views around equality and change towards equality we hope to be able to grasp the particular nature of the resistance in this specific social context.

4. Method

In order to survey the attitudes among the students attending the program, a questionnaire was constructed. It consists of three main parts:

Background questions, e. g. sex, years in the program etc.

Open ended questions, concerning the culture, which involves the study situation and social aspects of being a computer scientist.

Multiple choice questions, in which students were to indicate to what degree they agreed with a statement. This part consists of statements regarding gender issues. (See Appendix A for examples of questions.)

The questionnaire was distributed to students attending the program in spring 1996. It was distributed to all the women (18 at that time) and to 100 men (randomly selected). 12 women responded, but only 30 of the men responded, in spite of being reminded several times. One reason for the poor response frequency among the men is probably the length of the questionnaire (it took 30-60 minutes to fill out). However, this can also be interpreted as a lack of interest for these questions among the men.

Qualitative in-depth interviews have been conducted with 9 female students, and 6 graduated women who are now active in either industry or academia. Interesting to note is that the latter were much more interested in participating than were the former. These interviews are presently being analyzed and some indications are reported here. Similar interviews with male students are currently being conducted.

4.1 Analysis

In the analysis of the questionnaires and the interviews, the male and the female students were separated. Somewhat different methods have been used in analyzing the two groups. The female minority is as a group probably both more aware of and affected by the existing problems than the male majority. Therefore it is important to get a picture of how the women view the current situation and if they have any personal experience of discrimination. It is also interesting to study if this group internalizes values, attitudes and norms as smoothly as the men. The male group is interesting to study to find out what the dominating attitudes towards equality are. Since resistance to equality seldom is overt, we expected we would have to analyze this group's accounts carefully. Attention should not only be paid to the dominating norms and attitudes, but also to what variations in these mean. Reflections on behalf of the male students may reveal what parts of the culture they see as most loaded with status and prestige.

We use deconstruction of the accounts [12]. Deconstruction is possible if we see language as a construction. The language used in a specific context (e. g. computer science in the USA) is created out of an already existing language (in this case English), from which the social culture chooses to take certain concepts, terminology, etc. , while others are excluded. This use of language has consequences for the development of the culture, which individuals will be attracted to it, and what status society will attach to it. In the process of deconstruction the original text is broken down and analyzed piece by piece until some kind of pattern emerges from the material. In this study, the accounts are made within the specific context of the CSP, and are probably affected by the fact that the study focuses on the low number of female students. This is important to consider when analyzing the data.

The method used here is influenced by discourse analysis (DA) as developed by Jonathan Potter and Margaret Wetherell [9]. This fairly new branch in social psychology criticizes traditional methods used in the field for being too focused on finding consistencies in data obtained. Although DA recognizes the importance of consistencies, the main attention is here instead paid to variation and inconsistencies in the material. To understand how participants themselves experience their social context is to be able to explain why they contradict themselves and what function these variations have in the context. To strip participants accounts of variation in order to reach some “hard core” or “real” beliefs is an approach discourse analysis firmly rejects. Instead inconsistencies are there for some reason and they are central to account for in the analysis of how people use their discourses.

If an individual (or group) expresses different views on a phenomenon at different occasions all these should be considered. Depending on in what situation or context a question is posed, the answers to it are expected to vary. These variations reveal something about the individual’s view of the phenomenon under study. One answer can not be extracted as representing the view of the individual, while the others are regarded as irrelevant. For example, what the individual thinks he or she is expected to answer affects the account being made.

The accounts often maintain and profile the discourse specific to the culture, where the attitude or belief is expressed, thereby excluding other social contexts from ones own. Through revealing what functions certain expressions, norms and attitudes have for the culture, a more profound understanding of accounts made by members of the community can be achieved.

Influenced, among other things, by speech-act-theory, ethnomethodology and conversation analysis [9], DA concentrates on language use. Descriptions or accounts of phenomena and events are never neutral, in fact the firm conviction in DA is that they cannot be. All talk is in some way or another goal oriented - people do things with talk. Thus, it becomes important to examine the way people express themselves in different social texts or discourses. There is no search for underlying meanings beyond the material the analyst is trying to make sense of. This does not mean taking it at face value. Rather it means looking at what is *actually* going on in the text. For example, if a participant in an interview responds to a question as if it was an accusation, it should be treated like an accusation in the analysis. Discourse analysis involves close readings of verbal and non-verbal transcripts and constant re-evaluations of the analyst’s own interpretations and former readings of the text. In this process it is important to ask questions about for example: What do participants try to accomplish with their talk? What consequences do certain ways of describing or accounting for particular phenomena or events have? And in what ways do talk (as well as other language use) shape, maintain or resist the current orders or situations? In the analysis of power and interest the analytical tool is to look at what is at stake in the context.

The analysis of the questionnaires was inspired by DA. However, DA is better suited for analysis of longer, continuous discourses, such as, for example, discourses

obtained in interviews. DA will mainly be used in analyzing the interviews with the male students, in order to catch inconsistencies and contradictions in the discourses and thereby focus the complexity instead of simplifying. From the questionnaires we have noted that the male students often contradict themselves when it comes to questions concerning equality and gender issues.

5. Results and Discussion

We present the results from the analysis of the questionnaires together with a more general discussion of problems in the academic computing culture. The social impact on the female minority by this culture is illustrated through interpretations of the accounts given by the students.

Among the female students, two groups can clearly be distinguished. Approximately half of them (called group A) seem to have adjusted themselves to the male dominated culture. These women tend to have similar views on equality as the men. They accept the culture and do not feel that they experience any gender-related problems. The other half of the women view their own situation differently (group B). They are more interested in equality questions, and are more positive towards changes in the environment. In addition, they seem to have experienced more problems as women in the computing culture. We could see that these women had a different background than the first group, e. g. they were not used to a male dominated culture before starting their university studies, and had not adjusted to the culture in the same way as the first group.

Among the men, no such differences could be detected.

5.1 Non-sexism versus Anti-sexism

Linda Briskin [2] suggests that we should distinguish between *non-sexism* and *anti-sexism*. Non-sexism means seeing problems of equality as stemming from prejudice, and deals with this prejudice by making sex irrelevant. Anti-sexism “highlights the function of structural inequality and empowers . . . through knowledge” (p. 3). While non-sexism focuses on personal moralities (“I am not sexist”), anti-sexism demands active actions against discrimination (“What can I do about sexism?”). To focus on morality means taking no responsibility for the existing problem, which leads to neutrality “that can inadvertently serve to bolster the status quo” (p. 3).

The non-sexist standpoint seems to be strongly represented among the male students. This is shown by a critical stance against affirmative action (see below) and attitudes avoiding the importance of gender, instead putting forward individuality and uniqueness.

There is a clear difference among the female students in the answers given in relation to non-sexism and anti-sexism. The women in group A seem to have a strong non-

sexist view, when asked about equality. The rest of the women (group B) show a tendency towards an anti-sexist view.

A typical non-sexist viewpoint was expressed by one of the students, when asked if he believed that equality is important in order to promote the development in the field of computing:

“No! It is individuals who lead development. Whether the individual is male or female I believe is irrelevant.”

Through non-sexist statements the importance of gender is played down. Taken at face value the motivation may seem quite sympathetic and liberal. However, looking at it more closely, it becomes just another way of saying that there is no need for equality. By pointing to the importance of individuals, instead of men and women, the obvious power imbalances in the field of computing are concealed. As we all know being a man or a woman is an important aspect of our individuality, and in fact shapes our lives. Agreeing with this, there is really no point in talking of individuality alone, when dealing with problems of equality. Individuals lead the development, but the more important questions here are for example: “What individuals are engaged in the development?”, “What does this development look like?” and “What development do we want?” If one has a non-sexist view, there is no need to discuss such issues. Silence about the existing problems is perfect for the dominant culture and its members. The path of development chosen becomes the only way of doing things. By creating a community of genderless “computing people”, where the function of gender and power is hidden, and indeed regarded as irrelevant, women are effectively excluded. In this community, where only ability and interest for computing counts, everybody is greeted. The strange thing is that almost only men come to this party. Half of the women in our study feel as if they were not invited, while the other half consider themselves invited, and accept that the dress code is set by the men.

5.2 Affirmative Action

There seems to be a fairly firm resistance to affirmative action among the students. When defining equality, many of the male students mention dislike for affirmative action at large and more specifically the use of fixed quotas for women. The women do not explicitly mention an aversion towards affirmative action, and only one woman mentions quotas. However, some answers imply aversion towards affirmative action. Affirmative action is seen as “reverse discrimination”, and no discrimination should be allowed.

5.3 Equality - A Woman's Problem

Many of the male students attribute the low percentage of women attending the program to a general lack of interest for computing. Some of the men, however, are willing to see culture as a contributing effect. Among the women, we can see a clear

difference between groups A and B. Women in the former group have similar answers as the men, while group B see the reasons as more cultural.

With this dominating view, equality becomes primarily a woman's problem. From this follows questions of the type: "How do we change women's attitudes towards computing?" Actions taken on the basis of this line of reasoning are bound to have short term effects. When the actions are withdrawn, these effects are lost.

Instead of concluding that the shortage of women depends on their lack of interest for computing, there is a need to go beyond this line of reasoning, asking questions that not only include the female minority, but also the male majority. Through questions of the type: "How do we change ourselves (and the dominant culture) in order to open up for individuals that today are more or less excluded?", more long-lasting effects are likely to be obtained. This requires that the dominant group is willing to let go of some of its power, which in turn requires that the existing problems and the responsibility for these, on part of the dominant group, are recognized.

5.4 Qualitative versus Quantitative Change

The reasons for wanting to increase the number of women in computer science may differ between different groups of interest. Some may want the increase in order to get more qualified individuals into the field, some may want it for a shift in the power imbalances between men and women, and some may just want it because it would be nice with more women. Needless to say, there are also those who do not want, or do not see, any need for increasing the number of women at all (this group is left out in this discussion). We can identify two groups: those that are only interested in a *quantitative* change (i. e. an increase in the number of women), and those that are interested in more far reaching and *qualitative* changes.

Qualitative changes aim at, for example, alterations in teaching methods [5] and questions the present order in the computing culture. An indirect effect of qualitative changes is an increase in the number of women. Quantitative changes focus primarily on what can be done to attract more women to computer science. The present order is not questioned, instead the main strategy is to change the attitudes of women towards the existing culture.

In the study the students were to take stand towards three claims dealing with qualitative versus quantitative changes (Appendix A statements 9-11). The two claims addressing quantitative aspects received much more positive responses than the claim addressing qualitative aspects. A majority of the students thought there was a need for more female role models in computer science (this was especially the case with the women where 75% agreed with this statement), and that it was relevant to increase the number of women attending the program in order to improve the education. Only a small minority of the men thought it would be relevant to introduce a course in the curriculum about the significance of gender in computing

(statement 11). Among the women, those in group A tended to disagree strongly with this statement, while those in group B were positive to such a course.

This may indicate that while the interest for quantitative changes seems to be quite large, ideas for changes to the existing program have little support. Also interesting to note in this context is that when comparing the three claims, it seems like the less concrete and more distanced from the own environment a claim is, the more popular (or less threatening) it seems to the students. The definition or form of the program seems to be under little questioning, at least from the male students.

5.5 The Belief in Relevant Sex-differences - Being Politically Correct

Even if there was very little support among the male students for claims stating that men are more creative, efficient and ambitious when it comes to computers (Appendix A statements 14-16), comments with respect to these claims revealed some beliefs in relevant sex-differences. In these comments, men are characterized as more rational, focused, mathematically-minded and curious (when it comes to technical matters), and women as more creative, disciplined and socially able. This indicates that there might be a belief among some of the male students that the lack of women is due to the differences between the male and the female essence.

The women were more willing to agree to the statement that men are more efficient when working with computers. They explained this with the fact that men spend more time “hacking” and are more interested in computers as such, while women like to use computers more as tools. On the other hand, the female students regard themselves as more creative with computers. Their comments also imply that, on the whole, women are more ambitious than men.

The high “political correctness” is at least in part due to the context in which the study is conducted. As a study whose purpose is to examine the attitudes of students attending the program, in order to improve the climate for women, the students were aware that their answers may have consequences for their education. Showing a liberal and free-from-prejudices mentality can in fact be important in maintaining the dominant culture. A non-sexist attitude (women are not less ambitious, creative, efficient, etc.) draws the focus to individual differences and the realm of morality – “I am not sexist and there are no differences between men and women”. With such an attitude, there is no need for further equality work. Even among students showing a categorical dissociation from straightforward claims recognizing relevant sex-differences, beliefs in such differences are found in other answers made by the same students. These variations tell us not to see the answers given by the students as reflecting their real attitudes. Instead they mirror the picture the students want to show us of the current situation.

6. Conclusions and Further Work

The results from the study so far show that half of the women attending the program seem to adjust to the dominating culture. Those who do not adjust, experience more problems. Interviews with female graduates indicate that many of them have gone (or are going) through a process leading to re-evaluation of this adjustment and stressing their femininity. In this process, there can arise a conflict between the identity of being a woman and the identity as a computer scientist.

We have found a contradictory view mainly among the men: sex is irrelevant (or at least it should be), *but* men and women are different, they think and function differently. This contradictory view is further explored in the interviews with the male students.

In this study we have concentrated on the culture of the computer science program, in the sense of the social context. As Flis Henwood points out [7], in order to transform the gendered relations of technology, we also need to examine technology itself as culture. Technology and gender are not fixed and “given”, but cultural processes that interact with each other.

References:

1. Badagliacco, J M. Gender and race differences in Computing attitudes and experience. *Social Science Computer Review* 8.1 (Spring 1990).
2. Briskin, L. Gender in the classroom. *Newsletter of the Centre for support of teaching* Vol. 1, 2-3 (Spt. 1990).
3. Caplan, Paula. *Lifting a ton of feathers: a woman's guide for surviving in the academic world*. University of Toronto Press 1993.
4. Colley, A M et al. Effects of gender role identity and experience on computer attitude components. *Journal of Educational Research*. Vol. 10, 2 (1994), 129 - 137.
5. Frenkel, K. A. Women and computing. *Com. of the ACM*. Vol. 33, 11(1990), 34-46.
6. Hemenway. Human nature and the glass ceiling in industry. *Com. of the ACM*. Vol. 38, 1 (1995), 55-62.
7. Henwood, F. Establishing Gender Perspectives on Information Technology: Problems, Issues and Opportunities. In Green, Owen and Pain, *Gendered By Design*. Taylor and Francis 1993.
8. Pearl, A. et al. Becoming a computer scientist. *Com.of the ACM* ,Vol. 33, 11 (1990), 47-57.
9. Potter, J and Wetherell, M. *Discourse and social psychology: Beyond attitudes and behaviour*. Sage Press, London, 1987.
10. Shashaani, L. Gender-differences in Computer experience and its influence on computer attitudes. *Journal of Educational Computing Research* Vol. 11, 4 (1994), 347 - 367.
11. Turkle, S. *The second self*. Simon and Schuster Inc. , New York 1984.
12. Wetherell, M. and Potter, J. Discourse analysis and the identification of interpretative repertoires. In C. Antaki (Ed), *Analysing everyday explanation*, (1988), 168-183.

Appendix A - Examples from the Questionnaire

The questionnaire was written in Swedish. Below are translated examples of questions. The examples are chosen (and numbered) to illustrate the discussion in the text.

Open-ended questions

- 1 What characterizes a proficient computer scientist?
- 2 Do you believe you can become a proficient computer scientist?
- 3 What are the most important reasons for the low number of female students at the program?
- 4 What do you mean by equality between men and women?
- 5 Is equality important to promote development in computing? (motivate your answer)
- 6 What types of persons study at the program? How would you characterize these?

Multiple-choice questions

The students were asked to indicate to what degree they considered a statement to be correct. They were instructed to answer spontaneously, and to comment on the questions.

- 7 “No women have contributed to the development in computer science”
- 8 “The social environment at the CSP benefits men more than women”
- 9 “It is relevant to increase the number of female students to improve the education”
- 10 “More female role models are needed in computing”
- 11 “It would be relevant to have an obligatory course about gender roles in computing”
- 12 “Women lack some basic qualities to become successful computer scientists”
- 13 “The number of women at the program does not depend on the structure of the program”
- 14 “Men are more efficient computer users than women”
- 15 “Women are not as ambitious as men”
- 16 “Men work more creatively with computers than women”
- 17 “The low number of female students are mostly due to women’s lack of interest in computers”
- 18 “Women at the CSP must behave in a male way “
- 19 “There are no really competent female computer scientists among faculty”

Paper II

This article was presented at GASAT 10 Conference,
Copenhagen, July 2001.

A Project for First-year Female Students of Computer Science

Christina Björkman

Abstract

This paper reports¹ on a one-year long project focusing first year female students at the Computer Science Study Programme at Uppsala university, Sweden. The idea behind the project was to support the women by starting in their own ideas and expressed needs. The aim was to gain increased knowledge and understanding of important issues for promoting female students within the programme and improve their situation. The results from the project are taken as starting point for a discussion of what can be done to create a gender balance within Computer Science, a discussion that should be relevant also for other technical fields where women are under-represented.

Introduction

Many education programmes in Computer Science (CS) suffer from a clear gender imbalance, often attracting a very low number of female students. Questions on how to recruit, support and retain female students at these study programmes are central if we want to obtain a better gender balance within the discipline. The problems are complex, involving many issues. In order to choose the right line of actions, we need a good knowledge of background and actual situation for the female students of CS.

The Computer Science study programme at Uppsala university in Sweden (below abbreviated CSP) is a four-year education within the faculty of engineering and science, leading to the degree of Master of Science. It is comparatively mathematically/theoretically oriented, focusing on theories and methods for computer systems and programming. During 1985-1995, approximately 10% of the students were women. After 1995 there has been a slight, although not stable, increase in the number of female students, numbers fluctuating between years. The attrition rates for the female students has varied greatly over the years, many years being significantly higher than for the male students.

Questions regarding the situation for the female students have been discussed for several years. Experiences from earlier projects have shown that affirmative actions in order to promote female students is considered highly provocative among all

¹ For a full report, see [1] (in Swedish).

students. These experiences led to the idea of a project aimed at gaining a better understanding of the situation for the female students, with the long term purpose of increasing recruitment and retention. The project, named Q+, took place the academic year 1998/99, and mainly focused first-year female students. The idea behind the project was to start in the ideas and needs expressed by the female students themselves. The aim of the project was to gain increased knowledge and understanding of important issues for promoting the female students within the programme and improve their situation. One of the concrete goals was to be able to recommend certain activities to be introduced at programmes with low female participation, especially within computing. By following closely a number of individuals, we also hoped to be able to give a picture of the difficulties that female students meet within this type of education.

Background description of the student group at the beginning of their first year

72 students started the CSP in the fall 1998, of which 20 (28%) were women.²

In a background questionnaire, male and female students valued a number of motives for choosing CS somewhat differently. For all students, the possibility of getting an interesting job was the most important reason for going into CS. However, the male students stated interest for programming and computers as more important than the female students did.

Earlier experience with computers differed significantly between genders, both in the amount of, and the nature of experience. The male students considered themselves to have significantly more experience with computers than the women did. The most common use of computers among the male students was “games”, stated by more than 50% of the men, followed by “programming”, mentioned by almost 50% of the men. For the women, the corresponding numbers were 25% and 15% respectively. The most common use of computers among the female students were word processing and Internet use, both given by more than 50% of the women (and by slightly less than 50% of the men). There was a strongly significant gender difference in programming experience: 74% of the men had prior programming experience, compared to 31% of the women.

Considerably more women (62%) than men (33%) expected courses in mathematics to be interesting or very interesting. This finding raises once again the much debated question of whether mathematics really is a hindrance for women to choose computing. More than 50% of the female students considered courses on

² This was a high and totally unexpected increase in the number of women (in 1997, 12% of the first year students were female). The increase is likely to have been purely coincidental, since the number of women starting the programme decreased again both in 1999 and in 2000 (20% and 15% respectively).

programming to become difficult or very difficult, compared to 33% of the male students. This is not surprising, given the women's considerably lower degree of experience with programming.

Admittance to the programme is based on marks from high school, or a special test. There were no gender differences in the mean marks/test scores, but the men had a higher average mark in mathematics.

The project, activities and results

Activities within the project were formed in a continuous dialogue with the female students. These activities can be grouped into three types:

- Extra tutoring sessions, lead by older students and open to all first-year students
- Regular informal meetings with the female students, some of these for first-year students only, to some of them we invited all the female students at the programme
- Support function. As project leader (with many years of experience as teacher and study counsellor at the CSP), I had close contact with the women and could help with different problems.

At the beginning and end of the project all the students answered questionnaires. The project was also evaluated by interviews with a number of the female students. After the project, we analysed the study results of all first-year students and followed up on female students who had left the programme.

The project was on the whole greatly appreciated by the female students. The extra tutoring sessions were very positively judged. These were arranged in connection with most of the courses, both mathematics and programming, and were mainly run by students in their 3rd or 4th year. The female students participated in these sessions to a much larger extent than their male peers. Among the students participating in the sessions, the women considered them very important for their studies, while the men did not regard them to be of the same importance. From the resume of the interviews: "The tutoring has been of crucial importance for most of the interviewed women, for their possibilities of succeeding in the classes. I am completely convinced that without this tutoring, more women would have quit during their first year. "

All the women held positive attitudes to the arranged informal gatherings for female students. These meetings seem to fill the function of a psychological support. The students get to know, and can support, each other. By meeting women in higher grades, the first-year students obtain role-models. The women felt it easier to open up and talk when there were only women present, and they said the male students do not fully understand what it means to be a minority. However, some of the women pointed out that male students also need support, and that some men show a certain amount of jealousy.

The support function offered was appreciated by the women, for several reasons. There was someone who cared, tried to support and encourage and who was able to arrange for example tutoring when the need arose. Several of the women mentioned that it was easier to talk to me than to a study counsellor, since they knew me better.

Student group after their first year of studies

In the first course, programming methodology, a functional programming language (Standard ML) is used. Since practically none of the students have ever seen, much less programmed in this language, faculty has always believed that all students are in the same situation in the first course. This assumption has been shown to be false, at least for the students in this project. There is a clear correlation between on the one hand a student's programming experience before entering the programme, and on the other both how well the student judges his/her knowledge of programming after the first year, and the results in the programming classes. After accounting for the differences in programming experience between male and female students, there are no significant gender differences. It is obvious that prior knowledge of programming is a factor, that, if not completely necessary, definitely facilitates the studies during the first year. Since the women to a much larger extent than the men lack this knowledge, the result is that the women as a group suffer a drawback. Interviews with female students also showed that lack of programming experience had made the studies harder.

The total results from the first year courses (measured in number of credits passed by the students) show that the men did significantly better than the women. If we look at results from single courses, the women have performed less well than the men on every course except a course on HCI. These differences can not be explained solely based on the differences in programming experience. There is no statistical correspondence between the mean mark from high school and study results, however, there is a statistically significant correlation to the mathematics mark from high school.

This study is too small to permit any general conclusions concerning how the students' results relate to other factors. However, we note that facts that might be of importance are gender (even though we do not know why gender is a factor), programming experience before university and results in mathematics from high school. These factors also influence each other. Students normally take two classes in parallel, usually one mathematics class at the same time as a "programming" class. If a student finds one of these classes fairly easy, that will give her/him more time to spend on the other class.

Situation for the female students

The women experienced the education as harder and requiring more work than expected. They had less experience of computers and programming than the men, leading to less good results, lower self esteem and harder workload. They were on the whole very ambitious and were strongly affected by the high workload. They worried about their studies and as a result also experienced stress related symptoms.

When asked what they should have needed during the first year, the answers were mainly: an introductory course to programming for those without prior knowledge, organised group work, better balance between parallel courses, and help from older students. In order to successfully finish their studies, they saw as most important: peer support (network of women), tutoring, support and encouragement from faculty, better teachers and role models (compare e.g. [2,3]). They seemed to accept the education as such, but felt the need of much support in order to succeed.

In the last questionnaire, 60% of the women compared to 20% of the men said they had had thoughts about quitting. By the end of the spring semester 1999, five women (25%) had left the programme. To our knowledge, none of these went to a similar education. At the start of the fall semester 1999, considerably fewer students than expected came back for their second year: 23% of the men and 55% of the women did not come back (the normal attrition rate is 10-15%). Of the six women who finished their first year but never came back for their second year, five had actually changed to another education within science or engineering (in three cases even another education within computing). Some of the men are likely to come back after a year, (due to doing their military service) while that is very unlikely for the women. The unexpected fact that so many women decided during the summer not to come back raises another question: did the project in fact just delay the process of leaving the programme? If so, that is certainly not a result that we intended. Another factor can be that many of them worried for the second year, since they heard this is a very demanding year (including two large projects requiring very good knowledge of programming).

There are, in my opinion, some serious problems here. One is the workload, due mainly to very large assignments and projects. More often than not, late evenings and weekends are spent in the computer rooms. Effects of this are e.g. that there is very little time left over for reading course literature, which must be considered a problem. Social relations suffer hard from the workload, since almost all spare time is spent at the university. It seems that women generally suffer more from these circumstances than men. Maybe for some of the men, their social life is found in the computer rooms? Besides the high workload, there is a prevailing culture demanding a "real" CS student to spend nights in front of the computer. This "night hacking" seems laden with highly positive values, although it is actually mainly kept up by a small minority of male students. Several of the female beginners have expressed that they think this is a very "macho" culture, but it can be hard for them to question it, if they want to be taken seriously as CS students.

Consequences of the project and final discussion

We believe the project has given us a clearer picture of the situation for female students at the CSP. We have seen that comparatively simple and inexpensive actions can be very appreciated. The strong positive reactions to this limited project has most of all shown the great need of e.g. support, that the female students have. As a result of the project, a number of concrete suggestions were made:

- Start an introductory course in programming or change existing programming courses, so that students lacking prior knowledge of programming can “catch up”
- Introduce regular tutoring in all courses, alternatively the method of Supplemental Instruction[4]
- Organise or facilitate group studies
- Regular meetings for female students
- Introduce a permanent support function of the same type as in the project.

As a concrete result of the project, there is now a position as “Q+-assistant”, to be held by a female student in her second year or higher. Her task is to arrange tutoring, meetings for female students and also to have a certain support function. She has close contacts with the study counsellor and program co-ordinator, and has the support of a female teacher acting as mentor.

When looking at the problems women face in CS education, we can distinguish three parts: *individual qualifications* (e.g programming experience), *structure* of the education and the *culture* (the strongly male environment). All of these can, in different ways, work to the disadvantage of women, and the additive effect could become very strong. However, I would like to point out that the problems above should be considered as *structural*, not individual.

The problem with low female participation in computing contains two parts: recruiting and retaining female students. As for recruitment, this is still mostly viewed as a problem of information. In taking this view, it is easy to assume that the problem is in fact the women themselves and their attitudes, and so it will become a question of changing the women. Such a view of recruitment will not lead to any sustainable improvements, and it is also highly problematic since it assumes there is something wrong with the women who choose not to go into computing. If we are serious in our efforts to change the gender balance, we need to focus on how to change education, asking why it is not attractive to women. The same approach should be used when addressing retainment. A supportive and positive environment is important in a clearly male dominated education, but it will not make any substantial changes in retaining the female students, if the education does not function well.

So, what can we do “here and now” to support the female students that we do have? We need to support them both in the social situation and in their studies, to strengthen their identity by providing role models and to discuss teaching methods:

work load, assignments, how work is divided in projects etc and to educate faculty in gender issues. By doing so, we can improve the situation for our female students. I would however like to point out that these suggestions, even if important and valuable, are not likely to be enough for obtaining a sustainable increase of female participation in CS. In my opinion, we need to take more radical measures. We need to ask questions around CS as a discipline, how it is formed, mediated and mirrored in education and surrounding cultures. From this ground, we can work for radical changes concerning all parts of the education: structure, content, teaching and environment.

References

- [1] Björkman, *Projekt Q+*, Arbetsrapport 6, Development and Evaluation unit, Uppsala university, Sweden, 2000 (in Swedish).
- [2] McGrathCohoon, J: "Departmental differences can point the way to improving retention in Computer Science". In *Proc. of the 30th SIGCSE Technical Symposium on Computer Science Education*, New Orleans, 1999.
- [3] Haller, S M, Fossum, T V: "Retaining Women in Computer Science with Accessible Role Models". In *Proc. of the 29th SIGCSE Technical Symposium on Computer Science Education*, Atlanta, Georgia, 1999.
- [4] Martin, D, Arrendale, D: *Supplemental Instruction: Increasing Achievement and Retention*. New Directions for Teaching and Learning, number 60. Jossey-Bass Publishers 1994.

Paper III

Women and Computer Science

Christina Björkman

Introduction

Women are severely under-represented within computer science (CS)¹, and although significant effort has been put into different attempts and projects², as yet little progress has been made in changing the gender balance within the discipline. The issue of female under-representation has been widely recognised as a problem, in the community of computer scientists as well as among other researchers and in society at large for the last 15 years and is the cause of much concern. The reason(s) why CS is so male-dominated, and what can be done to remedy the situation, has been the focus of much research and discussion.

This paper presents an overview and discussion of research and literature that focuses on the problem of low female participation within the field of computer science. I have chosen to use two dimensions in my study. The first dimension deals with *how* the problem is perceived; the second dimension concerns *who* perceives it. It is clear that these two dimensions are connected: the location of the researcher tends to influence how the problem is perceived and what solutions are suggested.

The way a problem is represented and defined does in itself carry with it delimitations and assumptions. Thus, the problem definition strongly affects the solutions suggested and becomes a limiting factor on the potentials for change. This means that it is important to analyse the presuppositions implied or taken for granted, as well as what is left un-addressed, in the representation of the problem (Bacchi 1999, see also Mörtberg 2001).

At this point, I would like to make my position and my aims with this survey clear. I regard the issues of women in CS from within the community of computer scientists and at the same time as a gender researcher. My aim is transformative in that my goal is to discuss the issues from the starting point that I want change, that I am looking for a sustainable increase in women's participation in CS. I am therefore also trying to identify problems and limitations entailed by the approaches found in the reviewed literature; in other words, I am attempting to '*problematise*' the views and suggestions. "If the interpretations of the nature and/or causes of the problem miss the mark, so to speak, we can expect little to change" (Bacchi 1999, p. 66).

¹I use the term 'computer science' (CS) in a broad sense to include software engineering and all relevant parts of computer engineering.

²In Sweden, several initiatives to recruit women into CS have been evaluated in Wistedt (2001). For statistics on men and women studying computer science, see the Computing Research Association's Taulbee Survey: www.cra.org/statistics/ (USA) and www.scb.se (Sweden).

Why is the Under-Representation of Women Seen as a Problem?

Before discussing the issues of how and who mentioned above, I will briefly discuss what the motives can be for why the issue of the lack of women in CS should be given attention, time and effort. These motives can be divided roughly into four categories³:

- Shortage of labour force. This argument is quite common, especially when a researcher is trying to advocate why changes are necessary. However, it can be seen as a rather cynical argument, suggesting that women are inferior: their importance is solely as a reserve labour force, when there is a shortage of (talented) men. An example of this argument is: “In short, there is a critical labor shortage in CS...” (Camp 1997 p. 104).
- Missing women’s contribution. This argument can actually have two distinctly different motives. Either, it means simply that we miss the contributions from a number of talented people who choose to do something else. This argument is non-controversial; for example: “It is one of our major follies that, whatever we say, we don’t in reality regard women as suitable for scientific careers. We thus neatly divide our pool of potential talent by two” (C.P. Snow, Rede lectures, Cambridge, 1959, quoted in Pearl 1995 p. 26). The other motive, which has been rather commonly voiced in the Nordic debate, is the idea that women have special qualities simply by virtue of the fact that they are women. “Women may also contribute different ideas and interests in the development and use of computer technology” (Rasmussen and Håpnes 1991 p. 1007). This latter interpretation of the argument can be seen as supporting essentialism⁴ in its view of women, and women are seen as a homogeneous group. Women are then burdened with the responsibility of being representatives of their gender and contributing “something new and extra”.
- Gender equality motives. Women should have the same rights and opportunities as men to participate in and influence technology, as well as access to good career opportunities. “...the disturbing possibility that the field of computer science functions in ways that prevent or hinder women from becoming part of it. [...Need] to ensure that fair and equal treatment is being provided to all potential and current computer scientists” (Pearl et al 1990 p. 48).
- With CS’s dominant position as a field of knowledge and technology follows the need for a broad representation of developers within CS. This argument does not explicitly mention women, but broadening the representation implies diversity within gender, race, class, ethnicity, interests etc. “The more diverse our profession, the more creative and flexible we can be – and the more important our contribution to the world we live in” (Pfleeger 1990 p. 14).

³ See also Verne 1988, for a discussion about motives for recruiting women into CS.

⁴ Essentialism means attributing to women (and men) inherited, specific qualities. Often, however, it is unclear what these specific qualities are. Usually, men and women are also seen as homogenous groups.

How is the Problem Perceived?

Drawing on Sandra Harding's terminology (Harding 1986), I group the obstacles that women face within CS into three different levels:

- *individual* - for example, female students often have less experience with computers and programming than their male peers when they enter the academic education system
- *structural* - in the form of the structure, curriculum and pedagogic of the education programmes, as well as structures and hierarchies within academia and industry
- *symbolic* - the obvious and strongly male-dominated culture within the field as well as prevailing images of men, women and what it is to be a computer scientist.

Most initiatives taken so far to increase the number of women in CS started by focusing on issues of information (trying to change the attitudes of women) and the individual level (often identifying women as the problem). "The low female representation in technical faculties is often seen as a quantitative problem, that is the problem is placed outside the own practice and the solution is to inform girls (preferably from day care and all through school) about the interesting content in technology. Women shall be enticed into existing practice and adapt to it" (Trojer 1999, p. 13). With this view, it is only the women who are expected to change.

On the individual level, psychological, social or biological sex differences have been suggested as possible causes for women's low participation, thus locating the problem with women. This could be seen as essentialism, since certain qualities and roles are attributed to women (as well as to men). There are countless studies and reports focusing on the individual level, many of which are connected to outreach programmes, mentoring, and role models. Another common topic is to discuss women's lack of computing experience and psychological issues such as self-confidence. The methods suggested can be called additional, or "add women and stir", i.e. they require a one-sided adaptation on the part of the women.

Recently, we have seen an increase in the work on and interest in questions regarding the structure and content of education as well as social and cultural issues surrounding CS. Many studies and projects treat both the structural and symbolic level. These studies are often attached to reform and intervention programmes addressing pedagogy and occasionally curricula, as well as climate, gender stereotyping and images of computer science and computer scientists⁵. Focus is turned away from individual gender and towards larger and more complex issues. However, essentialism can appear also at this level.

⁵ In the Swedish context, we can note the D++ project at Chalmers Institute of Technology (Jansson 1998) and the DTI project at Luleå University of Technology (Brandell et al 1998, Wistedt 2000). See also Wistedt (2001) and Salminen-Karlsson (1999).

Joanne McGrathCohoon summarises the current status (McGrathCohoon 1999, p. 198):

“Low female participation has most frequently been attributed to female disadvantages that stem from gender differences in computer interest, motivation or experience, mathematical ability or academic preparation, self-efficacy, early socialization, [...] culture of computers and its particularly male character, [...] and environmental factors such as competition among students and pedagogical techniques. [...] In spite of these efforts, no adequate explanation of CS’s gender disparity has been agreed upon. Research results are varied and conflicting”.

What seems to be lacking in many of these discussions are questions regarding *the discipline itself*. While all the issues mentioned above are of great importance, so far, however, these efforts have not led to a stable increase in the representation of women within the core areas of CS (e.g. Wistedt 2001). These results, and my own experiences from working with female students of CS (Björkman 2000, 2001), noting their reactions to the discipline during their first year of study (which resulted in many of them dropping out), has led me to conclude that the problem goes deeper and is more complex. As a result, I want to suggest a fourth level of obstacles:

- discipline and epistemological⁶ issues concerning computer science itself and its knowledge processes. By this I intend to highlight the importance of issues surrounding knowledge and how this is constructed, such as what is considered knowledge within CS, and who has knowledge, i.e. epistemological questions, as well as how paradigms are constructed and maintained. So far, this level has not been acknowledged as important, except by some researchers, mainly gender researchers within CS (see p. 64 below).

Who Perceives the Problem?

For the sake of simplicity, I distinguish and discuss four different communities. These communities sometimes overlap, and their boundaries are not rigid. In my overview, I have not attempted to cover everything that has been written on the topic of women and CS, but rather to focus on the one hand on research that I have found to be influential from the CS point of view, and on the other hand on research that presents different and new approaches. I have concentrated mainly on research done since the mid-1990’s, with some exceptions to provide a background or point to earlier influential work.

I have chosen to give most attention to the community of computer scientists, since my focus is within CS, and it is within this community that change takes place and must develop. However, there are other ways of approaching the issue, where research in other disciplines can contribute much valuable knowledge.

⁶ Swedish National Encyclopaedia defines epistemology as the ‘theory of knowledge’.

Computer Scientists

I have studied how the issue has been discussed in articles in Communications of the ACM⁷ (CACM) during the period 1995 – 2001 (plus a thematic issue on Women and Computing⁸ from 1990) and within the SIGCSE group⁹ (the SIGCSE Bulletin and the SIGCSE technical conferences) during the same period of time. I believe this selection of articles provides a good picture of the interest and knowledge that an ‘ordinary’ (though interested) computer scientist would have in the issue. With a few exceptions, these articles have been written by computer scientists. In some cases, the work has been done in collaboration with researchers from the disciplines of education and psychology, and two articles are written entirely by a sociologist. I have chosen to treat their research under this heading, since the articles are published within the community of CS and are intended to be read by people from this community.

How has the problem been perceived?

The approach adopted by most researchers within this group can be characterised as the “women into technology” approach (Adam 1995). This approach focuses on the low number of women and issues of recruitment, education, training and equity. The focus is clearly on women. Statistics, information and the individual level have been the most prevalent issues discussed. Below I give a few examples of general articles that have received a great deal of attention within the community of computer scientists. The article by Tracy Camp on the “incredible shrinking pipeline” (Camp 1997¹⁰) focuses on the depressing statistics concerning female representation within CS. In the November 1990 issue of CACM, with the theme “Women and computing”, the ACM Committee on the Status of Women in CS reported their findings (Pearl et al 1990). Five years later, in the January issue of CACM with the theme “Women in computing”, Klawe and Leveson (1995) report on the current knowledge status. Both these latter articles cover a broad field of explanations and suggestions for solutions, addressing mainly the individual and to some extent the structural and symbolic levels.

Arguments calling for efforts on the individual level have been voiced in many articles, including discussions on role models (e.g. Childress Townsend 1996, Haller and Fossum 1998) and recruitment programmes (e.g. Rodger and Walker 1996). The problems facing women in introductory programming courses, often because they

⁷ ACM, the Association of Computing Machinery is one of the largest international professional organisations within CS.

⁸ The term ‘computing’ is often used as a broader term than (some views of) computer science and usually also includes computer engineering and software engineering. Used in this sense, the term ‘computing’ is essentially equivalent to how I use ‘computer science’ in this paper (i.e. a field that is closely related to mathematics, engineering and the natural sciences). Unless otherwise stated, this is how the word ‘computing’ should be interpreted in this paper.

⁹ The Special Interest Group of Computer Science Education, a group within ACM.

¹⁰ A follow-up of this article is available on the web: see Camp (2000).

have far less experience with computers and programming than their male peers, is a recurring theme (e.g. Sackrowitz and Parker 1996). Psychological approaches can also be found, such as trying to explain the low number of women with psychological personality components (Haliburton et al 1998).

However, issues of education, culture within CS and perceptions of CS are also addressed, and these have been given increasing attention over the last years. In the November 1990 issue of CACM, Karen Frenkel acknowledges the importance of these factors, in her report from a workshop¹¹ (Frenkel 1990). Other topics include the glass-ceiling in industry (Hemenway 1995) and suggestions to introduce students to the culture of computing, such as acronyms, buzzwords, non-academic literature, advertisements, movies, magazines and so on (Bernstein 1997). The influence of ethnicity in combination with gender on how CS is viewed has also been addressed (Von Hellens and Nielsen 2001). Ellen Spertus made an early contribution to the discussion of women and CS. Her report “Why are there so few female computer scientists?” (Spertus 1991) stresses the importance of social and cultural causes for women’s under-representation.

A never-ending debate is that of the role of mathematics in CS, where there seems to be a widespread belief in the idea that women are put off by mathematics, although no research actually supports this (Haliburton et al 1998, Scragg and Smith 1998). However, there are also advocators of the opposite opinion, that CS ought to be more like mathematics in order to improve female participation: “Could it be the ill-defined nature of computing is what drives them away?” (DePalma 2001 p. 27).

The idea of getting girls interested in computers through computer games appears in an article that I want to mention as an example where I find reason to query the motives and the underlying view of women. The article “Engaging Girls with Computers through Software Games” (Gorritz and Medina 2000) argues that if girls get accustomed to computers and software through game-playing, this might lead them to pursue an education in CS. The authors claim, without underpinning their argument with research findings, that there are brain-based sex differences in attitudes towards games. Mattel’s Barbie fashion designer is held up as an excellent example of software for girls. However, it seems that the real motive for claiming the importance of computer games is commercial: “The market is ripe, the time is now, for tapping into the potential gold mine that surrounds computer games for girls” (*Ibid* p. 42). This shows how important it is to ask why a problem is framed the way it is.

The reasons given for female under-representation in most articles are the same as those that were found in a study commissioned by the ministry of education in Australia. I quote this article to summarise and confirm how the problem is commonly viewed (Selby, Ryba and Young 1998):

¹¹ This workshop is discussed further under Cross- and Interdisciplinary Groups and Forums below.

- (1) *Lack of Knowledge about Career Prospects*
- (2) *The Image of Computer Science and Information Technology*
- (3) *A Perceived Lack of Confidence Amongst Women Students Despite Their Obvious Abilities and Successes*
- (4) *A Lack of Women Lecturers*
- (5) *Computing as a Male Domain*
- (6) *The Learning Environment Is Often Not Informed by Contemporary Learning Theory*
- (7) *The Importance of Prior Computing Experience.*

In the overwhelming majority of the articles I have reviewed, basically the same issues are discussed, the same results from studies presented, and the same suggestions for improvement made. There is a general belief in rather clear and simple solutions and at the same time that changes are necessary in society. It seems there is a willingness to accept the need for revolutionary changes in society, culture and attitudes, but not when it comes to one's own discipline, where more surface-oriented solutions are suggested. The view of the discipline is thus characterised by the habit of taking CS as a given. This is confirmed by the results from an on-line survey done by Tracy Camp (Camp 1998) as a follow-up to her article "The incredible shrinking pipeline" (Camp 1997). 111 computer scientists responded to this survey where they among other things were asked to rank activities to increase the number of women in CS. The alternatives that were ranked highest by the respondents are all on what I call the individual level, and the only alternative that touched on the discipline: "modify curricula", was seen as important only by 16% of the respondents. However, it should be noted that the way the survey was formulated and the issues it focused on helped define the problem and the suggested solutions in certain ways.

Most of the studies mentioned above were carried out by computer scientists who seem to be unaware of other research, for example research done by social scientists. This can be seen in the lack of references to publications from other fields, and the lack of references to gender research publications is especially notable.

New approaches?

Despite the efforts made within the community, as yet no sustainable increase in the number of women within CS has been achieved, demonstrating that the way the problem has been delimited and treated by computer scientists thus far leads to a limited understanding. This has been recognised by some computer scientists: "The nature of the computing discipline itself needs to be addressed by its participants: what is computing science? This need is slowly being recognised but the variety of answers reflects the problem" (Stack 1997 p. IX).

During the last year, however, critique of the status quo and 'cracks' in existing views have become visible. One such sign is the publication of an article by sociologist Joanne McGrathCohon in the CACM, focusing on departmental characteristics and practices as an important factor for the retention of female students

(McGrathCohoon 2001). She also notes that another key factor is “discipline characteristics”.

Issues of social relevance and responsibility surfaced at a conference that gathered together 50 senior and successful technical women from the computing field in industry. The topic of the conference was to explore the most important issues for computing to address in the next 10 years. “The group decided to turn the creative process on its head. As a field, computing has been driven by technical or scientific goals. [...] Imagine the societal challenge driving the investigation...” (Borg 2001 p. 140), thus letting the needs of people drive research and creation of technology. However, starting from people’s needs is not without problems; for example, how are genuine needs separated from created needs? Nevertheless, I find the emergence of issues such as these, a positive sign. Anita Borg also discusses how such a change in focus could affect recruitment (Borg 2001 p. 141):

“We have educated thousands of developers, engineers, and researchers who see their roles as technology inventors, and only a few who start by understanding situations and people and let that drive the creation of technologies. By presenting the major challenges of computing as technical challenges, we have lost the interest of many brilliant technical minds – often female – because their interest is in using that brilliance to solve real problems rather than creating technology for technology’s sake.”

Maria Klawe, president of the ACM, recognises the need for change within CS in her article “Refreshing the nerds” (Klawe 2001). Based on a survey among 7500 high school students in Vancouver, she concludes that the image of CS has to be changed, but “also the reality of how we teach computer science, and how we design computers and computer applications. [...] We tend to value abstractions rather than examples, technology rather than applications” (*Ibid* p. 68). She points out that there is an urgent need to broaden recruitment into the discipline (*Ibid* p. 67):

“The point here is that computer science also needs to attract students with broader interests and abilities than the traditional computer scientists—nerds. [...] But nerds are not enough. We need more computer scientists whose passions are art, language, literature, education, entertainment, psychology, biology, music, history, or political science. We need them because computers have an impact on all areas in our world. We need people with passion and vision from every area to drive the development of computer technology as well as the applications”.

Maria Klawe acknowledges the insufficiency of the current approaches: “Most of the current experiments are Band-Aid solutions that address only a piece of the problem. We need to look at the whole picture. [...] We need non-nerds in computer science, so let’s figure out the proper approaches to integrate their talents and perspective into our field” (*Ibid* p. 68).

These examples, found within the last year, open up possibilities for new approaches to the “women and CS problem” that will hopefully also include giving attention to the discipline level I identified above.

Strengths and weaknesses

I find the real strength within the community of CS is the commitment to transformation. This desire is not only due to more abstract ideas of equality or broader representation, but also stems from lived experiences, from daily work and situations encountered. Change is the focal point on the agenda, and although ideas and knowledge from other groups must not be ignored, change can, in my opinion, only be made from within. This points to the weaknesses in this group – there is far too little communication with research and knowledge acquired within other disciplines, and there is also, as I pointed out above, an unwillingness to question the discipline itself and its practices. In short, I believe the current understanding of the problem of female under-representation is too shallow – the problem has been constructed in a way that limits the solutions. The focus is still strongly on women. This is easily visible in that the word ‘women’ is always used when the problem is discussed. There is very little, if any, focus on the second part of ‘the problem’: computer science. However, above I pointed out some promising openings towards a discipline-oriented focus, and an understanding of the role of CS in society.

Social Scientists

The issue of low female participation in computing has triggered research and studies mainly within the fields of education, psychology, sociology and the interdisciplinary field of Science and Technology Studies (STS). I have chosen to focus on research that is relatively visible from the CS point of view (most probably because the researcher is interested in transformation and thus trying to communicate results to computer scientists). The overview I present is not intended to cover the whole area of research within social science that is relevant for the issues of women and computer science, but rather to point to some trends and contrast these with the approaches found within the community of computer scientists.

How has the problem been perceived?

Within social science, the issue, and thus the problem, is usually discussed in terms of ‘gender and CS’ – or at least in more recent publications. This difference in terminology is more significant than it might appear at first glance. It signals a move away from a focus on women and towards a focus on issues of *gender*, i.e. both men and women are included, and socially constructed gender is emphasised over the biological sex.

For the most part, it is some early research that can be characterised as approaching the problem on the individual level. This research often expresses essentialist views of women, e.g. that changes within CS may offer women a unique opportunity because changes in the mental model of computing will make it more ‘feminine’, or that object-oriented programming would require a reconsideration of traditional concepts of masculinity and femininity (Perry and Greber 1990).

A well-known researcher who employs a psychological approach on the individual level is Sherry Turkle. She assumes that technology is gender neutral in itself, but that men and women have different “cognitive patterns”, based on psychological sex differences. Her approach can thus be seen as essentialist. She develops the concepts of ‘hard mastery’ (manifested for example in control over the machine and competitive behaviour) and ‘soft mastery’ (a more interactive approach to the computer as a tool and co-operative behaviour). She argues that most men take the hard-mastery approach while women tend to be soft masters. Neither style is superior for programming, but computer expertise is defined in terms of hard mastery as the rational, logical approach and the only correct way to program, while soft mastery is seen as inferior (Turkle 1984)¹². Is it possible that her approach on the individual level, with the emphasis on psychology, is one reason why her work has had influence within the community of computer scientists?

By contrast, research among social scientists seems to concentrate mainly on the structural level and, increasingly over the years, on the symbolic level (e.g. Sanders 1995). The approach adopted by most researchers within this group can be characterised as the “gendering of technology” approach (Adam 1995).

Another common approach is the social constructionist approach, where the historical and cultural contexts are seen as dominant factors behind the under-representation of women in computing. Kramer and Lehman (1990) is an example of an early critique centring on the role of contexts and embedded social contents of computer learning. Much work within this group has focused on the social construction of computing – both as a discipline and as computer-related activities – as masculine.

In her book “Feminism confronts technology” (Wajcman 1991), Judy Wajcman argues against Sherry Turkle’s view. Judy Wajcman claims that “cognition can not be stripped of its social content to reveal pure logical reasoning” (*Ibid* p. 157). Psychological development cannot be understood disconnected from the social context. She brings up the history of computer programming: “It was because programming was initially viewed as tedious clerical work of low status that it was assigned to women. As the complex skills and value of programming were increasingly recognized, it came to be considered creative, intellectual and demanding ‘men’s work’. Thus, depending on the circumstances, different cognitive styles may be characterized as ‘masculine’ or ‘feminine’ according to the power and status that attaches” (*Ibid* p. 158).

Flis Henwood has criticised what she perceives as technological determinism and essentialism in existing research (including feminist research). “Continued existence of biological and technological determinism is seriously inhibiting the development of appropriate transformation strategies” (Henwood 1993 p. 31-32). Instead, she suggests that “A suitable framework for analysing gender and IT relationships then,

¹² See also the discussion of the work done by Sherry Turkle and Seymour Papert under Cross- and Interdisciplinary Groups and Forums below.

is one which understands both technology and gender not as fixed and 'given', but as cultural processes which (like other cultural processes) are subject to negotiation, contestation and ultimately, transformation" (Henwood 1993 p. 44). The problem of determinism is observed in a 'traditional' CS course (on data structures): "both 'gender' and 'technology' are taken at face value and their cultural nature is not understood. This limits the space that exists within such courses for students (or staff) to examine the gendered relations of technology and the resistances to change in those relations" (Henwood et al 2000 p. 128).

Linked to this approach are studies of 'computer culture', or the 'culture of CS', which is described as a whole complex of processes forming the image of the discipline and activities connected to the discipline. Fundamental work here concerns hackers, and hacker culture (e.g. Turkle 1984, Håpnes and Rasmussen 1991, Rasmussen and Håpnes 1991, Nissen 1993, Håpnes and Sørensen 1995). This research argues for a concentration of attention on ongoing cultural production. Female students are defined (also by themselves) as marginal, because they distance themselves from this culture. The male domination is created by sharing certain values such as machine fascination, playful attitude towards computers, and total absorption in them (Håpnes and Rasmussen 1991).

"The culture and ideas of a small male minority of students, the computer hackers, come to dominate computer science in the eyes of the female students. This minority culture is reinforced by the values and interests of the most powerful (male) groups in computer science, the male professors and teachers, and their disciples, the dedicated students. In this way, a male-dominated and machine-fixated culture works to marginalize women" (Rasmussen and Håpnes 1991, p 1107).

Jørgen Nissen discusses different answers to the question of male dominance within computing¹³ arguing that the reasons are not to be found in psychological differences or in the 'essence' of computer technology. He sees technology as made by men for men, as linked to activities seen as traditionally male, and the control of the machine as a masculine symbol (Nissen 1996).

Minna Salminen-Karlsson (Salminen-Karlsson 1999) has studied curriculum reform processes aimed at making computer engineering education more attractive to female students. Focus is on how "gender contracts", denoting engineering as a masculine sphere, are reproduced within the education. She shows that lack of knowledge in gender issues among faculty can be a strongly limiting factor on change. "Thus, while engineering faculty seem to be the only agents who really can enforce even such reforms that can break gender contracts in the education, at the same time they seem to be limited in their views of what is possible and thus are unable to make such radical reforms as would be needed to change the contracts" (*Ibid* p. 239).

¹³ By computing, Jørgen Nissen means the whole field of computer-related activities, but since this is strongly related to the culture within CS, I find it relevant here.

Along with the culture of computing comes the problem of inequalities within the discipline and the ensuing dilemma for women who do not want to be seen as 'other'. By claiming "we are not different", they emphasise similarity of abilities and so avoid being segregated and excluded from science (Wilson 1997). Female students inhabit complex positions as both insiders and outsiders in the domain, and this enables them to engage with 'the rules' in various ways (Stepulevage and Plumeridge 1998)¹⁴. An important question is "whether students can develop approaches that challenge the dominant discourse¹⁵ of computer science from within and create new possibilities for engagement" (*Ibid* p. 324).

Yet another aspect of culture is the 'occupational culture' of computing, which is seen as distinctly masculine, and thus alienating women. Engineering, especially electrical engineering, is regarded as having a strong influence on the construction of this culture (Wright 1997, Lewis 2000).

Gerda Siann (1997) argues against this focus on culture. She points out that women have gone into other areas that are dominated by a strong masculine culture, but that women choose not to go into computing because it is seen as lacking social involvement and commitment.

New approaches?

Sue Clegg (Clegg 2001) criticises what she sees as tendencies to reduce technology to the social. She argues that we need to understand how the discipline of computing is constituted historically. Computing was institutionalised alongside other male-dominated disciplines, establishing itself as intellectually challenging, tough and abstract.

There is some emerging research within this community that is calling for a focus on the paradigms of computer science or what I have called the discipline level. Sue Clegg (Clegg 2001) claims that computing is neither an extension of mathematical thinking nor an applied science. The reasons it came to be thought of as such are due to the historically contingent ways computing developed. Instead, computing is best characterised as a concrete rather than an abstract science, containing materiality and social practices. She points to the need for research into CS: We should "ask what is wrong with computing rather than what is wrong with women" (Clegg and Trayhurn 1999). Linda Stepulevage and Sarah Plumeridge (1998) discuss how certain dogmas of science, such as physics as the paradigm of science, and 'pure mathematics' as value-free, are relevant to computer science. Connected to this is the separation of abstraction, as the 'pure', from the applied:

¹⁴ See also Christina Mörtberg under gender researchers within computer science below.

¹⁵ "Discourse is a regulated method of dialogue that determines what is 'allowed' to be said or done and what is not allowed to be said or done" (Johansson, Nissen, Stureson: "IT-ism" *Informationstekniken som vision och verklighet*. Telematik 2001, KFB och Teldok, KFB-rapport 1998:11 p.39).

“Computer science as the pure focuses on understanding the world via a rationality based in the abstract; therefore, the concrete products resulting from the discovery and development of algorithms can exist outside the domain of computer science and there is no need for critical self-reflection” (Ibid p. 316-317).

Just as with the community of computer scientists, examples of fairly recent research open up possibilities for more complex and new approaches to the issue of women and CS, including asking questions on the discipline level.

Strengths and weaknesses

On the whole, the strength of this group of researchers comes from their being outsiders to the community of CS, in the sense that they have no pre-understanding of what computer science is or should be, and as we have seen above, they question technological determinism. They also bring more complex issues, such as social construction, on to the agenda. However, there are simplifying features in this research too, for example in the strong concentration on social aspects such as history and culture. In constructing the problem as solely social/cultural, other factors might be overlooked, thus limiting the suggestions for action. There can be a tendency to focus on questions of *why*, i.e. to explain, rather than to suggest what can be done about the problem. How can we change these historically and socially constructed cultures? The position of outsiders looking in is also one reason for the weakness of the research in limiting its possibilities to contribute to the transformatory project. For one thing, even if on a political level these researchers are strongly committed, the issue of women in CS is generally not part of their everyday life and experience. We can also note the absence of references to work done within the CS community. Furthermore, there is the problem of communication between disciplines. In my experience ‘the two cultures’ do exist, with a deep chasm separating the different disciplines. This is rendered visible in everything from the view of knowledge and what the goals of knowledge production are to traditions of writing and language and what is seen as acceptable and ‘good science’. It can be just as difficult for a computer scientist to read a research publication within social science as for a social scientist to read a technical publication within computer science.

Cross- and Interdisciplinary Groups and Forums

In this section, I have chosen to present two types of research, both characterised by some level of cross- or interdisciplinarity. One is interdisciplinary research groups, the other is research done within the respective disciplines but published and communicated deliberately at what I call a ‘meeting place’ for researchers from different disciplines. By presenting this type of research (cross- and interdisciplinary) separately, I want to point to the fruitfulness of interdisciplinary work. “The challenge is to continue what has begun, both so that ‘women into technology’ research can be more theoretically informed, and social science/philosophical

research can be more directly linked to social action, which is in the best tradition of feminist thinking” (Adam 1995 p. 43).

Here we find research ranging from the individual level and essentialist perspectives to the symbolic level. I have chosen to present some approaches and groups that are particularly interesting, either because they have attracted attention and/or brought about changes within CS education, or because they adopt approaches that I find new and promising.

How has the problem been perceived?

One early meeting place that brought together participants from many disciplines was the workshop *In search of gender free paradigms for computer science education*, held in 1990 (Martin and Murchie-Beyma 1992)¹⁶. The premise of the workshop was that “the decline in the number of young women selecting computer science majors was attributable to a male-oriented paradigm in computer science” (*Ibid* p. VII). The organiser (Dianne Martin, computer scientist and educational researcher) discussed the power of paradigms. It seems clear that she is referring to *educational* paradigms rather than paradigms within the discipline: “the decline in young women...can be attributed to the existing educational paradigm that separates studies of science, math, and computer science from studies of the humanities” (*Ibid* p. 1), and she advocates a more integrated approach. Thus, she focuses on the structural level combined with the symbolic level. Robin Kay, psychologist, discussed how most of the research undertaken focuses on questions of ‘what’ instead of ‘why’ or ‘how’. He advocates a shift towards greater focus on process, encompassing for example complex interactions, social construction and context. In another contribution, Danielle Bernstein (computer scientist), discussed how students are best introduced to CS, in order for them to gain confidence. She argued for a new approach in the introductory course, using application software packages instead of procedural programming. This would give students immediate success in doing something useful, while still illustrating and reinforcing CS concepts. This is an example of an intervention at the structural level.

An example of interdisciplinary work is the research undertaken by Sherry Turkle (psychologist) and Seymour Papert (mathematician and pioneer within artificial intelligence) (Turkle and Papert 1990¹⁷). In studies of programmers they have identified two distinctly different styles: the ‘planning’ approach (rational, structured, controlled) and the ‘bricolage’ approach¹⁸ (concrete, negotiating). The ‘bricolage’ approach is related to closeness to the objects of work, while ‘planning’ is coupled

¹⁶ This has been given attention within the computer science community, for example in Frenkel 1990.

¹⁷ This paper has been reprinted as an appendix to *In search of gender free paradigms for computer science education*.

¹⁸ The term ‘bricolage’ is borrowed from Claude Levi-Strauss, who used the concept for the knowing within primitive societies, meaning “a science of the concrete”. Levi-Strauss, Claude (1968), *The savage mind*. Chicago: University of Chicago Press.

with keeping a distance. There is no difference in the quality of the product obtained using the different approaches; the difference lies in the process. They have found that most men are planners, while most women prefer the 'bricolage' approach. This is explained in terms of psychoanalytical theories, and I would argue that there is a tendency towards essentialism. These different approaches are seen as different attitudes towards knowledge, as different epistemological standpoints. Turkle and Papert argue for an "epistemological pluralism", and a "reevaluation of the concrete". The emerging object-oriented approach is seen as potentially revolutionary: "first, within the world of programming through legitimising alternative methods; second, in the larger intellectual culture, by supporting trends in cognitive theory that challenge the traditional canon"¹⁹.

There are some more recent examples of interesting interdisciplinary research in the UK, where a group of researchers from Glasgow and Strathclyde have done research on women in the UK software industry. They argue that the software development process needs examination and interpretation from a technical as well as an organisational perspective, but since these are interdependent there is also a need for collaborative analysis. They emphasise the strong need for interdisciplinary research, as research findings are more easily communicated into the CS community if computer scientists are part of the research group (Panteli et al 1997).

Another area of research and action concerns so-called 'gender inclusive teaching' within CS. This forms the basis of research undertaken by pedagogues and computer scientists (e.g. Nightingale et al 1997, Involve project 1997). Gender inclusive teaching targets teaching (and learning) practices in order to improve participation by women. It covers many aspects related to the individual, structural (especially pedagogical) and symbolic levels (e.g. classroom climate). A central goal is "to enable all students to feel ownership of, and competency in, the aims and outcomes of their courses" (Nightingale et al 1997). An important element is introducing awareness among teachers about gender issues and different learning styles.

New approaches?

I have chosen to discuss at some length one of the few recent examples of extensive interdisciplinary co-operation concerning the issue of women and CS. The reason for devoting so much space to this single project is that it has aroused a lot of attention among computer scientists and is often quoted as an excellent example. I will start by presenting the research, after which I will discuss some of the assumptions and potential limitations of the project.

At Carnegie-Mellon University (CMU) an interdisciplinary programme of research and action started in 1995, headed by computer scientist Allan Fisher and social scientist and expert in gender issues in education Jane Margolis. The programme is called: "Women in Computer Sciences: Closing the Gender Gap in Higher

¹⁹ No such epistemological changes, as an effect of object-orientation, have been observed yet. Compare also with the ideas expressed by Perry and Greber above, p. 55

Education” (Fisher, Margolis: project homepage). As motives for their project, they cite: “The under-representation of women among the creators of information technology has serious consequences, not only for those women whose potential goes unrealised, but also for a society increasingly shaped by that technology” (*Ibid*). Their aim has been “to understand male and female students’ engagement - attachment, persistence, and detachment - with computer science, with a special focus on the gender imbalance in the field” (*Ibid*). Their research question could be summarised as “do women approach the study of computer science differently from men?” (Margolis et al 1999). The goal of the action component has been to “devise and effect changes in curriculum, pedagogy and culture that will encourage the broadest possible participation in the computing²⁰ enterprise” (Fisher, Margolis: project homepage). Focus is mainly on the structural and symbolic levels, and to some extent also the individual (giving psychological explanations).

The field of computing, as represented by expectations, culture and curriculum, is very much oriented towards a narrow slice of males, while women approach it at a different pace and with different forms of attachment. Moreover, curriculum and culture do not acknowledge an interdisciplinary, contextual orientation toward CS (Margolis 2002). Students’ understanding (both intellectual and social) of the nature of the field is a key concept, but women often find the area too narrow, they feel they have to be too narrowly focused (Fisher et al 1997). This is connected to the effect of “boy wonders”, the perception that there is only one way (the male way) to come to computer science (Margolis et al 2000). When the world around the female students grants prestige to the “boy wonders,” any departure from this path becomes “lesser than” (Margolis et al 1999), leading to erosion of women’s confidence.

“The computer science culture assumes that men will succeed. [...] Hence it bolsters men’s confidence and sense of belonging. This same culture does not assume (often accurately) that women conform; hence they enjoy no default expectation of success, and their interests and attachments to computing may be regarded as deviant from the norm, and less serious than those of the male students” (Margolis et al 2000).

The aim of the group has been to broaden the culture and curriculum, to show that there are multiple ways to be a computer scientist and to be interested in the subject, and to demonstrate that valuable contributions to the field come from people with different sets of attachment to computers (Margolis et al 2000). Among examples of the changes that they have implemented in the curriculum are: different entry points in the first programming course, an “immigration course” to expose new students to a wide variety of CS issues and applications in order to counteract the “all programming” stereotype, and interdisciplinary courses. So far, the project has been a success, with an increase in female enrolment in the computer science programme from 7% in 1995 to 42% in 2000 (Fisher, Margolis: project homepage).

²⁰ The group uses both terms: computer science and computing, but they do not seem to differentiate explicitly between them, as a result of which I assume that they use them in the same sense that I have used them in this paper, i.e. as essentially synonymous.

I will now discuss and query a number of aspects of this project. What will happen in the long run with the female enrolment? Will it stay on a high level, or will it decrease again when the interventions are no longer new and some might even have been discontinued? Has the project really accomplished fundamental changes?²¹

Although I whole-heartedly support the aims of the group and I regard it as an excellent initiative to bring gender competence into computer science, I nevertheless identify some problems in the approaches and underlying assumptions. The first, and in my opinion most serious, criticism is that they do not pose any questions concerning the discipline of CS as such; thus, their attitude appears to be that they take the fundamentals of CS as given. As noted above, they explicitly concentrate on curriculum, pedagogy and culture. As I have argued above, this will lead to a limited understanding. The basic argument is: “Behind the commonplace observation that ‘women are not interested in computer science’ lies a complex of influences. While some people believe that it is the inherent nature of computing itself that turns women away, we have documented social and cultural expectations within the field that discourage girls and women” (Margolis et al 2000). I argue that by exclusively focusing on social and cultural factors, we limit ourselves and fail to see other deeply rooted influences (such as issues of knowledge).

A discussion of critical factors that change the attitudes of female students in favour of CS is presented in Margolis and Fisher 1997. This, along with the title of their new book: “Unlocking the clubhouse” (Margolis and Fisher 2002), can be seen as showing that to a certain extent they are trying to find ways to adapt women to fit into the existing discipline, without having to fundamentally reconsider CS and its paradigms, i.e. they have avoided the discipline level. Women should be given help to find the key to “the clubhouse”, but the club and its house are never questioned. Thus, I conclude that they are not ready to question the discipline per se; their underlying approach is more like those found in most of the work within the CS community discussed above – help women to adapt and succeed, and make some not-too-far-reaching changes to the curriculum and pedagogy.

As we have seen, this project devotes a great deal of attention to women’s perspectives. Such projects are important in that they result in new knowledge about women, making their experiences and knowledge visible. However, these projects can also have negative effects: for example, relating women and women’s experiences to men and their experiences strengthens the idea that men and their experiences and conditions are the norm. It can also lead to the categories men and women being oversimplified, meaning we end up in a dichotomic deadlock (Mörtberg 1999). The possible pitfalls of this approach are not discussed by the group at Carnegie-Mellon.

²¹ The long-term results of some major intervention programmes in Sweden have been somewhat depressing. When the computer engineering programme at one of Sweden’s largest universities was reformed, the number of women increased in the first few years, but then decreased again back to the same low level as before the interventions (Wistedt 2001).

In summary, what is positive about this project is that it is thorough and consistent; it is not just an isolated intervention, but rather a whole complex of research and action. As I pointed out above, I wonder what will happen now that the project is essentially finished (the project leaders have moved on to other projects). I also find that in this case the promising initiative of bringing gender expertise into CS has not led to any fundamentally new approaches. It seems that the project is situated in the equality approach, i.e. the ‘women into technology’ approach. This approach is in itself harmless for both computer science and computer scientists, as it does not challenge anything; on the other hand, it is not likely to expose any hidden problems either.

Strengths and weaknesses

The strength of interdisciplinary groups and meeting places lies in their ability to bring together researchers from several communities, allowing them to share and use each other’s knowledge and experience as resources, and thus possibly creating space for more radical approaches to change. Researchers from interdisciplinary groups are also well informed about work from different areas. There are however many difficult positions to be negotiated for these groups, including navigating the internal requirements from within the separate disciplines, as well as trying to bridge the many gaps that exist between disciplines²². In the best of cases, they manage to achieve this and can then open up ‘cracks’ in existing views and problem definitions. However, the problems of acceptance for a ‘foreign’ discipline within CS should not be underestimated and can necessitate compromises in order to be accepted and to be able to work towards transformation.

Gender Researchers within Computer Science

I will end this survey by mentioning a number of researchers who are themselves both computer scientists and gender researchers. We can see how these researchers approach the problem of female under-representation in new, often radical, ways arguing the need to discuss issues concerning the discipline itself and its knowledge processes. Many of them also discuss the importance of doing research from within computer science, since it is from within that transformation needs to be staged²³.

Several researchers point out that there is an increasing amount of relevant literature on gender and computing, but that most of it has been produced outside of the discipline:

“There is no shortage of literature that is in some way relevant to our construction and understanding of the “under-representation” of women in the computing profession. However,

²² See also the discussion on page 59, concerning the strengths and weaknesses of work done by social scientists.

²³ This focus from within does not mean that the work is not done by an interdisciplinary group of researchers!

little of the “knowledge” that has been produced in the course of researching this situation is of practical use for women working “inside” but seeking to effect change in computing.... [...] Most of this research is conducted from the “outside” using established theories to help interpret observations of attitudes and events “inside” (Moggridge 1998, p. 32).

Anne Moggridge further argues (Moggridge 1998, p. 35):

“in seeking to understand and change the “under-representation” of women in computing we should be less concerned with traditional theorising than with understanding, sharing and developing our own knowledge of technology and work, knowledge which is grounded in our experiences of both.”

Tone Bratteteig and Guri Verne have discussed what a feminist perspective could imply for computer science, and how it could be used as a resource for transformation (Bratteteig and Verne 1997). As an example, they discuss the idea of getting girls interested in computing through games, but they find it difficult and questionable to design alternative games for girls: “The question we are left with is whether we change anything or rather conserve status quo by implementing the conditions and characteristics of some present female culture” (*Ibid*, p. 67)²⁴. They also discuss the question of doing research from inside CS, arguing that the perspective on something differs according to whether it is seen from the inside or from the outside, and that a critique of the discipline requires knowledge about it.

Frances Grundy examines possible solutions to the problem of the lack of women in computing (Grundy 1996, 1997). She discusses what she sees as three levels of criticism and solution: “add-more-women”, the “liberal level” (qualitative changes to the environment, including teaching), and the “radical level”: “This is where we start looking for a really new science and encouraging a transformation not only of the way we do it, but also what it is that we do” (Grundy 1997, p. 9). She also offers an interesting view of role models. Contrary to most computer scientists, who emphasise the value of female faculty as role models, she argues that young women might see these women as bearers of traditional views of CS and society and as “reinforcing the idea that there is no room for questioning the basis on which the subject is founded” (*Ibid*, p. 7).

Ulrike Erb (Erb 1997) has studied the professional ways and experiences of female computer scientists within their discipline and concludes that many of these women feel there is a lack of needs-oriented and use-oriented questions and complain about the marginalisation of so-called “non-technical” skills. She discusses issues of what is excluded in CS, in terms of the missing accountability, the absence of subjectivity and the excluded views of the system users. She argues for changes and challenges to the discipline (*Ibid*, p. 207-208):

“Integration of the excluded and a corresponding change of the image and the paradigms of computer science could open up new identification possibilities for women in this discipline,

²⁴ Compare with Gorritz and Medina above, p. 52.

and it would also augment the possibilities for both women and men to realise their creative potentials in computer science.”

Christina Mörtberg (Mörtberg 2001) has carried out an interesting analysis of an all-women programme in computer science and computer engineering. She examined the assumptions implied in the diagnosis of the problem of the under-representation of women in the field, and whether these assumptions actually limit the possibilities for change. “Given the way the problem is represented to be, special types of solutions are reasonable. Consequently, the equality programmes create both the problem and the solution of the problem” (*Ibid*, p. 3). For example, the founders of the programme assumed that women would have special understandings and experience, but what these were was never made explicit. Moreover, women were treated as a homogeneous group. In the programme, the female students become constructed as ‘others’ compared to mainstream students. The female students are actors moving in certain circumstances and dealing with often contradictory discourses. By crossing boundaries, by being at the same time insiders and outsiders, these students can have an advantage in casting light on what is taken for granted within the discipline²⁵.

Within this group, we find approaches towards the discipline level. Researchers here point to the importance of focusing research on issues concerning the discipline itself. These questions lead right into the heart and core of CS paradigms and understandings. I regard this group as very promising, since they combine gender research with a position within the community of computer scientists. Their work can be seen as challenging the canon surrounding the “gender question” in CS. However, gender research within computer science faces a particular problem: is it possible both to do gender research and to maintain the legitimacy as a computer scientist? “Movements towards doing feminist research might weaken our contact with and ability to do technological research” (Bratteteig and Verne 1997 p. 70).

Discussion

Against the backdrop of this survey of what has been said and done concerning the low number of women in CS, I want now to discuss, perhaps in a somewhat provocative way, how the issue might be seen by an (imaginary) computer scientist. These reflections build on my own experience.

How might a member of the community of computer scientists (most probably but not necessarily a man) regard the problems of recruiting women into the discipline? I am aware that the views expressed below are by no means representative for all computer scientists, but I want to bring matters to a head, in order to demonstrate how attitudes and values become mixed with alleged ‘scientific’ approaches. Our ‘ordinary’ computer scientist (I will say ‘he’ below, which is the most likely sex since about 90% of computer scientists are men) might ask why the efforts (by efforts I

²⁵ Compare with the work by Stepulevage and Plumeridge discussed above, p. 58

mean those that have been undertaken within CS, mainly targeting the individual level) to attract women to the discipline have proved unsuccessful? Maybe he might even feel a little disappointed with women? In the end, perhaps he claims that the only conclusion we can draw is that most women are obviously not interested in or fit to do CS. Something must be wrong with women, but whatever it is, it seems that we are unable to fix it. Even if our computer scientist does not draw quite such a drastic conclusion, he is trained to solve problems, by delimiting a problem, making it as simple as possible, and then applying the simplest solution. This approach does not work here, and this leads to confusion.

The kind of explanation that our imaginary computer scientist gives obviously blames women, making them the problem. By taking this standpoint, CS is, has always been and is likely to continue to be, a male arena (unless, of course, women change!). The explanation chosen by our computer scientist is a comfortable, easy and simplistic one. By adopting this standpoint, there is absolutely no need to critically scrutinise the discipline and its practices, and the community can carry on reproducing not only the internal culture, but also the discipline as such.

My next question is: how come the explanation that our computer scientist gives even exists at all? The methods and ideas that all these failed efforts build on are seen as 'correct' ways of approaching the problem, but how can that be claimed? Within an area where scientific (preferably mathematical) proof is considered as the only real 'truth', how come it is so easy to jump to conclusions without asking for 'proof'? How can there be such reliance on methods and ideas that are not built on so-called 'scientific facts', but on attitudes, images and values?

This phenomenon, i.e. mistaking ideas, values, prejudices, and even feelings for knowledge and competence, is very common when gender issues are on the agenda. Anna Wahl, a gender researcher within the area of organisational and leadership theory, has created a model called "the cloud" to describe this phenomenon. "The cloud" represents all the preconceived notions that people have in connection with the word 'feminism' or gender research issues (Wahl 1996). I believe this mixture of 'science' and cultural ideas and values has a lot to do with epistemology – the concept of what counts as knowledge and who can possess knowledge.

Concluding Remarks

As I stated in the introduction, the way a problem is defined affects the solutions suggested, and becomes a limiting factor on the potentials for change.

This is clearly seen in some of the works discussed in this paper. If the problem is defined in terms of arguments such as: women have less experience with computers, women lack self-confidence, women have too few role models, then the approaches are rather straightforward: give women experience with computers, strengthen their self-confidence, provide role models. What happens then when the expected effect of the action fails to appear? Do we return to the definition of the problem or do we

react in the same way as our imaginary computer scientist in the discussion above? Moreover, as I have discussed above, what implications do the problem definitions have? At least the first two definitions above directly imply that something is wrong with women, i.e. women are compared to an existing 'male' norm of success, albeit most often implicitly.

My discussion above refers mostly to the individual level, but what about the problem definitions that exist on the structural and symbolic levels? It is likely an oversimplification to believe that changes in teaching and pedagogy can be the whole solution; they may well be necessary but they are unlikely to be sufficient. One part of the problem may certainly be that the under-representation of women depends on the social construction of computing. However, the risk is that this research stops at the level of explanation, instead of promoting change, and also that many other factors contributing to the problem might be overlooked.

The discipline level has so far not been the focus of much research or discussion. How the paradigms and knowledge processes within CS are formed, mediated and mirrored, e.g. in education, is a large, but so far mostly overlooked, part of the complex problem of low female participation in CS. Till now, the group that has approached this more radical level of change is gender researchers within CS. However, during the last years voices have been raised, both within the community of computer scientists, and among social scientists, calling for research focusing the discipline of CS.

I believe in the need for looking critically at the discipline of CS. Thus, I argue for research focusing on CS and its paradigmatic basis. We have to "ask what is wrong with computing rather than what is wrong with women" (Clegg and Trayhurn 1999).

References

- Adam, Alison, 1995: "Women and Computing in the UK". In *Communications of the ACM*, Vol 38, no 1.
- Bacchi, Carol Lee, 1999: *Women, Policy and Politics, the construction of policy problems*. Sage Publications.
- Bernstein, Danielle R. 1997: "Computing, Diversity and Community: fostering the computing culture". In *Proc. of the 28th SIGCSE Technical Symposium on Computer Science Education*, San Jose, California.
- Björkman, Christina, 2000: *Projekt Q+ - med och för kvinnliga studenter i datavetenskap*. Arbetsrapport 6, Development and Evaluation unit, Uppsala university.
- Björkman, Christina, 2001: "A Project for First-year Female Students of Computer Science". Paper presented at GASAT 10 Conference, Copenhagen, July 2001.
- Borg, Anita, 2001: "Universal Literacy – A Challenge for Computing in the 21st Century". In *Communications of the ACM*, Vol 44, No 3.
- Brandell, Gerd, Carlsson, Svante, Ekblom, Håkan, Nord, Ann-Charlotte, 1998: *Encouraging more Women into Computer Science: Initiating a Single-Sex Intervention Program in Sweden*. Dept. of mathematics, Luleå University of Technology.
- Bratteteig, Tone, Verne, Guri, 1997: "Feminist or merely critical?". In Moser, Aas (eds) *Technology and Democracy: Gender, Technology and Politics in transition?*. Centre for Technology and Culture, University of Oslo.
- Camp, Tracy, 1997: "The Incredible Shrinking Pipeline". In *Communications of the ACM*, Vol 40, No 10.
- Camp, Tracy, 1998: "Survey says! Results on the incredible shrinking pipeline". www.mines.edu/fs_home/tcamp/results/paper.htm (Read 2001-10-10).
- Childress Townsend, Gloria, 1996: "Viewing Video-Taped Role Models Improves Female Attitudes Toward Computer Science". In *Proc. of the 27th SIGCSE Technical Symposium on Computer Science Education*, Philadelphia.
- Clegg, Sue, 2001: "Theorising the Machine: gender, education and computing". In *Gender and Education* vol 13 no 3.
- Clegg, Sue, Trayhurn, Deborah, 1999: "Gender and Computing: not the same old problem". In *British Educational Research Journal*, Vol 26, no 1.
- Erb, Ulrike, 1997: "Exploring the Excluded. A Feminist Approach to Opening New Perspectives in Computer Science". In *Spinning a web from past to future*. Proceedings of the 6th International IFIP [TC9/WG9.1] Women, work and computerization Conference Bonn, Germany, p. 201-207.

- Fisher, Alan, Margolis Jane, Miller, Faye, 1997: "Undergraduate Women in computer science: Experience, Motivation, Culture". In *Proc. of the 28th SIGCSE Technical Symposium on Computer Science Education*, San Jose.
- Fisher, Alan, Margolis, Jane: project homepage:
<http://www.cs.cmu.edu/afs/cs.cmu.edu/project/gendergap/www> (Read 2002-03-20).
- Frenkel, Karen, 1990: "Women and Computing". In *Communications of the ACM*, vol 33 no 11.
- Gorritz, Cecilia, Medina, Claudia, 2000: "Engaging Girls with Computers through Software Games", In *Communications of the ACM*, vol 43, no 1.
- McGrathCohon, Joanne, 1999: "Departmental differences can point the way to improving retention in Computer Science". In *Proc. of the 30th SIGCSE Technical Symposium on Computer Science Education*, New Orleans.
- McGrath Cohoon, Joanne, 2001: "Toward Improving Female Retention in the Computer Science Major". In *Communications of the ACM*, vol 44, no 5.
- Grundy, Frances, 1996: *Women and Computers*. Intellect Books.
- Grundy, Frances, 1997: "Where Do We Go From Here?" In Lander and Adam (eds) *Women in Computing*, Intellect Books.
- Haliburton, William, Thweatt, Mack, Wahl, Nancy, 1998: "Gender Differences in Personality Components of Computer Science Students: A Test of Holland's Congruence Hypothesis". In *Proc. of the 29th SIGCSE Technical Symposium on Computer Science Education*, Atlanta, Georgia.
- Haller, S M, Fossum, T V, 1998: "Retaining Women in CS with Accessible Role Models". In *Proc. of the 29th SIGCSE Technical Symposium on Computer Science Education*, Atlanta, Georgia.
- Harding, Sandra, 1986: *The Science Question in Feminism*, Cornell University Press.
- von Hellens, Liisa, Nielsen, Sue, 2001: "Australian Women in IT". In *Communications of the ACM*, vol 44, no 7.
- Hemenway, Kathleen, 1995: "Human Nature and the Glass Ceiling in Industry". In *Communications of the ACM* Vol 38 No 1.
- Henwood, Flis, 1993: "Establishing Gender Perspectives on Information Technology: Problems, Issues and Opportunities". In Green, Owen, Pain (eds) *Gendered by Design*, Taylor and Francis.
- Henwood, Flis, Plumeridge, Sarah, Stepulevage, Linda, 2000: "A tale of tow cultures? Gender and inequality in computing education". In Wyatt, Henwood, Miller, Senker (eds), *Technology and In/Equality, Questioning the information society*, Routledge.

- Håpnes, Tove, Rasmussen, Bente, 1991: "The Production of Male Power in Computer Science". In Eriksson, I.V.; Kitchenham, B.A.; Tijdens, K.G. (eds) *Women, Work and Computerisation*, Elsevier Science Publishers B. V., North Holland.
- Håpnes, Tove, Sörensen, Knut, 1995: "Competition and Collaboration in Male Shaping of Computing: A Study of a Norwegian Hacker Culture". In Grint, Gill (eds), *The Gender-Technology Relation, Contemporary theory and Research*, Taylor and Francis.
- Involve Project, 1997: *Guidelines for Good Practice in Inclusive Teaching: a practical approach to improving Women's Participation In Computer Science*. Computer Science Division, School of Mathematical and Computational Sciences, University of St Andrews, UK.
- Jansson, Peter, 1998: *D++-projektet. Förnyelse av datateknikutbildningen för jämställdhet och kvalitet*. Chalmers Institute of Technology.
- Klawe, Maria, 2001: "Refreshing the nerds". In *Communications of the ACM*, vol 44, no 7, p. 67-68.
- Klawe, Maria, Leveson, Nancy, 1995: "Women in Computing: where are we now?". In *Communications of the ACM*, Vol 38 No 1.
- Kramer, Pamela, Lehman, Sheila, 1990: "Mismeasuring women: A critique of research on computer ability and avoidance". In *Signs: Journal of Women in Culture and Society*, vol 16, no 1.
- Lewis, Sue, 2000: "Masculinity and IT: computing gender in the IT industry" www.swin.edu.au/corporate/ncgcd/newslett/keyarticles.html (Read 2002-05-11).
- Margolis, Jane, Fisher, Allan, 1997: "Geek Mythology and Attracting Undergraduate Women to Computer Science". In *Impacting Change Through Collaboration*, proceedings of the Joint National Conference of the Women in Engineering Program Administrators. Also at <http://www.cs.cmu.edu/afs/cs.cmu.edu/project/gendergap/www> (Read 2002-03-20).
- Margolis, Jane, Fisher, Alan, Miller, Faye, 1999: "Caring About Connections: Gender and Computing". In *IEEE Technology and Society Magazine*, vol 18 no 4. Also at <http://www.cs.cmu.edu/afs/cs.cmu.edu/project/gendergap/www> (Read 2002-03-20).
- Margolis, Jane, Fisher, Allan, Miller, Faye, 2000: "The Anatomy of Interest: Women in Undergraduate Computer Science". In *Women's Studies Quarterly*, Spring/Summer 2000. Also at <http://www.cs.cmu.edu/afs/cs.cmu.edu/project/gendergap/www> (Read 2002-03-20).
- Margolis, Jane, Fisher, Allan, 2002: *Unlocking the clubhouse* MIT Press.
- Margolis, Jane, 2002: Interview in CNET News.com. <http://news.com.com/2008-1082-833090.html> (Read 2002-05-11).

- Martin, Dianne, Murchie-Beyma, Eric.(eds), 1992: *In Search of Gender-free Paradigms for Computer Science Education* , ISTE, Eugene Oregon.
- Moggridge, Anne, 1998: "Women in Computing: Inside Knowledge". In *AISB Quarterly*, issue 100, p. 32-36.
- Mörtberg, Christina, 1999: "Technoscientific challenges in feminism". In *NORA (Nordic Journal of Women's Studies)* Volume 7, Issue 1.
- Mörtberg, Christina, 2001: "An all-women programme in computer science and engineering: whose success?" Submitted for publication.
- Nightingale, Wendy, Halkett, Andrew, Hammond, Kevin, Mason, Colin, Wilson, Fiona, 1997: "Involve: Inclusive Teaching in First-Year Computer Science Courses". In Lander and Adam (eds) *Women in Computing*, Intellect Books.
- Nissen, Jörgen, 1993: *Pojkarna vid datorn, unga entusiaster i datateknikens värld.* Symposion Graduale, Stockholm/Stehag.
- Nissen, Jörgen, 1996: "Det är klart att det är grabbar som håller på med datorer, men varför är det så?" In Berner (ed), *Från ymaskin till cyborg*, Nerenius and Santérus förlag.
- De Palma, Paul, 2001: "Why Women Avoid Computer Science". In *Communications of the ACM*, Vol 44 no 6.
- Panteli, Androniki, Stack, Janet, Atkinson, Malcolm, Ramsay, Harvie, 1997: "Women in the UK Software Industry – How Much do we Know?" In Lander and Adam (eds) *Women in Computing*, Intellect Books 1997.
- Pearl, Amy, Pollack, Martha, Riskin, Eve, Thomas, Becky, Wolf, Elizabeth, Wu, Alice, 1990: "Becoming a Computer Scientist". In *Communications of the ACM*, vol 33 no 11.
- Pearl, Amy, 1995: "Women in Computing". In *Communications of the ACM*, Vol 38, no 1.
- Perry, Ruth, Greber, Lisa, 1990: "Women and Computers: an Introduction". In *Signs: Journal of Women in Culture and Society*, vol 16, no 1.
- Pfleeger, Sheri, 1990: "President's letter". In *Communications of the ACM*, vol 33 no 11.
- Rasmussen, Bente, Håpnes, Tove, 1991: "Excluding women from the technologies of the future?". In *Futures*.
- Rodger, Susan, Walker, Ellen, 1996: "Activities to Attract High School Girls to Computer Science". In *Proc. of the 27th SIGCSE Technical Symposium on Computer Science Education*, Philadelphia.
- Salminen-Karlsson, Minna, 1999: *Bringing Women into Computer Engineering. Curriculum Reform Processes at Two Institutes of Technology*. PhD Thesis, Dept of Education and Psychology, University of Linköping.

- Sackrowitz, Marian G, Parker Parelius, Ann, 1996: "An Unlevel Playing Field: Women in the Introductory Computer Science Courses. In *Proc. of the 27th SIGCSE Technical Symposium on Computer Science Education*, Philadelphia.
- Sanders, Jo, 1995: "Girls and Technology: Villain Wanted", In Rosser (ed) *Teaching the Majority*, Teachers College Press.
- Scragg, Greg, Smith, Jesse, 1998: "A Study of Barriers to Women in Undergraduate Computer Science". In *Proc. of the 29th SIGCSE Technical Symposium on Computer Science Education*, Atlanta, Georgia.
- Selby, Linda, Ryba, Ken, Young, Alison, 1998: "Women in Computing: What Does the Data show?" In *SIGCSE Bulletin*, Vol 30, no 4.
- Siann, Gerda, 1997: "We Can, We Don't Want to: Factors Influencing Women's Participation in Computing". In Lander and Adam (eds) *Women in Computing*, Intellect Books.
- Spertus, Ellen, 1991: *Why Are There So Few Female Computer Scientists?* MIT Artificial Intelligence Laboratory Technical Report.
- Stepulevage. Linda, Plumeridge, Sarah, 1998: "Women Taking Positions Within Computer Science". In *Gender and Education* vol 10 no 3.
- Stack, Janet, 1997: "Women into Computing". In Lander and Adam (eds) *Women in Computing*, Intellect Books.
- Trojer, Lena, 1999: *Kompetens för ledarskap inom forskningsorganisationer – en kvinnlig forskarskola för förändring vid teknisk fakultet*. Luleå University of Technology.
- Turkle, Sherry, 1984: *The Second Self: Computers and the Human Spirit*. London: Granada.
- Turkle, Sherry, Papert, Seymour, 1990: "Epistemological Pluralism: Styles and Voices Within the Computer Culture". In *Signs: Journal of Women in Culture and Society*, vol 16 no 11.
- Wajcman, Judy, 1991: *Feminism confronts technology*. Polity Press.
- Wahl, Anna 1996: "MOLNET – att föreläsa om feministisk forskning". In *Kvinnovetenskaplig tidskrift* nr 3-4 1996.
- Verne, Guri, 1988: "Rekruttering for enhver pris? Problemstillinger ved rekruttering av flere kvinner til informatikkfaget". In *Rekruttering av kvinner til forskning innen informasjonsteknologi og informatikk*. Arbeidsnotat 1/88, NAFS sekretariat for kvinneforskning, Oslo.
- Wilson, Fiona, 1997: "Computing, Computer Science and Computer Scientists: How they are Perceived". In Lander and Adam (eds) *Women in Computing*, Intellect Books.

Wistedt, Inger (ed), 2000: *Datateknisk ingång för kvinnor, en utvärdering*. Teknisk rapport nr 2000:15, Luleå University of Technology.

Wistedt, Inger, 2001: *Five Gender-Inclusive Projects Revisited*. National Agency for Higher Education.

Wright, Rosemary, 1997: "Women in Computing: A Cross-National Analysis". In Lander and Adam (eds) *Women in Computing*, Intellect Books.

Paper IV

This article is a revised and extended version of the article “Computer Science and its Paradigmatic Basis – Using Gender Research from Within to Transform Education”, presented at GASAT 10 Conference, Copenhagen, July 2001.

Computer Science and its Paradigmatic Basis – Broadening Understandings through Gender Research from Within

Christina Björkman and Lena Trojer

Introduction

*“From its inception just half a century ago, computing has become the defining technology of our age.”*¹

Computer science (CS)², as one of the core disciplines within the broad area of information technology, has become one of today’s most important disciplines by virtue of its influence on the shaping of technology and thus also society. There is little technical research, development and production done today that does not, in one way or another, involve results from (mostly in the form of applications of) CS. Computer science thus strongly influences the direction and content of technical research and development. It is reasonable to assume that this influence of CS on the current and future developments of technology will continue to grow, and that the discipline will continue to be located at the centre of information technology. This centrality means that what happens within CS will have effects that reach far beyond the discipline as such, having consequences for the whole of society. Thus, CS as a field of knowledge and technology holds a dominant position, and because of this dominant position, there is a need for CS to be a broader, multifaceted discipline with many angles of approach. By this we mean a broader understanding of the core of the discipline, rather than including more areas in CS.

Equally important as a broadly defined discipline is the issue of broad representation of developers of knowledge and technology within CS. We wish to explore the connections between these two issues. A broader understanding is likely to result in a more diverse representation of people being attracted to the field. However, this is

¹ACM and IEEE-CS Computing Curricula 2001, Computer Science Volume, chapter 3. The report can be found at <http://www.acm.org/sigcse/cc2001/>. ACM (Association of Computing Machinery) and IEEE-CS (Computer Society of the Institute for Electrical and Electronic Engineers) are probably the largest international professional organisations within CS. These organisations regularly appoint committees to oversee recommendations for curricula within computer science.

² We use the term ‘computer science’ (CS) in a broad sense, including software engineering and all relevant parts of computer engineering. For a comment on the usage of ‘computing’ and ‘computer science’, see the section ‘Computer Science and its Paradigmatic Basis’.

not the case today. It is well known that CS has a low percentage of women, even when compared to most other technically oriented disciplines. The under-representation of women in CS is becoming increasingly serious in a society more and more dependent on research and technical development. The reason(s) why CS is so male-dominated and what can be done to remedy the situation have been the focus of much research and concern, and many different approaches and actions have been tried³. It has been recognised that women in CS face obstacles on different levels: the individual level (for example they often have much less experience with computers and programming than their male peers when they enter the academic education system); the structural level (in the form of the structure, curricula and pedagogy of the education programmes); and symbolic (the obviously and strongly male-dominated culture within the field as well as prevailing images of men, women and what it is to be a computer scientist). Traditionally, most initiatives taken to increase the number of women in CS started by focusing on issues of information and the individual level. However, there is now increasing interest in and focus on questions regarding the structure and content of education as well as social and cultural issues surrounding CS. What seems to be lacking in many of these discussions, however, is deliberation of the 'nature' of the discipline itself. So far, most efforts have not led to a stable increase in the participation of women within core areas of CS⁴. This fact, together with our own experiences of working with female students of CS (Björkman 2000, 2001), has led us to conclude that the problem is more complex. Apart from the issues mentioned above, it also includes issues concerning computer science itself and its knowledge processes. These conclusions are supported by other researchers, who have underlined the importance of focusing research on issues related to the discipline itself (see the section 'Gender Research within Computer Science', p. 84 below). Thus, the question of the under-representation of women within the discipline takes us right into the very heart and core of CS paradigms and understandings. How these are formed, mediated and mirrored, e.g. in education, is a large, but so far mostly overlooked, part of the complex problem of low female participation in CS.

We claim that the under-representation of women is one indication that the understanding of CS and the basis for recruitment into the discipline are too narrow. It is likely that this means that many men too choose not to go into CS, for the same reasons. There is a need to get rid of the 'nerd' image, which is a very prevailing image of the 'pure' computer scientist, and which is known to cause many talented students, both male and female, to choose more application and socially oriented subjects (or other disciplines that they find broader and thus more interesting) instead of choosing core CS. This demand for change is gaining recognition within the community of computer scientists. Maria Klawe, President of the ACM, expresses this (Klawe 2001 p. 67-68):

³ For an extensive discussion on women and CS, see Björkman 2002.

⁴ Within Sweden, several initiatives to recruit women into CS are evaluated in Wistedt (2001).

“The point here is that computer science also needs to attract students with broader interests and abilities than the traditional computer scientists—nerds.[...] But nerds are not enough. We need more computer scientists whose passions are art, language, literature, education, entertainment, psychology, biology, music, history, or political science. We need them because computers have an impact on all areas in our world. We need people with passion and vision from every area to drive the development of computer technology as well as the applications. [...] We need non-nerds in computer science, so let’s figure out the proper approaches to integrate their talents and perspectives into our field.”

There is thus a growing need to broaden the understanding of knowledge production and research processes within computer science, for two reasons:

- The under-representation (indeed, near absence) of women in the area of CS is becoming an increasingly serious problem in a society more and more dependent on research and technical development
- The influence of CS on the current and future development of technology is escalating.

These issues are interrelated and are both of vital importance in the development of computer science.

In this paper, we argue the need for research that examines the fundamental knowledge grounds and epistemology of computer science. We discuss how gender research from within CS enables us to develop broader and more complex understandings and interpretations of CS. We strongly believe that this is important for the development of CS and its practices, especially education, and will give possibilities to obtain a sustainable increase in women’s participation in the discipline.

Computer Science and its Paradigmatic Basis

What is computer science? What constitutes the ‘core’ of the discipline? Is CS a mixture of other disciplines or does it have its own unique core? What fundamental paradigms guide knowledge production within the discipline?

CS is fairly young as a discipline in its own right and is still being formed and the subject of many discussions regarding its core character and content. The boundaries of CS are constantly debated: what is to be considered to be within the discipline and what is to be considered to be outside (but connected to) it, for example where does software engineering belong? The paradigmatic basis for computer science, on which all education and research, as well as development of applications, are based, is fundamental for the production of knowledge. However, this basis has not been subject to much reflection or research.

One dilemma we face is related to the terminology. The term ‘computing’ is often used in a more inclusive sense than computer science. Some researchers use the term computing to mean (more or less) the whole field of IT, some use it to disconnect

the discipline from the physical computer (Dijkstra, see McGuffee 2000), and others use it to mean “all of computer science and computer engineering” (Denning et al 1989 p.10). In the works referred to below, we have taken pains to identify what the authors mean when they use the word ‘computing’, and unless otherwise stated, it can be understood as synonymous to our use of the term ‘computer science’ in all relevant matters⁵.

One of the most well-known contributions and attempts to define computing was made in 1989 by the ACM Task Force on the Core of Computer Science (Denning et al 1989). They identify three major paradigms or “cultural styles”: theory, rooted in mathematics; abstraction (modelling), rooted in the experimental scientific method; and design, rooted in engineering. These processes are seen as closely intertwined; they cannot be separated but they are nevertheless distinct, since they each represent different competences. Thus, the task force concludes: “Computing sits at the crossroads among the central processes of applied mathematics, science and engineering” (Denning et al 1989 p.11). A short definition of computing is given as:

“The discipline of computing is the systematic study of algorithmic processes that describe and transform information: their theory, analysis, design, efficiency, implementation and application. The fundamental question underlying all of computing is, “What can be (efficiently) automated?”” (Ibid p. 12).

In this definition, the notion of ‘algorithm’ is seen as a central concept in CS.

The algorithmic side of computer science is emphasized by Judith Gal-Ezer and David Harel in their discussion “What is CS” (Gal-Ezer and Harel 1998 p. 78):

“The point is that CS is not only the scientific basis of a major technological revolution, but has at its heart a special and powerful way of thinking—algorithmically—which is required in dealing with the ever-complex modern world, and which is becoming crucial in many other scientific and engineering disciplines, too.”

So then, what does an algorithmic definition of CS entail for the understanding of knowledge within the discipline? Abelson and Sussman directly address this (Abelson and Sussman 1985⁶, quoted in Denning et al. 1989 p.11-12):

“The computer revolution is a revolution in the way we think and in the way we express what we think. The essence of this change is the emergence of what might best be called procedural epistemology – the study of the structure of knowledge from an imperative point of view, as opposed to the more declarative point of view taken by classical mathematical subjects. Mathematics provides a framework for dealing precisely with notions of ‘what is’. Computation⁷ provides a framework for dealing precisely with notions of ‘how to’”.

⁵ We use CS to emphasise the discipline aspect, an aspect that is not always clear from the word ‘computing’, and at the same time argue for a broadened understanding of the discipline of CS.

⁶ Abelson, Sussman, 1985: Structure and interpretations of computer programs. MIT Press.

⁷ ‘Computation’ in this quote should be understood in the same sense as ‘computing’.

What are the implications of this “procedural epistemology” for knowing within the discipline?

Judith Gal-Ezer and David Harel recognise two sides of CS: the algorithmic side and the systems side, and claim that “CS itself is an unusually dichotomic subject – one facet is more mathematical and the other is a type of engineering” (Gal-Ezer and Harel 1998 p. 79). They argue that there are also dichotomies within these facets: mathematics encompasses computability, complexity and logic on the one hand as well as numerical analysis on the other, while engineering encompasses the design and construction of hardware as well as the development of software.

So, what are the implications of a discipline based on inherent dichotomies, and what tensions, useful as well as restrictive, exist because of this dichotomic nature? Can we deconstruct and go beyond these dichotomies, and if so, what would that entail for the discipline?

One side of the dichotomy discussed above refers to mathematics. Abelson and Sussman bring up issues of knowledge in connection to the discussion of mathematics vs. computing (see above). The role of mathematics in and for computer science is a cause of much dissent within the community of computer scientists. A fairly strong and influential group within CS defines the discipline as closely related to mathematics. In a famous paper from 1989: “On the cruelty of really teaching computing science”, Edsger Dijkstra claims that “computing science is - and will always be - concerned with the interplay between mechanized and human symbol manipulation usually referred to as ‘computing’ and ‘programming’, respectively” (Dijkstra 1989 p. 1401), and that computing should be localised in “the direction of formal mathematics and applied logic” (*Ibid* p. 1402). He even goes so far so as to propose that computing science be called ‘VLSAL’ (Very Large Scale Application of Logic) (*Ibid* p. 1402). The discussion about mathematics is far more complex than a mere discipline issue; to a large extent it is also about power, about ‘who is best/right’, and about what counts as ‘superior’ knowledge⁸.

Many other definitions of CS have been suggested too, some quite simple: “computer science is the study of computers” (Newell, Perlis and Simon⁹ quoted in McGuffee 2000 p. 74), or the Computing Sciences Accreditation Board: CS is “a discipline that involves the understanding and design of computers and computational processes” (McGuffee 2000 p.74).

Another interesting question is whether any recent changes can be seen in the view of computer science. In the ACM Computing Curricula 2001, the Computer Science Volume (ACM CC2001), the rapid evolution of the discipline is discussed. There is

⁸ The issues of knowledge and the role of mathematics are treated by gender researchers in CS, see below.

⁹ Newell, Perlis, Simon: “What is Computer Science?”, *Science*, No 157 (1967), 1373-1374.

no attempt to define CS in this document¹⁰, since the report is focused on curricula for CS education, but the report observes that technology has undergone radical changes during the last decade, not the least with the development of networking and the WWW. It also recognises that cultural factors affect computer science and CS education. What this report calls computing¹¹ has become broader, encompassing more areas. However, this is not the same thing as we argued for in the introduction above: the need for a broad understanding of the core of the discipline of computer science. The acceptance and inclusion of more areas does not necessarily entail a fundamental change in the core.

One of the central changes that can be seen in CC2001 is the inclusion of professional practice as an integral component in the CS curricula. Where the 1989 report identified three paradigms, this could now be seen as expanded: “All computer science students must learn to integrate theory and *practice*, to recognize the importance of abstraction, and to appreciate the value of good engineering design” (ACM CC2001, chapter 4, our italics). However, whether the integration of practice in the curricula should be interpreted as a change in the view of the discipline is not clear, and many computer scientists are likely to argue that practice might be part of the profession, but it is not part of the discipline. What would it mean if practice were actually regarded as part of the discipline? Such a change could be fundamental, if it were really incorporated into the core of the discipline.

Computer scientist Peter Denning is one of the prime movers in the ongoing discussion of “the profession of IT” and the related topic of practice within computing¹². He argues for accepting the importance of professional practice: “Practices are as important a part of knowledge as discourses, mental models, conceptual frameworks, processes and rules” (Denning 1999 p. 2). He claims that “applications domains are the front lines of the profession” (*Ibid* p. 2) and that “Value skills connect a professional’s technical performance with the customer” (Denning and Dunham 2001, p. 24). He regards computing as the discipline and IT as the profession, and he claims that there is currently a gap between the two. Computing is no longer the driving force, controlling the field, and he advocates that it should cross the chasm and seek leadership within the new profession, by for example accommodating “embodied professional knowledge” (Denning 2001, p. 24). A similar argument is made by Steve Cunningham: “Any computing education that does not pay attention to the user’s role in computing is missing the most vibrant and exciting part of computing today” (Cunningham 1998, p. 4a).

¹⁰ In chapter 4 of the report, the committee lists what they see as the areas encompassing the body of knowledge within CS. This list includes for example Software Engineering, Human–Computer Interaction and Information Management.

¹¹ The computing curricula 2001 also includes information systems in what they term computing, an area that we do not include when we talk about computer science.

¹² Peter Denning uses the term ‘computing’ in the same sense as defined on page 80, i. e. as equivalent to our use of CS.

Another noteworthy point in CC2001 concerns what the committee regards as important for a curriculum, in the sentence: “Development of a computer science curriculum must be sensitive to changes in technology, new developments in pedagogy, and the importance of lifelong learning” (ACM CC2001, chapter four). This puts the focus on technology and knowledge, but no reference is made to society or issues such as sustainability etc.

A discipline does not exist on its own; it is defined and held together by its practitioners. Computer science and computer scientists are constructing, and are constructed by, each other in a mutual and constantly ongoing process. What then is a computer scientist? How is a computer scientist ‘created’? How do computer scientists understand CS, what ideas and concepts do they find central to the discipline, how do they understand and create knowledge and images of concepts, and how do they do research? How is CS ‘thought’ and ‘talked’?

James McGuffee (McGuffee 2000) argues that a good alternative to defining CS is to describe what a computer scientist does. He quotes Dirk Siefkes: “As computer scientists we discuss problems, describe solutions, design and use computers and formalisms” (Siefkes 1997¹³, quoted in McGuffee p.76). But how broadly accepted is this definition within the community? There is a tendency to discuss CS as something separate from computer scientists, existing on its own. This becomes especially clear when we look at the issues of women and computer science, where focus is almost always and solely on the first word: women, and the discipline itself is usually taken for granted as something given (Björkman 2002). From this kind of perspective, adaptation comes solely from the side of the (prospective) computer scientist, and the mutually constructed character of the relationship is obscured.

We introduced this section by asking what fundamental paradigms exist within CS. Above, we have acknowledged the notion of algorithm and the mathematical foundations as paradigms of this nature. As another example of a fundamental paradigm within CS, we can consider the digital nature of computers. In simplified terms, modern computers can be regarded as based on discrete mathematics, algebra and logic. As a complement or alternative to these, could we have had computers based on continuous mathematics, if research and development had taken a different path? Apart from the technological problems with such solutions (there have been attempts to develop different models for construction of computers, for example analogue machines for solving differential equations), is there not perhaps also subconscious resistance to the idea, simply because we are so used to the systems we have? Is this not a prime example of technological inertia?

As it is now, the word ‘digital’ has come to represent much more than merely the digital logic used in computers; for example, it is frequently used to represent virtuality or simply the fact that something is computer-based. In that sense, ‘digital’ is no longer used as the opposite of ‘analogue’, and thus that dichotomy has been

¹³ Siefkes, Dirk, 1997: “Computer Science as Cultural Development: Toward a Broader Theory”, in *Foundations of Computer Science: Potential-Theory-Cognition*, Springer.

blurred. This is an example of the effect of a paradigm reaching far beyond the technology itself, getting adopted and changing meaning in unexpected areas and ways.

What other fundamental paradigms exist within CS, and are some of them hidden? What effects do the paradigms have both inside and outside the immediate core of CS (as in the example of ‘digital’ above)?

What constitutes the core and the fundamental paradigms of a discipline can always be the focus of study, it can be debated and perhaps reformulated, broadened and changed, since production of knowledge and our understanding of it are ongoing processes. We need to consider the possibility of creating new, additional views of the core of CS, that in turn can render new approaches to the discipline.

In our opinion, one of the most central concepts in CS is that of programming and its paradigms¹⁴. This concept is one of the first things that students learn. How has the knowledge foundation in programming (theories, methodologies, methods and languages) evolved? What constitutes the fundamental knowledge base, and what assumptions and choices have been made during the course of time? Is there support for different styles of approaching programming (see for example Turkle 1984, Turkle and Papert 1990), and what would be the implications of that? Does object-orientation in any substantive way constitute a paradigm shift in the sense defined by Thomas Kuhn (Kuhn 1970)? Or is it just a minor change in methodology, neatly incorporated into existing paradigms? And if it is a new paradigm, what would that mean for the discipline and its practices? For example, Abelson and Sussman (p. 80 above) talked about the “procedural epistemology” within CS. Does object-orientation have an effect on this? Sherry Turkle and Seymour Papert argue that a shift towards object-orientation might potentially mean a shift in thinking and the legitimising of alternative methods of programming (what they term ‘bricolage’ as contrasting with the commonly taught ‘planning’ approach, Turkle and Papert 1990).

These are some of the questions that we believe it is important to ask and to pursue in research.

Gender Research¹⁵ within Technical Science

When trying to find strategies for dealing with questions concerning CS and its paradigmatic basis, we turn our attention towards gender research. A certain kind of gender research has developed within the field of technology. Before looking at what

¹⁴ It is common to call, for example, functional programming, declarative programming and object-oriented programming different programming paradigms. However, we use the word also in the sense of the paradigms underlying the concept of programming as such.

¹⁵ We use the term ‘gender research’, which is the most commonly used term in Sweden. However, many researchers, mainly from Anglo-Saxon countries, use the term ‘feminist research’.

gender research within CS has to offer, we will make a short presentation of gender research more generally within technical disciplines.

Gender research has two general 'objects of study':

- Women/men/gender/sex and power relations
- Science itself, its theories, methods and knowledge processes.

Gender research within technical disciplines concentrates mainly on the second object defined above. Thorough reflexive work has been done on theory and method (Haraway 1991, 1997, Harding 1986, 1991, Fox Keller 1985, 1992), which has made science observable as discourse¹⁶ by illustrating the kinds of understandings represented in knowledge production as well as by formulating additional understandings.

Fifteen years ago, an explicit turn was suggested in gender research by focusing attention on the discipline core (the science question) more than on the woman question (Harding 1986). This turn has been called the Harding turn and entails moving towards the epistemological bases of the disciplines. Technology as well as natural science is built on classification, standardisation and formalisation. These standards make up, in one way or another, the basis of the discipline. Gender research discusses this basis and develops additional ways of thinking to help us approach the foundations of the discipline and its knowledge production. The work of Donna Haraway (e.g. Haraway 1991, 1997) is of uttermost importance in advancing this type of gender research and its relevance within technical disciplines.

This shift in the axis away from women's and gender issues and towards the theoretical methodological foundation of the individual discipline is not unique to gender research in the technical sciences (Wahl 1996, 1997). What probably distinguishes gender research in technical disciplines from gender research in other areas is that it moves beyond gender as an object of study relatively quickly. For example, it is obvious that the advanced technical research into and development of speech prostheses for female cancer victims who have had a laryngectomy is not a natural object of study for gender research in its own right; rather, it is an unprioritised part of normal science that has given precedence to the development of speech prostheses for men. This type of research is often labelled addition research – women are 'added' on as an extra category in the existing research. Addition research can have a considerable value, if it is founded on documented and applied gender research theory; however, most frequently this is not the case.

¹⁶ Discourse is a concept that refers to certain understandings or patterns of thinking, which manifest themselves in official documents, media and discussions. "Discourse is a regulated method of dialogue that determines what is 'allowed' to be said or done and what is not allowed to be said or done." (Johansson, Nissen, Stureson: *"IT-ism" Informationstekniken som vision och verklighet*. Telematik 2001, KFB och Teldok, KFB-rapport 1998:11 p. 39). Our relationship to reality is expressed through discourses – the discourse that we are in controls our perception of reality. (Swedish National Encyclopaedia).

In order to make gender research within technical disciplines understood as a field of scientific knowledge, there are two important demarcations that it is necessary to keep explicit. The first is the importance of differentiating between work to promote equality between the sexes and gender research. In order to be able to regard and understand gender research as a scientific field of research, it must be made clear that this activity is separate and distinct from equality work. If this distinction is not made clear, gender research risks finding itself in a serious dilemma of relevance, and particularly so in the technical sciences. It is not difficult to see why issues of equality easily become very dominant when the gender perspective is applied to technology. The number of women following technical courses of education, doing technical research and employed in technically oriented jobs is remarkably low and constitutes a problem that has proven to be particularly difficult to resolve. Nevertheless, equality issues are primarily about achieving a more balanced representation of women and men and equal conditions and opportunities in – in this context – the technical-scientific sphere. Gender research entails the development of special scientific competences in technical-scientific fields of research. However, this paper presents a different approach to the Harding turn by attempting to bridge these two positions (equality issues, the ‘woman question’ and gender research, the ‘science question’) in order to facilitate strategies for sustainable change in computer science.

The second demarcation concerns technical science as an area of research for gender research and is related to discussions about perspectives from within. Studies performed in fields such as sociology, economics, history, education, work-organisation, etc. from a gender perspective, in which technology is the research object, have attracted a great deal of interest. What characterises this research is that women and gender or gender–power relations are the focus of the research and not the technical-scientific knowledge production per se. This research is marked by an outside–in perspective in relation to technology with its specific qualities and is situated beyond the field of gender research in technical science. Science and technology studies (STS) is an example of research mainly within social science and the humanities where technology, natural science and the relations between technology, natural science and society constitute the ‘object of study’. Within STS, feminist STS is as old as ‘mainstream’ STS. Although feminist STS has tended to be and still is dominated by social scientists, strong alliances have been formed with actors from the humanities, natural sciences and technical sciences.

A common characteristic of gender research is the emphasis on its ambitions to change research. In many ways, this is a self-evident starting point. From the very beginning, it was inadequacies and imbalances in established research that motivated gender researchers’ work. Thus, gender research is critical of science. If we regard gender research as a research-changing project, it appears in an international context as part of a long-term, far-more radical project of change (Genusforskningens relevans (“The relevance of gender research”) 2000 p. 11).

Gender Research within Computer Science

The body of gender research into computer science done by computer scientists is still small, but it is growing. Although at present this area is much less explored than that of gender research within the natural sciences and some technical disciplines, work has been done that inspires us to continue and intensify research within the field. In this section, we will mention some important work done by computer scientists, and show how gender research provides us with the means and the opportunity to explore issues related to computer science and its paradigmatic basis, which we discussed earlier in this paper.

Norwegian informaticians¹⁷ Tone Bratteteig and Guri Verne discuss gender perspectives within CS. In the article “Feminist, or merely Critical? In search of Gender Perspectives in Informatics” (Bratteteig and Verne 1997), they discuss the potentials yielded by gender research for the establishment of alternative understandings of knowledge within CS. Using the work of Sandra Harding as their starting point (Harding 1986), they discuss different ‘research programmes’ for gender studies, where they see “epistemological inquiries to establish alternative understandings of knowledge” (Bratteteig and Verne, p. 60) as the most challenging, with the greatest potential for contributing to change within the discipline. They believe that use of technology and applications ought to be included as an integrated part of computer science (cf. Denning and the discussion of practice earlier in this paper), and that alternative understandings of knowledge are developed through the experience of application. One way of influencing computer science from within could be to demonstrate how different “models of the world” result in different computer systems – and thus also different consequences for the users. The complex understandings that gender research and other disciplines that are critical of science contribute, illustrate the reality-producing dimensions of computer science.

The suggestion to broaden the concept of what computer science is, to include previously excluded aspects, is also put forward by other gender researchers within CS, for example Ulrike Erb. In her research, she interviewed female faculty in CS. She found marginalisation of so-called ‘non-technical’ skills, but also that the views of what it means to be competent in computer technology or be a “technical insider” are vague within the community of computer scientists. She discusses issues of what is excluded from CS, in terms of the missing accountability, the absence of subjectivity and the excluded views of the system users. Referring to excluded issues of this kind, she argues that “in particular if we do feminist research inside the discipline of computer science, one main purpose of this research might be to explore forgotten and excluded aspects of computer science. [...] to reveal the excluded and to integrate the excluded in order to enrich computer science by means of the forgotten perspectives” (Erb 1997 p. 206).

¹⁷“ Informatics is the term for computer science departments in universities in Norway, indicating that the discipline is defined more broadly than in traditional computer science departments” (Bratteteig and Verne 1997, p. 59).

Bratteteig and Verne touch on the process of naturalisation¹⁸, whereby something is stripped of its origins, context and consequences and seen as given, i.e. it is taken for granted. This is further developed by Christina Mörtberg. As an example, she discusses object-oriented design and programming, where “objectification entails the loss of the situation and localization that were implicit in the basic pre-conditions and point of departure for the development” (Mörtberg 1999 p. 56). She argues that models and programming languages can reinforce this objectification process, plus the fact that high-level languages on the whole tend to lead to increased abstraction, and she queries the implications of this. Designers, machines and software are made invisible, thus hiding the choices that have been made during the process. “There is a mutual process in which the views of knowledge, experience, values and needs are integrated in the development of artefacts, programs, networks, databases, etc” (Mörtberg 1999 p. 58).

Christina Mörtberg demonstrates how computer science and other technical-scientific disciplines build their competences on consensus-marked classifications, standardisations and formalisations. She discusses representation in a way that can serve to illustrate the reasoning (Mörtberg 2000 p. 58):

“Formal representations are created in processes that entail abstractions, quantifications, hierarchisations, classifications, standardisations and simplifications (Star 1995). In these processes, there are negotiations about borders and content and in these negotiations, technology and gender are shaped.”

Categorisation is not only a means of structuring the outside world – it also limits and affects our way of thinking. By leaving established categories, new forms of understanding can be created.

If we take the gender-marked structural and symbolic levels in knowledge production in CS seriously, it is important to consider what kind of presumptions, choices, standardisations, classifications etc. are involved in the research processes. So far, gender-marked representations and metaphors are neutralised, made implicit and integrated in the development of programming languages, models, computer systems, etc. The use of language has proved to be very important in our understanding of ideas and the images they call to mind. The presence of clearly gender-marked metaphors can be a factor in supporting the gender structure within the discipline. Metaphors create images that will be of importance in the knowledge process (Keller 1995).

¹⁸ “By *naturalization* I mean stripping away the contingencies of an object’s creation and its situated nature” (Star, Susan Leigh, 1994: “Misplaced Concretism and Concrete Situations: Feminism, Method and Information Technology”. In *Gender-Nature-Culture Feminist Research Network* Working paper No 11, Odense Univ, p. 21).

Alison Adam has focused on questions of epistemology in her work on Artificial Intelligence (AI)¹⁹ (Adam 1998). She discusses issues of knowledge, such as ‘whose knowledge’ and ‘what knowledge’ is represented in AI systems. Among other topics, she discusses the differences between propositional knowledge (‘knowing that’) and skills knowledge (‘knowing how’), or mental vs. embodied knowledge, and how the former has been seen as superior to the latter (Adam 1995).

The issue of knowledge is also developed by Anne Moggridge. She discusses how an extended epistemology can begin to account for more practical and personalised aspects of knowing, situated in social and cultural contexts. She considers the connections between gender research and conceptions of knowledge and conceptions of what she terms ‘human inquiry’ (Moggridge 1997, 1998). “Knowing is not necessarily a matter of saying and representing what is the case but can also be a kind of practical involvement with the world” (Belenky et al.1997²⁰, quoted in Moggridge 1998, p. 34). She discusses how this can be used within computing, to transformatory ends.

Questions concerning ‘what knowledge’ and ‘whose knowledge’ are among the most central issues for gender research to focus on. As Christina Mörtberg writes in her dissertation on female system developers (Mörtberg 1997, p. 25):

“Despite new procedures and new possibilities, questions of knowledge are as central today as they were in the past, and the problems of translation still remain, as do questions about what kind of knowledge, whose knowledge and the extent to which knowledge is representable at all.”

Questions concerning the ‘fundamental nature’ of the discipline of computer science are raised by Frances Grundy. She challenges what she sees as three paradigms within CS: mathematics, science and engineering (Grundy 2000a, 2000b, 1998). She discusses the role of mathematics in computing, including the design and analysis of algorithms, complexity theory, discrete mathematics and formal methods, and what role mathematics actually plays for abstraction. Her argument is that mathematics is only one type of abstraction involved in computing, and she further claims that mathematics is a status symbol and has been used as an argument for making CS into a science: “Mathematics is used to bolster the political power of computer ‘scientists’”(Grundy 2000a)²¹. She also challenges the notion of CS as a ‘science’, comparing CS with natural sciences. Her argument is that there is nothing ‘out there’ for computer science to ‘discover’ and thus it is not a ‘science’ (Grundy 2000b). Instead she wishes CS to develop in a direction that she calls interactionism. Interactionism is a cluster of ideas, involving for example a blurring of the distinction between the subject and object (Grundy 2000b). “Interactionism

¹⁹ AI is often regarded as a subdiscipline of CS – or at least some aspects of AI are. It can be argued that AI is a separate discipline, with its own epistemology. However, the issues concerning knowledge are highly relevant for CS.

²⁰ Belenky, Clinchy, Goldberger, Tarule, 1997: *Women’s ways of knowing: The development of self, voice and mind*. New York, Basic Books.

²¹ Compare with the discussion of mathematics on p. 81.

emphasises the practicality of computing; it also recognises that much computing is about communication and it recognises the importance of pluralism” (Grundy 2001).

Complexity and indeterminacy are treated in the context of the object-oriented paradigm by Cecile Crutzen and Jack Gerrissen, in their paper “Doubting the object world” (Crutzen and Gerrissen 2000). This is an excellent example of feminist critique of a paradigm within CS. To our knowledge, this is one of the first cases where gender research has been used in an explicit and thorough analysis of a CS paradigm, and it is an inspiring example of what can be done using gender research and feminist theory. In this article, the authors analyse the ontology and epistemology of the object-oriented (OO) paradigm, and present a feminist critique of these. They argue that OO should not be used for the analysis of human worlds, but only for what it was originally intended: the realisation of software²². OO has reinforced functionalism, and it enhances the idea of the controllable and deterministic. In OO, the process of change is modelled like a stimulus-response procedure. OO conforms fully to “Enlightenment traditions” (Crutzen and Gerrissen 2000 p.132-133):

“[It is] based on the same illusions of objectivity and neutrality of representation; the negating of power and dominance by translating it into ‘natural and obvious’, and on the existence of truth by transforming it into progress”

This paper too constitutes a discussion of classification and standardisation, and how a case is made for making hidden abstractions visible: “OBJECTS should stop acting behind their surface, even if this would render our self-created OBJECTS unpredictable or unreliable” (*Ibid* p. 134). It is interesting to compare this analysis of OO with the views expressed by Sherry Turkle and Seymour Papert ten years earlier (Turkle and Papert 1990, see also the discussion under ‘Computer Science and its Paradigmatic Basis’), where they see OO as potentially revolutionising programming methods and also as challenging traditional ways of thinking and knowing.

Finally, we would also like to mention an example of gender research within mathematics. Leone Burton has developed an epistemological model of what it means to know and come to know mathematics. She has shown that broadening the understanding and images of “the nature of knowing” within a discipline, has gender implications (Burton 1995).

Summary and conclusions

In this paper, we have argued that there is a growing need to broaden the understanding of knowledge production and research processes within computer science. This need is based on the fact that CS has a growing influence on current

²² Note that what they criticise is the paradigm of object-orientation at a fairly high level, for example for making analysis of “human worlds”, *not* the low level object-oriented programming, used for “realisation of software”.

and future technological development and the need to broaden recruitment to the discipline.

It is our belief that it is necessary to research the core of CS and its knowledge production in order to effect real improvements in recruitment to the area, and that this will also renew and enrich CS and its practices - not least in education.

We have also argued that using gender research to analyse CS and its knowledge processes provides potentials for the development of new conceivable and broader understandings and interpretations of what CS is, and what it means to “know CS”, all of which is of vital importance for the needs we have identified.

We consider it of vital and decisive importance that gender research is done from within computer science. We argue that focus should be within the discipline itself, and that research should go inwards in search of the core issues in CS. Since the focus is very clearly within the discipline, the work has to be done from within. The fundamental knowledge questions that need to be studied can only be fully understood from within, with the knowledge and experience of CS and gender research integrated. To work from within is necessary in order to attain a potential for transformation. Our goal is change, and thus we want our research and work to have influence within the discipline. However, integrated gender research by no means excludes interdisciplinary constellations.

As we have seen above, gender researchers within CS have focused on issues such as naturalisation, choice of representations, knowledge and epistemology. They argue for changes, such as to expose decisions and assumptions made during knowledge processes, to explore forgotten and excluded aspects that could lead to potentially new and valuable directions in knowledge production, to render visible what is hidden, to integrate use and applications into the discipline, and to acknowledge complexity. Common for these researchers is the way they see gender research as a resource for transforming the discipline. As pointed out above, this research is still scarce and so far mostly has the character of raising questions and researching selected areas. Although its importance has been acknowledged and researchers within the area have pointed to important issues, much still remains to be done.

We wish to see this research covering more areas of the knowledge foundation and paradigms of CS, such as for example the algorithmic core of the discipline, the notions of ‘digital’, the inherent dichotomies within the discipline, and programming paradigms. We argue the need for a comprehensive approach in gender research within CS. Through analyses based on theories and methodology from gender research, but also from traditional CS, underlying paradigms and understandings can be exposed, which will yield possibilities for suggesting new interpretations, and new conceivable and broader views and interpretations of what constitutes CS and what it means to “know CS”.

References

- ACM and IEEE-CS, 2001: *Computing Curricula 2001, Computer Science Volume*.
<http://www.acm.org/sigcse/cc2001/>.
- Adam, Alison, 1995: "Artificial Intelligence and Women's Knowledge: What Can Feminist Epistemologies Tell Us?" In *Women's Studies International Forum*, vol 18, no 4, p. 407-415.
- Adam, Alison, 1998: *Artificial Knowing: Gender and the Thinking Machine*. London and New York: Routledge.
- Björkman, Christina, 2000: *Projekt Q+ - med och för kvinnliga studenter i datavetenskap*. Arbetsrapport 6, Development and Evaluation unit, Uppsala university.
- Björkman, Christina, 2001: "A Project for First-year Female Students of Computer Science". Paper presented at *GASAT 10 Conference*, Copenhagen, July 2001.
- Björkman, Christina, 2002: "Women and Computer Science". In manuscript.
- Bratteteig, Tone, Verne, Guri, 1997: "Feminist or merely critical?". In Moser, Aas (eds) *Technology and Democracy: Gender, Technology and Politics in transition?* Centre for Technology and Culture, University of Oslo.
- Burton, Leone, 1995: "Moving Towards a feminist epistemology of Mathematics". In *Educational Studies in Mathematics*, vol 28, no 3.
- Crutzen, Cecile, Gerrissen, Jack, 2000: "Doubting the OBJECT World". In *Charting a course to the future*. Proceedings of the 7th International IFIP [TC9/WG9.1] Women, Work and Computerization Conference, Vancouver, Canada.
- Cunningham, Steve, 1998: "Outside the Box: The Changing Shape of the Computing World". In *SIGCSE Bulletin*, vol 30 no 4 p. 4a-7a.
- Denning, Peter, Comer, Douglas, Gries, David, Mulder, Michael, Tucker, Allen, Turner, Joe, Young, Paul, 1989: "Computing as a Discipline". In *Communications of the ACM*, vol 32 no 1 p.9-23.
- Denning, Peter, 1999: "Computing the Profession". In *Proceedings of the Thirtieth SIGCSE Technical Symposium on Computer Science Education*, New Orleans, Louisiana.
- Denning, Peter, 2001: "Crossing the Chasm". In *Communications of the ACM*, vol 44, no 4, p.21-25.
- Denning, Peter, Dunham, Robert, 2001: "The Core of the Third-Wave Professional". In *Communications of the ACM*, vol 44 no 11, p. 21-25.
- Dijkstra, Edsger W, 1989: "On the Cruelty of Really Teaching Computing Science". In *Communications of the ACM*, vol 32 no 12 p.1398-1404.
- Erb, Ulrike, 1997: "Exploring the Excluded. A Feminist Approach to Opening New Perspectives in Computer Science". In *Spinning a web from past to future*. Proceedings

- of the 6th International IFIP [TC9/WG9.1] Women, work and computerization Conference Bonn, Germany, p. 201-207.
- Gal-Ezer, Judith, Harel, David, 1998: "What (Else) Should CS Educators Know?", In *Communications of the ACM*, vol 41 no 9 p. 77-84.
- Genusforskningens Relevans, Slutrapport från integreringsarbete i åtta svenska forskningsråd*, 2000, Rapport från forskningsrådets expertgrupp för genusforskningens integrering (Trojer, Lena; Eduards, Maud; Glass, Marianne; Gulbrandsen, Elisabeth; Gustafsson, Bengt; Björling, Sofie; Leman, Gunnar; Runesson, Ingegerd; Roemer Christensen, Hilda; Sandahl, Ingrid, Westerholm, Barbro) Stockholm.
- Grundy, Frances, 1998: "Computer Engineering: Engineering what?" In *AISB Quarterly*, issue 100, p. 24-31. Also available at <http://www.keele.ac.uk/depts/cs/staff/a.grundy/home> (Read 2002-04-18).
- Grundy, Frances, 2000a: "Mathematics in Computing: a Help or Hindrance for women?" On CD-ROM from *Charting a course to the future*. Proceedings of the 7th International IFIP [TC9/WG9.1] Women, Work and Computerization Conference, Vancouver, Canada.
- Grundy, Frances, 2000b: "Where is the Science in Computer Science?" On CD-ROM from *Charting a course to the future*. Proceedings of the 7th International IFIP [TC9/WG9.1] Women, Work and Computerization Conference, Vancouver, Canada.
- Grundy, Frances, 2001: "A New Conception of Computing: Interactionism Replaces Objectivism". Paper presented at presented at *GASAT 10 Conference*, Copenhagen, July 2001. Also available at <http://www.keele.ac.uk/depts/cs/staff/a.grundy/home> (Read 2002-04-18).
- McGuffee, James, 2000: "Defining Computer Science". In *SIGCSE Bulletin*, vol 32, no 2, p. 74-76.
- Haraway, Donna, 1991: *Simians, Cyborgs and Women: Reinvention of Nature*, Free Association Books.
- Haraway, Donna, 1997: *Modest_Witness@Second_Millennium, Feminism and Technoscience*, Routledge.
- Harding, Sandra, 1986: *The Science Question in Feminism*, Cornell University Press.
- Harding, Sandra, 1991: *Whose Science? Whose Knowledge?*, Cornell University Press.
- Keller, Evelyn Fox, 1985: *Reflections of Gender and Science*, New Haven.
- Keller, Evelyn Fox, 1992: *Secrets of Life, Secrets of Death*, Routledge, London.
- Keller, Evelyn Fox, 1995: *Refiguring Life – metaphores of twentieth-century biology*, Columbia University Press.

- Klawe, Maria, 2001: "Refreshing the nerds". In *Communications of the ACM*, vol 44, no 7, p. 67-68.
- Kuhn, Thomas, 1970: *The Structure of Scientific Revolutions*, Chicago University Press, Chicago.
- Moggridge, Anne, 1997: "Feminist Perspectives in Computing Research: A Place for Human Inquiry?" In Lander and Adam (eds): *Women in Computing*. Intellect Books.
- Moggridge, Anne, 1998: "Women in Computing: Inside Knowledge". In *AISB Quarterly*, issue 100, p.32-36.
- Mörtberg, Christina, 1997, "Det beror på att man är kvinna...", *Gränsvandrerkskor formas och formar informationsteknologi*. Ph.D dissertation 1997:12, Luleå University of Technology.
- Mörtberg, Christina, 1999: "Technoscientific challenges in feminism". In *NORA (Nordic Journal of Women's Studies)* Volume 7, Issue 1.
- Mörtberg, Christina, 2000, "Teknikvetenskap och genusforskning eller Creating Better Worlds Through Imaginations" in *Genusforskningens Relevans*, Stockholm.
- Turkle, Sherry, 1984: *The Second Self: Computers and the Human Spirit*. London: Granada.
- Turkle, Sherry, Papert, Seymour, 1990: "Epistemological Pluralism: Styles and Voices Within the Computer Culture". In *Signs: Journal of Women in Culture and Society*, vol 16 no 11.
- Wistedt, Inger, 2001: *Five Gender-Inclusive Projects Revisited*. National Agency for Higher Education, Sweden.

Paper V

An earlier version of this article was presented at the conference:
Information Technology, Transnational Democracy and Gender,
Ronneby, November 2001.

Computer Science, Gender and Knowledge: Readings from Partial Perspectives

Christina Björkman

Introduction

On the surface, the problem of low female participation in computer science (CS)¹ might appear simply to be a problem of equality. It is about “the woman question” (Harding 1986). However, I would argue that it is not quite that simple. If we follow the track of attempts to increase the number of women within CS, and if we are frustrated by the poor results to date, we will find that one area has scarcely been touched upon so far: that of science and epistemology². If we are seriously committed to a project of change in its deepest sense, following a thread of questions will lead us to more complex questions around the discipline of CS and its knowledge processes. Focus will be shifted towards “the science question” (Harding 1986).

I will read and analyse two texts about women and computer science in an attempt to move away from questions of equality and towards more complex issues. My aim is to try to get beneath the surface of the texts in order to see what I can find in them. Can a reading and interpretation based on theoretical and methodological considerations from gender research help us gain a broader and more complex understanding of how the problem of the under-representation of women is perceived and discussed? Furthermore: is it possible to connect the seemingly unrelated questions of equality and epistemology? Is it possible to read epistemological issues into a text that is not about epistemology, but about the low number of women within computer science? Thus, I have three main focuses for my analysis of the texts:

1. How is the problem of female under-representation perceived and what does that imply? (Basically equality issues)
2. How are science and knowledge viewed and what does that imply? (Epistemology issues)
3. Are the two connected?

The reason that I have chosen to undertake this text analysis exercise and my choice of texts are found in my background. The first paragraph above refers to my own experiences from ‘following a thread of questions’. I am a lecturer in computer science, and for a number of years I have been interested in questions and issues

¹ I use the term ‘computer science’ in a broad sense to also include most aspects of computer engineering.

² See Björkman 2002 for an overview and discussion of literature that focuses on the low female participation in CS.

surrounding the under-representation of women within computer science and in the various different attempts to define, describe and suggest solutions to this ‘problem’. I have gone from taking part in, and actively leading, projects targeting women within CS (as a lecturer in CS), to an interest in trying to gain a more complex understanding of this issue and challenging existing frameworks and explanations (as a doctoral student in gender research within Technoscience Studies³). I have come to be especially interested in issues of epistemology and paradigms within the discipline of CS⁴.

I have analysed two texts, which were deliberately chosen to represent different approaches and authors. The first is an article from the Communications of the ACM⁵ 1997. This article has been widely distributed and is frequently cited within the community of computer scientists. The second text is an article from a project in which I participated five years ago. Analysing my own text is of course very difficult, as there is a risk of being either too understanding or too critical. However, I look upon it as a fruitful exercise, trying to follow my own development from working with questions of equality to becoming a gender researcher. I also hope that I have managed to see this old work with ‘new eyes’ and to reflect on what patterns and views exist in it.

In the following sections of the paper, I will discuss some epistemological and methodological considerations and starting points and the way in which I use certain concepts in my analyses, as well as how I read the texts. After that, I will describe more concretely, in the form of questions, what I look for in the texts, before presenting the analyses. Finally, I will make some concluding remarks.

Epistemology and Methodology as Points of Departure: the Issue of Partial Perspectives

My readings make explicit use of *partial perspectives* and of being *located*, *positioned* and *situated*, as Donna Haraway advocates:

“I am arguing for politics and epistemologies of location, positioning, and situating, where partiality and not universality is the condition of being heard to make rational knowledge claims. These are claims on people’s lives; the view from a body, always a complex, contradictory, structuring and structured body, versus the view from above, from nowhere, from simplicity” (Haraway 1991, p. 195).

³ See www.iar.bth.se/forskning/itg/

⁴ The importance of studying the paradigmatic basis of CS is discussed in Björkman and Trojer 2002.

⁵ ACM, the Association of Computing Machinery, is one of the largest international professional organisations within CS.

By *located* I here mean simply 'placed' in a geographical, describing, stating sense without any connections to purpose, 'cause', before or after, but still involving context.

Positioned implies the use of power or strategy and a subject (and sometimes also an object). A position can either be forced upon me by others, in which case my subjectivity is limited, or I can choose it, take it strategically and use it as a conscious subject. Thus, I can either be *positioned* or I can *position* myself.

Situated is the most far-reaching concept, especially when used in connection with knowledge, as in *situated knowledge*. Important for me is Donna Haraway's use of the term as she describes it in *Situated Knowledges, the science question in feminism and the privilege of partial perspective* (Haraway 1991) and later in *How like a leaf* (Haraway 2000):

"I would like a doctrine of embodied objectivity that accommodates paradoxical and critical feminist science projects: feminist objectivity means quite simply situated knowledges" (Haraway 1991, p. 188).

"Sometimes people read "Situated Knowledges" in a way that seems to me a little flat; i.e. to mean merely what your identifying marks are and literally where you are. "Situated" in this sense means only to be in one place. Whereas what I mean to emphasize is the situatedness of situated. In other words it is a way to get at the multiple modes of embedding that are about both place and space in the manner in which geographers draw that distinction. Another way of putting it is when I discuss feminist accountability within the context of scientific objectivity as requiring a knowledge tuned to resonance, not to dichotomy" (Haraway 2000, p. 71).

I understand and use *situated* as implying an epistemological standpoint. Thus, *situatedness* refers to conscious epistemological positioning. It is not simply a matter of an individual place or state, it is part of practice and knowledge production, and it means actively taking a stand.

I agree with the idea that when reading and interpreting texts we are never objective observers, but actively participate in the creation of meaning. Thus, the 'meaning' of a text is created by the author(s) and by the reader(s) and by the locations, positions and/or situations that author(s) and reader(s) assume, as well as by the text itself.

The next question is therefore: how and where am I located, positioned and/or situated in relation to the texts I read and analyse? There is no one location that I can claim to be in, nor are the positions I take in themselves clearly defined. I have tried to break down 'me' into different 'me's', with every 'me' or *partial identity* reflecting different experiences in my professional life:

Engineer
Lecturer in CS
Study counsellor within CS
Project leader on projects for women within CS
Gender researcher
Woman in CS

Before I present these partial identities more closely, I will comment on my use of *identity*. By identity I do not mean unity, but rather partial identities, “ ‘identity’ is in fact a sort of conglomerate resulting from a fusion of identities” (Munnik 1999, p.108), “Identities seem contradictory, partial, and strategic” (Haraway 1991, p. 155).

The identities above are not clearly separated, nor are they defined. They go into one another and can never be seen as ‘points’ in a universe (in the mathematical sense), but ought rather to be thought of as vaguely shaped multi-dimensional figures, as ‘shapes’ without clear boundaries between inside and outside. They are not static, but are alive and dynamic, changing size and form continuously. These shapes have overlapping areas between them, and they are also partly and sometimes in conflict with each other. To complicate things even further, each of these shapes contains conflicts within itself. “We move between positions, which we take or are placed in, that can be both filled with conflicts and conflicting” (Mörtberg 1997, p. 36).

As a lecturer, for example, I do not only face conflicts regarding what is (more or less) outside ‘my’ boundaries, but the shape I take up is also full of internal conflicts. These conflicts come from all my varying experiences, the tradition in which I have been trained and all the different ideas I meet in my working life. Although these inner conflicts make it more difficult to describe and put boundaries on the shape ‘lecturer’, they are in fact both inevitable and absolutely necessary for the task of trying to be a ‘good teacher’, to be in constant motion, questioning, learning and changing.

The shapes are not abstract, they are very physical, embodied and inhabited. They are places where I have been, and where part of me still is, places that I sometimes inhabit (more or less) unconsciously, and sometimes position myself deliberately in for strategic reasons. They are the identities that have provided me with the experiences that I can now use in my analysis.

The partial identities of the shapes offer me the possibilities of *partial perspectives*. Recognising partiality is a rich resource in attempts at transformatory work: “We do not seek partiality for its own sake, but for the sake of the connections and unexpected openings situated knowledges make possible. The only way to find a larger vision is to be somewhere in particular” (Haraway 1991, p. 196).

I will try to make some crude and partial delimitations to these ‘shapes’, to describe their most important features in order to make an attempt at describing my locations/positions/situations when reading and interpreting the texts. It is necessary to be aware of these, since this affects the reading I do to a large extent. Using the conflicts, both between the shapes, and within them, can enable me to reveal and render visible underlying views and assumptions in the texts, as well as ‘cracks’ in them. I explicitly try to make use of the shapes in my analysis of the texts.

I mostly regard the shapes as ‘positions’, i.e. I have been placed and/or place myself strategically in them. However, some of them also imply epistemological standpoints, which I will try to make clear.

Engineer

I have an M.Sc. in Engineering Physics. I studied in the late 1970's and early 1980's, during a time when I would call the education I received extremely streamlined and directed by behaviourist ideas. I sometimes think of my training as depriving me of the ability to read, write and think/reflect. I never heard of anything remotely resembling a discussion of knowledge, philosophy of science or epistemology. The education was fundamentally built on positivism⁶, but this was so implicit that I had no idea whatsoever that science could be anything else but what we were learning and doing. There was simply just Science, and I remember vividly that when I much later learnt a little bit about the history and philosophy of science, I felt I had been betrayed throughout my entire undergraduate education. Yet, the training as an engineer, with its positivism and main focus on problem solving, is deeply rooted within me.

A reading starting in the position of a 'traditional' engineer, a position in which I have more or less unconsciously been placed but which I can now use strategically, will be problem-oriented with the focus firmly on defining, delimiting and solving a problem. It will acknowledge and look for simplicity instead of complexity. The (unacknowledged) underlying epistemology is that of objectivism (in the positivist sense) and a belief in something vague and undefined, which is believed to be the 'scientific method'.

Lecturer in CS⁷

In the mid 1980's in Sweden, university education within CS had just started, and teachers holding a degree in the discipline were not to be found. Thus, universities would hire people who had at least some background in computer science (which I had). I started out in this location as the positivist-trained engineer, but with a burning interest in students and pedagogical issues. As a lecturer, I regard myself as belonging to the community of computer scientists, thus I am (partly) an 'insider'. At least for my first few years as a lecturer, the subject matter (and the community) had the highest priority. Later, however, cracks and conflicts started to appear as my focus gradually shifted more and more towards students, learning and pedagogy, and I started questioning the importance of concepts and contents. This meant that the position became a tricky one – balancing 'scientific rigour' with aspects of the learning process such as understanding and reflecting.

From this position, I can move between different 'sub-positions', being able to understand (if not agree with) different positions that computer scientists assume vis-à-vis education, students and the subject matter. This is a position that I can both claim to have taken up consciously and to have been placed in, but the emphasis

⁶ I use a simple definition of positivism, borrowing the words of Elisabeth Gulbrandsen: "By 'positivism' is meant the idea of science as neutral and objective" (Gulbrandsen 1995, VI: p. 20).

⁷ I am still employed and active as a lecturer in CS.

varies depending on whether it is my strategic position or not. I try to use this position as an 'insider' strategically, in that I know how the discussion goes within the community and sometimes also agree (at least partially) with many of the values and principles upheld within the community. The epistemological ground is still the same as the engineer had, although it is beginning to be a little 'shaken'.

Study counsellor within CS

I spent 4 years working part-time as a study counsellor, alongside lecturing. This position involved being placed by others, in fairly limiting ways, since being a study counsellor means having very little power and belonging to the lower ranks of the academic hierarchy. However, taking and using it strategically involves the acquisition of much knowledge through experience. In this position, my focus shifted more and more towards students, assuming responsibility in different ways and beginning to see accountability differently. However, I could not fully take a stand for students, since I was hired as faculty and thus had to balance my loyalty towards the community and my colleagues. I started to see problems and structures within the academic institution as well as within the discipline, but had very limited opportunity to act for substantial changes. I would say that this position is definitely more strategic than epistemological.

Project leader on projects for women within CS

In this position, I could really take a stand for female students and did not have to negotiate loyalties. I was invited to look into their lives as students, to share some of their experiences, and learn about the conflicts they lived in. The experience was eye-opening and often deeply upsetting, my knowledge, thoughts and the way I perceived things were shaken and changed. This position thus involved identification and experiences, including the conflicting identities that some of the women talked about. Change and transformation became increasingly important, and my frustration over the lack of change grew.

I see the value of this position mainly in terms of the strategic insights it offered, but it also started the process of my questioning the epistemological grounds of the earlier positions, for example I developed a belief in the bodily experience of women as a valid basis for knowledge. I started to think about the limited possibilities for acting that these women had, and how their subjectivity was constructed and confined (although at that time I did not explicitly think in terms of 'subjectivity'). This is also the position where I finally gained an interest in exploring the real complexity of the problems facing women in CS, and where I started to consider issues of paradigms and knowledge within the discipline.

Gender researcher

I belong to the research group Technoscience Studies at Blekinge Institute of Technology. This group is placed within Technical Faculty. With a foundation in gender research, the work done within the group aims at creating knowledge for development processes within IT-related scientific disciplines, as well as in IT-strategic contexts. Here, interdisciplinarity is considered very important. Lena Trojer (professor and head of the group) writes: "...in the scientific work within gender research, not least gender research within science and technology, inter-disciplinarity is a prerequisite" (Trojer 1995a, p. 113). Another important issue for the group is to work from within the technical disciplines. For me, this implication within is of utmost importance – staying within the discipline of CS allows me greater possibilities to work for change.

"There is a critical and crucial situation for an innovative and research transformative gender research, and that is the ability to place oneself within the field of research, to let oneself become implicated, to work from within. If you are a gender researcher and engineer, the location within technical disciplines is of fundamental importance in order for a research transformative and research policy work to become possible" (Ibid, p. 113).

As a gender researcher, I see myself as situated and taking certain epistemological points of departure, in this paper more explicitly those of *partial perspectives*.

Woman in CS

I experienced this position mainly as a lecturer, study counsellor and project leader, i.e. this position interrelates with some of the other positions above. This is clearly both a position that others have placed me in, attributing certain qualities to me and expecting certain behaviour from me, and a position that I realised could be used strategically. However, the strategic use of it comes mainly from generating experience and thus knowledge. The position in itself gives very little, if any, strategic power. This position is both very personal and shared by other women. It contains strong feelings and experiences that have been hard earned. It also entailed going through a difficult period of questioning my own abilities and suitability for my profession. From this, insights slowly grew about structures, and the questions were subsequently turned instead towards the discipline and the structures and cultures within academia. Thus, after some eight years as a lecturer, I became a feminist as a result of my experiences within academia.

Since the position of woman in CS can be seen as subjugated, it could also, according to feminist standpoint theory, be seen as privileged (see for example Hartsock 1998, Harding 1986, 1987, 1993). However, a standpoint is not something that I have as a person, it is something I have through belonging to a group. I find the epistemological approach of standpoint theory somewhat problematic and difficult to grasp, entailing that I might misuse the concept in this text, but I will try to use it as a way of touching on epistemological negotiations.

In my experience (from the position of ‘woman in CS’), the dominant scientific discourse within natural science and technology disqualifies the position of ‘woman in science’ for being ‘subjective’ and very ‘partial’ (in the negative sense that the words are used within positivism), thus not rendering any kind of ‘knowledge’ or ‘truth’ (this becomes especially clear when we talk about questions concerning the under-representation of women). In doing so, it is very easy to maintain the status quo and reject all critique as coming from a ‘non-objective’ position. However, what is seldom recognised, is that the one position holding the preferential right of interpretation is just as ‘subjective’ and ‘partial’ as the so-called standpoint position of woman in science. This conflict can lead to interesting tensions. The conflict is not dissolvable, since the positions are opposites. In fact, there is no reason to want to dissolve it, since it can shed useful light on underlying, hidden views.

I have mentioned conflicts, contradictions and paradoxes. Yet another paradox that must be dealt with is: how can the ‘shapes’ be both used and questioned? Sandra Harding argues that we need to accept ambivalences in the project of developing feminist critiques of science: “I propose that we think of feminist epistemologies as still transitional meditations upon the substance of feminist claims and practices. In short, we should expect, and perhaps even cherish, such ambivalences and contradictions” (Harding 1986, p. 141). “We shall try to keep ambivalences, contradictions and tensions... It is in the ambivalences and contradictions that the potentials for a steady radicalisation – a steady transgressing – lies” (Gulbrandsen 1995, VI: p. 22⁸). But how to handle this in work and life? I believe in giving up the positivist striving for unity, simplicity and universality, and see the potentials and possibilities in complexity, to start living in and with all these conflicts, contradictions and paradoxes:

“The split and contradictory self is the one who can interrogate positionings and be accountable, the one who can construct and join rational conversations and fantastic imaginings that change history. Splitting, not being, is the privileged image for feminist epistemologies of scientific knowledge. ‘Splitting’ in this context should be about heterogeneous multiplicities that are simultaneously necessary and incapable of being squashed into isomorphic slots or cumulative lists” (Haraway 1991, p. 193).

On Discourse, and the Issues of Presence and Absence

The concept of discourse is often used in analysing texts, and I will make use of it as well. However, I want to make it quite clear that I am not attempting a discourse analysis of the texts. The discourse concept is difficult to handle, and numerous texts have been written on the topic of discourse and its different uses (and it is enough to consult two books to get two quite different ways of defining concepts such as discourse theory and discourse analysis). In my understanding of discourse, I primarily lean on Sara Mills’ book *Discourse* (Mills 1997).

⁸ Elisabeth Gulbrandsen writes this as an interpretation of what Sandra Harding is arguing for.

I think of discourse as referring to “certain understandings and patterns of thinking” (Ekdahl and Trojer 2002, p. 18), as “a specific way of talking about and understanding the world (or a slice of the world)” (Winther Jørgensen and Phillips 1999, p. 7), as something that manifests itself in and becomes visible through, for example, a written text. Sara Mills writes about Michel Foucault’s thinking on discourse:

“... a discourse is something which produces something else (an utterance, a concept, an effect), rather than something which exists in and of itself and which can be analysed in isolation. A discursive structure can be detected because of the systematicity of the ideas, opinions, concepts, ways of thinking and behaving which are formed within a particular context, and because of the effects of those ways of thinking and behaving” (Mills, p. 17).

Our views and perceptions of phenomena, things, ‘reality’ and ‘the world’ are both shaped by and manifested in discourses. In my case, I will discuss discourses in connection with the three main focuses I listed in the introduction above. I will concentrate on what I see as discourses specifically found within or relating to CS, even though they are in themselves likely to be part of other discourses, for example discourses on equality within society and discourses on science within academia. Do the texts reflect, maintain and strengthen dominant discourses or do they challenge them?

I see discourses concerning computer science as closely linked to the canon within the discipline – through discourse, the canon is maintained and communicated. What discourses and views of the canon dominate in the texts? Dominant discourses act to stabilise, maintain and reproduce the status quo. “Different discourses with different authorities exist simultaneously and those that dominate are often taken as something natural and given and are accepted without being questioned. The dominating, prevailing and predominant are created by what is taken for granted and regarded as normal” (Mörtberg 1997, p. 63-64). Dominant discourses are often implicitly understood, and in that sense ‘invisible’ in the text.

So what might we expect the dominant discourses on the topics that I am focusing on to look like? As far as equality is concerned, the two dominating discourses within CS are, to put it simply: “It is totally irrelevant, we don’t care” and “The under-representation of women is bad, we need more women” (this is seen as a fact, the reasons given as to *why* more women is ‘good’ can vary greatly). The latter discourse on women in CS usually implies (implicitly) that women’s attitudes towards the discipline need changing, which could be called an ‘add-women’ approach⁹. For the question of science and epistemology, it is important to have an idea of where among the academic disciplines CS can be placed. “Computing¹⁰ sits at the crossroads among the central processes of applied mathematics, science and engineering” (Denning et al 1989 p.11). The dominant scientific discourses within

⁹ See Björkman 2002.

¹⁰ ‘Computing’ is used here in essentially the same sense as I use computer science.

CS are likely to relate to discourses about science found within these 'parent disciplines', i.e. they are likely to be basically built on positivism.

Is it possible to find 'cracks' or competing discourses in the dominant discourses? "The dominant discourse as Mörtberg defines it is not hermetically sealed, however. There are always "cracks, or inadequacies". Alongside the dominant discourse grow alternative discourses and counter discourses" (Elovaara 2001, p. 18).

In order to gain a more complex understanding of a text, it is not enough to ask questions about what is *in* it. It is equally important to ask questions about what *is not* in the text: "What is present by being absent?"¹¹. Shulamit Reinharz calls this "the study of what is missing": "Thus feminist content analysis is a study both of texts that exist and texts that do not" (Reinharz p. 162). She points out that what is interesting for the feminist researcher is the question *why* things are missing and the implications of these gaps, and she continues: "Viewing documents in this way contributes to an understanding both of the subject matter and the sociology of knowledge, or as I call it, "the sociology of the lack of knowledge"" (Ibid, p. 163).

Sara Mills discusses the question of absence in terms of exclusion from discourses: "A further aspect which all these views of discourse have in common is that they consider discourses to be principally organised around practices of exclusion. Whilst what it is possible to say seems self-evident and natural, this naturalness is a result of what has been excluded, that which is almost unsayable" (Mills, p. 12). Discourses thus regulate what is acceptable, and what is not: "Discourse is a regulated method of dialogue that determines what is 'allowed' to be said or done and what is not allowed to be said or done"¹².

"What is present by being absent" can be understood and used in two ways: on the one hand, what Mills calls "the excluded" and Reinharz terms "what is missing", and on the other hand in the sense of the invisible discourse(s). The absent, implicitly understood issues confirm the discourse, and this should be made visible and explicit. On the other hand the explicitly absent questions or issues raise questions as to *why* they are absent, and this can also point to possibilities of creating cracks in the dominant discourses.

Questions

Asking questions, rather than looking for answers in the first place, is a way of starting a reflective process as well as a way to communicate. Asking questions is a way to stay alive and alert, to continually move and to stay curious. "The important thing is to keep finding new ways to ask the questions because as long as you're

¹¹ This expression is inspired from Pirjo Elovaara in her discussion on ANT, see for example Elovaara 2001, p. 109.

¹² Johansson, Nissen, Sturesson: "IT-ism" *Informationstekniken som vision och verklighet*. Telematik 2001, KFB och Teldok, KFB-rapport 1998:11 p. 39.

asking the questions you are still alive and your discourse is still alive and your discourse can take risks and change... and be able to move on” (Stone).

There is an infinite number of questions that it can be interesting to ask in connection with a text, for example: general questions such as who wrote the text and why was it written? What were the motives and agenda(s) of the author(s)? Who were the intended audience, and what effects could the author(s) have wanted their text to have? And why is this story being told and not another story?

In my analysis, I will deal with questions relating to the three focuses I identified in the introduction.

Questions concerning my first focus, women within CS, include:

- How is the problem perceived? The way a problem is perceived, represented or defined does in itself entail delimitations and assumptions. Thus, the problem definition strongly affects the solutions suggested and becomes a limiting factor on the potentials for change (Bacchi 1999).
- How are the causes and consequences of female under-representation constructed in the text and what are the motives for change? Where is the problem located (with women, within the culture, within structures, with men, within the discipline)? Is it mainly discussed in terms of quantity (more women) or do qualitative aspects enter the discussion, and what do they in that case indicate (better science, better education, better situation for women)?
- What solutions are suggested? Is it mainly additional methods: “add women and stir” i.e. a one-sided adaptation on the part of women?
- Can I see tendencies towards essentialism, in the sense that certain qualities and roles are attributed to women and men?
- How is the subject/object relation framed? Who is active and who is passive? Are women present as passive objects for interventions and efforts, or are they constituted as active subjects?
- Are women’s experiences articulated? Starting from the perspectives of women can result in knowledge about women, rendering their experiences and knowledge visible. However, a female perspective can also give rise to negative effects, such as for example by relating women and women’s experiences to those of men, whereby men and their experiences and conditions are reinforced as being the norm. It can also mean that the categories of men and women are oversimplified, so that we end up in a dichotomic deadlock (Mörtberg 1999).

My second focus is to look for underlying views of the discipline and issues of knowledge:

- On what foundation does the text build, for example in its view of ‘science’ and ‘computer science’? Is this foundation ever questioned and problematised or is it perhaps invisible?

- What ideas about theories of knowledge: “concepts of knowers, the world to be known and the process of knowing” (Harding 1986, p. 140) are represented in the text?
- How are issues viewed in relation to simplicity and complexity, paradoxes, contradictions and conflicts? How do norms, values and ideas influence, and is this openly stated or hidden?

Relating to both focuses are questions of presence and absence:

- What is excluded, what is missing?
- What is invisible, but implicitly present, taken for granted?

Is it possible to connect the seemingly unrelated questions of equality and epistemology? Can ideas and discourses that seem to be about equality contain epistemological issues, and vice versa? Questions that I see as connecting equality issues with issues of knowledge are:

- Who is allowed to speak and what is allowed to be said? For whom does the voice speak?
- Who has the preferential right of interpretation? Whose knowledge is reflected in the text?

Drawing on Sandra Harding’s terminology (Harding 1986), I group the obstacles that women face in CS into different levels. I use these levels in connection with how the problem is perceived, i.e. to which level(s) the author(s) primarily refer the problem:

- *individual* - for example female students often have less experience with computers and programming than their male peers when they enter the academic education system
- *structural* - in the form of the structure, curriculum and pedagogy of the education programmes, as well as structures and hierarchies within academia and industry
- *symbolic* - the obvious and strongly male dominated culture within the field as well as prevailing images of men, women and what it is to be a computer scientist.

To this, I want to suggest a fourth level, which also connects the issues of equality and epistemology:

- the *discipline/epistemological level* concerning computer science itself and its knowledge processes¹³.

In the presentation of the analyses below, I have extracted what I deem most interesting in each text and present these findings as themes. These themes surfaced during repeated readings: spontaneous reflections; readings from different shapes;

¹³ I used this categorisation scheme in Björkman 2002. I found that most research identifies the obstacles on one or several of the first three levels. Within gender research in CS, however, several researchers have pointed to the importance of the fourth level.

thinking around discourses, presence and absence; and the explicit questions I have discussed above.

Analysis I

Camp, Tracy, 1997: “The incredible shrinking pipeline”. In *Communications of the ACM*, vol 40 no 10, p. 103-110.

Background

The article was written by an assistant professor in computer science. The main theme is the decline in the number of women involved in CS during the years 1985 to 1995 in the USA. The article tries to establish this as an indisputable fact by analysing statistical data. These data show that the number of Bachelor’s degrees awarded in CS to women decreased, while the corresponding percentages in other science and engineering disciplines increased. This adds to the effect commonly called “the pipeline shrinkage problem”, which refers to the decrease in the number of women in the academic pipeline (the higher up in the academic ranks you go, the fewer women you find). This is also sometimes called “the leaky pipeline”, which implies that women ‘leak’ out of the pipeline at every stage. The author also investigates the relationship between degrees awarded to women and the location of the CS department in engineering colleges, finding that “CS departments in engineering colleges graduate proportionately fewer women on average than CS departments in non-engineering colleges” (p. 107). Towards the end of the paper, the author invites the CS community to respond to an online survey to identify possible causes for female under-representation and asks them to suggest strategies that could be used to attract and retain women in CS. She says she will process and present the results in a forthcoming issue of CACM¹⁴.

The author is alarmed over this decline in the number of women, and she wants the community to respond to the situation. Her intended audience is computer scientists within academia. This article is interesting in my context because it has been widely read and is frequently cited in the community of computer scientists.

How is the problem of female under-representation perceived?

The problem of female under-representation is discussed solely in terms of numbers, i.e. quantitatively. There is no tendency to see women as the problem. In fact, the author does not attempt to locate the problem anywhere at all; it is merely presented as a problem.

¹⁴ This has not been done yet, but the results are available on the Internet (Camp 1998). See also conclusions below.

The author only very briefly touches on the motives for concern (p. 104):

“There are a number of reasons why we need to improve the percentage of degrees awarded in CS to women. In short, there is a critical labor shortage in CS and, although women are more than half the population, they are a significantly underrepresented percentage of the population earning CS degrees.”

Thus, Tracy Camp’s main argument is the labour shortage. This argument implies that women are regarded as a reserve labour force. In itself, this is not a neutral argument: are women a concern *only* in their capacity as a ‘reserve’, i.e. when there are not enough (talented) men? It then becomes a cynical argument, even though it is presented as a completely reasonable one, that points to a (perhaps subconscious) view of women as inferior to men, as ‘second best’. However, I also want to point out that this type of argument does not necessarily reflect the author’s ‘real’ views. For example, she writes: “there are a number of reasons...”. The argument of labour shortage is sometimes used in the belief that this is politically acceptable or neutral. By using this argument, it is possible to avoid discussions concerning equality and gender issues, which are often considered more or less irrelevant by the community. It thus becomes a means to obtain changes that might actually be wanted for other reasons (e.g. equality). So the motive of a critical labour shortage in the field might in this context be used strategically. “We need to keep open the possibility that a particular representation has been selected for purely instrumental reasons, to achieve a particular goal, and has nothing to do with the values of the one making the representation” (Bacchi 1999, p. 9). However, a person invoking the labour force argument must ask her/himself: in what way am I helping maintain and reproduce dominant discourses of ‘non-gendered’ science by using this argument? Can it even reproduce the idea of women as inferior to men?

It is not possible to identify any construction of a possible cause of women’s under-representation in the article, except from the sentence: “There are, however, other factors [than the location of the CS department within an engineering college] that may affect the percentage of degrees awarded in CS to women as well” (p. 108). The author never mentions what these other causes might be. The consequences are merely predicted as bad for the labour market. However, there may be other things going on under the surface – there are some signs of a crack visible in the author’s obvious interest and engagement in the issue.

Neither are any solutions suggested, except that the community as a whole should become involved in ascertaining reasons for the female under-representation and implement the necessary changes. “If we work together, perhaps we can identify and implement the changes that are necessary to reverse the alarming decline of women’s participation in CS” (p. 110). It seems that the author believes that it is possible to find solutions, but there is a hint of caution, in that she uses the word *perhaps*.

As I wrote above, one of the dominant discourses in CS is that more women are wanted. The article supports this discourse, pointing to the “alarming decline” in the number of women. By presenting this simply as a problem that needs to be fixed (thus implying that the community can fix it), and not discussing the issues of *why* or

how, the dominant discourse is also strengthened, since there is nothing that could be interpreted as questioning or criticising either the community or the discipline in the text. This may be one reason why this article has been so positively received by computer scientists.

Neither women nor men are present, they are only discussed passively as abstract entities, as groups and numbers. Because of this, they are not attributed any qualities, essentialist or otherwise.

Quantity/quality?

The paper is concerned with *numbers*, i.e. the inequality in the representation of men and women. It is statistics-heavy, and the larger part of the paper is taken up with data from statistical surveys.

Using statistics can be a natural way for a person trained in science and engineering to approach a problem, but it can also be used as a strategy within the community of scientists and engineers. My experience, which is also shared by others, is that starting out in a 'safe place', using 'data', 'facts' and statistics, serves several purposes. For one thing, it legitimates the project and is a way of gaining authority within the community. It also seems to make the listeners/readers feel secure – they feel at home, they can identify with the methods used and the issues become recognisable. In this way, starting in a quantitative analysis can pave the way for more qualitative, critical issues and discussions. The author might thus use it as a way of reaching the community. (See also "Reflections from the engineer" below).

Science and knowledge: paradigms and epistemology

Although it is never stated explicitly, the traditional positivist ideas of science are obviously upheld and taken for granted. There are no signs of any kind of questioning of the discipline of CS, with the possible exception of establishing that CS departments located within a college of engineering graduate even fewer women than those located within other types of colleges. The foundation is invisible, but still very much present since the article makes no attempt to challenge existing discourses on science in general or CS. Instead, it further bolsters the idea of statistics and measurable quantities as indicators of a problem and as important carriers of information. The prevalent use of statistics can be regarded as saying something about what knowledge is, stating implicitly that measurable quantities represent knowledge.

The author never uses the first person singular: 'I'. Instead, she uses 'we' in many places: "We hope the CS community will become involved in exploring the options and steering those changes" (p. 110). "*We urge the CS community to consider the posed questions and respond to the survey*" (p. 110, original italics.). Who then are the 'we' she uses? Has she written the paper as a representative of a group of people, or is this simply another example of the common scientific tradition never to use 'I' in

scientific articles? (Trojer 1995b). Her use of 'we' instead of 'I' in this way also confirms the existing discourse within science. Sometimes she also uses 'we' to mean the whole community.

The author seems to have taken great care to remain invisible in the article and not to threaten existing discourses etc. This is yet another sign of the underlying epistemology: the invisible researcher confirms the objectivity paradigm, "the god-trick of seeing everything from nowhere" (Haraway 1991, p. 189).

However, 'the invisible author' can be interpreted in another way (this interpretation is commonly given by scientists as the explanation for why they never talk in the first person singular): you should not draw attention to yourself, as that is considered 'boasting', claiming that 'I' am important. This explanation can be seen both as influenced by cultural values, and as a means of maintaining the discourse.

Thus, the article confirms the discourse of 'science as usual'.

There are however some very small cracks in this attitude, in the few places where the author becomes visible and (albeit indirectly) expresses her own opinion. This can be seen for example in the discussion of motives: "there are a number of reasons" and "there are other factors that may affect the percentage of degrees awarded in CS to women as well" (see also *Power* below).

Power and knowledge: who has the right to speak and what is allowed to be said?

The author is very cautious about expressing her own thoughts on the issue of female under-representation. Instead she uses the voice of another person:

"In a paper on women in science and engineering, John White, Dean of Engineering at Georgia Tech Institute of Technology, said: "If we want a different outcome, we're going to have to do things differently. We're making too little progress doing more of the same thing. The time for evolution is passed; it's time for revolution". White requests a revolution to improve on the small amount of progress in attracting and retaining more women in science and engineering over the last decade..."In order to eventually make progress, computer scientists and educators seem to need dramatic change in direction" (p. 109f).

Since she uses this quote, I am assuming that she agrees with the opinion voiced in it: a need for revolution. It is common within academia to reinforce one's own opinion by quoting someone else, preferably someone who is seen as an authority. But Tracy Camp *only* repeats someone else's statement; she says almost nothing herself. Does this improve her chances of being heard? Is she using an authority in the area of science and engineering in order to justify her own opinion, although not daring to state her own opinion explicitly? Is this a careful way of saying that what has been done has not been enough (or is perhaps of no use?), without putting her own position at stake? Is it about who has the right to speak, the preferential right of interpretation (she uses the voice of a man in a high position)? She is an assistant professor, thus she does not have a 'safe' position within academia. This can be

about power in several ways. On the one hand, the (male) dean she quotes has more power, so his words weigh more heavily than hers. On the other hand, she might not want to risk her own position by sticking her neck out. When she speaks with her own voice in the quote cited above, she is more careful: ...*seem to need...* [my italics]. Why is she being so cautious? Is she herself not certain of whether we need dramatic changes or not, or is she navigating dangerous waters?

I see this as one point where issues of dominant scientific discourses on how to behave interact with equality issues, and the issues become intertwined.

However, it is interesting to note that she uses this quote from the dean at all, as this points to a hidden view that she might hold: that there is a need to do things differently.

The community of computer scientists

The only real actors in the article are the community of computer scientists, whom she addresses at the end of the article (p. 110):

"We hope the CS community will become involved in exploring the options and steering those changes. [...] We urge the CS community to consider the posed questions and respond to the survey. [...] If we work together, perhaps we can identify and implement the changes that are necessary to reverse the alarming decline of women's participation in CS."

Here, the community of computer scientists is seen as being able to solve the problem, which makes them feel involved (in a positive sense) and empowered. This is also likely to be one of the main reasons why the article has been so successful.

Reflections from the gender researcher

Many questions come to mind as to the author's motives, and I have discussed most of them above: Why does she use the labour force argument? Why is she so cautious in expressing her own standpoint? Why this excessive amount of statistics? Why has she not included any thoughts at all about the 'why' issues? What is actually hidden behind the text? Why no hint whatsoever at what she thinks should be done? Obviously she is very engaged in the issue, she has gone to a lot of trouble to write this paper, but what are her real motives and interests?

Reflections from the engineer/lecturer

The paper is very well written, with a good foundation in statistics and a good presentation.

To the 'ordinary' computer scientist, it gives the impression of sound research and thus it can be regarded as trustworthy, and it is still eye-opening, because the statistics cannot be denied.

It is not threatening, but invites me to take part in a survey to explore what can be done about the situation, thus I get the feeling of involvement.

Reflections from the project leader/woman in CS

When I first read the article in 1997, I was very enthusiastic about the quotation from John White. In fact, I have used this quote myself many times in presentations on the topic of “women in CS”. I was also very happy about the conclusions at the end and the invitation to the community, believing this could come to mark a breakthrough. To me then, the strategy the author used was completely understandable and ‘correct’. I did not problematise it in any way.

Conclusions

It is easy to understand why this article was so successful in gaining interest within the community of computer scientists. What I find most interesting about the article is how it shows that in order to gain interest, existing discourses need to be adhered to and confirmed, as doing this makes the community feel at home and thus listen. This article does in fact, by its invitation and belief that computer scientists can help solve the problem, strengthen and bolster the community. However, then the problem remains unsolved – if it is necessary to conform to existing discourses in order to make the community react, then it is also more than likely that the solutions presented will be located firmly within existing discourses, thus not providing much hope for change.

It is interesting here to reflect on the results from the survey that the article talks about (Camp 1998). The way the survey was formulated and the issues it focused on helped define the problem and the suggested solutions in certain ways. The reasons for female under-representation, and thus the solutions, are mainly identified on the individual level (role models, mentoring, raising girls’ self-esteem, providing girls with more training with computers, etc). Some suggestions target the symbolical level, but these are noticeably few (classroom climate, nerd perception of CS). The respondents were asked to rank different activities that they believed would help increase the number of women. 111 computer scientists responded to the survey, and the *only* alternative that could possibly be seen as touching on the discipline: “modify curricula” (this alternative should actually be regarded as belonging to the structural level), was regarded as important by only 16% of the respondents.

Thus, the survey confirms that Tracy Camp stays firmly within existing discourses.

Analysis II

Björkman, Christina; Christoff, Ivan; Palm, Fredrik; Vallin, Anna, 1997: “Exploring the Pipeline. Towards an understanding of the male dominated computing culture and its influence on women” in Lander and Adam (eds.): *Women into Computing*. Intellect Books. Reprint in ACM SIGCSE Bulletin, vol. 30, no. 2, June 1998.

Background

This paper was written as part of a project the goal of which was to try to make a study programme in computer science¹⁵ in Uppsala, Sweden, more attractive to female students. At the time, I was a lecturer and study counsellor on the CSP. The project was initiated by me and the programme director (Ivan Christoff). Against the backdrop of our earlier efforts to recruit female students to the programme, we had decided that we wanted “a study of the programme from a gender perspective”¹⁶ (p. 1). For this reason, two Master level students in psychology and women’s studies were engaged to perform the study as part of their thesis work. They were supervised by a professor in psychology.

The paper reports on and discusses findings from parts of the study only (mainly questionnaires completed by male and female students). The main theme of the article is equality issues, but they are treated in a way that challenges the traditional discourse within computer science.

The intended audience was computer scientists. The motive for writing this paper, on my part at least, was to spread information about our results and ideas about the problem of the lack of women in CS. We wanted to promote change, to introduce new approaches, and to make the community consider issues such as culture, which previously had seldom been on the agenda. However, it is likely that the different authors all had different motives, and the Master’s students may well have had other motives (in addition to the fact that they were more or less required to participate in the writing).

I will end this analysis by reflecting back on my role in the project. However, I want to make it clear that in the analysis below, I do not try to separate ‘myself now’ from ‘myself then’, i.e. I have used my experience and memories of that time in the analysis reported here. I believe that knowing how I thought about it then is important in shedding light on it now.

¹⁵ Below and in the paper abbreviated as CSP.

¹⁶ There is no attempt in the paper to define and explain what is meant by ‘a gender perspective’ (note also the singular form!). The most likely explanation is that it is used in order to recognise gender as an issue within the context of computer science education.

How is the problem of female under-representation perceived?

The article confirms the existing discourse that the low number of women within CS is a problem; indeed this seems to be taken for granted. The motives for increasing the number of women are not clearly spelled out, but there are strong indications in the paper that they are equality motives, “a shift in the power imbalances between men and women” (p. 9). In contrast to the article by Tracy Camp, however, this article clearly discusses the issues of *why* and touches briefly on *how*. The problems facing women within CS is seen as mainly cultural, in the sense of the social culture, and is thus localised on what I have called the symbolic level, but also interacts with structures.

“The main focus of the project is the culture, norms and attitudes among students and faculty. We seek to establish how the male dominated computing culture affects both male and female students. If we can understand what norms and attitudes dominate, and why, we believe we can find reasons for the imbalance between female and male students. We realize that these are complex issues, which most likely interact with issues such as curriculum design and teaching methods” (p. 1).

There is a clear standpoint against seeing women as the problem:

“Instead of concluding that the shortage of women depends on their lack of interest for computing, there is a need to go beyond this line of reasoning, asking questions that not only include the female minority, but also the male majority. Through questions of the type: “How do we change ourselves (and the dominant culture) in order to open up for individuals that today are more or less excluded?”, more long-lasting effects are likely to be obtained” (p. 9).

The problem is thus located both within the culture and with men. This also indicates what types of solutions are suggested, although the paper does not clarify precisely what these solutions are¹⁷. Part of the problem construction seems to be the assumption that women are faced with a difficult situation in the programme, that they are more or less subjugated.

Quantity/quality

The article discusses the problem in terms of both quantity and quality:

“The goals are both quantitative (to increase the number of female students) and qualitative (to create a computing culture that is more ‘female-friendly’). We believe that these two goals are strongly connected, since a different computing culture could attract more women, while more women in computing would hopefully lead to positive changes in the existing culture” (p. 1).

Several questions spring immediately to mind here: What exactly is meant by ‘female-friendly’? And why would the education/culture improve with more women? The assumption that changes are automatically brought about when women come into an

¹⁷ The paper presents the results from the study, and these results will, in the next phase of the project, provide a basis for determining and implementing changes (p. 1).

area is dangerous. There is nothing that suggests that the mere presence of women will change a culture, education or power relations; rather the opposite tends to happen – resistance grows. “Universities live under the presumption that changes come about by themselves, if only the number of women increases” (Trojer 1999, p. 13).

Men and women: essentialism and dichotomies?

Even though the authors do not seem to be aware of it, there are tendencies towards essentialism and dichotomies in the article. There is a dichotomy between men and women, where the groups are made rather stereotypical:

“Are there differences in the identification with the role of ‘the computer scientist’? In more general terms, do women’s and men’s different experiences and the promotion of male experience over female experience, serve the exclusion of women in computer science? [...] Thus, skills and subjects considered most important in computer science today are closely linked to traditionally masculine interests in western society. At the same time as attracting men in large numbers to the field, this emphasis excludes traditional female fields of interest” (p. 3).

The concepts of ‘men’ and ‘women’ are used as if they were clearly defined categories. This is also visible in other parts of the text, where the categories are not problematised at all. However, there are some small attempts to break down these unproblematised notions, illustrated by the use of the word ‘traditional(ly)’ in the quote above.

There is an emphasis on the importance of the categories men and women, or gender. It seems the authors stress sex/gender (it is not clear which) as important for the individual:

“By pointing to the importance of individuals, instead of men and women, the obvious power imbalances in the field of computing are concealed. As we all know being a man or a woman is an important aspect of our individuality, and in fact shapes our lives” (p. 8).

There is also a dichotomising between two allegedly different groups of women:

“Among the female students, two groups can clearly be distinguished. Approximately half of them (called group A) seem to have adjusted themselves to the male dominated culture. These women tend to have similar views on equality as the men. They accept the culture and do not feel that they experience any gender-related problems. The other half of the women view their own situation differently (group B). They are more interested in equality questions, and are more positive towards changes in the environment. In addition, they seem to have experienced more problems as women in the computing culture” (p. 7).

This division of the women into two groups is distinct through almost all of the results part of the paper. It also seems that there are tensions between these two groups.

In the questionnaire, the students were asked to take a stand on some claims addressing changes to the education. What can be called 'qualitative change' is represented by: "It would be relevant to have an obligatory course about gender roles in computing" (appendix). Not surprisingly, only a minority (both men and women) agreed with this statement. This is taken as indicating that "ideas for changes to the existing programme have little support" (p. 10). I see the claim about an obligatory course as rather problematic, as it must seem quite provoking in this allegedly genderless culture. Reading between the lines, it can be seen that the answer "yes" to this question would be considered 'the right answer', but in fact, the statement in itself is in danger of simply preserving the dichotomies of men and women, of 'gender roles'.

On the whole, I see many of the questions and statements used in the questionnaires¹⁸ as too simplistic and generalising, even though this was a conscious choice at the time in order to find out if students attribute behaviour to male/female 'essence', or to social/cultural reasons. But what effect does using this kind of statement have? Do they serve to reveal attitudes and ideas within the informants or do they also maintain and reproduce them?

The cause of the problem-challenging existing discourse

In the same way that the article confirms the discourse that few women in CS is 'bad', it also clearly challenges what is implicit in that discourse, i.e. that the problem basically rests with women. Instead, this article confirms another discourse concerning power within academia as well as in the specific area of CS. This is clearly a discourse about 'gender power' and how this structures basically everything. "Taking a gender perspective, we're acknowledging the power dominance of men in the field of computing. This power can partly be viewed as exercised through the overwhelming emphasis on male interests" (p. 3). One way that men maintain this power and culture is by appearing to be free from prejudices (p. 11).

Male power is seen as (one of) the 'cause(s)' of the problem of the lack of women in CS.

"By creating a community of genderless "computing people", where the function of gender and power is hidden, and indeed regarded as irrelevant, women are effectively excluded" (p. 8).

Power dominance is discussed as an ongoing process: "it can be viewed as a constant struggle where the social constructions of computing, technology and masculinity are both resisted and defended" (p. 3). Here, along with the issue of power, the concept of social construction is introduced. There are signs of anger and frustration in this part of the text, while discussing how male dominance is constantly upheld: "Ignored and subjected values and perspectives can therefore [by the use of

¹⁸ E. g. "Men are more efficient computer users than women", "Women are not as ambitious as men", "Men work more creatively with computers than women" (appendix).

flexibility] both actively and indirectly be resisted” (p. 3). Related to this is the idea that women are seen as ‘victims’ of male power.

The solution is seen as disrupting the power balance: “This requires that the dominant group is willing to let go of some of its power, which in turn requires that the existing problems and the responsibility for these, on part of the dominant group, are recognized” (p. 9). The authors and their values are clearly visible, in the sense that they take a very clear stand against male dominance and values. But is this the view of all the authors? It is not the voices of computer scientists that speak loudest, it is a voice from psychology/women’s studies. It is this claimed knowledge about academia and the power imbalance between men and women that is given the preferential right of interpretation, surrounded by minor voices. It also seems to be taken for granted, even if it is discussed, that men hold the power. The voices in the paper seem to speak for the women, but they have taken that right themselves, and decided that the women needed speaking for.

The article claims that women have problems within the culture of computer science, and that this culture is ‘bad’. The results from the study, presented in the article, can be seen as confirming the common discourse on gender and equality within CS: no interest for equality work, individuals are emphasised, women are not interested in CS, quantitative changes (more women) are good, but no (real) changes to the education or culture, a belief in sex differences under the surface, etc. If this is the discourse that the article confirms, it also takes a strong stand against it, wanting to disrupt it, but no alternative is suggested. The “ambition to free students from, for example, stereotypical gender identities ... is usually represented as a matter of doing away with constraints and the negative effects of patriarchy, but not as also a matter of instituting other (feminist) forms of regulation and self-management” (Bacchi, p. 114). The article mostly consists of critique against the prevailing culture, thus making the discourse on equality within CS culture visible, but no constructive suggestions towards change are made. Taking a stand against the prevailing culture means that much is turned upside down. What is usually not allowed to be said is fine in this context, and vice versa. There is a regulation in the text itself as to what is ‘right’.

Active subjects and passive objects

The subtitle of the article is: “Towards an understanding of the male dominated computing culture and its influence on women”. Men, or their computing culture, are the subject, while women are the object. In the paper on the whole, men are pictured as more active, while women are regarded as more passive, as subjugated, or as ‘victims’. This is not explicit, but women are seldom treated as active subjects. There are some very short discussions of what the female students think and their attitudes, and in the conclusion there is a little about their experience.

Cracks

There is a small crack in the idea of gender and equality issues being the most important reason for change, paving the way for larger questions concerning development: "...more important questions here are for example: "What individuals are engaged in the development?", "What does this development look like?" and "What development do we want?" (p. 8).

Science and knowledge: paradigms and epistemology

There is nothing openly in the paper about science or CS. The discipline, including its knowledge processes and paradigms, is absent. It seems that the culture of CS is questioned, but never the discipline itself.

What traces of underlying epistemology can be found in the text? I would point here to two themes: the first one is the emphasis on trying to find cause–effect relations, simplifying, delimiting and defining, emphasising quantitative findings vs. looking for complexity and variations; and the second is the individual knower, stripped of personal traits. I treat these themes separately below.

Cause and effect relations: simplicity and control vs. complexity

There is a clear tendency in some parts of the texts towards a belief in fairly straightforward 'cause and effect' relations – believing that the 'only' problem is to find these causes. This is especially visible in the abstract and introduction. "The main goal of the project is to find explanations for the low number of female students attending the programme, and to identify possible solutions to this problem" (abstract). The phrase "In order to *thoroughly* analyse..." (p. 1, my italics) further illustrates this belief in being able to grasp and control.

In chapter 4.1, the method of analysis is described and the concept of discourse analysis is introduced. In this part of the text, words like 'variation', 'inconsistencies', 'contradict' are used frequently and seen as important for the analysis. It is stated explicitly that discourse analysis firmly rejects "to strip participants' accounts of variation in order to reach some 'hard core' or 'real' beliefs" (p. 5). Instead, "DA will ...be used... in order to catch inconsistencies and contradictions in the discourses and thereby focus the complexity instead of simplifying" (p. 6).

Thus, we notice internal tensions between different parts of the text, tensions that it seems the authors were not aware of. Some parts of the paper deal with finding ways to *define*, *delimit* and *solve* a problem, trying to frame the problem and its solutions according to unwritten, although probably not conscious, scientific rules from natural science/technology, focusing on simplicity and control. Other parts of the article focus on complexity and aim at discussing discourses and taking an active political stand. These parts were written following traditions from social science (psychology). This can be interpreted as illustrating conflicting scientific discourses.

The importance of the individual

There is an interesting discussion of gender and individuality in the text. A quote from one student is used to illustrate this: “No! It is individuals who lead development. Whether the individual is male or female I believe is irrelevant” (p. 8). This viewpoint, stressing the individual and disregarding gender totally, permeates the students’ views as reported in the questionnaires. In the text, the authors discuss this as an issue of power and equality. However, I think that this idea of the individual is also a sign of the underlying epistemology within CS (and most likely science and technology on the whole): the concept of the knower as an individual stripped of everything that makes up the personal identity, such as race, gender, etc. It is, once again, the objectivity paradigm that becomes visible. In the article, it is emphasised that this individual is in fact not at all genderless, but a man, so in a sense the authors are approaching the epistemological question, although this is never quite achieved explicitly, nor is it problematised. I see this discussion of the individual as connecting equality and epistemological issues.

Culture vs. discipline

In the paper, there is a clear demarcation between the *culture* of CS on the one hand and the content and knowledge of the discipline on the other. The only elements that are recognised as connected to culture are “curriculum design and teaching methods” (p. 1). However, the very last sentences in the article show an opening towards other issues:

“In this study we have concentrated on the culture of the computer science program, in the sense of the social context. As Flis Henwood points out¹⁹, in order to transform the gendered relations of technology, we also need to examine technology itself as culture. Technology and gender are not fixed and ‘given’, but cultural processes that interact with each other” (p. 12).

This could open up possibilities for more complex analyses, even though it remains unclear what is meant by “technology itself as culture”.

Reflections from the gender researcher

Much is going on in the text, both in what it says and what it does not say, but there are also many internal tensions in it as discussed above. It is unclear why there is a long section describing discourse analysis, when this method is not really used in the analysis.

Many concepts and words are used without defining what is meant by them, for example ‘culture’, ‘gender perspective’, ‘identity’, etc.

¹⁹ Henwood, Flis, 1993: “Establishing Gender Perspectives on Information Technology: Problems, Issues and Opportunities” in Green, Owen and Pain, *Gendered By Design*. Taylor and Francis.

I also miss many 'why questions' in the text. Many statements are made about the culture and how students view it, for example about belief in gender differences, but there are very few questions or problematisations of assumptions or findings. There are clear simplifications in, for example, the view of men and women. There seems to be very little, if any, reflexivity in the text.

Reflections from the engineer/lecturer

Reading the text from the position of engineer or lecturer within computer science, it is a difficult text, indeed partly incomprehensible, and very critical (which for a computer scientist is a negative word). It is political, and not really 'scientific' or objective. It is difficult to accept that variations and inconsistencies are interesting; the engineer is trained to look for 'the real beliefs' and to gather quantitative numbers. There is an obvious clash between different disciplines and cultures, and the strong focus on power makes the engineer/lecturer feel quite uncomfortable, getting a feeling of being blamed for the problems that women face. Thus, it is very easy to dismiss the article.

Reflections from the project leader/woman in CS

I was enthusiastic about the new approaches and knowledge this project provided me with, and it became a starting point for subsequent work I did. I think the main reason for this was my feelings of recognition. I could identify with the groups of women and with the problems they are struggling with. This paper gave me the chance to be able to integrate my positions, to be able to have the woman in CS with me in the other positions, and it opened the position of project leader. Also, it was the first time I read a text on social constructionism²⁰, and I found it very interesting. It became a key text for me in developing an interest in more complex issues and discovering that there were other ways of approaching the issue than those I had encountered within CS.

At the time the article was written, I found some of the themes in the article particularly interesting, such as the alleged finding of two groups of women. This proved to be the best way to communicate the results to the community of computer science educators. Why? My idea is that this illustrates the same phenomenon as I wrote about above: the need to simplify, delimit and define.

What probably captured me most was the identity problems that graduated women talked about:

"Interviews with female graduates indicate that many of them have gone (or are going) through a process leading to re-evaluation of this adjustment [to the dominating culture] and stressing their femininity. In this process, there can arise a conflict between the identity of being a woman and the identity as a computer scientist" (p. 11).

²⁰ I here refer to the text by Flis Henwood discussed on the preceding page.

I now wonder about the word 'femininity'. It might have been taken from the interviews directly, meaning that it was used by the informants themselves. It seems as if it is used to try to explain something about the women's feelings concerning being a woman, adapting to the male-dominated world, and being a computer scientist.

At the time, I saw this as a serious problem, maybe because I could recognise the conflict from my own situation. I saw the possibility to identify oneself as a computer scientist as fundamental. I saw it as a lived problem, experienced bodily, but *only* as a problem, as something to be solved. Sandra Harding talks about this: "Women scientists often talk about the contradictions in identity between what they experience as women and scientists.... These fragmented identities are a rich source of feminist insight" (Harding 1987, p. 7f.). However, although I obviously saw these conflicting identities as central, I did not realise that they can in themselves be used as an opportunity – that they represent an experience that can be used in the process of change.

The naïve computer scientist?

Finally, I want to be the 'reflective reader' looking back at the 'naïve writer'.

My role was that of the main person responsible for the project. In this paper, I wrote the abstract, introduction and conclusions, while the two Master's students wrote most of the other chapters. However, I participated actively in the writing of the whole text, reading, discussing and working with it. So the tensions I have written about above are tensions between the parts that I have written and the parts that were mainly written by the Master's students.

The text was aimed at computer science educators on the university level. However, it proved difficult to reach this community when we first tried to publish the article. It was subsequently accepted at a conference, which was far more interdisciplinary in nature and geared towards gender research. Later on, however, it was reprinted in a forum for computer science educators.

At the time the text was written, I had only recently started asking questions about the low female participation in CS. I had realised that it was not a problem that rested with women. Nor was it a problem the solution to which was information, so I had tried to reach beyond the individual level, but I was still very much caught up in the idea of a panacea. The first feeling that we needed to go beyond the surface had started to wake in me. I had very little knowledge of feminist theory and practice. I also had clear problems understanding some parts of the text, especially those discussing theory. Particularly difficult for me was the concept of 'discourse'. I did not question many of the notions used, such as culture, identity, gender perspective, nor the dichotomising of men vs. women. My perspective in the text is clearly action-oriented.

Another way of looking at the tensions between disciplines in the paper is to focus on the tension and dichotomy between ‘doing’ and ‘reflecting/understanding’. My goal in the project was clearly to make change happen. I was impatient and very oriented towards acting. This may be a direct result of my training as an engineer, since at least in Sweden, engineers are often characterised as being very good at solving problems. But a problem cannot be solved until it is known! I experienced this as frustration – feeling a deep need and urge to solve a problem that I could not grasp and describe. It was then quite hard to stop, to take a few steps back and start asking the necessary questions – to realise complexity.

This raises the general discussion of theory vs. practice. At that point in time, I clearly emphasised the latter and believed there was a dichotomy between the two. As I see it now, this dichotomy is not relevant, and theory and practice can never be put in opposition to each other, nor do they inhabit a linear relationship, as is often claimed within traditional science. Theory grows out of practice, and vice versa. “...the impossibility in separating theory from practice (empiric). They are mutually overlapping which means that a dichotomic thinking risks to limit and blind us for what is common in them, i.e. to think theory as practice and practice as theory” (Mörtberg 1997, p. 59).

Conclusions

What I find positive with this article is the clear attempt to move focus from women and towards more complex issues. However, it seems that we (the authors) instead fell into another ditch – blaming men. The way the text simplifies and dichotomises risks in fact to reinforce the categories of men and women. I do not deny the existence of mainly male-dominated power structures within academia or within computer science. However, the way this article emphasises male power, can cause effects rather opposite to what was intended. One aim was to point to issues of culture, but this becomes hidden behind the discussion of power structures. Instead of gaining attention and promoting change, the article can just as well trigger conflicts or denial, which will not lead anywhere.

Another problem with the article can be seen in the reflections from the engineer/lecturer above. Parts of the text are clearly difficult for a computer scientist, and it is made no easier by the focus on complexity and understanding instead of simplicity and doing. To all this comes the ‘non-objectivity’ in the article. I think this highlights how hard it really is for a person trained through all his/her school and scientific life in the positivist tradition to rethink or even to understand any other way of reasoning and thinking. What this illuminates is, to put it simply: how can we expect an “ordinary computer scientist” to understand anything at all from texts that try to problematise issues of women and CS, and to reach beyond the simplest additional perspectives? The problem remains: even if it would be possible for gender research to move from “the woman question” to more complex issues, such as culture and “the science question”, how do we communicate this within the community of computer scientists?

Concluding Remarks

These two articles represent very different approaches, and also authors. The first article is written by a professor within computer science. It is clear, coherent and adheres strictly to existing norms within science/technology for how to write scientific articles. It thus conforms to what is well-known, accepted and seen as 'good practice' within the community.

The second article is here quite different. It is written by an interdisciplinary team, indeed including computer scientists, but none of these is professor. Furthermore, two of the authors are students from psychology/women's studies. To this comes that it is not written in a way that is seen as 'correct'. It is partly written following traditions from other disciplines, and it expresses values.

The first article confirms existing discourses, both the prevailing discourse on women and CS, and the discourse(s) on science: objectivity, measurable results and so on. "Exploring the pipeline" is different. It does not confirm to the discourse(s) on science and objectivity. Furthermore, the article challenges the existing discourse on women within CS, by pointing to issues of culture and power, and by taking a strong stand, almost 'agitating'.

The positive effects with Tracy Camp's approach are clear: the issue of "the incredible shrinking pipeline" has gained widespread recognition. It becomes incorporated into the existing discourse on women and CS, since it does not change but merely strengthens it. By not discussing issues of why or how, the author on the one hand avoids too simple problem definitions and solutions on the other hand she does not risk upsetting people. Thus, she balances well. However, the downside is clear: just pointing to a problem is not going to solve it. As we saw in the conclusions from this analysis, apart from gaining much attention, and causing much 'talk', nothing has really happened. And talk is not going to take us anywhere.

As for the second article, there are some clearly negative effects with this approach. By not confirming, but even challenging, almost turning upside down, existing discourses, the article will not gain attention within the intended group. The issue of culture within CS, and the problems women face, could have been accepted, but these issues are hidden behind the strong discourse on male power. This will trigger more conflicts and denials than interest. In a very different way than Tracy Camp's article, this text will neither lead any further.

The first article can communicate within the community of computer science, but it does not say anything about the causes of the problem or what ought to be done. The other article has the opposite problem: it points to issues that can have a negative effect on women's participation within CS, but it is not communicable within the community.

In my opinion, there are connections between the equality and the epistemology issues, and that this can be seen in the texts, for example in the issues of complexity and the individual in the second analysis, and the discussion on power and who has

the right to speak in the first analysis. The connection is also visible in how a text has to conform in order to be accepted.

I believe that these kinds of analyses can be fruitful. They can show what the problems are with different approaches to issues of women and CS, especially if these approaches are done within the community of CS, and are aimed to bring about change. By pointing to the problems behind the representations and their relations to existing discourses, we might be able to gain a more complex and thus better understanding.

References

- Bacchi, Carol Lee, 1999: *Women, Policy and Politics, the construction of policy problems*. Sage Publications.
- Björkman, Christina, Christoff, Ivan, Palm, Fredrik, Vallin, Anna, 1997: "Exploring the Pipeline, towards an understanding of the male dominated computing culture and its influence on women". In Lander and Adam (eds) *Women in Computing*, Intellect Books.
- Björkman, Christina, 2002: "Women and Computer Science". In manuscript.
- Björkman, Christina, Trojer, Lena, 2002: "Computer Science and its Paradigmatic Basis –Broadening Understandings through Gender Research from Within". In manuscript.
- Camp, Tracy 1997: "The Incredible Shrinking Pipeline". In *Communications of the ACM*, Vol 40, No 10.
- Camp, Tracy, 1998: "Survey says! Results on the incredible shrinking pipeline". www.mines.edu/fs_home/tcamp/results/paper.htm (Read 2001-10-10).
- Denning, Peter, Comer, Douglas, Gries, David, Mulder, Michael, Tucker, Allen, Turner, Joe, Young, Paul, 1989: "Computing as a Discipline". In *Communications of the ACM*, vol 32 no 1 p.9-23.
- Ekdahl, Peter, Trojer, Lena, 2002: "Digital Divide - Catching up for What?" In *Gender, Technology and Development*, vol 6, no 1.
- Elovaara, Pirjo, 2001: *Heterogeneous hybrids. Information technology in texts and practices*. Lic. Dissertation series No 01/01, Dept of Human Work Science and Media Technology, Division IT and Gender Research, Blekinge Institute of Technology.
- Gulbrandsen, Elisabeth, 1995: *The reality of our fictions. Notes towards accountability in (techno)science*. Licentiate thesis, division of gender and technology, Luleå University of technology.
- Haraway, Donna, 1991: *Simians, Cyborgs and women, The reinvention of Nature*. Free Association Books, London.
- Haraway, Donna, 2000: *How like a leaf*. Routledge.
- Harding, Sandra, 1986: *The science question in feminism*, Cornell University Press.
- Harding, Sandra, 1987: *Feminism and Methodology*, Indiana University Press.
- Harding, Sandra, 1993: "Rethinking Standpoint Epistemology: "What is Strong Objectivity?" In Alcoff, Potter (eds) *Feminist Epistemologies*. Routledge.
- Hartsock 1998: *The feminist standpoint revisited and other essays*, Westview Press 1998.

- Mills, Sara, 1997: *Discourse*. Routledge.
- Munnik, René, 2001: "Cyborgs for earthly survival?" In Achterhuis (ed) *American Philosophy of Technology, the Empirical Turn*. Indiana University Press.
- Mörtberg, Christina, 1997, "Det beror på att man är kvinna...", *Gränsvandrerkskor formas och formar informationsteknologi*. Ph.D dissertation 1997:12, Luleå University of Technology.
- Mörtberg, Christina, 1999: "Technoscientific challenges in feminism". In *NORA (Nordic Journal of Women's Studies)* Volume 7, Issue 1, 1999.
- Reinharz 1992: *Feminist methods in social research*. Oxford University Press, 1992.
- Stone, Sandy: *A Conversation with Sandy Stone*.
http://proxy.arts.uci.edu/~nideffer/_SPEED_/1.2/stone.html (Read October 2001).
- Trojer, Lena, 1995a: "Teknikvetenskapliga utmaningar inom kvinnoforskningen". In *Viljan att veta och viljan att förstå, kön, makt och den kvinnovetenskapliga utmaningen i högre utbildning*, SOU 1995:11, Utbildningsdepartementet, Sweden.
- Trojer, Lena, 1995b: "Rena och orena fakta, reflektioner kring naturvetenskaplig/teknisk kunskapsproduktion i ett könsteoretiskt perspektiv". In *Häftet för kritiska studier*, 1995 no 4.
- Trojer, Lena, 1999: *Kompetens för ledarskap inom forskningsorganisatoner – en kvinnlig forskarskola för förändring vid teknisk fakultet*. Division of gender and technology, Luleå University of Technology.
- Winter Jørgensen, Marianne, Phillips, Louise, 2000: *Diskursanalys som teori och metod*. Studentlitteratur.

