

Rocket science or social science? Involving women in the creation of computing

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INTRODUCTION

Female scientists and social scientists from eleven countries, and representing many of the key professional bodies in computing in the world, came together in June 2004 at the Oxford Internet Institute to review the position of women internationally in the computing professions in an all-day forum entitled "Women in Computing Professions: Will the Internet Make a Difference?". Countries represented were Australia, Austria, Canada, the Czech Republic, Germany, Norway, Pakistan, South Africa, Turkey, the UK and the USA. No one was able to tell a story of burgeoning uptake among women in their country of work; in fact the stories were mostly of falling percentages of female participation.

Nonetheless, the meeting came to see itself as part of a new wave of initiatives aimed at tackling this lack of representation by joining up schemes and connecting individuals. And the work that forum participants shared during the day was indicative of how much is being undertaken at different levels in society to resist the current trends.

The main argument of the day hinged on whether the issue was one that could be solved by generating new solutions (rocket science), or whether solutions were known, but a lack of will had resulted in poor implementation. Could working through existing solutions with the combined weight of professional bodies worldwide address the issue meaningfully? Maria Klawe, president of ACM (Association for Computing Machinery), and Dean of Engineering at Princeton University, argued that the knowledge exists about what to do but that it would take time and money to do it.

Wendy Hall, president of the BCS (British Computer Society) during 2004 and Professor at the University of Southampton, was more impatient: 'I've tried all these things. How much money and how long will it take to really make a difference?' she asked.

In fact, as Teresa Rees, professor of Sociology at Cardiff pointed out, social science research suggests that implementing equal opportunities is 'rocket science' in the sense that it is a complex and multi-faceted issue, involving multiple layers of society and many interacting policies and practices. It is far from tractable to one-off solutions. The unspoken question of the day was, then, how much worse might the situation be without the work that has been conducted and is continuing to support those women who do want to train and practice in computing.

Participants discussed whether it is important to have a gender balance throughout the whole IT development process or just overall within the industry. What emerged implicitly was a desire for women to have more influence in the industry, more control over the kind of technology produced and an easier passage as practitioners and researchers in the domain.

As part of achieving this, the group set out to address, first, the impact of the Internet and, second, the role of professional associations. This exploration of the impact of a technology drew attention to the impact of technological changes in general, and then to the issue of whether any technological change alone is going to make a difference.

Looking back to the take-up of personal computers, Wendy Hall demonstrated that the marketing and introduction of PCs to schools in the 1980s had a major impact on the gender divide, but a negative one. Looking ahead, she advocated putting in effort now to prepare the way for a more balanced contribution to what is expected to be the 'new' computing: large interconnected systems with a myriad of smaller components, which behave more intelligently as a whole; an increase in courses that incorporate computing and another science, such as the one planned at her own institution involving biology and the study of complex systems. This, she felt would be more attractive to women than the current focus is proving to be. She suggested:

- Let us focus our efforts on the ten year horizon rather than the computing industry as it is today.
- Let us ask what skills the computing profession will require then.
- Let us make sure we don't repeat the mistakes of previous generations.

However, her optimism about the potential to use new technologies to change the status quo did not go unchallenged. Analysis of the social effect of the Internet showed there has undoubtedly been a significant impact on the gender balance with the rise of networked computing. For instance, the Internet has eliminated gender differences in access to domestic information technology in the United States. US census data for 1989, 1993, and 1997 (Anderson, Bikson, Law and Mitchell 1995; Bikson and Panis 1999) shows that during the period represented, the gender gap in access to a home computer disappeared entirely. And, by 1997, the gender gap in use of email and network services had narrowed to one percentage point. The Economist (May 15–21 2004) reports that, in the United States, women now outnumber men online. And one can attribute the increased uptake of computers and network services among women in the 1990s to the Internet, because of the motivating role of communication, which is widely cited as the leading influence on IT use.

However, while it would be reasonable to think that increasing access to, and use of, information technologies, over time might lead to increasing numbers of women in the computing professions and a decreased gender gap, this has not been the case. Through the 1990s the figures for women in computer science (CS) and computer engineering (CE) stayed static at approximately 19% average in the States, and has since been worsening this decade. Hidden in these figures is a rise in international women studying computer science and computer engineering. What foreign students may see as a passport to a good job, underscores poor performance at recruiting and retaining US women.

These figures are typical, or better, than those for many other industrialised countries. Thus, it seems that women, while well represented among consumers of IT products and services are significantly under-represented among those who contribute to their invention and development. And new technologies alone will not change the employment picture.

If the situation is as complex as this, what may the professional organisations do to improve upon it? Clearly, their involvement must be part of wider movements in society, but as a major influence on the initial training and subsequent development of people in the industry, they are gatekeepers to good practice.

Professional bodies (both 'official' and less formal interest groupings) are important in defining an industry's practices and creating a sense of identity. Such value systems and sense of identity are not primarily conveyed through formal instructions. They are rather learned as one becomes increasingly a member of a 'community of practice' (Wenger 1998). This perhaps raises the possibility of a different way of improving the context for women in computing from either the individual mentor or the top-down, management-led equality policy. Communities of practice might be seen as unlikely change agents since their primary role is to sustain an existing identity and set of practices. However, such continuity is challenged both by changes in the body of knowledge which constitutes the profession's domain and by members who are simultaneously members of other communities of practice, or bring with them differing perspectives based on their social group membership. In this respect, the professional associations represented at the forum might be seen as very well placed to consider and effect change.

CHALLENGING THE STATUS QUO

With the rapid development of new kinds of networks – both the Internet itself and the new groupings enabled by the Internet, the Oxford Internet Institute identified a need to address the impact of these trends on women in the computing professions. This one-day forum was a step towards doing this, bringing senior women in the computing industry and those whose role is to research gender and computing issues, together to explore the state of the industry in the early 21st century. That the discussions of the day ranged widely and did not always address the topic in its narrowest sense reflects the fact that, while the Internet appears to have had some impact, especially in terms of connecting women across companies and continents, little research exists into this area and far broader anxieties dominate the gender agenda. The first section of this report looks in more detail at the reasons for the forum and gives a short background to the day.

Facts and Trends

Women's participation in the computing professions is low worldwide. For instance, the average intake into Austrian universities is about 10% female, and in the States participation runs at about 14%. In Eastern Europe, it is currently as low as 5%. In Australia, only 21% of the industry's positions are held by women, while at Microsoft less than 10% of software developers are women. The reason for the poor representation of women is acknowledged to vary between countries, but similar effects extend globally to produce a clear trend. Women are not going into computing as a career in the same numbers that men do.

For those women who venture in, the prospects are stacked against them. Particularly in Europe, the gender balance is worse the higher up in senior management you look. In many areas of the world, a disparity exists between pay rates for men and women undertaking the same work within the industry. And, as a worldwide trend, the number of women involved in the industry has declined from the early days of computing, despite increasing equality for women in other areas and increasing representation in professions that were traditionally seen as male strongholds. Typically, there has been a steady decline in the percentage of women in ICT branches of study. In some cases, a change in culture has made the fall more dramatic: at Czech universities, the number of women was three times higher some twenty years ago. Meanwhile the computer industry has developed a 'geeky' image.

More than twenty years of equality policies in some countries¹ has had, at best, a limited impact on the recruitment, retention and promotion of women in IT occupations. And bringing women into science education does not guarantee that the figures will improve. In the UK alone, it has been calculated that there are 50,000 women with science, engineering and technology degrees (including computing) not using their qualifications. Later sections of

¹ such as Britain, the US and Scandinavia

this report review some of the many initiatives being pursued to tackle this failure of recruitment and retention.

Women's increasing engagement with computers as users has not been accompanied by a parallel increase in the proportion of women studying for and working in computing jobs. Hopes that the Internet and mobile phones – both, in general, now used by women in equal numbers to men – would level the playing field have not proved grounded. Women seem inclined to regard these technologies as enabling tools for communication and the execution of other goals, rather than interesting objects of study in themselves. So, while the ever changing nature of technology itself is, no doubt, introducing new challenges, and therefore demanding new strategies, it would appear that the discomfort and indifference that many women feel with technology persists.

There is some evidence that with the emergence of new areas of teaching and research relating to computing, telecommunications, information management and the use of ICTs in more walks of life is attracting a growing number of women. One example is the merging of former schools of library science with computing into new schools of 'information studies' or 'library and information systems'. Another is the development of programmes in 'informatics' – again finding more women among students and faculty than is typical of the more mainstream computer sciences. This indicates that women are moving into the study of topics closely related to computing and computing professions, but not through the traditional paths of mainstream computer science. But, though there are now colonies of women in new disciplines such as web design, most programmers - at the 'heart' of what computer scientists see as the development process - are male.

There are many people who believe there should be diversity and balance in the IT workforce. One argument has it that women can bring a different perspective and alternative skills that will help create better systems for all. Others argue that women are increasingly frustrated with using systems that have been created by people who do not understand their requirements.

There are specific economic, as well as social, reasons for continuing to look for ways to address the imbalance in gender representation in computing. In Europe, for instance, the labour supply is both shrinking and ageing. More specifically, the projected numbers of new graduates entering the labour market with science, engineering and technology degrees, including computing, are insufficient to meet demand. Women have been identified as the major supply source to make up for this deficit and allow the European Union to meet its targets for increased R&D spending, both by the EU and by major R&D companies.

The forum and the paper

The OII hosted a lecture on "Women in Computing Professions: Will the Internet Make a Difference?" on 17 June 2004, followed by a full day forum on 18 June. This forum discussion paper is based on the issues raised at these events, organised by Professor Ursula Martin, Oxford Internet Institute (OII) Visiting Fellow and Chair of the Women's Committee of the ACM, and her

colleagues, in collaboration with the British Computer Society and the ACM (see Box 1). The forum was deliberately a collaborative, multidisciplinary effort, bringing together senior women from the social, as well as the computer, sciences and representing more than 10 nations, to find contemporary answers to the challenge of recruiting and retaining women.

Box 1. The key players

ACM: The Association for Computing Machinery (ACM) is an international scientific and educational organization dedicated to advancing the arts, sciences, and applications of information technology. With a world-wide membership, ACM is a leading resource for computing professionals and students working in the various fields of Information Technology, and for interpreting the impact of information technology on society. ACM is responding to the increasingly powerful effects that computing and communications are having on the way the world works by extending the Association's influence and expertise into matters of public concern and policy.

ACM-W is the ACM committee on Women in Computing. It celebrates, informs and supports women in computing, and works with the ACM-W community of computer scientists, educators, employers and policy makers to improve working and learning environments for women. It runs a number of initiatives and has provided inspiration for a number of women's groups in professional associations worldwide.

BCS: The British Computer Society (BCS) is the industry body for IT professionals in the UK, and a Chartered Engineering Institution for Information Technology (IT). With members in over 100 countries around the world, the BCS is the leading professional and learned Society in the field of computers and information systems.

BCSWomen is an active and lively specialist group that provides networking opportunities and support for all women working in IT around the world. The main point of contact for all members is the egroup which lends itself well to national and international networking. The group has several objectives such as mentoring and encouraging girls/women to enter IT as a career. Several members have secured new positions in the IT sector after support and advice given via the egroup.

As already noted, the women were largely drawn from the professional associations that support the computing industry throughout the world and this is reflected in the perspectives taken. Meanwhile, the analysis in this document is necessarily limited, for it remains the output of a single day and must be viewed more as a statement of intent and a 'to do' list, than a set of guidelines. The purpose in producing this document is to

- celebrate and connect a number of successful initiatives taking place worldwide,
- recognise areas of ignorance in the field and the differences in opinion that exist about the most effective approach to take,
- offer some thoughts for ways of extending this work, and
- provide a starting point for further discussion with any women and men for whom these issues have resonance.

The paper quotes participants' discussions extensively. The initials that follow speakers' comments are attributed to their owners in the second appendix.

DEFINING PARAMETERS

Although the original motivation of the day was to inquire as to whether the Internet has a relationship with trends being seen in education and employment of women, the outcome was a much broader discussion.

While both education and professional take-up were considered during the day, the emphasis rested upon the former, with the nature of education, educational opportunities and the skills and representativeness of educators given particular scrutiny. Participants regarded this area as more influential in the long term and less well reviewed than that of initiatives in the workplace. It also reflected the make-up and interests of the participants, many of whom work in academia as well as professional bodies where part of the brief is to consider the training that supports the profession.

Scope

'Women in computing professions' was taken to encompass both research and teaching institutions, and industry, but this still left much open. For instance, how far should the study for or pursuit of a career in 'the computing professions' be extended? Should IT technicians and web designers be included, or seen as related professions that have a different success rate in recruiting and retaining women when compared to mainstream computing? Developments with the Internet have changed the industry, but the question was raised as to whether these were relevant to getting women into the core of the development process. The forum represented academia and industry from around the world, reflecting regional differences in organisational structures, experiences of the problem, and ways of thinking about the issues. This, and the ill-defined boundaries of the profession, led to a swift agreement to live with the blurring. But some distinction was felt to be needed about the kinds of role that women play in the industry. As noted:

Gender diversity can happen in the design team at large, or, more narrowly, within the software engineering area. (WD)²

First expressed as 'hard' versus 'soft', to distinguish between the coding and engineering core of computing, and the attendant business, aesthetic and social positions supporting the core, this was rejected by a number of delegates:

Can we reflect on our language a bit – hard and soft? Can we use the real terms? The use of 'soft' conveys the view that design is wishy-washy, not serious or important. (SL)

Reframing the distinction clarified the issues at stake:

I think it is important to distinguish between technical professions that create intellectual property versus those that consume it by way of using applications. In the

² Initials correspond to names in the delegate list, in the second appendix.

creation of intellectual property, there is a lot of room for future work in a diversity of professions. The intellectual creation side does give you more power. (TB)

but did not resolve the dilemma as to whether the goal of introducing more women into computing was to permeate all areas of the industry, or to produce a better representation overall. It was noted that there are power distinctions perceived between the different roles and that challenges exist in getting mutual respect and meaningful collaboration established in multidisciplinary teams. It was acknowledged that these last issues only related to gender in as far as women are better represented outside the core programming areas, rather than within it.

More generally in defining the scope of the gender issue, it was also pointed out that it is often only possible to talk statistically about 'women in science' because information on 'women in computing or computer science' is harder to come by. And data is not always inclusive: for instance, the number of PhDs in computer engineering is relatively easy to establish, but this would not include IT in business schools.

Further complicating a simple reading is the way that computers have become pervasive in more than one sense over the last couple of decades. There are, for instance, new domains where computing is inextricably mingled with another discipline, such as computational linguistics and medical informatics. And many professions have come to depend on computation: industrial design, commercial art, geology, seismology, land use planning, environmental protection, and scientific visualisation are among the examples. It is possible that traditional assessment methods may underestimate the presence of women in the computing professions.

Another problem with categorisation was acknowledged to be the rapidly changing nature of the industry and, thus, the courses feeding it:

What might have been an IT profession five years ago has transmogrified, been added to and modified, and that will continue to be so. I think that dynamism is something we have to keep hold of in our minds if we try to pin this down. (JW)

ATTRIBUTION

Why is there a significant difference in most countries in the world between the number of women and the number of men going into computing? Some participants in the forum believe the reasons, and even the means of addressing them, are well known, and lack of political will and other social and economic constraints prevent these solutions from being pursued. Others believe that not enough is yet known about the enablers and constraints. Some went as far as to challenge the sacred 'truths' that have informed 20 years of action on women's representation in computing, suggesting that we have instead learnt that:

The symbolic association of computing and masculinity was never the principal deterrent to women entering these areas. Clearly, though, the image of computers in the consumption sphere and the types of use that girls and women are making of them does not translate straightforwardly into perceptions of IT and experience of learning about and working with the technology. (SL)

Regardless of these divisions, the forum began with a consideration of the causes of women's poor representation. In doing so, various factors were identified and one point was agreed: that apparent solutions have done little to change the situation.

Though disagreements and differences in theoretical standpoint surfaced from time to time, there was little formal discussion of the matter. The next section examines the main area of contention that did arise – over the issue of women's agency and perceived agency.

There was also a comparison of conditions in different national and regional cultures. These are presented below. However, it was noted that framing the issue as a matter of national culture or of individual choice can be seen as representing two extremes of the 'there is nothing you can do about it' argument. The scope for policy and initiatives comes in the space between the two, where one can see how organisational cultures and support systems can be changed to change the context within which people are making their choices.

Framing the issue as a matter of choice

One of the few theoretical disagreements to arise during the course of the day was over the nature of women's agency - and sense of agency - in their career paths. The argument focused on the appropriateness of using the construct of 'choice' as a way of framing the behaviour that the forum was investigating and hoping to change.

Should we not create a world where girls see the possibilities? I believe that we should cherish the ability to reason, use reason, and solve problems. (OS)

This is apparent in the next section, where descriptions of national and regional variations use a discourse of choice. Consider the young women of

the Czech Republic who have opted to study humanities and social science subjects now that they are again politically available to them. Or the Americans at Carnegie Mellon University who abandon their computer courses when other women feel compelled to continue them. Or, indeed, the women of South Wales who puzzled the researcher when they could not conceive of choosing.

And in the introduction to the day, choice was highlighted as a significant behaviour, among others:

The choices women and girls make not to go into computing professions, which might not be a matter of being excluded but that they self-select out. (WD)

But this framing of women's behaviour met with some opposition as it was seen to put too much onus on women.

A lot of the initiatives in various countries in the 1980s and 1990s seemed to ask why women did not realise this is the best thing for them. Why do they not realise that engineering is wonderful and not an 'oily rag' profession? It is the idea of blaming the victim. I think women are quite smart in the decisions they make in that they know there are certain cultures that are very masculine in their orientation; they are very geared to people who do not have to balance work with other kinds of things, and they choose not to do that. The emphasis needs to go away from the 'victim' towards looking more at the organisations and cultures and encouraging them to take more responsibility. (TR)

The discussion continued to centre round the notion of real or forced choice. Participants who dismissed the construct of choice did so on the basis that women's choices were limited and that the cultures they lived in presented only certain options to them. It was not seen to be an adequate portrayal of the problem to be discussed, and yet, choice was acknowledged to be a large part of why individual women were or were not involved in computing. The degree to which women more generally were able to exert agency, or perceive themselves to have agency, over their lives was agreed to be one more cultural factor varying by region, age and class.

At heart, this debate reflected the participants' concerns about assigning accurate responsibility for the state of computing and women's interest in it. The idea of choice was emotive. But, finally it was agreed that there were many choices of interest to the group: not least why women choose to enter computing professions; and why they choose to leave them again in their 40s and 50s instead of applying for senior jobs.

At the same time, there was an acknowledgement that their choice often amounted to 'take it or leave it', since few individuals had any significant power to alter their work conditions. Indeed, the situation is worsening as the IT sector becomes more homogenous:

You are confronted in the IT sector with a growing predominance in many countries of large multinationals and, at the same time, a few small players. That means that the kinds of initiatives being mounted and the experience of women IT professionals – or those women attempting to enter, considering entering or are in the labour market for entering – are becoming increasingly similar across countries. In a sense,

there is a lesson for the way in which we can exert levers over corporations and their behaviour and the way women's choices are constrained by the reality of the nature of work in the sphere, which I think is becoming increasingly similar in more countries because of the predominance of large companies which operate in much the same way. (JW)

The complexity of the interplay between opportunity, environment and choice went on to be the focus of the rest of the day. The main point to be stressed here was that it was decided that choice could not be considered without some reference to the culture and other contextual factors which constrain the choices that women feel are open to them (and whether they were able to conceive of themselves as having agency or not).

National and regional variations

In all, women from eleven countries were represented in the forum: Australia, Austria, Canada, the Czech Republic, Germany, Norway, Pakistan, South Africa, Turkey, the UK and the USA. So, in addition to a large British contingent and a dominance of Europeans and North Americans, there were three participants from developing countries. Several participants brought knowledge about other cultures.

The forum was, in part, a move to take a global view of the situation: developing networked and international responses at a level at which individuals and organisations can make a difference.

When you put together the international flow of students and consider how computer science departments are depending more on students from abroad, and put that together with the difference in national resources, it surprises me that we still think about this from a national perspective and not about the global interconnections. (WD)

However, national variations in societal structure, education, work context, women's attitudes, and representations of the industry meant that participants recognised differences as well as similarities in the situation in different parts of the world. Information about national variations took on significance in looking at the obstacles and opportunities involved.

The following descriptions all refer to the situation from a national or cultural perspective. Box 2 features descriptions of countries where the number of women in computing is, or has been, higher than average. In one case, a cultural norm changed abruptly: Germany and Austria are still recruiting senior female academics from what was Eastern Europe; there are many more available as role models than in western universities. But the ratio of women in computing in Eastern Europe worsened dramatically with the breakdown of the Soviet political system. In Czechoslovakia (now the Czech Republic and Slovakia), the new freedoms brought with them a change in what young women would study.

A longitudinal study of all women doing undergraduate degrees in computer science at Carnegie Mellon University (CMU) in the States revealed a cultural

trend: at the time of the study, most of the women who started and stayed in computer science were immigrants to the US.

Box 2. Countries with an untypically high percentage of women in computing

Source: participants at the OII Women in Computing Forum

Malaysia: 'In Malaysia, women outnumber men in most informatics studies throughout many universities. At the University of Malaya, over 50% of the students are women; the staff are predominantly women, and the dean and heads are women. Very many of the women associated with computing and computer science are becoming teachers, which has traditionally been a very female profession in Malaysia. In that sense, computing is looked upon as a suitable career for women because it involves flexible working hours - especially teaching at a university. It combines well with having a family. It is also a very well-paid, secure job. It is very popular. The government has worked quite aggressively on ICT in Malaysia as a way to leap-frog into the information society, as many other Asian countries like Singapore and Taiwan have done. They had projects to establish computer clubs among younger people. The older students I have talked to did not have much previous knowledge about computers, but some joined these computer clubs; some have computers at home and in schools. It simply was not looked upon as a boys' thing; the girls participated and thought it was interesting. Some of them decided early to pursue an education in computer science. Some of them had the notion that boys were more interested in computers or programming and spent more time on it, but it did not matter. That was not an obstacle, or the same as having a career in computer science. One said that she had no previous knowledge when she entered university; she just had to work a bit harder, but she caught up.' (VL)

Qatar: 'In that country, girls are the ones thought of as having the brains; boys do not do very well in school. There, the stereotypical image of the boy is of someone who wants to join the military or be in the police force. Girls go into biotechnology, computers and information technology; everyone thinks of them as being more capable and motivated. Of course, they have strictly gender segregated education; perhaps this would go away in a mixed system. I have not become very familiar with the culture yet, but that is one of the most salient things I have noticed when I am interviewing people.' (TB)

The Czech Republic: 'At the time I was studying, there was no barrier for women because there was a negative influence from the political right. If you were not politically correct, you were not supposed to study a humanistic subject. For the girls, there was a glass ceiling in the direction of humanistic education. It was not so in technical subjects, so there were more girls going into technical and scientific fields. However, you see now that this does not reproduce itself. From the beginning of the 1990s when the field opened, girls again were choosing a humanistic education. When I studied, we had a quarter of girls studying technology, natural history or physics, while now our technical engineering faculty has 5% girls. Mothers, aunts and other role models of my age are available, but they are not accepted. None of my daughters decided to follow a technical subject because they think I work so hard. They decided on medicine and law because they thought it would be easier.' (OS)

It was not that they found computer science easier, more attractive or more enjoyable than the women from North America who chose to leave the programme; their

families expected that they would work hard to succeed, and the fact that they did not particularly like some of the aspects of it was not something that would cause them to think about leaving it. (MK)

Imported cultural values and the pressure on immigrants to make good in their adopted country could both be cited as reasons for the difference between their behaviour and mainstream behaviour, which found young American women who began computing courses were inclined to leave them when they discovered that they didn't enjoy the work. In Pakistan, by contrast, local women tend to see their studies out, finding their own value in doing so:

All the women who have gone into computer science programmes tend to follow it into the industry and then stay in the industry. They are not kept out. However, most of them go and look at areas where it is going to help their communities and take subjects in the social sciences and try to combine the two things. That is where I find that there is a difference [between female and male uptake]. (JA)

Box 3. The Chinese delegation

Source: Maria Klawe at the OII Women in Computing Forum

'We were visited by a delegation of principals from 27 women's colleges in China, which historically has separate colleges for women. When I raised this question initially, they quietly discussed it and answered that there was no gender discrimination whatsoever; women participated as much as men. I continued with the presentation and asked the question a second time, but I asked them to think about the jobs that women computer programmers and computer science graduates went into and the ones men went into, such as management positions and leading technical positions in companies. This time, there was clearly an argument. The interpreter told me they did not agree. The third time, I asked something about how we educate men and women, whether they have different learning styles and if they are more interested in applications rather than the technology itself. After 10 minutes of strong discussion, the answer was that they decided there were differences, but they had never realised it. It was clear that when they started the morning session, they were convinced that there were no differences whatsoever. When I started to push them into examining things, they unanimously came to the conclusion that there were significant differences and none of them had realised it. Politically, it probably was not correct for there to be differences, which is an issue.' (MK)

And reasons vary, more or less subtly, for rejecting computing as a career, long before a woman might consider enrolment on a relevant course:

My research in South Africa has given some indication that girls may enjoy these things [using computers, etc], but they do not see them as serious. They do not link that to computer science. They know women who use computers and they see them using applications, but they think it is not a serious thing to study; they do not even see the gap. Computer science and the computing professions struggle with the general image: people do not see the difference between using a computer and doing research. It is very compressed. Why should girls go to university to learn to use a computer? They have done that at school and do not understand the space. (VG)

Especially in countries where equality is a widely shared value of the society, it may be difficult for people to acknowledge that there are differences

between men and women in relation to computing. Box 3, on the Chinese delegation, captures one such situation.

However, awareness of the issue and even concerted attempts to change practice, doesn't necessarily lead to improvement:

There is a tendency in European policy writing to point to the Scandinavian countries and welfare states that are good at prosecuting gender equality policies. I found surprising, not so much the example of Malaysia, which was very interesting, but more the rather depressing picture painted of Norway: despite the government interventions; despite the gender awareness at state level; despite, by British standards, social policies that are streets ahead of anything we have; and general efforts to integrate women more fundamentally into the labour force. I think it is true in Finland, as well, that the proportion of women represented in the IT profession is actually declining. It must tell us something about the role of top-down, government-led initiatives. (JW)

And in Britain, awareness programmes have not much effect over the last 20 years. The numbers of women entering courses has fallen too.

Indeed, Britain, a very diverse society, might best be seen as a range of regional, ethnic and class-based cultures, all with a discrete relationship to choice, ambition and acceptability of deviance from the norm. These intra-national variations need attention too in developing a global response.

I did a study of 2,000 South Wales schoolgirls who attended a careers fair for girls. The girls met 50 role models of women doing jobs normally being done by men. There were a lot of engineers among the role models. The girls kept asking: 'Are you really an engineer?' They said: 'Well, yes, that's why I am here. Why do you ask?' The girls would say: 'Because you have a handbag'. (TR)

The same example shows that prejudices have a longer term corrosive effect:

We asked them six months later to remember as many of the role models as they could. They met and talked to an airline pilot, but they wrote 'air hostess'; they met a bank manager and they wrote 'bank teller'. Their minds reconstructed the evidence of their own eyes within a period of six months. When we asked them about their ideas for future career trajectories, it puzzled them that this was something they had choices about. They did not construct it in that way. That this was a working class area in South Wales with high unemployment has to be added in, but I do not feel, in the research that I am familiar with, that girls or women have a concept of choice or agency at all. (TR)

It was agreed that culture could be a significant factor influencing women's interest and opportunity in IT, in particular, the effect on women's motivations and behaviour.

Knowing enough to solve the problem

Having identified the two aspects that appear intractable, personal choice and national trends, the other concern to surface was whether enough is known about how to improve the situation. It has been noted already that there was a

split between those who regarded the solutions as apparent but the will lacking and those that felt new solutions are needed. It has also been mentioned that not all the relevant data needed to assess the situation is available. Forthcoming were also suggestions about knowledge needed to inform the development of suggestions. For instance,

We do not have a global perspective on the flow of computer training and jobs and how that mixes in with gender shifts. (WD)

In terms of what has been attempted, there have been surprises and disappointments. Government initiatives have not been effective in changing the trend of falling contribution by women in northern Europe. In fact, the placing of computers in schools in Britain, which was an initiative expected to inspire greater interest in computing, actually corresponded with a general downturn in applications for computer-related subjects at universities.

There were some differences of opinion about the effectiveness of proposed solutions. In particular, at a macro level, suggested solutions to one aspect of the problem were seen by other participants as aggravating other aspects. At a micro level, participants reminded themselves repeatedly that women are a heterogeneous group, with different interests and needs. And the difficulty of fighting with something entrenched in the culture in multiple respects was touched on:

When you are trying to clear the jungle, if you do not keep at it all the time, the minute you take your eye off it comes back again. It is still there, and that is the main culture. (WH)

In looking at what has proved effective, both in computing and elsewhere, with the intention of spreading good practice, it was noted that it is all too easy to see and adopt the outward aspects of a scheme's success without recognising what interplay with culture and organisation made it effective:

It is important to go behind things and understand why they were successes, which we do not always do. We say: 'This got lots more women in', and somehow assume that people can copy it. We need to understand why that was successful in that context and how you might replicate it rather than assuming the formal details are what were important; often they are not. (SL)

And it was suggested that the problem is exacerbated by the nature of the industry involved, which mutates more swiftly than others, following both business and technological trends:

I would like us to acknowledge the macro-level changes that are taking place in computing: outsourcing and sub-contracting. Those sorts of things might very well have fundamental implications for the nature of women's work and their experience of work within this sector. I cannot see how organisations will behave over the next 10 years, but it is something we have to be prepared for in any changes or initiatives we advocate. What companies are doing and the way they are shifting activities around the globe and reorganising their processes is key for women and men. (JW)

Of course, there was also the day's orientation towards considering what Internet technologies and networks were offering to the situation. This was also felt to be an area where not enough is yet known.

Given these conditions, some participants felt that the discussions of the day could have been more challenging:

We are where we are; tinkering is not going to have an effect. We have to change cultures and attitudes; it is a deep and difficult issue. I would have liked to have brainstormed some radical things, even if they were completely off the wall. (WH)

Interrelated factors affecting women's current status

The day concerned itself with understanding the underlying causes of the current situation with respect to women in computing, and, having identified some of the influences, proposing ways of changing the situation. In doing so, participants attributed aspects of the situation to several factors tractable to intervention at the level at which they could operate in professional associations and groupings; factors which have been loosely grouped as those relating to education, women's attitudes, work context, and representations of the industry.

These groupings are for clarity only. It was stressed that for an issue as complex as this one, viewing factors in isolation has limited effectiveness:

It is a case of having a multi-pronged attack; there is no one solution. The way gendered cultures work, as soon as you tackle one thing, it will all shift and something else will pop up. What we need to do is tackle it at different levels at the same time. Perhaps part of it is creating more synergy between them and sharing good practice rather than seeing it as fragmented. (CH)

The categories used below are neither exhaustive, nor definitive. They overlap broadly and their effect cannot be meaningfully separated, even if they can be treated separately for the purposes of developing responses. They are used here to provide foci for action.

Education

- Schoolteachers – their training, perceptions of the industry, response to female students, understanding of the range of the subject matter

In a country like mine, the teachers are part of the problem. (JA, Pakistan)

We are teaching as if we were in the mediaeval period. I have a friend who is a teacher; when she became a teacher she had to pair with a senior teacher for one year. Although she was a female in physics and mathematics, the male senior teacher told her he left the girls alone and worked more with the boys. There is an extreme conservatism in our schools which we have to change, because this is where we get our female students from. (GK, Austria)

Computer science teachers tend not to know anything about computer science, at least in North American high schools: they are math, physics or even physical education teachers who got 'stuck' doing computers. The chances that they are

going to think that it is something they should spend time getting girls involved in is going to be very small. (MK, Canada)

- Careers advice – breadth and topicality of advice, expectations for women

Many of them are not aware of the careers that are available in science and technology because they were not available when they were at school; they are not caught up with trends. When approached by students, they point to traditional careers. I found that to be very common, and it is not just a problem with women, but with men. Even when they do go into computing careers, it is as programmers. They are not looking at the bigger picture, the modern technologies, or up-and-coming technologies and innovations. (JA)

- Styles of university teaching – uninspiring and non-interactive teaching in HE, individual learning, poor standards of teaching generally

They [computer science instructors] walked in the room, walked to the board, started writing, finished and walked out. She came to the conclusion that women were not being discriminated against. She wanted something different out of the classroom environment. (WD)

- Lack of female role models

We try to get role models, which I believe in. Of the 17 professors in my department, only three are female, which is too few. (GK)

Women's Attitudes

This section looks at the challenging aspects of what is known of women's attitudes to IT and working in computing. The term 'attitudes' is used here to describe responses associated particularly with women, without the intention of suggesting that these characteristics are fixed.

- Women are not interested in technology *per se*, but favour communication or arts

Men and women both have cars, but boys fiddle with the engines and girls do not. Rather than expecting that, because girls use the Internet they will want to go and fiddle, we have lots of evidence from other areas that this is not how girls get into things. There are lessons to be learned that just because they are using the Web, girls and boys may use it very differently. Girls like group interactive things, so being forced into this more technical role is not for them. They like chat rooms; boys are much happier doing technical things. (LT)

Girls making webpages do not see that as related to computer science, whereas boys programming their computer to make a game do. There is an issue about the connection. (MK)

In the study we did of 7,000 pupils in grades 8, 10 and 12 about their interest in various subjects, there was a correlation between girls who were interested in taking a computer science class with an interest in fine arts, which was not there for boys. (MK)

- IT is too difficult/pressured a career to combine with child rearing

It is also not seen as an option for those who want a career and a family, as one or both of these choices will likely suffer. (TR)

The difference is that when asked about their futures, girls envision becoming mothers. They know, particularly in this part of the world, that for mothers there is very little childcare, and if they later go back to work it is likely to be on a part-time basis. Those sorts of jobs tend to be ones that are not, on the whole, professional. (TR)

Girls have a fear: they say, 'I will study computers, but in 10 years my knowledge will be obsolete unless I work hard and keep up with the technology. If I want to be a mother, how am I going to work, have a life at home, be a mother and keep up?' (RA)

- Women lack self confidence

They need confidence in themselves, as well. (TR)

- Women do not see that there is inequality, they believe they have choice (see Box 3)
- Women feel that they have to face the problem alone

One of the issues I find interesting is that we have made life difficult for the guys who want to support us. There are a number of men who are supportive in spirit but are afraid of putting a foot wrong. (UM)

- Women are getting tired of challenging the status quo

I feel that the initiatives to encourage women and girls in school to think about going into the computing profession as it is today is a lost cause. It is possibly that I feel that I have tried too many things myself and sat around these tables so many times, but it still ends up going nowhere. I am starting from a negative frame of mind, which could be the wrong thing to do. (WH)

Work context

- Much opportunity is in the hands of a few key employers, who do not take responsibility for addressing the issue of gender

A well-worn phenomenon of gender oblivion: the gender issue becomes invisible. I would like to see companies no longer saying: 'We recognise there is an imbalance and a gender culture in this field, but we cannot do anything about it because the problem is somewhere else, probably in the education system. By the time we come to recruit, girls do not want to take jobs in computer science; they are not interested in applying. We try to recruit them, but what can we do? Nothing.' ...An attitude on the part of any institution, or part of society, that they are somehow not part of the society that is creating these social relations. (JW)

Women get treated as minorities. We are put in that 'equality, diversity' pot. (WH)

These projects need champions; when champions leave, not much is going to happen. (WD)

- Women are still likely to find themselves working in the less well remunerated areas of IT and computing, or doing equivalent work for less money

She would caution us about the sheer fact of getting more women into certain areas of work because there is a question mark around the terms and conditions on which women work in these newly constructed professions. (JW)

- Women end up in support roles rather than core roles and are therefore less respected

Programmers at Microsoft have no respect for the people doing the design; they know that they are the real computer scientists. There is a status issue, which is problematic. (MK)

- Women are not well represented in activities that lead to advancement

[Looking at the funding of academic grant applications] we are quite convinced there is not any differentiation in whether proposals come from males or females, but we do not see the right value or number of proposals coming from females in the UK population as PIs [principal investigators, or, in other words, the person that takes overall responsibility for the organization and delivery of the project]. (LT)

- Women taking time out for to care for a family and then returning to the workforce face particular challenges in the IT industry because of the rate of change

We have been talking about women's careers as if there is not a break, but the reality for a lot of women in this sector is that there is a career break. There is then a question of how one gets back in. This is an issue particularly in areas which are particularly fast moving or changing. Not only have you the question of relocation and being in a place where you may not be able to find a job, but you also face issues about self-confidence, up-skilling and getting back up to speed. (CH)

- Some of the professional associations do nothing to support women, either because they do not see the problem, or because they do not see it as a core function

Looking at it from the perspective of the Australian Computer Society, I would like them to recognise that there is a problem in the first place. A lot of members do not realise there is a problem. (AC)

BCS has 'parked' the women's issue in a specialist group. There is no money, administrative support or representation anywhere. (WH)

Representations of the industry

- The technical aspects of computing work are stressed

The public image of the profession is not seen as one which involves creativity, problem solving, working with people to help people, nor requiring lateral thinking and good communication skills. (AC)

- There is little differentiation between using computers at work and creating tools and services
- It lacks glamour as a career, a factor aggravated by the media

A complex array of factors exist for why girls do not choose to study computing, including: the perception that IT is 'nerdy'; 'geeky'; 'boring'; 'isolating'; and the overall *male* image of the profession. (AC)

The media reinforce that for boys and girls. If we think of movies over the years where computer careers have been displayed, even if there is a female, she is a geek in front of a computer; she does not have a personality or an identity. For teachers and students who do not know about the different careers, it is continually reinforced that it is not an appealing area to enter. (AC)

There was a drama series on the BBC a few years ago called *Attachments*. It was riddled with the classic stereotyped images of geeky guys and girls playing non-technical roles. (JW)

ASSESSING CURRENT INITIATIVES

Despite the disillusion of many participants about the effectiveness of general initiatives, there were many success stories to share, particularly those in an educational context where thoughtful schemes that were changing conditions locally. This section gives descriptions of successful projects that involved forum participants, as well as concerns that were expressed about how well they might work in different contexts.

Effective initiatives

It was pointed out that a good body of social and organisational research exists on successful implementation of new initiatives, which could be used to support both current initiatives and others being mooted.

Typically it happens that the mood goes away when the champion leaves, but there are ways to try and embed initiatives in institutions to move them off special funding and become budget line items, making sure that the item gets increased a little every year so it does not get taken for granted. (TB)

This was felt to be very important, since a lot of resources have gone into pilot studies without a consequent rolling out of the successful aspects.

It is almost an alternative to doing something 'real'. Unless we see these pilots as leading to being adopted and practiced in other countries, it seems one has to question the value of it. It can be a huge diversion. If, at the end of the pilot you are still seeing [poor] statistics, then it is the women's fault. You have provided a space for them but then nothing changes. That is why I continually return to changing the culture. (TR)

And, although some of the initiators had received funding to pursue their work, much is usually dependent on people's passion and commitment. It was felt strongly that this energy should be leveraged in a meaningful and sustainable way.

When looking at champions, some thought was also given to whether men could and should lead successful initiatives.

I have found that it is much more effective – and I hate saying this – when you have a male carrying the flag because it legitimises it in many ways. (MK)

In the section below, the main projects that forum participants raised are described. They are offered with the name of the person involved so that they can be easily followed up. In addition, the fullest account of the circumstances in which they were successful has been given (usually in the woman's own words) so that the less formal features that might contribute to success are visible.

Details of specific projects

Education

Most of the initiatives outlined by the participants were educational, or belonged to hiring in the university sector. Annemieke Craig, lecturer at Deakin University, points to the many programmes that have been introduced in Australia to redress the range of factors which affect young women's choice to commence and successfully complete a degree in computing, and to equip them to with the necessary skills and contacts to obtain jobs and career recognition in the industry. These include mentoring, networking, the provision of accurate information, development of classroom management strategies to ensure equality of access to facilities, class discussion and teacher time, the use of gender inclusive language, improving curriculum, 'taster' days, outreach programmes, bridging programmes and profiling female graduates. Professional bodies might play a role supporting the initiatives led by universities, schools and employers.

These strategies all have their place and have made some impact in terms of addressing the issues of women and computing. (AC)

Included here are details, as given, by women involved in schemes that seek to address the gender imbalance in university courses. Although there was some discussion of whether women go into computing through the route of studying computer science, these initiatives focus on getting take-up at this point and in this subject area to increase.

Gerti Kappel, Professor of Computer Science at the Technical University of Vienna, is involved in a five-year project supporting women in computer science, which started last January. The project has two main paths. One path is a PhD curriculum solely for women in computer science. They can do their PhD in any area, but they must be women. The goal is to develop a curriculum just for women, in order to discover what attracts women to a PhD. The second path involves developing supportive programmes, starting with pupils and moving up to young researchers. There are four initiatives to the support programme at the Technical University of Vienna (Box 4.)

The experience so far is that the women take up these measures and accept them; they are not against being treated in a special way. (GK)

Veronika Oechtering, Scientific Chief at the Center for Women in Natural Science and Technology, University of Bremen, points at Bremen's 20-year history of doing things for women. In 1997, Bremen started a summer university for women in computing at a student level, which works with women who are in the profession as lecturers, professors or researchers. The summer university lasts for two weeks and concentrates on computer science in the very narrow sense. About 250 female computer science students come from around Germany to Bremen and take university level courses from some 60 women in industry and academia. Courses include artificial intelligence and programming languages such as C++ or Java.

Participants come from more than 70 universities each time. And the concept has spread. Three years ago, Bremen developed a regional programme: for two weeks it is held in Bremen, and for one week it transfers elsewhere. This has now reached as far as Austria, where it has been taken up as a national initiative, and France, where the University of Strasbourg and the University of Applied Sciences in Strasbourg together hold it for two weeks. New Zealand

Box 4: The four initiatives of the support programme at the Technical University of Vienna *'Source: Gerti Keppel at the OII Women in Computing Forum'*

1. 'For five years there has been a programme in Austria called Women in Technology; women on the technical faculties of universities go into schools, attract female pupils and explain the technical subjects, and take them for one to three days into the universities for hands-on experience. We are supporting them with IT subjects and have an all-IT day where we give them a special course to introduce them to IT. We have small experience groups where they learn how to build a robot or take apart and rebuild a PC.
2. 'The second initiative is, for me, the most successful. When you get pupils into the universities, you then have to do something to keep them there. It is not enough to attract them. After the first year, they become distracted. We have developed two or three day 'crash courses' where we give them such practical knowledge as installing operating systems, web servers and disk drives. These are held for groups of 10-15 girls who then get to know each other. We have 800 beginners in computer science every year; out of this, only 10% are women and do not see each other very much. They can now study together. We started this programme half a year ago, and now 80-90 girls have taken the crash courses. At the beginning, my fear was that girls would not accept this kind of support because they are not disabled, for example, but it did not turn out this way. They realise that someone told us how this PC works, which you do not learn at university; now male students come and say they want such courses. There is a positive attitude to this.
3. 'Of the 17 professors in my department, only three are female so we bring in female guest lecturers. These lecturers also support the PhD programme, and we are building up a mentoring programme. Mentoring is not a habitual practice in Austrian universities. We try to build up mentoring for beginners, masters, and PhD students.
4. 'My experience is that we should share good practice. We are therefore building a communications platform. We have a colloquium called Women's Postgraduate College and Internet Technology (WIT) to which we invite famous people and demonstrate that women can attract them to Vienna to talk. They are not only from computer sciences, but from social sciences and politics. It shows that there is something women can do. We have high attendance at these. We are building up tutorials, and we tell them there are females building up these programmes.'
(GK)

has also picked up the idea and, next February, the University of Waikato will offer this concept to women in computing.

When they are there once, they come back in high percentages. The generation which is giving some of the lectures now were in the university seven years ago. It is

a big network. If you look on the website you will see there are hundreds of women in computing in Germany who could search for job availabilities, chairs and professorships. They look at this website and see that there are women who can teach or research. (VO)

During the life of this initiative, the university has seen big changes. Since 1998, there has been a new female chair each year; so that one-third of the 18 chairs are now women.

This shift happened in many other places, as well. We have also augmented our proportion of female students during this time. It is a big department with around 300 new students each year, 25% of whom are women. At other places in Germany, the numbers have increased. There are a number of universities that have 25% female students. (VO)

Internal changes to teaching can also make a significant difference. Work conducted at Stanford shows just how important it is to raise the quality of the curriculum. This was found to benefit women in particular. It proved one of the things that made it possible to retain women at Carnegie Mellon University. Elsewhere, the Norwegian University of Science and Technology managed to raise the number of women from 6% to 39% in one year through introducing a high-profile, wide range of inclusive activities, at considerable cost.

The range and variety of inclusive measures, as well as the high profile, contributed to the result. The most important thing was that a lot of attention was drawn to this. We felt very welcome and believed that they were serious about this. (VL)

Caroline Wardle, Senior Science Advisor for the NSF, has worked to promote 'pair programming': a way of getting students to collaborate, in that two people work together; one designs and the other checks, and then switch roles. This was brought in to change the way the first programming course for new intake at universities in the USA is taught. Pair programming has long been known to be effective in industry, but there had been no scientific experiment with hard data to show if it would be beneficial. Working in pairs increases support and, with it, confidence, while making the learning of computing an intrinsically more social experience – all of which are likely to make it more appealing to women.

Researchers at the University of California Santa Cruz, which has very large computer science courses and 400 students who take the courses, did a formal experiment with pair programming to tackle their drop-out rate.³ They had two women paired and a woman and a man paired, whom they compared against the traditional singular way of teaching computing, whereby you work by yourself in the computing lab and do not allow anyone to see what you are doing.

The results were fabulous, not just for women but for men as well. It was statistically significant that more women stayed through to take the final exam and pass the course; more men passed, as well. There was no difference between the increase in

³ Every year a lot of students drop out of their first course; they do not even stay and take the final exam, much less move on to the second course.

the women who were retained, and the men: it was equally good for both. They also tracked them into the second course, and more women who took the second course passed it successfully. It is so successful I tell everyone you must do pair programming in the first course. It propelled a lot more men and women into taking the traditional computer science courses, whether it is programming, C++ or Java, algorithms or data structures in the second course. Now we have hard scientific data that shows us what we intuitively thought based on industrial practice. (CW)

Interestingly, pace, as well as collaboration, can be used to support women. While female students tend not to participate in the speed programming competitions that are popular, such as robot football tournaments, there is some evidence that they do like doing competitive project-based work. At a number of conferences there are Microsoft-sponsored prizes for the best undergraduate and graduate research projects. There are a number of women's entries and a lot of women winning.

That, in some sense, is redressing the balance and is more attractive to women. It is also more in the spirit of what some of think deep science is about: it is not speed programming. (UM 60)

The same spirit of changing the shape of the opportunities on offer informs the development of some new courses. Wendy Hall is Head of School in ECS at the University of Southampton, where they are designing courses in complex systems that will require a biology or chemistry qualification; maybe maths as well, though the department thinks this would not be ideal since there has been such a drop in the number of students studying maths. She sees this as a way of bringing women into computing: by preparing women for where matters will have reached in 10 years, rather than looking at the landscape now.

They will be very different to the way things happen today. That is hard because we do not know what it is going to be like, and we do not know what qualifications, degrees or skills will be required. It is easy for me to say this and it sounds exciting, but in reality, how do you paint that picture to 14-year-old schoolchildren, girls and boys? (WH)

Some attention, though rather less, was also given to initiatives intended to have an impact on young people of school age.

Reyyan Ayfer, instructor at Bilkent University, is helping launch a new computer education programme to produce teachers who understand computers and computing. The five-year programme comprises three and a half years of computer science and one and a half years of education; upon completion students will get an MS degree and can become a secondary level teacher. The expectation is that there will be more women in the programme than boys, since, although it is computer science, it is computer education. But, as well as bringing women into universities to study computing, the course is clearly designed to have knock-on effects in other tiers of the education system.

And specifically in terms of improving teaching methods below the tertiary sector, UK initiatives to encourage collaborative learning with computers

include the OII's own work, a study of the use of the Internet across subjects in Oxford charter schools. Use of the Internet appears to encourage collaborative work at the computers.

Work context

As well as considering students' experience of computing, some participants had material to share on initiatives that were intended to target the workplace. Much of the discussion revolved round the university as workplace and hiring and retaining women: critical in terms of offering role models to students in addition to offering employment opportunities for women in research and development.

Maria Klawe, now Dean of Engineering and Applied Science at Princeton University, had a profound impact on the hiring policy at the University of British Columbia (UBC) when she joined as head of computer science. She was the first woman faculty member; they had never had a female head of a science department; there were three female full professors out of 300 in the faculty of science, and 11 in total.

15 years' later, they have over 50 women out of 300. In the computer science department, there are seven women faculty. This came about through a very explicit policy (see Box 5) about who they would hire, that applied to women and men. Four thresholds were devised for discussing with and assessing candidates.

Box 5. The thresholds that candidates needed to exceed to work at UBC

Source: Maria Klawe at the OII Women in Computing Forum

1. You first had to be committed to being an outstanding researcher.
2. Secondly, you had to be committed to teaching.
3. Third, you had to agree that we were trying to make this department better and that you would put your energy into doing that; a number of people turned us down on this point. We told our assistant professors that they were the most important people, you are coming from better departments and you know what better departments are like.
4. Finally, you had to be committed to working in a collaborative, nurturing environment and that you would support each other. People would ask how we could tell if they were doing that. It takes a lot of time to do that, so we told them they will take time away from your research and teaching to make it a collaborative place.

The truth is, I was head for six and a half years and I did not succeed in hiring a single woman faculty member. We made lots of offers, but not one said yes. However, we were very careful about the men we hired. (MK)

Nonetheless, eventually these criteria led to a change of culture and female staff followed. UBC has continued to use these rules, for instance in a recent external search for a department head.

The most important place to get women is to go to your vice-chancellor in the UK or president in the US; the next most important place is with your provost or dean. After that, it is your department chairs and heads. It works pushing from the top down. (MK)

Box 6. University Faculty Awards and their like

Source: Maria Klawe at the OII Women in Computing Forum

If it were not competitive, women would not be willing to be nominated for it and departments would not want to take the women who were chosen in this way. The rule is, you have to be better than an average faculty appointment in order to get this; you have to be a quantum above the appointment bar in order to get one of these things.

What I found when it started was that no one from the faculty of sciences at UBC nominated women for this. When I asked why, they said they did not have an open position or funding to cover the difference in salary. I asked if it would make a difference if we would top up the salary for the first five years, so it would cost them absolutely nothing to do this initially. They agreed. The next year they nominated and won three out of 21 across Canada. The next year they nominated four and won four, but one woman turned us down; the next year they got five. We got a huge amount from this.

By the time I did the first, I had no more money to top up the salary of additional women. I asked the department chairs if they wanted me to stop the programme or tax them to continue. They voted to a person to be taxed, because they all thought they would be more successful than the other departments in being able to do this. Over four years, we doubled the number of women faculty.

We went from 24 to 48 in four years; it has continued to rise. Of those, less than half of those were part of this programme. They looked so hard for women to nominate for these awards that they started to hire more women in their normal positions.

At Princeton they are doing the same thing, but they are doing it within the university. They have four half slots in this programme, which is called the Target of Opportunity, and it allows them to hire four people. They consider women, minorities and someone who is interdisciplinary; virtually no white men have succeeded. They have four half slots that will be given to people significantly superior and where it can be argued that the person will increase the diversity of the department. This last year, of the 20 full professor offers that were made in the university, 10 were to women. Before, it had been 15 to one. People try hard to get people for these positions and may end up using six half slots. They have found wonderful women and hire them anyway. The combination of setting the bar very high to remove any stigma and a small amount of bribery seems to work well. (MK)

Klawe also embraced the government initiative aimed at getting women faculty in areas where women faculty members are underrepresented. Led by NSERC, the idea is to give a university a certain amount of funding to help pay the salary of women faculty who get hired in departments where women are underrepresented. The amount of funding is quite small – CAD40,000 per year for three years (less than £20,000), which represents about half the salary of the new recruit. It is very competitive, and there is a national

competition for these University Faculty Awards. Klawe discussed the acceptability and execution of this award at length in the forum (see Box 6).

Klawe concludes that there is a critical point at which it becomes much easier to hire women. Her opinion is that it takes seven women in a department to make the change.

If there were seven women in the department, they took over the culture, regardless of the size of the department. That was one of the things on how you keep change happening: once you have a critical mass, it seems to sustain itself. (MK)

Another initiative that has made it easier for women to take up academic posts in North America, where distances between universities are vast, was to provide support for the other, 'trailing', partner in finding a new job.

If the department that the trailing partner would enter is strongly enthusiastic, the provost, the receiving department and the department getting the leading partner each put up one-third of the cost of the first n years, where n is usually three. After that, the receiving department has to pay the usual amount. At the time I left, of the 48 women at the end of that period, 16 were married to a spouse in the faculty of science. It was very effective in getting a number of the women we managed to hire. (MK)

It was felt that this supportive approach could usefully be broadened and employed elsewhere, for instance, even where money would not be available to bring in the other partner, there could be help, such as circulating CVs in the area to key businesses and academic institutions.

There was some talk of women's professional involvement in a broader context. Telle Whitney, President and CEO of the Anita Borg Institute for Women and Technology, has been spearheading an effort called the National Center for Women in IT, which is looking to systematically change the participation of women at all levels of the pipeline. It is most focused in the US and still small, but one of the purposes is the active dissemination of findings such as these and to form a space in which to talk about best practice.

Whitney was also one of the women who formed the Grace Hopper Celebration, which functions as a forum for women. Through the Grace Hopper conference, now having been in existence for 10 years, and other newer initiatives of a similar kind, discrete communities have found out about each other. Consequently, a growing number of senior women have been getting together: coming to know each other and develop further initiatives. These networks operate as support, alert members to opportunities and in doing so, tackle the disadvantages of being more finely spread across the workforce.

Several people pitched in with initiatives to encourage women to juggle a career in computing and having a family, rather than fall out of the field. In the UK, Daphne Jackson Fellowships are aimed at women scientists who had taken a career break and want to get back. The scheme has become

established and quite well respected. But there is evidence that even women who get that funding find it difficult.

More broadly, at UBC, a programme for women and men, called “Alternate Routes to Computing” targets women who might have been awarded a bachelors degree in science in the 1980s but then stayed home with kids or switched professions. This programme seeks to tackle the issue of keeping up to date. UBC has had about 100 students go through this two-year programme that combines work experience with hard-line computer science courses. Approximately one-quarter of the students who sign up for it drop out of the programme after the first year, because it is too strenuous. Once they make it through the first year, the scheme has managed to keep most of them and they have been successful getting jobs when they finish. The pilot got special funding. Now the department has put it on regular funding and got it classified as a BA in Information Technology.

Politically, this was very unpopular because it is very expensive in that students are taught separately in the first year; we have small classes and there is much more tutoring, which we have found is absolutely necessary for the students to succeed. The percentage of men versus women is still over slightly 50% women, which is significantly better than other programmes. (MK)

What is apparent from the discussions above, and from the next section too, is the importance of mutual support and networking, and how the Internet has made initiative in this area easier to set up, sustain and extend. But this is only part of the whole picture: a lot of work has taken place on values and the role of the social – both in mediated and face to face form – in making women feel more comfortable in computing education.

Lessons learnt from other industries and academic fields

Examples of initiatives that had worked in other domains were shared as part of looking at what might provide leverage, influence or change.

In the Czech Republic, as in other places, the effect of the media to make professions attractive has been exploited. There was a gap in applications to medical faculties, but then a popular television show appeared with doctors and there was a big boom in applications to the medical faculty.

It would be helpful if a popular female appeared as a computer scientist. Harry Potter’s friend Hermione, who is scientifically minded? It would be great and would help a lot if she did something with computers. Maybe the British Computing Society could approach JK Rowling. (OS)

On a more institutionally specific note, professional bodies have been able to change the gendered nature of much traditional academic writing. The American Psychological Association (APA) decided years ago that any APA-approved journal was not going to tolerate the singular ‘he’ any more. That stopped the use of ‘he’ in these journals, which, in turn, gave a different perception of the active community in psychology.

If you cannot get published in an APA journal, you are dead. Right away the singular 'he' went away. The view was that it was damaging, particularly in psychology because you cannot tell if people are talking about an individual or a trend. It was very good; people learned how to write in plurals. (TB)

And the key health journals hold a similar sway over what is acceptable:

None of the health journals will accept an article unless you can show that your research was reviewed and approved by your institutional review board. But if you cannot publish your medical and biobehavioural research, you are dead. Suddenly, people are self-referring their projects. (TB)

To encourage the networking that supports the development of this kind of initiative, the science unit of the European Commission in Brussels has launched a successful network of networks that connects up women in science, engineering and technology from within and outside Europe.

What was interesting is that they started to compare notes on what they did and realised that there were many different practices, initiatives and networks from engineering to physics; it did not really matter, as we were looking at how they addressed the issue. It was barnstorming, really, because a lot of these women had been working in isolation and getting quite tired. Suddenly, they met all these opposite numbers, some of whom had tried a number of different things. There was a real buzz about it. (TR)

The issue of credentials for professionals was also pointed at, in the belief that what is standard in other professions where women are better represented, might bring or keep more women in computing by tackling, not least, self confidence.

You can say 'I am a doctor or a lawyer. I have a certificate and you cannot take that away from me.' There is a career path, and it is clear and unequivocal that you have made it. (WH)

However, this was just one of the suggested initiatives that met with opposition from other participants in the forum. Many women do not follow computing studies to arrive in computing jobs. They might be discouraged or disadvantaged. Further, evidence from other professions also suggests that it would not make any difference:

I completely disagree with the impact of credentialisation. If you look at Canada, it is incredibly credentialled for engineering and is much more strict than the US, but there are not more women in engineering in Canada than there are in the US. (MK)

Problems with solutions

There were other concerns raised with proposed solutions and, indeed, with some initiatives that were already proving effective in another context. As well as the subject of credentials (mentioned in the previous section), and the unexpected failure of a sizeable number of well placed role models in Eastern Europe to woo the next generation of women (see the section on national variations above), a further group of issues was raised.

In particular, there was a lot of concern about schemes that discriminate towards women. In some countries 'positive discrimination' is illegal (USA, UK), though 'positive action' is acceptable. But there were social as well as legal concerns.

We set up a similar programme at our university and had difficulty getting women to partake in it; they did feel they would be looked at differently. We spoke to the girls individually, and once we had a few say it would be good, others came in because they could see it was not just them. However, it took a lot of time and effort to get them involved. (AC)

We did something similar here at IBM, and women said they did not need this help and that we were leaving out the less assertive men who needed it. We started talks and pushed at the women to make it available to men; we therefore had an audience that was 50/50. (BH)

This is something that I find troubling: labelling women with this kind of initiative. (UM)

It was judged important to consider the message that women-only initiatives sends to the wider community as well as the potential beneficiaries.

One of the problems with these initiatives is thought to be that the men think a particular group must not be very good because they need extra help. If you introduce it carefully and explain what you are doing and why, then you will not get that result. It is really important to think about the way those initiatives are framed and explained to people. (SL)

Many participants were drawn to the idea of creating courses that attract more women, but that do not have to be labelled as 'women only'. There was a call for subtlety in developing initiatives designed to appeal particularly to women.

Subtlety was also called for in promoting the success of the initiatives outside the interested parties:

The problem is, as we know, if you have a whole issue of ACM on gender, there will be people who do not open it. The majority will not pay attention, but if we have it something that is a bit broader but has this as half of it, it will reach a broader population. (MK)

Box 7. Summary of current initiatives

- PhD curriculum solely for women in computer science
- Supportive programmes, starting with female pupils and moving up to young researchers
- Summer university for women in computing at student level
- Women on the technical faculties of universities go into schools, attract female pupils and explain technical subjects
- Two/three day 'crash courses' to give female students practical knowledge
- Mentoring for beginners, masters, and PhD students
- Forums for sharing good practice, such as the colloquium called Women's Postgraduate College and Internet Technology (WIT) to which we invite famous people from the computer sciences, and social science and politics
- Raising the quality of the curriculum.
- Pair programming: students to collaborate, in that two people work together; one designs and the other checks, and then switch roles
- Setting competitive project-based work, rather than speed-programming
- Designing courses that mix computing and other disciplines
- Computer education programmes to produce teachers who understand computers and computing
- Studies of the use of the Internet, since the Internet appears to encourage collaborative work at computers
- Explicit policies about who to hire for both women and men, to change faculty culture
- Funding initiatives aimed at getting women faculty in areas where women faculty members are underrepresented
- Getting seven women into the faculty, as this seems to be the critical point at which it becomes much easier to hire women
- Financial support for the 'trailing' partner in finding a new job
- Help, such as circulating CVs in the area to key businesses and academic institutions, to support the trailing partner
- Collecting and widely disseminating findings about good practice
- Spaces in which to talk about best practice
- Grace Hopper Celebration functions as a forum for women
- Daphne Jackson Fellowships are aimed at women scientists who have had taken a career break and want to come back
- Programmes for women and men, such as "Alternate Routes to Computing" target women who might have been awarded a bachelors degree in science in the 1980s but then stayed home with kids or switched professions
- Professional bodies have changed the gendered nature of much traditional academic writing
- Forming networks of networks that connect up women in science, engineering and technology from within and outside Europe

TAKING THE AGENDA FORWARD

As soon as the need for change was raised in the forum, there came a discussion of what was to be changed: women or the environment in which they would be working. The first section below addresses this distinction. The remainder looks at what participants thought would be useful to do next and what might be manageable as first steps.

‘change the water, not the fish’

Equal opportunities initiatives may be good at getting women ‘in’ (recruitment) but are not good at keeping them (retention) – identified as the ‘leaky pipe’ problem – arguably because they do little to change the underlying masculine culture of organisations which is unappealing to women and hostile to their advancement. A related aspect is that while the approach appears to be treating women equally, it is actually judging them against a male standard (in terms of working patterns, career histories, etc) against which they are likely to be seen as less adequate. A related problem occurs when equality initiatives construct women as in some ways deficient or in need of help to succeed.

So in proposing change, participants in the forum made a distinction between initiatives that seek to change women and those that change the environment; elegantly caught in the phrase: ‘change the water, not the fish’. The participants raised the question that comes up in all debates about equal opportunities: do we focus on attempts to change women – such as giving them different skills and making them tough enough to cope in masculine cultures – or do we want to change the culture so that women are more comfortable in it in the first place? The initiatives mentioned above can be seen to fall into one of the two groups. For example, the pair programming, different teaching styles, repositioning of computing within the academic curriculum and the different styles of competition can be seen as examples of ‘changing the water’ whereas the skill-enhancement courses which target women students are probably more ‘fishy’.

When you allow men to participate and take the courses, then you have changed the water. If you only do it for women, you are changing the fish by giving them the opportunity to swim in the water better. (MK)

Of course, discussions also revealed the interconnectedness of the two aspects. By changing the environment, you change the people in it. By skilling women in particular ways, you equip them to make changes elsewhere.

We need to both change the culture and the way it is perceived. (TW)

However, implicit in the discussion was the sentiment that change needs to be performed on the widest scale, and that responsibility for doing this does not only lie with women, though it may be led by the people who feel most strongly.

Harnessing positive trends

The importance of recognising the impetus already at work in society and turning it to advantage came up several times.

I remember that Margaret Thatcher was famous for saying essentially that market forces are market forces. I think that is my thesis. We are where we are; tinkering is not going to have an effect. (WH)

Within the corporate world, the tendency towards homogeneity was seen as both opportunity and challenge.

IBM tries to have a similar culture in Germany as it does in the US or Brazil; that could be a lever for us. They care a lot more about this issue than most universities, and certainly more than schools care. (MK)

Although there was some disagreement about how fast the industry is changing, the dynamic transforming processes in the computing professions was seen as something that could be used to benefit women. Within 10 to 20 years, a new kind of computing will bring in new opportunities.

In my research, I am increasingly aware and convinced that the nature of our profession is going to change radically. If you look at females who are interested in the way the profession is going to change over the next 10 years, then I think you have a picture where you can start attracting women into trying to be successful in that profession. I would like to encourage women to get into the new areas. (WH)

Related to this is the tendency for women to come into computing and IT from other, sometimes related, disciplines. US Census Bureau statistics for people in the high-skilled information technology workforce – computer programmers, software engineers, computer scientists and computer systems analysts – reveal that, of any profession, IT has the lowest percentage of people holding the same degree. Only 40% have ‘computer science’ degrees. The next largest proportion of degrees for women is in the social sciences. For men it is engineering. The third is mathematics both for women and for men.

I am doing research on women who are IT technicians [in the UK]; not computer scientists, but they are coming into a technical area which is generally out of bounds for women. One of the interesting things is the range of routes through which those women have come into that work. Out of all of them, only one went through a traditional apprenticeship-type model; some had come in through administration and had moved into technical work. It is a similar scenario to new media. There are routes which circumvent this ‘no go area’; women are finding their way not necessarily into computer science but more techie areas. They are moving into it because they find a back route where those opportunities are available and those traditional barriers are not there. There are opportunities within that for finding ways around what we see as a real block in the pipeline. (CH)

Lots of women and men are going in from different areas. Universities are not comfortable dealing with that issue. I do not know any computer science department that recruits from the social sciences; it goes the other way. (CW)

So there is some evidence that a computing science that extends its boundaries wider, as it is likely to do, would bring a greater number of women

into contact with it. The trend towards ubiquitous computing and the deployment of digital tools in domestic as well as work spaces, might also impact on women's response to technology. But this new contact does not necessitate a change in the current trends; in fact the evidence is to the contrary: personal computers and mobile phones have not lured women into development positions. What it does do is bring computing further and further into the realm of the social and the every-day.

The social impact is very important, and even in our part of the world women are getting fed up with using machines or computers that have been created by people who do not understand them. (JA)

A catalogue of good ideas

There were an abundance of ideas for changing the gender balance of the computing professions. Some are already in development and these have been described above. Others were developed more fully on the day and taken up as immediate goals: those are listed in the next section. Here, though, are all the ideas that got a mention without further vetting; ideas that might otherwise be lost. They are again organised in the loose framework of education, women's attitudes, work context, and representations of the industry.

Education

- getting involved in primary and secondary education and working with teachers in those communities to ensure they have the resources they need and can be more effective in the job. In the process, looking at how to make changes there that will impact upon how the field appears to young girls.
- having resources available to women all over the world through a single centre and providing a support mechanism, email lists, mentoring, or a simple way to hook into things. Specifically: linking up with MentorNet to set up online mentoring; and publicising it through ACM publications; establishing and promoting a website where you can find information.
- ensuring that the social behavioural sciences are feeding into computer science.
- strengthening the careers link between the computing professions and what girls enjoy in using the Internet.

Women's attitudes

- making connections in terms of the way women and girls enjoy using things, the way we teach, the way we think about the subject and the way we make connections: 'if you enjoy doing that, you might enjoy even more what goes behind that'.
- reflecting on the way initiatives are talking to women and about their attitudes to computing.

Work context

- encouraging all the research councils to publish gender-segregated statistics about application rates for proposals, the success rates, and the gender makeup, collected as part of the annual reporting mechanism.

Representations of the industry

- exploiting the correlation between girls who were interested in taking a computer science class and their interest in fine arts.
- persuading the BBC to write further strong roles for women that show computing professions in a more glamorous way. Specifically, finding the right champion and a real writer rather than relying on amateurs to sell this concept. As an example of positive action already taken: all the computer stories in BBC Radio 4's *The Archers* are women-centred; the computer training is run by the barmaid; the website is written by women.
- convincing *Harry Potter* creator JK Rowling to make the leading female character, Hermione, a computer expert when she grows up.⁴
- approaching magazines targeting 14-year-old girls, perhaps with a vision of what computer science will be like in 10 years' time.
- promoting success stories and throwing a spotlight on individuals as role models. Specifically: finding the female and contemporary 'Alan Kaye' figures.

Plans of campaign

The main focus of the forward thrust was directed at what the professional associations and societies might do, since most participants are senior figures in their national body and it was felt to be an area of immediate influence. Some attention was also given to the future of the forum. However, caution was urged in restricting activity to this level and losing sight of the interrelated nature of the agenda – the interconnectedness that had been such a feature of discussions when the obstacles to change were being discussed.

Many of the problems identified are not specific to professional associations. They are common dilemmas for any organisation trying to decide how to promote equality issues. For example:

- Do you promote initiatives via a special committee about women which at least makes sure someone is talking about it, but risks it being seen as a marginal issue?
- How does one ensure equality issues reach mainstream agendas – and if they get there make sure that they are treated in more than a tokenistic way?
- Is it better for equality initiatives to have dedicated people responsible for them or should it be everyone's responsibility?

⁴ Maria Klawe has taken on this challenge, inasmuch as she is to organise an invitation for Rowling to give a creative writing workshop at Princeton so that she might talk to her in person about this.

These are all things which have been debated within the equal opportunities literature, company initiatives and in local authorities in the UK. I think there are distinctive things about professional associations, but the issue of how you get equality taken seriously is not one of them. (SL)

Actions for the Associations

The biggest news in this area was the announcement by Ursula Martin that she is setting up a UK initiative called Women in Computing Leadership (WICL) for senior women in IT, which is to be initially funded for three years by the EPSRC and will then be ensured sustainability through the BCS. It already has ties with the IEE through the professional membership.

Going beyond this particular initiative, participants recognised the status of professional organisations as communities of practice with the opportunity to develop values and support a sense of identity. They were urged to change occupational cultures, going beyond providing women to act as mentors who help new entrants understand 'the system', to changing the system to make it more 'women friendly' in the first place.

More needs to be done to restructure organisations (cultures, career ladders, working hours, performance measures, teaching approaches, etc) to recognise different ways in which subjects can be learnt or jobs done that are attuned to women's approaches and experiences - sometimes discussed under the label of 'managing diversity'. And note that there is a distinction between changing expectations or patterns for all workers and offering, say, policies on work/family balance aimed primarily at women, or which are seen as exceptions to normal ways of working. (SL)

Other suggestions for actions by the associations were:

- take initiatives that come out of the university research area and driving awareness in the commercial sector, linking to employers.
- create bridges between the academics, industry and government.
- exploit the ACM's policy office in Washington to lobby on women's issues.
- start a dialogue with other professional organisations in other sectors, such as the UK's Institute of Physics, which has a number of interesting initiatives of its own.
- organise a summit of the presidents – male or female – of as many societies as possible and holding a meeting to share what the different societies are doing within their own societies to look at making a difference on an international scale. This would lead on to meeting regularly, every few years, so that the attendance model shifts from opt-in to opt-out.
- engage with other international agendas that might further the goals of the professional societies, such as UNESCO and its World Summit on the Information Society (WSIS).

Moving on from the forum

Particular actions that related to the forum and the promulgation of its message included:

- use photos from the day to show a group of international senior women doing something constructive about women's role in computing and circulating them widely.⁵
- write papers for the ACM or a similar publication about different regions and aspects; bearing in mind that a whole special issue might be less effective than part of an issue.
- develop a seminar series that could continue work on the issues raised in the forum discussions.

Extending the debate

It is possible to pull out of the discussions of the day some issues that would clearly benefit from research and debate. Since this report reflects the material covered in the forum, it is only possible to raise them here in the form of questions. It is hoped that, by doing so, the forum will have contributed to debates taking place more broadly.

The following were considered to be unresolved issues and tensions:

Just what is computer science nowadays? Is this still the most useful way of couching discussions around training for and employment in the ICT professions and, if not, what are we striving for?

Are solutions available? Do we know enough? Is it a lack of political will and other social and economic constraints preventing existing solutions from being pursued? Or is there a lack of understanding of the enablers and constraints?

Is it useful to frame the discussions in terms of personal choice vs structural determinism? Which arguments most empower the people attempting to perceive areas of influence and then have an impact?

Are all areas of the issue receiving enough attention? The debates of the forum concentrated largely on education, but much energy is given over to exploring employment practices. How far are the connections between these spheres made and are they being made in the most useful way?

Are international variations a source of new policy and educational models, or simply a reflection of a global flow of skills and labour?

How far the Internet indeed can be harnessed to alter the dynamics of the situation. Clearly it is supporting networking and the development of initiatives, but can the courses and areas of work that are being spawned in response

⁵ Photos are available at: www.oii.ox.ac.uk/collaboration/?rq=specialevents/20040617

make a significant difference to the landscape? If so, will they only impact on the peripheral areas of computing, rather than the core programming areas?

What evidence is there that a change in the nature of computing, such as the increase in importance of networks and connections or the new uses for computing in the sciences, would alter the employment balance? Is it too fatalistic to attribute changes in balance to changes in technology and its uses? Does this reek of technological determinism?

A footnote (to hearten the dispirited)...

Annemieke Craig reports that as a direct result of the event at the OII, she got herself invited to speak at the Australian Computer Society's (ACS) national conference. The argument followed the lines that:

- women are just as capable,
- the numbers however of women are poor in ICT in Australia,
- this is an issue,
- why it is an issue,
- ACM and the BCS are doing a number of things because they recognise the problem,
- it is time the ACS recognised the problem, and
- here are some things the ACS should be considering....

At the same time, the board of the ACS has agreed to make what was previously a sub group called WIT into a full board called ACS-W, modelled on the ACM-W in the States.

I think the discussions I have had with WIT and members of the ACS have played a role [in these developments] - and these discussions came about because of the information we generated at Oxford. (AC)

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Box 8. Contacts and acknowledgments

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If you are interested in the issues discussed in this paper, here are some points of contact:

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