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WOMEN AND COMPUTING: SOME RESPONSES TO FALLING NUMBERS IN HIGHER EDUCATION

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During the past decade there has been an expansion in computing courses in higher education in the United Kingdom, but the number of women participating has fallen steadily. The nature and image of academic computing is examined, with reference to the mathematization of the syllabus in contrast with the linguistic approach of earlier years, the mechanistic view of computing, and the absence of discussion of social, ethical and legal issues. The decline in number has been marked as a problem by teachers and government, particularly in the context of vacancies in the computing industry. Responses include taster courses for schoolgirls, with the short-term aim of getting more women onto computing courses, and the establishment of a national co-ordinating body for Women into Computing. A radical feminist response argues that computer culture is man-made and that there is a need for an alternative vision. Teachers should review the method and content of their teaching to reflect and change the social nature of computing.

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When I left school and started work, over twenty years ago, the large electronics company which I joined put me in the computer programming section of their research and development laboratory. The office I worked in contained four women, all computer programmers. Our bosses were male but my impression then was that programming was done by women and it was a job which needed linguistic skills. In my second and third jobs, in the seventies, there still seemed to be plenty of women computer programmers and systems analysts - although the office containing no male programmers was becoming scarcer. I moved on to lecturing in computing at a university. One October morning two or three years ago I looked around the lecture hall at a hundred students and realized that there weren't any women in the room - where were they?

In this paper I examine the current position of women in computing degree courses in the United Kingdom. My perspective is a British one but has relevance for computing practitioners, teachers and students in other countries. It is informed by critiques of science as a discipline influenced by social values and relations - science structured by gender, race and class (Keller, 1985; Harding, 1986; Rosser, 1988).

The figures for women entering computing degree courses in the United Kingdom show that numbers have fallen in both real and percentage terms since 1980. Table 1 shows the numbers and percentages of male and female candidates accepted through the Universities Central Council on Admissions system for university entrance in various science subjects for the past decade (Universities Central Council on Admissions, 1977, 1980, 1983, and 1987). The percentage of home candidates accepted for computing studies who are women has dropped from 24% in 1980 to 10% in 1987, a drop in actual numbers from 423 to 193, although the percentage of women accepted altogether has risen in the same period from 37% to 44%. All other science subjects show rises: in Biology, from 47% to 55%; in Chemistry, from 19% to 35%; in Mathematics, from 30% to 31%; in Physics, from 11% to 16%; and in Engineering, from 5% to 11%. Similar data are not readily available for polytechnics, but a recent parliamentary answer revealed that the percentage of home and overseas candidates accepted for computing studies through the Polytechnics Central Admissions Scheme who are women dropped from 23% in 1982 to 17% in 1986 (Parliamentary Briefing, 1988).

The decline in numbers of women taking computing degrees, seen against the background of increasing participation of women in higher education generally and in all other sciences, has been widely observed, and various reasons have been suggested (Lovegrove and Hall, 1987). Perhaps the most obvious reason is gender stereotyping in school and society; research on education in science and technology has identified avoidance of science subjects by girls in school, different learning patterns, girls' unwillingness to make mistakes in public (for example at a computer terminal), and girls' passivity and conformance, as factors influencing girls against computing (Equal Opportunities Commission, 1985b; Kelly, Whyte and Smail, 1984; Ward, 1985). The widespread introduction of microcomputers into schools and homes has coincided with the fall in numbers. Home micros are predominantly the preserve of fathers and sons in the family; they are used by thirteen times as many boys as girls, and in only 4% of the homes do mothers use them. Micros in schools were typically taken first into the Maths department and there were few specialist teachers, most of whom were men. Computer clubs in schools were dominated by boys (Equal Opportunities Commission, 1985a).

At degree level, some of the more traditional science disciplines have been the subjects of intervention programmes with the aim of attracting young women into degree courses and careers in those professions. The Engineering Industries Training Board runs Insight courses for sixth-form girls studying Maths and Physics; the Institute of Physics promotes Women and Physics courses for fourth- and fifth-year schoolgirls.

Computing studies is relatively new as an academic subject. A subjective impression of computing at university shows an image coloured by the language: terminal, hacking, bugs. A visitor to a computing department of a university may find that her first view is of a terminal room where several men are apparently locked into combat with their machines, perhaps in games of destruction and death. To be a hacker is macho: the atmosphere is unpleasant, physically and otherwise. In the microprocessor laboratory there are heaps of unfamiliar spaghetti-like electronics kit with no explanations. The over-riding impression is one of *no women* here.

The content of the computing studies course shows a change in emphasis over its brief history, away from linguistic aspects of programming, data processing and systems analysis, towards more formal mathematical and technical content, while the subject develops as a branch of applied mathematics (Jones, 1988). The change is exemplified by two textbooks, *The Art of Computer Programming* (Knuth, 68), a key text for the seventies, and *The Science of Computer Programming* (Gries, 1981), a key text for the eighties. The shift in viewpoint is epitomized in the titles and the authors' approaches. Knuth (1968) stressed the aesthetics of programming in the opening sentence of his book:

> The process of preparing programs for a digital computer is especially attractive because it not only can be economically and scientifically rewarding, it can also be an aesthetic experience much like composing poetry

or music.

(It is however only fair to point out that Knuth did also emphasize the deep connection between computers and mathematics.) The foreword by Edsger Dijkstra to Gries' book (1981) spells the message out:

> The difference between the 'old program' and the 'new program' is as profound as the difference between a conjecture and a proven theorem, between pre-scientific knowledge of mathematical facts and consequences rigorously deduced from a body of postulates.

The academic image has become less "soft". In reflection of this image, the majority of computing degree courses require an A-level qualification in Mathematics, more as a demonstration of a student's mathematical ability and maturity than a requirement of knowledge of the maths syllabus. I am unwilling to concur with the school of thought that says that the mathematical approach to computing is unappealing to women: both because of a fundamental dislike of the categorization of work as appropriate or inappropriate for women, and because of evidence of the success of other "hard" science subjects in recruiting women.

Another feature of the content of computing courses, and a more serious problem, is the lack of relation of computing to the real world: many course syllabuses show no evidence of attention to the social, legal and ethical issues in the practice and work of a computer professional. There is plenty of material available in these areas. Ethical standards are published by the British Computer Society and the Association for Computing Machinery, the professional bodies in Britain and the USA. The British Computer Society's Code of Conduct (British Computer Society, 1985a) contains six principles covering professional conduct, professional integrity, public interest, fidelity, technical competence and impartiality. The Association for Computing Machinery's code of professional conduct in information processing starts:

> The professional person, to uphold and advance the honor, dignity and effectiveness of the profession in the arts and sciences of information processing, and in keeping with high standards of competence and ethical conduct: Will be honest, forthright and impartial; will serve with loyalty his employer, clients and the public; will strive to increase the competence and prestige of the profession; will use his special knowledge and skill for the advancement of human welfare.

Social issues are addressed in the Association for Computing Machinery's curriculum recommendations which include a course "Computers and Society", described as elementary material to be taken by all computer science majors. The course objectives are to present concepts of social value and valuations; to present models describing the impact of computers on society; to provide a framework for professional activity which involves explicit consideration of and decisions concerning social impact; and to present tools and techniques which are applicable to problems posed by the social impact of computers (Austing et al, 1979). Legal issues of particular concern in Britain include hacking, which although legal is the subject of a legal review, and the Data Protection Act. The British Computer Society specifically looks for content on these issues when considering degree courses for accreditation (British Computer Society, 1985b):

> The Society believes that preparation for a role as a computer professional requires not only a sound theoretical understanding and practical experience, but also consideration of the broader issues of ethical standards, of the legislative constraints within which engineers in computing must work, and of the social and economic implications of computers.

Despite detailed published recommendations, many computing courses apparently ignore social, legal and ethical issues. A random selection of university student guides showed that courses at the universities of Birmingham, Bradford, Cambridge, Hull, Lancaster, Kent and Warwick contain no such content. But Sussex University has a course on Computers in Society, and undergraduates on the software engineering degree course at Imperial College, London have to take a course covering professional standards and ethical and legal considerations.

The prospectuses for computing contained in the student guides share two common themes, the excitement and immediacy of the new computer technology, and the excellent career prospects for graduates:

> The past decade has been one of far-reaching changes not only in the technological advance of computing systems but also in the number and variety of the applications for which computers are used. The ever-growing complexity and usage of these systems have created a demand for skilled computer scientists who can utilize the power and potential of the digital computer by successful software and systems design. (Lanchester Polytechnic, 1987)

> Computer Science is a rapidly changing discipline which affects many aspects of modern life. There is an acute shortage of computer professionals, so career prospects for students following this course are excellent. The course is designed not only to teach students modern techniques using modern technology, but also to develop their intellectual capacity to adapt to the rapid developments which they will encounter as their careers progress. (University of Sussex, 1988)

Some prospectuses fail to mention the word *people* at all. This course is unusual in that it mentions people and does not require a mathematics qualification:

> CS is a discipline which requires a lively and enquiring mind, sound logical ability and a willingness to participate with people from every walk of life in the solution of problems. High mathematical ability is not essential and students with an Arts or Science background are welcome. (Lanchester Polytechnic, 1987)

Perhaps this is because the particular course is offered by a polytechnic which seems to have a more liberal view of computing; the following is more typical of universities' approach, both in the mechanistic view of the discipline and in requirements:

> The Computer Scientist works with machines, problems and solutions: not just any machines, but machines which can store information and perform instructions; and not all problems, but especially those for which systematic solutions can be found. .... Evidence of mathematical aptitude is essential ... Programming literacy is desirable... *Even those with no programming experience* are catered for by the course. (University of Warwick, 1988) (my italics)

The experience of a women student who enters on a computing degree course is typically one of male domination of her academic life by male lecturers, male tutors and male students; the sense of being in a tiny minority of women can lead to feeling out of place and unwelcome. Teaching methods such as a "sink or swim" attitude to programming set students with little or no previous experience - more commonly women than men - at a particular disadvantage. Transfers out of computing courses are disproportionately high among women. At Warwick University, over the last five years women made up 11% of the admissions to the Computer Science degree course and 52% of the transfers out (Dain, 1988b). Reasons given are that the final-year project, typically construction of a software system, is daunting, the subject is boring, and there is too much coursework forcing too much time to be spent at a terminal.

Recently the decline in numbers of women taking up computing degree courses has been identified as a *problem* (Lovegrove and Hall, 1987; Dain, 1988a), and part of the wider *problem* of girls and women in science, engineering and technology. The establishment view of the problem as one for society *and for women* is made starkly plain in an introductory address to a 1984 conference on "Information Technology and the Education of Girls", by the then Minister for Trade, Paul Channon M.P.:

> Unless more girls and women understand and use new technology they and the nation will be poorer ... No society can be complacent if one half of the population is showing a marked tendency not to acquire the skills that are necessary in these areas ... The failure of girls to respond to computers in the same way as boys is therefore a problem. Unless they can be encouraged to take a greater interest, both they and the nation have a problem ... The simple fact is that those who cannot come to terms with information technology will find it increasingly difficult to feel comfortable in modern society. (Equal Opportunities Commission, 1985)

But girls' rejection of information technology (IT) in secondary schools may be seen as a criticism of the subject matter and teaching method, rather than a problem inherent in girls; more generally, the lack of participation by girls and women has its roots in the masculinization of computer culture, a point to which I return below.

There is a parallel *problem* in the supply of qualified people for the computing industry, highlighted in the Department of Trade and Industry report *Information Technology Skills Shortages* (Butcher Committee, 1985). In one week in November 1988 there were 20,000 vacancies in computing jobs advertised in the national computing press. The House of Commons Trade and Industry committee estimates that there are 30,000 vacancies in the field of IT (Large, 1988), and that "serious inadequacies in education hold out little prospect of early remedy - we face a crisis both in quantity and in quality". Four hundred contract computer programmers are flown in from India to help fill the skills shortage in the City of London (and reportedly paid a weekly sum which is just 31% of the going rate) (Schofield, 1988). Is it a coincidence that government is making noises about involving more women in IT and computing, and that companies are looking at their labour force and wondering where the women are? The profile in computing jobs is the familiar pyramid with women occupying the lower-paid positions: 95% of data preparation staff, 18% of programmers, and 2% of data processing managers are women

(Blaazer, 1988). The 1981 Census shows that out of 78,000 economists, statisticians, systems analysts and programmers, 19,000 (19.5%) are women (Equal Opportunities Commission Statistics Unit, 1985).

Many initiatives have been set up recently to encourage women into IT. There are training courses for women only, run by independent organizations like Microsyster and centres like the Bradford Women's Technology Centre, the Edinburgh Women's Training Centre, the Stirling Women's Technology Training Centre. These courses are often supported financially by the European Social Fund, a source of money funded by the European Economic Community which provides money for projects concerning women's education and training in occupations where they are under-represented. The Department of Education and Science, together with industry, is sponsoring a feasibility study on Women and IT by the IT Skills Agency. Several universities and polytechnics have arranged open days and "taster" courses for sixth-form or fourth- and fifth-year girls. The aims of these courses include giving practical experience, careers advice and role models.

Such grassroots activites in universities and polytechnics led to the First National Women into Computing Conference, held at Lancaster in July 1988, followed by the establishment of Women in Computing, a national body whose aim is to increase the numbers of women taking computing degree courses. The conference delegates, mainly women, shared their experiences through workshops and commented on the positive atmosphere at the conference, but found that barriers of sex, age and race formed a common theme. Invited speakers stressed that there is no logical basis for gender stereotyping in computing, IT, or any new field, but acknowledged its existence, citing the lack of role models and the influence of school and family as possible reasons. Delegates were startled to hear one keynote speaker assert that "women are their own worst enemies", and advise a woman in computing to "play the game", be courteous not assertive, dress properly, and never cry, swear or lose her temper. Another keynote speaker stated that there was no discrimination against women in the company she worked for, which pays all employees on merit only; in order to achieve merit, an employee needs to work a ten-hour day, with weekends at short notice, travel a lot, and expect to burn out at forty and retire. Reactions to these speeches include disbelief that such things can be said at a women's conference and rejection of the values inherent in these statements. Who wants to take jobs under these conditions? Many women would rather *change the game* than *play the game.* In education this can mean recognizing emotions and feelings (Griffiths, 1988); including material on the social and political context of computers (Jennings, 1986); using coursework applications of personal interest (Hawkins, 1985; Shipp and Sutton, 1988); encouraging mutual cooperation, support and sharing (Equal Opportunities Commission, 1985b).

Morwenna Griffiths (1988) argues that men have masculinized computer culture and calls for vigilance, subversion and the creation of an alternative vision. The vision is given detailed life in Marge Piercy's novel *Woman on the Edge of Time* (1979), in which two parallel societies have developed their use of new technology in different directions, one for peace and one for war. Sandra Harding, in her study of androcentrism in science *The Science Question in Feminism* (1986), also uses Piercy's vision, to ask what understanding of science we would have if we started with the standpoint of the novel's protagonist, who lives in a culture free of gender. The acceptance of the masculinization of computer culture is highlighted - probably unintentionally - by Joseph Weizenbaum (1984), in his book *Computer Power and Human Reason*:

> That man has aggregated to himself enormous power by means of his science and technology is so grossly banal a platitude that, paradoxically, although it is as widely believed as ever, it is less and less often repeated in serious conversation.

Weizenbaum argues that teachers of computer science must have the courage to resist the temptation to assume that their knowledge is "harder" than humanists' knowledge, and must teach the validity of "softer" knowledge, inviting students of computer science to assess the impact and social meaning of projects in which they engage.

Computers are extraordinarily powerful general-purpose tools, whose pervasive image is as tools for defence and commerce. But they can also be used in projects with greater social benefits, such as writing tools for physically disabled people, seeing aids for people with poor or no vision, signalling systems for rail transport, air traffic control systems for civil aviation. The alternative image is for creation of a better society for all.

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Table 1
Home candidates accepted for university entrance 1977-87

Year	Men		Women		Total
All subjects					
1977	44,857	*63%*	26,721	*37%*	71,578
1980	46,891	*59%*	32,048	*41%*	78,939
1983	40,356	*58%*	29,275	*42%*	69,631
1987	43,911	*56%*	34,433	*44%*	78,344
Computer studies					
1977		*not available*			
1980	1,331	*76%*	423	*24%*	1,754
1983	1,326	*82%*	299	*18%*	1,625
1987	1,659	*90%*	193	*10%*	1,852
Mathematics					
1977	2,410	*71%*	1,002	*30%*	3,412
1980	1,926	*69%*	874	*31%*	2,800
1983	1,944	*67%*	964	*33%*	2,908
1987	1,825	*69%*	824	*31%*	2,649
Physics					
1977	1,882	*89%*	236	*11%*	2,118
1980	2,312	*86%*	363	*14%*	2,675
1983	2,290	*85%*	401	*15%*	2,691
1987	1,977	*84%*	388	*16%*	2,365
Chemistry					
1977	1,936	*81%*	451	*19%*	2,387
1980	1,914	*74%*	666	*26%*	2,580
1983	1,764	*72%*	683	*28%*	2,447
1987	1,620	*65%*	682	*35%*	2,482
Engineering					
1977	9,102	95%	498	*5%*	9,600
1980	10,050	93%	787	*7%*	10,837
1983	8,158	90%	912	*10%*	9,070
1987	8,517	89%	1,091	*11%*	9,608