Women in Computing Professions: Will the Internet Make a Difference?

Position Papers for an OII Policy Forum

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Turkish Women in Computing

This paper provides general information about the role of women in computing in Turkey and proposes some actions towards improving the prospects for Turkish women in computing, Internet technologies and IT professions.

The background in Turkey

Turkey has a population of around 68 million, of which 48% are women (Türkiye'de Kadın 2001). Women are represented in higher education with a comparable percentage: 42%. However, this ratio falls to 20% when IT-related undergraduate programs are considered. Furthermore, the ratio of women falls to 16% in IT programs of graduate schools (National Student Selection and Placement Center 2002). These figures are actually in line with the situation in other countries. Therefore, we in Turkey share the concerns about increasing the number of women in the IT field.

In order to be able to consider the Internet as a tool for improving the situation for women, we have to study the profile of women's utilisation of the Internet. Although precise up-to-date statistics are not available, Internet usage in Turkey is still increasing tremendously, with 600,000 users in 1997 and two million in 2000 (Sevdik and Akman 2002), and it will continue to enter the lives of people at a fast pace. In urban areas, Internet access is mostly from the workplace and homes. In rural areas, Internet cafés are the most widely used Internet access points.[1] Although, at first look, it may seem that the tremendous increase in the number of Internet cafés is allowing more people to access the Internet, the actual function of Internet cafés is in providing Internet access to a largely male-dominated group in the 18–24 age range, who use it mainly for personal communication and entertainment.

Some of the results of a survey of Internet use conducted among Turkish women living in Ankara include (Sevdik and Akman 2002):

- most of the women who use the Internet are: at least high school graduates; between the ages 18–40; have a moderate income; and are students or educators.;
- women use the Internet mostly for communication and information searching purposes (not for entertainment purposes);
- women who do not use the Internet claim that they lack the required skills, which can be interpreted as a lack of interest; and
- slow connection and high cost of access is a major problem.
- language is a barrier because there is not much Turkish content on the web.

Although these results may not reflect an overall view for the country, they give a concise idea about the situation.

[1] Turk Internet, www.turk.Internet.com/haber/yazigoster.php3?yaziid=1890, accessed 27 May 2004.

Obstacles to Turkish women's participation in computing professions

The primary obstacle to Turkish women's participation in computing professions has probably been the same as with many other professions. Generally, the women are the primary caregiver in the family, therefore it has always been difficult for women to juggle with any demanding job on top of their domestic responsibilities. Nowadays, especially in urban areas, with the economic, cultural and social changes in the country, women and men have started sharing domestic responsibilities and the number of women joining the work force has increased. However, in the computing professions, the rapid changes in the technology are a bit too challenging for women, probably due with the fact that one must spare a lot time to keep up with such fast innovation in the state of the art.

Given the advances in the Internet and mobile technologies, it may seem that the traditional workplace is becoming less common, making the work environment more flexible – with virtual offices allowing employees to work from home, from any remote location, 24 hours per day and 7 days per week. This seems to be an advantage for women, as it offers new opportunities, allowing more flexibility regarding work hours and location. On the other hand, life may become more difficult for women in the computing professions when they need to be accessible online outside work hours in order to answer urgent questions and deal with urgent problems.

The role of education in improving women's participation

Generally, girls do not have much of an interest in computing and related equipment during their early childhood. This lack of interest hinders them when the time comes for introducing computing-related topics into their education. Boys are already skilled in using computers because they have been more involved in playing games at early ages and they are ahead of girls of the same age group in this respect. This difference is an important obstacle for girls in approaching computers and related topics and they usually shift their attention to other topics where they feel more comfortable. Even the brightest female undergraduate computing students plan to work in jobs that are not directly related to computing.

To overcome this early educational issue, one starting point could be to educate young mothers. Internet and mobile technologies may serve an important role to this purpose. Websites maintained by authorised organisations may also play an important role for mothers who have Internet access at home. The language barrier and the cultural differences must be considered during the development of local web sites and implementation should be sponsored by organisations.

We believed that getting the WIC Student Chapters in our university involved in promoting the computing profession among women would be of value, so started to hold meetings with the female computing students. The main aim was to bring together the undergraduate computing students, providing the communication that would, for example, help seniors to mentor others or to arrange social activities with role-models. The secondary aim was to have the undergraduate female students spend some time with the elementary and high school girls to encourage them to get more involved in computers. However, after two meetings, their lack of interest in this sort of community work and the students' heavy course load hindered a third meeting.

To help overcome such difficulties, we believe student activities under WIC student chapters need more effective support from professional organisations in terms of providing training, motivation, monitoring and mentoring.

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Yes, No and Maybe: Answers to a Complex Question

The question posed for this forum – Will the Internet make a difference to women in computing professions? – is a complex one, susceptible to many different answers. I'm going to suggest three: yes, no, and maybe.[1]

Yes, it will make a difference

The Internet has already made a difference, it seems, at least in eliminating gender differences in access to networked information technology in the United States. As part of two RAND research projects, my colleagues and I analyzed US census data for 1989, 1993, and 1997 (Anderson, Bikson, Law and Mitchell 1995; Bikson and Panis 1999). During the period represented, the gender gap in access to a home computer disappeared entirely. And, by 1997, the gender gap in use of e-mail and network services had narrowed to one percentage point. (Controlling for other socioeconomic variables, this difference remained statistically significant, but we regarded it as not socially significant.) We have not had the opportunity to analyze more current census data, but the lead article in a recent issue of *The Economist* (May 15–21 2004) reports that in the United States women now outnumber men online. Another article in that issue (*E-commerce Takes Off*, page 9) also notes that women spend more online than men.

Why 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 across many research studies done at RAND and elsewhere. Contemporary growth in the use of Internet services in the United States has also been boosted, according to *The Economist*, by a rapidly rising number of high-speed broadband links. And why assume that gender equity in access will persist over future generations of advanced technologies? A detailed meta-analysis and empirical replication of models of user acceptance, reported in *MIS Quarterly*, finds no main effects for gender in the adoption and use of new information technologies (Venkatesh 2003). Rather, only moderate interaction effects emerged for gender on intention to adopt – with women's positive expectations being mediated by perceived ease of use, and men's by perceived utility. Neither of these interaction effects characterized actual behavior, where no differences resulted.

Thus, as consumers of advancing Internet-based technologies, women are at least the equal of their male counterparts in the United States.

No, it won't make a difference

It is 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, with associated decreases in the gender gap in the same period. This appears not to be so, according to

[1] This paper draws on work conducted at RAND, but the views expressed are those of the author and not of The RAND Corporation or its research sponsors.

Taulbee survey data published by the Computing Research Association (2004). Since the 1984/85 academic year, the Taulbee survey has tracked the percentage of doctoral degrees in the United States granted to women in computer science (CS) and computer engineering (CE); in the academic year 1993/94, it also began tracking the percent of CS and CE bachelor's and master's degrees granted to women. Comparing these data with the usage data cited above does not suggest similar trends toward gender equity, even allowing for substantial time lags. For instance, in 1993/43, 17 to 20% of the three types of CS and CE degrees were granted to women. By 1997/98, when the access equity gap closed in the United States, these percentages ranged from 16 to 22%.

Since then, the proportion of CS and CE degrees awarded to women in the United States has been 'worsening', according to Peter Freeman of the National Science Foundation's (NSF) Computer and Information Science and Engineering Directorate.[2] Freeman notes that, by NSF estimates, the proportion of women receiving bachelor's degrees in CS and CE is now under 20%, while the production of women in the doctoral pool remained 'stuck' at 13% for the last half of the 1990s. It appears to have risen again to 16% in 2001, still far below the proportion of women in the population in general, or the university population in particular.

Thus, it seems that women, while well represented among consumers of IT products and services in the United States, are likely to be significantly under-represented among those who contribute to their invention and development.

Maybe …

… and some additional points to consider

There are two additional points I'd like to introduce into this US landscape of women as consumers versus generators of advancing information technologies. One has to do with other sources of supply of women in the CS and CE professions; the other involves other types of computing professions.

International women in computer science and computer engineering

The data cited above show a 3% rise in the proportion of CS and CE doctoral degrees granted to women in US universities in 2001, even while the undergraduate production of women in these fields has been dropping. NSF's Freeman explains this seeming anomaly as reflecting that 'we are filling the graduate ranks with international women graduate students'. While welcoming their participation, Freeman says it 'underscores our poor performance at recruiting and retaining US women'.

Reading these remarks led me to reflect on a RAND IT project carried out for the Romanian government, where implementation of improved official information and communications media was viewed as part of the pathway to inclusion in the NATO and EU communities (Bikson, Anderson and Hunter 2002). In the course of that project, I met surprisingly large (to me) numbers of women in CS and CE. When I asked what had led them into these professions, their stories had a common thread. At the point at which they were choosing their career directions, it seemed to them that professions grounded in physical science and engineering would be likely to be less susceptible to the heavy hand of a political ideology that could more readily interfere

[2] Paper by Peter Freeman (delivered by Caroline Wardle) for the Grace Hopper Celebration of Women In Computing conference, Vancouver, British Columbia, October 2002.

with careers in the social sciences and humanities. And they felt well prepared by their earlier education to pursue CS and CE. Now their daughters (and sons) are making similar choices, but for different reasons. They believe such disciplines will equip them for good jobs in the more robust economies of western Europe and the United States, where they expect they will be free to pursue employment.

It is important not to make too much of such anecdotes – these individuals may not be at all representative of their peers in Romania or other parts of eastern Europe. It is, however, clear that, on the one hand, the United States will soon experience a workforce shortage in CS and CE, given the large cohorts now nearing retirement; on the other hand, there is a lack of new entrants into the study of science, mathematics, engineering, and technology. There is reason for concern, according to Shirley Jackson, president of the American Association for the Advancement of Science, that the United States 'will not have the talent to enable us to be globally competitive in the future' (American Association for the Advancement of Science 2003). It is not unrealistic, then, to think that international women graduates in CS and CE could meet part of the emerging demand.

Other types of computing professions

Finally, another point made by Freeman is worth underscoring: 'There is hardly an area of human activity in which computing hasn't demonstrated its potential for bringing about radical transformations in the conduct of that activity.'[3] While his examples were drawn from routine daily life, the same arguably holds true of a great many professions. There are, for instance, new domains where computing is saliently and inextricably mingled with another discipline: computational linguistics and medical informatics are two such examples. But even without such nomenclature, the direct interdependence of advanced work in a profession and new computational affordance is evident in many fields. Industrial design, commercial art, geology, seismology, land use planning, environmental protection, and scientific visualization are among the examples.

Those who do behavioral research on the introduction of innovative digital media and tools in varied work contexts have many opportunities to observe the continuing coevolution of computing and other disciplines. It is possible that traditional counting methods may underestimate the presence of women in the computing professions.

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Redressing the Gender Imbalance in Australian Computing Professions

The background in Australia

A recent snapshot of the computing industry in Australia revealed that only 21% of the industry's positions are held by women (ACS, 2003). The gender balance is worse the higher up in senior management you look and a disparity also exists between pay rates for men and women undertaking the same work within the industry.

At Australian Universities approximately 23% of tertiary computing students are female. 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'; it requires lots of maths; it is technically oriented; lack of experience with or access to computers; and the overall, male image of the profession. 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.

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

The research literature shows that there are however, many people in Australia who have established over time that they believe passionately about the need for diversity and balance in the IT workforce. They consider that women can bring a different perspective and alternative skills that will help create better systems for all. Consequently many programs have been introduced to try to redress the complex 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.

Strategies which have been implemented and evaluated 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 programs, bridging programs, profiling female graduates, and so on. These strategies all have their place and have made some impact in terms of addressing the issues of women and computing.

Due to the ever changing nature of technology itself, it would be simplistic to expect that the problems have remained the same over time and that the strategies that have worked in the past will be the same ones producing results in the future.

However, it would appear that the 'discomfort' many women continue to feel with technology is at the centre of the social construct of gender and computing (Singh *et al.* 1999). Women have preconceived ideas about the type of people who work in the computing profession and they exhibit fear of many new technologies. These ideas then inform what they tell their daughters and how they handle technology at home (fearful of porn, Internet addiction and violent computer games). Yet it must be possible to deconstruct what is socially constructed.

What can professional organisations do to encourage and support women working in computing?

Be proactive… promote and acknowledge the contribution of women; look at the messages that their publications are giving; ensure that articles are written by women (not just on gender issues but on technology issues too); include photos of professional women; write specific articles for women. Encourage the industry to consider more part time jobs, shared jobs, telecommuting and less long hours. Raise awareness of the subtle behaviours which discourage or hold back women's progression in the industry. Such actions need to be sustained – not a one off token gesture which is often the case.

Is there a role for international action or should we tailor strategies to national need?

Let us think outside the 'square'… Let us think big!!

While the issues, politically and educationally, are somewhat different in all our countries, we do have a lot of issues in common and can all benefit from a combined approach.

Gender shifts are possible. In Australia for example, in the early 1970s less than 15% of veterinary graduates were female. Yet almost all in the veterinary profession would agree that gender is not an important attribute to be a successful vet. Currently more than 50% of all enrolments in veterinary science are female. During this time period the image of veterinary science has undergone a remarkable shift. A very popular TV Show *A Country Practice* introduced a female vet who was charming, clever and attractive. Another show, *All Creatures Great and Small,* portrayed their two male vets in a 'highly positive, socially friendly and supportive, and people oriented way' (Byrne, 1994).

Television shows such as *CSI*, which is about forensic scientists, are sold internationally. How can we encourage *CSI*, or the like, to employ a female computer professional who does have to solve problems, be creative and work with others? Alternatively could one of the *Rugrats* start to dabble with writing some code?

Other wide appeal media avenues include magazine whose readership is predominately 12–16 year old girls. Could *Dolly*, *Girlfriend* and their equivalents not have a regular technology column? Articles can be tailored to suite the issues and the culture of the relevant country of publication.

Current programs and strategies have a valuable place in the effort to improve the participation of women in computing and should not be underestimated. However a united, international effort to create a mass media presence as outlined above could enable us to take great strides forward, rather then the tiny steps we currently achieve.

The place of the Internet – new opportunities?

A wealth of excellent information can now be found on women in computing on the Internet. Equally, there are numerous women in computing 'communities' to be found. Is it time to try to bring these together? A 'Women in Computing Hub'? Meta tags need to be used strategically so that good sites are easily found from a range of keywords which are linked to current issues and events.

The collective strength of these virtual communities may have a stronger voice which could be heard globally. The Australian Medical Association has grown from 27,000 members to 312,000 within 3 years by providing them with a strong political voice (Barker, 2004). Can we harness the Internet and create a stronger voice for women in computing?

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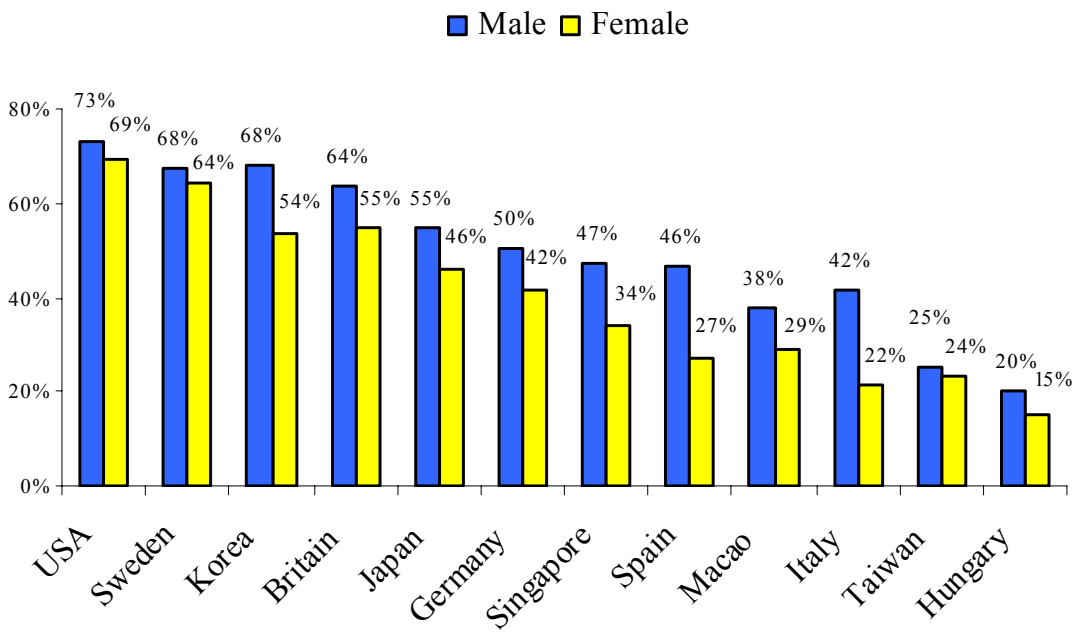
Opening Computer Studies and Professions

There is now much evidence to show that there is a trend across the world towards a more equitable gender balance in the computer professions and in studies related to information and communication technologies (ICTs) that do not focus on mainstream computer science and computer engineering disciplines (e.g. see position papers for this forum by, among others, Reyyan Ayfer, Tora Bikson, Annemieke Craig, Vashti Galpin and Olga Stepankova). This correcting of the gender imbalance is also seen in the use of the Internet and other computing-based systems. However, the continuing resistance to this trend in mainstream computer science and engineering leads me to promote a potentially major initiative for opening computer professions to more women: by opening computer studies through the development of more multi-disciplinary programmes around the study of ICTs, while also addressing approaches to opening mainstream scientific and engineering disciplines to women.

The declining digital gender divide

Let me briefly illustrate the relative balance of men and women in the use of computing, then try to connect this with contemporary trends in curricula. Survey data from nations of the World Internet Project (www.worldInternetproject.net) highlights the growing parity of women and men in the use of the Internet (Table 1). Men are still more prominent online – a gender gap remains (Liff and Shepherd forthcoming). However, this gap does not approach divides based on other social and cultural factors, such as socio-economic status or age.

Table 1. Gender and Internet Use, circa 2003.



Men spend more time online, and there are many differences in online activities between men and women, girls and boys. For example, women are less inclined to meet new people online than are men. Nevertheless, these differences are not orders of magnitude – men and women spend considerable hours online, meet new friends online and have virtual online friends.

The entry of women into new fields of computer studies

The emergence of new areas of teaching and research relating to computing, telecommunications, information management and the use of ICTs in more and more walks of life and scientific and engineering study is also 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', such as at the University of Michigan and Syracuse University. Another is the development of programmes in 'informatics' – again finding more women among students and faculty than is typical of the computer sciences, such as at Indiana University. The gender balance in Internet studies is illustrated by the diversity among the members of the Association for Internet Researchers (AoIR).

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. These new programmes often begin with work on application areas – libraries, information, design – and then move into application development, such as programming. Computer engineering is introduced as a means to further application: to do what students seek to accomplish, whether it is to design a database, create a web-based application, or conduct research online.

Opening to multi-disciplinary perspectives v. changing computer sciences

If the computer professions and associations embrace multi-disciplinary perspectives on computing and its application, the field might be more open to women. There are limits to this, stemming from the lower percentage of women in academia generally (Greenfield *et al.* 2002: Table 5). The history, male culture and mathematical foundations of mainstream computer science make the discipline very difficult to change. But as computing is becoming more central to a widening area of other disciplines, these other disciplines are becoming more central to the development, use and application of computing. Programmes in Internet Studies, Informatics, Information Studies, Social Studies of Science and Technology and other topics can enrich the development and application of computing and bring more women into the field, without diminishing any sub-disciplines. However, it requires an openness to multi-disciplinarity in computer studies and the professions, which is a tough challenge in itself.

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A South African Perspective on Women in Computing Professions

This position paper is written from my point of view as a South African Computer Science academic. South Africa is a developing country, and many things that may be taken for granted in developed countries cannot be taken for granted in South Africa: one example relevant here is computer literacy education at primary and secondary school level.

The focus of this paper is women in computing professions. I will start by looking at women's participation in these careers and barriers in South Africa, after which I will consider international versus national strategies. The next two sections consider what professional organisations can and are doing, and what activities might be successful. The paper ends with a summary of my position.

Participation and barriers

Women's participation in university-level computing degrees is typically low worldwide (Galpin 2002), and participation by women in computing professions is low. Some countries in Eastern Europe and in the Far East are exceptions.

Research has clearly shown that there are different motivators in different countries. For example, in South Africa women may stay away from computing professions because they associate computer use with clerical jobs (Herbert 2000).

What are the obstacles to women's participation in computing? We have some information about these barriers from prior research. In South Africa, obstacles include incorrect perceptions of the work that computer professionals do, and lack of positive role models (ibid.). Additionally, poor choice of subjects at school can lead to a restricted choice of subjects at university, excluding students from Computer Science and other disciplines with mathematical foundations. Within the work place, the glass ceiling plays a role together with the perception that when women rise to senior executive level, it is areas such as human resources that are seen as being more appropriate for them than technical positions.

Strategy: global or local?

In terms of promoting computing professions for women, I believe that there is a core of promotion that can be done globally. This core covers the following: women can succeed in these careers; these careers are exciting and interesting (and possibly lucrative); and these careers often involve interacting with people. These are universal facts about careers in the computing profession, and hence they can be promoted globally.

However, I also believe that there is a need for material tailored to local conditions. For example, in South Africa it is important to emphasise what the career is *not* about, in order to avoid confusion with clerical employment. It is also important to emphasise the status of the job, since anecdotal evidence suggests that students aspire to a limited range of careers that are viewed as having status: teaching and nursing for women, and law and medicine for men.

Professional organisations

Organisations for computer professionals can and do provide encouragement and support to women working in computing. Having women in computing as a continuing focus of the specific professional organisation is very important. I believe this has been done with success within the ACM in recent years. Another important issue I want to emphasise is the diversity of women in computing – it is not just about women in industry but also about women in research laboratories and academia, and female students.

Many strategies have been suggested over the years, and some have succeeded, some have not and some have not been implemented, or fully evaluated. I see two main problems here. The first is the problem of lack of resources for implementing and evaluating strategies. The second is the need for assessment and recording of what works and what doesn't.

I believe that keeping track of these strategies is very important, as well as recording when they have worked, where they have worked and why they have worked (with reference to local conditions). If we do not have this information, we may repeat mistakes, or be unable to determine which strategy will work in a particular situation. Collecting this information is a very large task, and an area in which professional organisations can extend their involvement.

Conflicting objectives

In my experience of trying to track activities to promote women in computing, I have found that it is important to identify what the activity is. I see that there is a large difference between those activities that are aimed at computer literacy, and those that are aimed at encouraging women to become computer professionals.

Activities with a focus on computer literacy, together with the ubiquity of computers, may indirectly lead participants to underestimate opportunities for careers as computer professionals. This may happen because computers are presented merely as an easy-to-use tool (like a car or a telephone). Also, by focussing on application software, computer literacy activities may emphasise the use of computers in clerical work. This is important to consider in countries such as South Africa, where general computer literacy education in schools is not yet universal.

Another important, but somewhat tangential, issue relates to the application of computers. We should not start with computers as a solution and look for a question, especially in developing countries. It is important to start from questions and consider computer technology as one possible solution among many possible solutions, each of which needs to be evaluated.

In summary, my position is that:

- participation by women in computing professions is low: there are barriers that are general and those that are specific to individual countries;
- there is room for a general international strategy in tandem with tailored national (or even local) strategies;
- evaluation and recording of strategies is important, since it allows for learning about what works and why it works; and
- there may be conflicting outcomes from different activities relating to women and computing.

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Looking to the Future: Vive la Difference!

There is no doubt that as much as we would have it otherwise, the world of computing is still very much a man's world. I have often wondered what made it possible for me to be successful in this world when other women either find it difficult or choose not to try. My great role model, Dame Steve Shirley, who was the first female President of the BCS, tells the story of how in the early 1960s she had to leave the civil service because she got married. We don't have to deal with issues as stark as that these days, but it is still hard to reach the top as a woman in a man's world.

I am privileged to be President of the BCS during an amazing year which represents the culmination of work that has been going on for many years to modernise the society and make it more inclusive and representative of the whole IT industry. But as a community we are responsible for a set of technologies that affects every aspect of people's lives – and, of course, 50% of people are women. So why are women so under-represented in our industry? If I knew the answer to that I would be a millionaire. It is a question I am frequently asked and it is so hard to answer.

The BCS has existed for only 46 years and in that time we have had equality legislation that has enabled women to succeed in all walks of life. Hence it is even more depressing that during that time we have seen the number of women involved in our industry decline rather than increase while the culture of the computer industry culture has developed a geeky, nerdy, macho image that is so difficult to break down. Of course, women use computers when they become useful to them. I draw the analogy with the car industry. Today most women drive cars, although most of us don't really care what is going on under the bonnet. In the past, car advertising was almost totally targeted at men. Now that the industry realises how big the market is for women drivers, the advertising is increasingly targeted at women and families. But there aren't many women working in the car industry and so cars are still designed by men. Women put up with things they don't like in cars, like the way they ruin the heels of your best shoes, because 'that's how they are' and cars are useful to us. But how much influence do women have on the design of cars? It's even worse in the computer industry.

So what do we do about this? When you look at the number of women on computer science courses at UK universities – for example at Southampton it is less than 10%, some years closer to 5% – you realise that, even if we start now, it will be decades before there are enough women coming out of university courses to make any impact on the industry. I am worried that this is such a deeply-routed cultural problem that if we had all the money in the world and could attack it at every level from primary school to board room, by the time we make any impact on the problem we won't need the same skills that we need today. And of course it may be that women just don't like programming, or fiddling around with things under the bonnet of computers, or being associated with an industry with such a macho image.

As it is going to take so long to turn things round, where would I put the resources and effort? I would look to the future and think about the type of skills we are going to need for the generation of computers after next. In a decade or so we will be entering the age of biologically-

inspired computing. For example, think ‘ants’: it will be a world of trillions of very small processes all working together in globally interconnected networks. We need to learn lessons from nature about how insect colonies such as ants work collectively to achieve tasks that independently they wouldn’t be capable of doing. Another example would be learning from the neuroscientists about how humans manage to think associatively, and using that to build software systems that more effectively find the information you want from a massive information space.

I suggest we stop trying to persuade women to be interested in careers based on computers as we know them today, when this is patently to difficult to do. Rather, we should look to future generations of computer systems and ensure that we seize this opportunity to change the image of our industry to one that women will be more interested to work in. The skills that will be required for such an industry are quite different from those required today. We will need people with backgrounds in biology or chemistry or medicine, and these are all subjects that attract women. If we work hard on this approach now, then I think we will stand a chance of attracting women to work in this new industry as it emerges.

Clearly women are going to be increasingly using computers as they become widely available at home and in the workplace, in areas that women care deeply about such as healthcare, education, government and the leisure industry. But this isn’t enough; we need to get women involved in designing computer systems at every level. During my year as BCS President I have taken every opportunity to find high profile women speakers for the events that I am hosting, and to celebrate the role of women in our industry as it is today. But I firmly believe that there is an opportunity to be seized here as we look to the future role of women in our industry.

Beth Hutchison, Software Architect, Women's Leadership Team, IBM UK Ltd, Hursley, Winchester

Strategies to Overcome Obstacles to Women's Participation in Computing Professions

What are the main obstacles to women's participation in computing professions?

There are two major inhibitors to women's participation in the computing profession: the unattractive image of the profession; and lack of confidence in their own abilities. The popular image of a computer professional is that of a geek, and this is reinforced by popular press stories of computer hackers breaking into government computers from their bedrooms. This unappealing image results in few girls considering computing as a career as they leave school, and even those women who go on to achieve computing degrees frequently do not choose to continue in the field after graduation. The unattractive image continues to undermine practicing computer professionals, as a conversation-stopper almost as effective as being a tax-person, or with the suggestion that other careers are of more value to society.

The other inhibitor to women's progression in the computing profession is a lack of personal confidence. This is popularly cited as a female characteristic, applicable to any field, but is a more significant inhibitor in the field of computing than elsewhere. Computing is a very fast-moving field, with new software paradigms and hardware technologies arriving in rapid succession. I see my colleagues and customers play acronym tag – 'what do you think of the new WS-CIO standard?', which translates as 'I know all about this cool new technology, but do you?' It takes confidence to answer the question based on a quick browse of a web article, when your natural preference is to study the full specification, and it takes more confidence to admit to a customer that you haven't yet heard of that one, but you will get back to them.

So, faced with low self-confidence in a world where nothing stands still for long enough to learn about it, many women undervalue themselves and their contribution to the profession, and choose to not aspire to higher technical positions, or even to leave the profession.

What can professional organisations do to encourage and support women working in computing?

Recent research from the European WWW-ICT project has shown that women are simply not aware of the breadth of roles and skills that are covered by the computing profession. If schoolgirls and university students were made aware of the range of opportunities, and were introduced to female role models, their impression of, and interest in, the computing profession should be improved. Similarly, if computing presentations focused more on its uses, and less on its technology, more women would understand why this can be a worthwhile and satisfying career.

The professional organisations have a significant pool of ambassadors, their female membership, whom they should empower and motivate to talk to schoolchildren, students, teachers and careers advisers about the computer profession. Women who are happy working in the profession are the best role models to convince others that they should consider a computing career.

Experience with school and university visits from IBM women suggests the membership would be willing to give a little of their spare time to achieve this. Further participation would be encouraged if the professional organisations recognised 'give-back' in their application forms, including the support of women in the profession. However, these organisations will need to create the collateral: presentations, posters, speaker notes, introductory e-mails, background on computer courses, etc. which will enable their female members to be effective ambassadors.

To increase their self-confidence, women need to understand that they are not alone, that many women with successful careers in computing have learned to live with their lack of self-confidence. In addition, they need easy access to an instant source of information, to answer their technical queries in a non-judgmental environment. Both of these requirements can be achieved effectively through electronic networking, with the members of the professional organisations supporting one another by responding to technical queries, referring to informative websites, reviewing CVs, discussing books on gender behaviours at work, etc. The BCS Women's newsgroup goes some way towards fulfilling this function, but it would benefit from having wider participation, both to ask the questions and to answer them, and from a moderator to facilitate some of the discussions.

Finally, addressing both the concerns of image and lack of self-confidence, the professional organisations should create a database of women prepared to be interviewed on computing topics, and offer media training to encourage them to put their names forward. With programmes like these in place, the professional organisations should participate actively in the 'networks of networks' which are springing up to coordinate and share activities for supporting Women in IT, science, engineering and technology. There, they would hopefully gain support and publicity for their activities, and possibly increased membership.

What particularly effective strategies have you been involved with – and what are the main problems in establishing effective strategies?

The Women's Leadership Team at Hursley has successfully initiated many projects, including:

- *Schools and universities:*
  - Women in Technology (WIT) workshops at universities;
  - mentoring schoolchildren;
  - WIT workshops and summer camps for schoolgirls; and
  - computer badges for local brownies.
- *Supporting existing computer professionals:*
  - mentoring (both internal to IBM and external);
  - checks on fair distribution of 'opportunities';
  - networking lunches and seminars;
  - book reviews; and
  - presentations and roundtables by female role models.

One of the major challenges is communicating to the women themselves that there is a real business requirement to recruit and retain more women in the profession. Many do not perceive any inhibitors to their own career, even though statistics show that there are fewer women in senior roles than should be expected.

Gerti Kappel, Business Informatics Group, Institute of Software Technology and Interactive Systems, Vienna University of Technology
Beate List and Ulrike Pastner, Women's Postgraduate College for Internet Technologies, Institute of Software Technology and Interactive Systems, Vienna University of Technology

Seeking Role Models to Support Women in Computing Professions

Problem statement

The Information Revolution at the end of the last century has changed our lives. Information technology has become ubiquitous. The Internet, especially, has rapidly accelerated this development. Information can be accessed from the remotest areas in the world and people have access to knowledge, learning facilities and communication in ways they never had before.

The Internet has made the world a smaller place. It has opened opportunities for creativity and for new forms of employment. As a result, the field of computer science is likely to melt into communication, design and art at some point. Information technology is moving to areas in which women are commonly seen as competent.

The Internet and mobile technologies offer a lot of new and interesting opportunities. But at the same time, this technology is not available to everyone. There is a huge gap not only between developing and developed countries, between near-illiterate social classes and highly-educated social classes and between rich and poor, but also between male and female. It is evident that women have less access to the Internet and computing technology than their male counterparts.

Women were excluded from education in the western world, and women are still being excluded from education in a lot of developing countries. Internet developments show some similarities with the access to education, and we have to make sure that an exclusion of women and other discriminated-against groups is not going to happen again. Information technology must not be exclusively available to a small and privileged group of people, rather than being a universal skill and basic right.

Information technology is ubiquitous. Thus, people are also often expected to be always available and to do their work wherever they are. This form of professionalism is more common and accepted for men than for women. Women are supposed to look after kids, do the household and keep the daily problems out of men’s lives. Consequently, for women it is harder to keep up with the fast pace of technology and its requirements. Many women have a fragmented employment history following employment breaks to raise children, and many people consider work by women to be merely a hobby.

Different expectations of society towards men and women have an impact on the way people plan their lives. Men tend to develop their career straightforwardly, while women often try to

combine their career with family live. This way of thinking has led to a division between traditional male occupations and traditional female occupations, as has occurred in the information technology sector. Few women are successfully employed in this industry due to many obstacles.

The dichotomy ‘technique is male, social is female’ – and beyond this the definition ‘computing is an engineering, i.e., technical discipline’ born in the 1980s – is one of the main reasons for the male domination of the computing sector. The classification of these into worlds divided (‘gendered’) into male and female expresses strong cultural values, which are continually supported by media and education.

Therefore, the organisational structures of the computing profession and institutions are male dominated and often not attractive to many women (i.e. conditions of employment like long working hours, culture and climate, language, competitiveness, and networks are orientated towards men without family responsibilities, etc.).

Those women who, despite of all these prejudices and obstacles, decide to go for a technical career often have to cope with a special status. As the world is changing slowly and traditional customs often prevent equality, special initiatives and programs that target only women have to be initiated to change the unsatisfactory position of women in the professional computing environment. Men promote men and get highly rewarded jobs. Women, because of their comparatively lower positions within organisations, have less opportunity to network with other high-profile influential colleagues.

Employers should be encouraged or, if necessary, even forced to create women-friendly working environments. Further professional and career developing activities like courses for women only, mentoring projects, image campaigns, innovative structures (work–life balance, family-friendly working times), and role models will increase the number of qualified female employees.

In order to change traditional organisations and customs, which are often hostile to women's rights, a shift in strategy is required. Therefore, it is essential to establish these activities and initiatives on a continuous basis. To ensure that these activities are successful, it is essential to have institutionalisation at the highest organisational level possible, a dedicated budget, and the support of women at every career step.

Solution scenario: the Women's Postgraduate College for Internet Technologies

At the Vienna University of Technology, a five-year project has been established for promoting women in the field of computer science and information technology, called Women's Postgraduate College for Internet Technologies (WIT). The Austrian Council for Research and Technology Development has initiated a project series on the promotion of women in science and technology (fFORTE) to provide for women’s competitiveness in the global marketplace and the scientific world. WIT is the largest project within fFORTE.

WIT has been established in response to the under-representation of women in science and technology, particularly in computer science. The Women's Postgraduate College for Internet Technologies offers a unique Ph.D. program pursuing research on the highest international level, in combination with mentoring activities for female students and female researchers. The implementation of WIT is based on various activities, which are structured into three main fields:

- *Ph.D. program for women in the area of Internet technology*. A Ph.D. curriculum and training program provides an introduction to the role of a scientist and an entry into the scientific community for eight female Ph.D. students. By means of a broad and diverse qualification development approach (technical as well as non-technical), the Ph.D. students are also prepared for managerial and leadership functions. The decision to have Internet Technologies as the main research focus was motivated by the emerging and fast growing character of the research field that exploits advanced information and communication technologies. Furthermore, the School of Computer Science at the Vienna University of Technology, of which WIT is a part, has based its scientific focus on Internet Technologies as well.
- *Mentoring for students and researchers*. Special programs encourage young women during their final year in school to study computer science. Hands-on computing workshops only for women, e.g., hardware, network, and operating systems workshops seek to provide basic knowledge for female students during their first year at university and to give them – as kind of spin-off – self-confidence. Personal and professional skills are fostered throughout the female student's university career, in order to actively motivate them to pursue a successful scientific career. Visiting female professors as well as international scientific cooperation and exchange programs act as role models and support the integration of pre-doctoral researchers into the scientific community.
- *Communication platform for research and further education*. A diverse set of communication initiatives (colloquium series, further education tutorials, web portal, etc.) aims to foster the exchange of knowledge, and make women visible in computer science.

The School of Computer Science at the Vienna University of Technology is more than thirty years old and has a high reputation for research and teaching excellence, both in Austria and internationally. The School of Computer Science is the largest school of its kind in Austria. The integration of WIT into the School of Computer Science provides a broad spectrum of research and personal expertise to the Ph.D. students.

The vision of WIT is to become an institution with an outstanding reputation for scientific excellence within the next five years. WIT is dedicated to providing its female researchers and students with an education that combines intensive academic study and the excitement of discovery with the support and intellectual stimulation of a diverse community. WIT is committed to advancing knowledge and educating its Ph.D. students in science and technology in a way that will best serve the challenges of a science- and technology-based industry in the 21st century.

A main drawback for long term success and impact is the limitation of the WIT project to 5 years. For long-term results, more stable and long-lasting structures are required.

Concluding remarks

It seems to be anachronistic, but women definitely require support to become successful under current hostile conditions in the computing environment. The only way to get more women into the computing field is to provide initiatives at various institutional, national, and international levels. These initiatives must be dedicated only to women. National programs should learn from each other, adopt 'best practices', and target the special shortcomings of each country. International actions should support national activities and should also force countries to focus on equal opportunities for women in computing.

Maria Klawe, President of ACM, Dean of Engineering, Princeton

A North American Perspective on Women in Computing

I've chosen to arrange my thoughts by providing brief answers to the suggested questions for the Forum. All of my statements are focused on the situation in North America and may not be accurate for most other countries.

1. How are computing professions changing and does this offer new opportunities for women?

One change is that almost everyone uses the Internet and mobile technologies as part of their daily life: at work, at school, at home and at play. Another is that because of the increasing need for application software in many new areas, there is a strong demand for computing professionals who are also expert in other domains (e.g. healthcare, shopping, entertainment, languages, etc.). The first change makes it easier to make the case that computing is something that affects everyone (and hence that women need to be involved). The second seems likely to provide more computing careers that are attractive to women because degree programs that combine computing with another area (e.g. computing and biology, computing and psychology, computing and multi-media design) tend to have much higher participation by women.

2. What, in your experience, are the main obstacles to women's participation in computing professions?

The obstacles fall into two groups, perceptions and reality:

- *Perceptions.* Women and girls perceive computing as something they will not be good at, and something they will not enjoy. They view computing professionals as antisocial people who program all day, and that the computing community is one in which they will not feel comfortable.
- *Reality*. The actions and statements of parents, teachers and children reinforce girls' perceptions about computing being a 'boy-thing'. Boys are aggressive in hogging computers at school and at home to play games. Many boys want to learn to program so that they can create their own games. Since computing classes are not compulsory, this results in boys making up about 80% of secondary school computing classes In addition, several factors make computing classes at secondary and post-secondary levels less attractive to many females. These include content that focuses primarily on technical issues rather than applications in introductory classes, the intimidating presence of hot shot males who have been programming since their early teens, poorly debugged assignments, and the absence of female instructors and TAs.

3. How can professional organisations encourage and support women working in computing?

Professional societies can do a lot to address the issues of perception and reality raised in the answer to question 2 above. Some specific initiatives include:

- Ensuring that women are well represented in all positions of influence and recognition within the society, e.g. on the executive and other governing bodies, journal editorial boards, program committees, award committees and among award recipients.

- Ensuring that women are well represented in publicity materials including special interest stories in publications, and that all educational and outreach efforts are designed to take the interests of women and girls into account as well as those of men and boys.
- Making gender-inclusiveness an integral part of the design of model curricula.
- Having a presidential-level group with responsibility for special initiatives to increase the participation of women in computing.
- Running programs to attract and retain females in computing at all levels (ages 12–15, ages 15–18, post-secondary students, graduate students, beginning faculty and computing professionals, mid-career faculty and computing professionals, senior faculty and computing professionals.
- Regularly collecting data on participation by women at all levels.

4. What roles can diverse organisations (employers, unions, professional bodies, etc.) play in pursuing this objective, and how can they most effective complement each other's activities?

Employers can make it clear to universities and colleges that recruiting women is a high priority for them, by for example, sending their recruiters to the institutions who produce the highest percentages of women. They can offer summer internships (work experiences) and mentors for female students. Collaborative efforts among different sectors help increase understanding, cohesion and effectiveness of initiatives. Regular meetings (possibly convened by professional societies or policy groups) that bring together representatives from different sectors are helpful in building such collaborations, and in forming coherent strategies for progress.

5. What particularly effective strategies have you initiated or experienced that could serve as an example to others, and what main problems do you see in developing and implementing such strategies?

One of the most effective groups has been the Computing Research Association's Committee on the Status of Women in Computing Research (CRA-W). I am biased as Nancy Leveson and I co-founded CRA-W in 1990. It is a committee of 10–12 individuals. The key components that have made CRA-W successful are as follows:

- A focused agenda (to increase the number of women in computing graduate programs, faculty positions, and industrial research labs).
- The requirement that each member of CRA-W be a highly respected researcher (which ensured the credibility of the committee in the computing research community).
- The requirement that each member of CRA-W lead a specific project during their term on the committee.
- Having a pair of co-chairs lead CRA-W for 3-year terms. Having co-chairs lightens the load of being chair, makes it more fun, and can provide more balanced leadership. Regular turnover of leadership keeps the group vital and energized, brings in new ideas, and gives leadership experience and opportunities to a broader group of women.

The work by CRA-W is widely viewed as being primarily responsible for significant growth in the number of female Computer Science (CS) faculty in North America.

The Anita Borg Institute (see paper by Telle Whitney in this collection) is another organization with several successful initiatives, of which I want to say a few words about the Grace Hopper Conference founded by Anita Borg and Telle Whitney. For almost all attendees, this Conference is the only event where women in computing have the experience of being in a room with over five hundred other women in computing. It is an amazingly powerful experience. I know of many

women, especially students, who decided to remain in computing careers after attending the Conference.

The third example is the Supporting Women in Information Technology (SWIFT) project at University of British Columbia (UBC) which ran the initiatives created through the IBM-NSERC Chair for Women in Science and Engineering that I held from 1997-2002. This was one of five regional chairs across Canada, and was funded jointly by IBM Canada and NSERC (Natural Sciences and Engineering Research Council, the main Canadian federal funding agency for research in science and engineering). Over the five years of the chair, the percentage of women in the undergraduate computer science majors at UBC increased from 16% to 26% and the number of women faculty in the computer science department increased from 2 to 7. The main factors that contributed to these successes were as follows:

- The department and university had to make a number of commitments as part of the proposal to get the chair. These commitments (such as recruiting a new female faculty member in CS whose responsibilities would include leading activities to increase the participation of women at all levels in the department) were controversial and required substantial discussion before the decision was made to proceed with the proposal. This discussion was highly effective in raising the awareness of CS faculty members about the issues affecting women in the department and the discipline.
- The new female faculty member who was recruited (Anne Condon) was a stellar senior researcher and teacher whom the department really wanted. Moreover, Anne made it clear that the primary reason she was willing to leave a more prestigious department (and a higher salary) was because she wanted to be in a department that strongly supported initiatives to increase the participation of women in CS. The success of recruiting Anne helped us recruit the other four women junior faculty.
- The chair funding allowed us to hire several women undergraduates each year to work full-time on SWIFT initiatives for periods of 4–8 months, and a staff coordinator. This provided the staff support for many outreach initiatives to high schools, for surveys that helped explain why women were currently not choosing to study CS, and for materials to support innovative approaches to teaching computer science and programming. Moreover, several of the students were deliberately chosen because they lacked confidence in programming. Almost all went on to graduate programs in computer science or to work full-time in computing-related careers.
- Several factors helped increase the number of women taking first year computer science classes, and the number continuing on to major in CS. These included:
  - a recommendation (but not a requirement) from the Dean of Science (who also happened to be me at the time) that all science undergraduates take at least one computer science course;
  - encouraging students who did well in the ‘computer literacy’ course to continue on with the first year course for CS majors, and to get credit for both;
  - encouraging students in biology (60% of whom are women) to take the first year computer science courses over the summer;
  - having more women teach first-year computer science courses and TAs the compulsory labs;
  - making sure that all the first year assignments could be completed during the compulsory labs;
  - monitoring to ensure that first year instructors and TAs were encouraging to women students; and
  - providing many programs that allowed students to combine a CS major with a major in another area.

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Getting more women into computer science and engineering

About this paper

This paper draws extensively from work done as part of the project 'Strategies of Inclusion: Gender in the Information Society' (SIGIS), funded by the EU (IST-2000-26329) and has benefited from input from Wendy Faulkner and Knut H. Sørensen. The SIGIS project was conducted in Ireland, Italy, Norway, The Netherlands and the UK, and it has analysed initiatives and efforts to recruit and retain more women to higher education in computer science and engineering. Based on the cases studies conducted by SIGIS, this paper suggests some efforts that appear to have been particularly useful to achieve successful enrolment of women. Visit www.sigis-ist.org for further information about SIGIS.

Introduction

The gender gap in access to, and use of, information and communication technologies (ICTs) has been reduced significantly. Still, however, the number of women who take a higher education in computer science and engineering is substantially smaller than the number of men. Women's increased participation as users of new ICTs, including the Internet and mobile phones, does not appear to have been translated into a greater interest in studying computer science and engineering. In order to achieve a gender balance, particular actions need to be taken to recruit more women to higher ICT education.

As a general point, our research has emphasised the importance of engaged and comprehensive inclusion projects, embedded in institutions of higher education, in order to achieve the goal of enrolling more women students to become ICT professionals. These projects need strong support from the board and leadership of the institution, as well as resources. Moreover, it is important to combine several instruments in order to give inclusion efforts a high degree of visibility and to make them convincing. It is very important to make women students feel welcome. Also, one needs to be concerned not only with the recruitment of women students, but also about how they may be retained through suitable socialisation efforts. Such efforts should include a strong focus on educational quality, since such quality seems to be particularly important to students who are unsure if they belong in the programme.

How to design instruments to recruit women students

It is no easy challenge to design instruments that serve to make more women apply to higher education in computer science and engineering. Our research suggests that the following actions may bring good results:

- *Allocation of quotas*. The experience from SIGIS research shows that an admissions quota reserved for women only is a good way to signal that women are really wanted. This instrument may be very important to secure a sufficient number of women students to achieve for them a peer-supportive community that is so crucial to their experience of the social environment. Also, it makes the education appear as more gender neutral or cross-gender; in fact, the inclusion of many women changes the gendered image of

computer science and engineering in a very significant way (at least for the student in computer science).

- *Extensive advertising campaigns* to inform and encourage women to apply may be highly effective. The use of humour and irony helps to gain attention among young people. Advertisements may also benefit from having a fashionable and trendy style. A lot of media attention about the efforts to recruit women may also be helpful, because it reinforces the message that women are particularly wanted as computer science and engineering students, and makes women more aware of the programme.
- *Role models* are important for making more women perceive computer science as an attractive education. Role models can be women students as well as women faculty and professionals.
- One way of making role models visible is by focusing on women in advertisements or using women to promote computer science programmes in media or schools. However, it is above all important to provide role models through the appointment of women faculty and to use women students as teaching assistants as much as possible.
- Inviting women applicants to *pre-visit the institution* in order to encourage them to accept their study place may also have a good effect. For example, one university that we studied organised what they called the Women's Day. Women who had applied to the computer science programme were invited to come to the university to get to know each other, learn more about the programme and take part in social events. The university covered travel costs. In this way, they got to see that there are fellow women applicants, and they could make friends with other future women students. For the university, it represented a good opportunity to promote the programme as well as the university, thus making their offer attractive.
- *Visibility effects in upper secondary school* may be quite important. The programme and the university can be promoted by letting women computer science students visit upper secondary schools to talk about and promote the computer science programme.

How to design instruments of socialisation

Socialisation efforts are meant to make women students stay in the programme. According to SIGIS research, the following efforts have proved effective in reducing the dropout rate of women students:

- *Curriculum reform* aimed at contextualising computer science. Women students may particularly benefit from learning about the future uses of a computer science education and the way it may lead to gainful employment.
- *Provision of adequate technical facilities* is important for student motivation. One successful arrangement consisted of ICT companies sponsoring technical equipment for use by women students.
- *Educational reform* by improving the quality of teaching and tutoring has proved to be a significant initiative to retain women students. By using women teaching assistants, one also provides important role models for younger students.
- *Gender-controlled composition of teamwork groups* is important when the number of women students is low, in order to avoid women students feeling marginalised.

Guidelines

In general, our research shows that a broad scope is required to achieve the best possible effect of the inclusion efforts outlined above. This should encompass guidelines such as:

- Combining different efforts is particularly effective in achieving a notable result and reaching as many potential and current women students as possible.

- Women are by no means a homogenous group. Thus, heterogeneous actions are required in order to reach as many women as possible. Stereotyping – drawing upon traditional images of women and femininity – is a bad strategy. First, it narrows down the segment of women, since few women actually fit such stereotypes and consequently will not feel targeted by the initiatives. Second, being perceived in a particular and inappropriate way often provokes women and makes them feel less appreciated.
- Usually, women students in computer science are quite resourceful. They dislike and refuse to be treated as if they need 'crutches'. It is important to emphasise that inclusion efforts should, as much as possible, be presented as not directed explicitly toward women only. On the contrary, they should preferably be seen as being available to all students, men and women, even if they are motivated by a concern for women students. Improving educational quality is a good example of such efforts.
- Relative numbers are crucial to avoid marginalisation of women students. In order to create and maintain a peer-supportive environment among women, there is a strong need to be beyond a certain 'critical mass' of women. Our case studies show that if one reaches a significant number of women students, computer science no longer appears as a particular masculine domain, but rather as an education just as suitable for women as for men.

In cases where women are in a marginal position or under-represented, it is a good strategy to facilitate the creation of networks in order to contribute to community building among women students or faculty.

Sonia Liff, OII and Warwick Business School

The Role of Professional Organisations

Background/orientation

I have a background in social studies of science and technology with a particular interest in gender and technology. I am also an academic researcher/teacher in the area of organisational behaviour/personnel management with a specific interest in workplace equality policies and a broader interest in professions as value systems and learning communities. I am not a specialist researcher on the computing profession.

My interests in this workshop are primarily:

- Puzzlement about the fact that women's increasing engagement with computers, the Internet, mobile phones, etc. as users/consumers does not seem to have been accompanied by a parallel increase in the proportion of women on computer/IT courses and in computing jobs – what does this suggest about the reasons why women are absent and what policies could be effective?
- Concern that more than twenty years of equality policies seem to have had at best a limited impact on the recruitment, retention and promotion of women in male-dominated IT occupations – what can be learnt from wider experience of equality policies and in particular debates about diversity and organisational culture?
- Interest in the potential of professional organisations, or more likely groups of professionals, to change occupational cultures and value systems – is it possible to go beyond women acting as mentors who help new entrants understand 'the system' to change values and approaches in ways that make systems more 'women friendly' in the first place?

Women's increasing engagement with computers

It used to be commonplace to explain women's relative absence from science, technology and engineering jobs by pointing to the masculine image of these subjects (in the same way as explaining their predominance in nursing, teaching, etc. as linked to feminine characteristics). Thus, it was believed that choosing to study or work in these areas would be a 'gender inauthentic' choice for women which could lead to role conflict. This led to a range of initiatives, particularly within the educational sphere, which aimed to change the image of these subjects and show, for example, that engineering wasn't all heavy and dirty, and that 'female' skills of intuition and collaborative working were important in science. High-profile women presented as role models can also be seen to be contributing to this approach.

Given the widespread ownership and use of IT-based equipment and the Internet by women as well as men, this argument would lead one to expect computing to be seen as less male gendered, with more women studying and working in this area. This does not seem to be happening. There are two broad explanations which could be explored:

- The symbolic association of computing and masculinity was never a (or perhaps more plausibly the principal) deterrent to women entering these areas (and if this is the case, clearly one needs to ask what else is important).
- The image of computers in the consumption sphere and/or 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, in which case is this a failure of curriculum or teaching methods to adapt, or of occupational roles/structures?

Limitations of equal opportunity policies

Many countries have had long-standing equality policies in workplace and educational establishments. These have been based primarily on an attempt to treat men and women equally, to ensure that merit is the basis for appointments and promotions, and to 'level the playing field' providing support for childcare, career breaks, etc. In some cases, this has been taken further (via positive/affirmative action initiatives) to offer targeted courses/places, etc. It seems likely that such measures have been important in removing the most explicit forms of discrimination and may be successful in helping individual universities/employers to attract relatively more female candidates. However, overall patterns of gendered occupational segregation both horizontally (between occupations) and vertically (at different levels in the hierarchy) have remained remarkably persistent.

The argument is commonly made that such policies merely need to be applied with more commitment/senior management engagement, etc. While this is undoubtedly part of the solution, it is becoming less convincing as a complete explanation. Other issues that have been raised include:

- 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 in the EU Helsinki group report – 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.
- In the light of this, 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/jobs done that are attuned to women's approaches and experiences (sometimes discussed under the label of 'managing diversity'). In line with the above point, note there is a distinction between changing expectations/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.

Professional organisations as value systems

Professions at their strongest control entry into an occupational area by: defining the bodies of knowledge that constitute their area of expertise and assessing whether individuals have attained it; developing and policing codes of behaviour and the exercise of self-management over and, where necessary, discipline of (including the power to 'dismiss') those whose knowledge or behaviour does not meet the required standards. Clearly many of the occupational areas commonly referred to as professions do not meet all these criteria, and in many cases rights to self management have been eroded over the last twenty years. Nevertheless, professional bodies (both 'official' and less formal interest groupings) remain important in creating a sense of the identity, good practice, etc. of the occupational group.

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'. 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. It might appear that this merely defers the problem, in that it suggests change needs to (and can) occur in one type of organisation (professional grouping) rather than another (university, business organisation, etc). 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(s). It would be good if the workshop could discuss whether the changes in the nature of computing education and practice associated with the Internet and a different constituency of members could form the basis of a different kind of change.

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The EPSRC Network for Women in Computing Research

Summary

The network for women in computing research (WICR) of the UK Engineering and Physical Sciences Research Council (EPSRC) aims to put in place a positive action programme for women in computing research, with a particular focus on interdisciplinary research, leadership and enterprise. Its long-term goals are to:

- increase the recruitment and retention of women in computing research careers, by offering support to current women in computing research, and by introducing women in related disciplines to the opportunities it offers;
- ensure that women are well placed to play a leadership role in new and emerging research areas, especially interdisciplinary ones;
- increase women's understanding of, and participation in, entrepreneurial ventures and commercialization; and
- increase public engagement in, and changing public perceptions of, computer science by providing public spokespersons who will contribute to changing the image of computer science.

Background

ICT subjects, information and communication technologies and related disciplines such as nanotechnology and bioinformatics, are the core of the technological developments driving the knowledge revolution. Yet, despite a few striking exceptions, the number of women in academic or entrepreneurial leadership roles in technology is small, women are under-represented at all stages in UK computing research, and the situation gets worse throughout the research pipeline, with the proportion of women declining at each career milestone: undergraduate to postgraduate, postgraduate to Research Assistant and RA into academic and industrial careers.[1] For example, in the UK higher-education Research Assessment Exercise (RAE) in 2001, only 190 (13%) of the category A staff submitted in the computer science unit of assessment were female. This is despite many years of well-intentioned activities and strategies, for example 'gender blind' appointment criteria.

However it is not just a matter of small numbers coming through the pipeline – research as presented in, for example, the recent Greenfield Report (Greenfield *et al.* 2002) has shown that the greatest obstacles to the progression of women already launched in the high-tech field are the lack of the support mechanisms such as mentoring, role models and access to informal networks that give the next hand up the ladder (Wellington, Kropf and Gerkovich 2003). Recent data presented in the UK Office of Science and Technology (OST) Athena Asset Survey of male and female university scientists showed that women, even at senior levels, felt disadvantaged in matters such as social inclusion and access to career development – yet 33% of women, as opposed to 22% of men, aspired to leadership positions (Gürer and Camp 2001).

[1] UK Higher Education Statistics Agency and other data are available at www.set4women.gov.uk

This is confirmed by more detailed US analysis of the position of women in the computer science pipeline carried out by the ACM and US National Science Foundation (ibid.).

While these issues arise across engineering and the physical sciences, they are particularly important in computing, both because of the low numbers of women compared with other sciences, and the role that computing researchers in universities and industry play in shaping new technologies with enormous commercial and societal implications. Better decisions will be taken if the nation does not lose the skills and talents of half the workforce in taking leadership roles to drive forward the knowledge economy. Interdisciplinarity and entrepreneurship are areas of great opportunity for computer science, and ones where confidence and access to informal networks are particularly important in getting early competitive advantage. Women are under-represented in entrepreneurial activity, and there are marked differences in attitudes to entrepreneurship between men and women (Lucas 2003). By contrast, women have often found interdisciplinary work attractive, and the proportion of women transferring to computing via masters/conversion courses from undergraduate degrees in other subjects, like maths or biosciences, has been relatively high (~25%):[2] these women are ideal candidates for interdisciplinary research careers if mentored and encouraged in the opportunities it offers.

Network activities

The WICR network's goal of positive action programmes for women in computing research aims to provide career development for under-represented groups, particularly through activities such as role-models, mentoring and access to informal networks. Note that while in the UK positive discrimination (for example appointing someone to a job just because they are female) is illegal, positive action is allowed for in legislation and encouraged by government through various programmes of the OST and the Higher Education Funding Council for England (HEFCE), and taken forward by many universities as part of their strategies for equal opportunities and access. Other disciplines already support such activities in various forms: for example the London Mathematical Society, Royal Society of Chemistry and Institute of Physics.

Regular events

The core of the WICR project will be regular events which will, we hope, have acquired momentum and sustainability by the end of the project. These will include:

- *Senior women*. The project will be steered and managed by around twenty senior women in computing research. Annual strategic planning workshops for senior women in computer science and related fields, and others from government, academic and private sectors will assist participants to network and will provide career mentoring, and help in planning, reviewing and evaluating the project.
- *Regional meetings*. Up to four annual, broadly-defined one-day regional (Scotland, North, Midlands, London & South-east England) workshops for women in computing research will bring together women at all stages of their technical careers, from final-year undergraduate upwards, to hear technical and career-planning talks from women in academia and industry, in computer science and related interdisciplinary fields. The goal here is to offer opportunities for networking, informal mentoring and interaction with role models, and for stimulating discussion of interdisciplinary or entrepreneurial opportunities. These will be based on the annual Scottish Hoppers meeting, which has run since 1999 with *ad hoc* support from Institution of Electrical Engineers (IEE), Scottish Higher Education Funding Council (SHEFC) and National e-Science Centre (NESC).

[2] See data at www.set4women.gov.uk

- *Postgraduate students*. Intel Research Cambridge (Professor Derek Macauley) has expressed interest in sponsoring an annual event for women postgraduate students at the EPSRC PREP conference.[3] The PREP women's event would concentrate on industrial internships and the potential of interdisciplinary research.
- *Interdisciplinary think-tanks*. These will bring together women in computing research and women leaders in the complementary areas, with a dual goal of stimulating new research in these areas, and capturing the enthusiasm of, and providing role models for, younger women, especially those with interdisciplinary qualifications. Suggested areas include:
  - computing and medicine;
  - computing and creativity: digital technologies and creative professionals; and
  - computing and interaction: ubiquitous computing and the social sciences.

One-off and pilot events

We have a number of plans for possible one-off pilot events to be run in collaboration with various third parties, subject to careful evaluation to determine routes for sustainability. If a pilot is successful, we hope this can be continued with other means of support. Initial plans include:

- *undergraduates*, e.g. a two-day summer school for women undergraduates concentrating on the excitement and challenges of interdisciplinary research;
- *postdocs and early-career women*, e.g. a leadership and career planning workshop for early-career women, with an emphasis on the nature of research leadership, choosing an independent research area and building a team, and juggling work-life balance, based on a programme already run by the University of Cambridge; and
- *an entrepreneurs workshop* for women in computing research, broadly defined, based on programmes currently provided by Cambridge Enterprise, a division of the University of Cambridge providing entrepreneurial training and advice.

Mentoring

Mentoring is recognised as a key activity for recruitment and retention of women in science, engineering and technology (SET) careers, and the national scale of our activities means we can draw on a wider pool of mentors, for both informal and formal support.

Dissemination and public understanding

It isn't a particular goal of our project to organise outreach further down the pipeline and burden our already busy participants with giving talks in schools, but we hope that as our project takes shape we will identify stories and themes suitable for wider dissemination, perhaps through media training or other public understanding work. In particular, we expect to:

- monitor participation of women in professional and policy activities, and ensure, for example, women apply for fellowship status in the British Computer Society (BCS) and IEE;
- maintain a roster of women speakers, and publicise this to departments;
- maintain web pages that include information about careers and role models, data on women in computing research careers and so on; and
- report progress and achievements of women more formally through EPSRC, BCS, IEE and other mechanisms.

[3] PREP is an EPSRC student-centred conference focused on the training and development needs of postgraduate students involved in computing science, communications, electronics and photonics.

Sustainability and the role of the British Computer Society

The BCS is the major UK professional organisation for computing science, with 70,000 members in industry and academia. Its President, Professor Wendy Hall, has made issues to do with women a top priority. BCS Forums provide high-level strategic leadership for themes of significant professional or research interest. For example, a BCS Forum planned for 2005 for women in computer science will hold a wider brief than ours, for positive action, recruitment and retention for women in all aspects of the profession. It will bring together a variety of activities such as the BCS women's group (for women in industry), Equalitec (a web initiative sponsored by the UK Department of Trade and Industry) and Women in Computing, a national organization with a focus on sociological issues. Thus, the network grant is expected to initiate the new programme; the BCS and the Forum will be responsible for its long-term development beyond the end of the EPSRC network funding.

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Women and Computing: Recruiting, Retaining, Promoting

Introduction

I am very pleased to have the opportunity to participate in this event. My mother worked at Bletchley Park during the Second World War on the Enigma code-breaking machine, arguably the world's first computer. I have worked for the last ten years as an expert adviser to the European Commission's Research Directorate-General Women and Science Unit on the issue of women in science, engineering and technology (SET), including computing. Projects have involved working with major companies, including for example Hewlett Packard, that have been seeking to address the question of how to recruit, retain and make better use of women. I draw on these projects in this paper to report what these companies say works.

Background

In 2000, Heads of State and Government of the European Union (EU) grew concerned about the economic competitiveness of the EU *vis a vis* other global regions and made a commitment to enhance the EU as a knowledge-based economy. At the Barcelona Council of Ministers in 2002, a target was set to increase the investment of EU GDP in Research and Development (R&D) from 1.9% in 2000 to 3% by 2010. This compares with Japan, where 3% of GDP is already spent on R&D and the US, where the figure is 2.7%. This would entail the private sector doubling the number of industrial researchers that it employs by 2010 (European Commission 2003a:18).

However, this target has been set in a context where the European labour supply is already 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 this demand. So how will the demand be met? Women were identified as the major supply source, both by the EU and by major R&D companies (Rübsamen-Waigmann *et al.* 2003). 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 (Greenfield *et al.* 2002).

Women are now over 50% of the graduates being produced in the pre-enlargement 15 countries of the EU (EU 15), but make up only 41% of those with degrees in science, mathematics and computing and 20% of those in engineering, manufacturing and construction courses. At Ph.D. level, they comprised 40% of all new completions in 2000, ranging from 50% in life sciences, 30% in mathematics and 27% in physical sciences to 20% in engineering and 19% in computing (all figures from Rübsamen-Waigmann *et al.* 2003; see also EC 2003b).

Women in Industrial Research

In 2001, the Women and Science Unit launched a project on women in industrial research. An expert group and sub-panels were set up including senior managers from companies such as Microsoft, IBM, Hewlett Packard, Astra Zeneca, Nike, L'Oréal and Schlumberger, as well as small and medium size enterprises. The expert group's report, *Women in Industrial Research: A Wake Up Call for European Industry,* was launched by the European Commission in Berlin in October 2003 (Rübsamen-Waigmann *et al.* 2003). The high profile event included seventy

presentations from companies and was attended by over 350 representatives of industry from forty countries with science, engineering and technology R&D functions.

Relatively little is known about the careers of women in industrial research compared with those in the public sector. However, from 1995 to 2000, the employment rate of highly qualified women scientists and engineers in industry increased faster than that of men in the EU 15. This may partly explain why nearly 60% of all women scientists and engineers in industry and the Business Enterprise Sector are under 34: younger than their male colleagues. They are also more likely to have temporary contracts, and to be employed in small and medium size enterprises. About 17% of female scientists and engineers in the business sector work part time: a lower proportion than non-scientist women employed in the same sector, but a higher one than male scientist colleagues. Finally, only 28% of women who work as scientists in the Business Enterprise Sector have one or more children, which is fewer than other women working in the same industry (all figures from European Commission 2003a).

The business case

Measures to improve the position of women in industrial research are motivated by a range of business case arguments, from the 'missing talent' one, to addressing recruitment and retention challenges. Reducing attrition saves considerable resource. Moreover, women are playing an increasingly important role as purchasers, whether as domestic customers or corporate buyers. To be able to offer female technical staff with whom to interface with customers was regarded as important for rapport and communication. Finally, companies reported that they wanted to create an innovative and creative work culture: 'cloned people produce cloned ideas'.

Initiatives to recruit, retain and promote women

What initiatives do leading companies take to seek to recruit, retain and promote women in R&D (including computing)? The members of the expert group, the sub-panels and representatives of 29 case studies presented and discussed accounts of practices in their companies, including what had worked and what had not, before identifying recommendations for the sector (European Commission 2003a; Rübsamen-Waigmann *et al.* 2003). The policies can be grouped under the following headings:

- *Schemes aimed at women*, such as role models, mentoring and networking are identified as important in challenging gender segregation.
- *Work/life balance* measures, designed to appeal to men as well as women. These include dual career policies. Some companies offer 'concierge' facilities, where employees can drop off dry cleaning or shopping requests at the entrance to the work place and collect them on the way out.
- *Flexible work schedules*, including opportunities for working at home, hot-desking, exploring alternatives to excessive travelling, reconsidering working hours, re-examining work remits and, of course, smart use of new technologies.
- *Transparency* in recruitment and promotion, including open communication systems, and reviewing succession planning, fast-tracking schemes, staff review systems and success criteria in promotion for gender biases.
- *Integrating equality* into the company's way of driving business characterised those making the most serious commitment. Tools used included target setting, statistical monitoring and evaluation, integrating equality objectives into departmental goals, performance review and reporting mechanisms.

Gender mainstreaming: moving beyond a critical mass

Positive action and work/life balance measures appear to be the starting point for companies. Positive action for women compensates them for their exclusion from male networks. Work/life balance policies, flexibility and transparency are in effect good employment practices. Of course, well-qualified men have nothing to fear from such policies. On the contrary, they may well benefit from them. Indeed, by linking appointments and promotions more closely and transparently to merit-driven criteria, opportunities are opened up not simply to women, but to a more diverse group of men.

Companies reported that such policies did lead to increased numbers of qualified women employed in scientific grades. However, once they reached a critical mass, the numbers plateaued. New and different policies were needed to move beyond the critical mass. These were policies designed for more radical organisational and cultural change.

These companies developed tools to *integrate gender equality* into the business objectives. They developed institutional arrangements and used tools which have been identified, *inter alia*, as fundamental to the 'gender mainstreaming' approach to promoting gender equality (Rees 1999; Osborn *et al.* 2000). Gender mainstreaming turns the attention away from the individual and his/her rights to equal treatment and from the group and its disadvantage in the workplace; instead, it focuses upon the systems and structures, processes and policies that cause that disadvantage in the first place. Institutional requirements for gender mainstreaming include commitment from the top, expertise, awareness-raising and training. Tools include gender disaggregated statistics, equality indicators, equal pay reviews, job evaluation, target setting, gender proofing, gender impact assessments, visioning, gender budgets, and integrating gender equality into performance review, business targets, annual reports and all the other normal mechanisms of the company's way of working. While the companies were not employing all of these tools, they were certainly using many of them.

Conclusion

There are lessons to be learned from the experiences of companies, *inter alia* those who employ computer and software design engineers, that have made efforts to improve their employment of women. Professional organisations could assist in the dissemination of these lessons more widely to the sector. They could work with some of the case study companies, who have made a public commitment to do more in this area (Gould 2004), to participate in local networks and foster links with women wishing to develop or return to careers in computing. In the UK, they could also work with the new Resource Centre for Women in Science, Engineering and Technology being funded by the Department for Trade and Industry following one of the recommendations in the Greenfield report. This should help to bring together women who want to work in the sector with employers who want to use their skills.

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Gender Stereotyping and ICTs: Insights from the Czech Republic

1. How are computing professions changing with the Internet and mobile technologies, and does this offer new opportunities to women?

Traditional gender stereotypes consider information and communication technologies (ICTs) to be a masculine domain. On the other hand, ICTs currently represent highly competitive and very complex environments where excellence is most frequently achieved by strong teams. The need for a team approach in ICT calls for the presence of some personal features which are traditionally attributed to women, namely the abilities that enable:

- team work and the synchronising of personal ambitions with those of the team;
- patient evaluation and discussion of priorities and possible risks of various design options with the intention of building mutual trust and loyalty; and
- the use of empathy, e.g. when designing user interfaces.

Women complement ICT teams in a distinctive way, and these teams benefit from their inclusion. Moreover, the Internet allows computing professionals to enjoy much more freedom in working hours and in workspace location. As a consequence, ICTs offer a very good opportunity to any woman who wants to combine her talents for rational reasoning with traditional feminine roles and motherhood. A woman in ICT does not have to fully abandon her professional career during her maternity leave – she can easily remain in contact with, or even participate in, all types of research or development using an Internet connection. This is very difficult, or next to impossible, to achieve in other research domains (biology, chemistry, etc.) where one cannot do without personal presence in the institution and its laboratories.

It sounds like a paradox, but although ICT is generally understood as a masculine domain, it is a very good and level-headed choice for a woman with a talent for scientific disciplines who does not want to break with her femininity, but to use it to its full potential. Computing professions require gifted persons capable of rational and analytical thinking and such persons (irrespective of their sex) are rather rare. This makes it clear that further advance of the field is impossible without increases in women's participation.

2. What, in your experience, are the main obstacles to women's participation in computing professions?

Statistical reviews from the Czech Statistical Office (www.czso.cz) point to a steady decline in the percentage of women in ICT branches of study at Czech universities – this number was three times higher some twenty years ago. There is no doubt that low female representation in technical disciplines in the Czech republic is closely related to the positive political changes of the last fiteen years and the liberalisation of access to the humanities. At present, 20% of students in engineering as a whole are female – while in ICT the corresponding number is only 4%. Although the situation is slightly better in the context of the natural sciences with 10% of

female students (Čermáková et al 2002), we have much reason to be concerned (Linková, Šaldová and Červinková 2002).[1]

The main problem is not a lack of talented females but the fact that their talents have not been identified and supported in time. Scientifically-oriented young women often exhibit very good dispositions for the study of several other diverse subjects (ranging from medicine and law to the arts) – their career options are not limited to computing professions. The young women carefully evaluate the pros and cons of all possible options and their choice is strongly biased by existing gender stereotypes, which warn them against ICT. The same stereotypes influence scientifically-oriented young men in the opposite way: the young men eliminate the other non-technical options more easily and their choice of the ICT branch of study is more straightforward.

In order to give preference to ICT studies, the talented woman has to overcome strong gender stereotypes. To break these stereotypes, girls have to be equipped by strong, convincing counterbalancing arguments. Such arguments can be divided into two main groups:

- *Universally-valid arguments* that stress the specific advantages or benefits a woman (and a mother) can enjoy as an ICT professional. They can be related, for example, to new individualised approaches to the organisation of work or to the impact of Internet. Such arguments should be collected by different professional organisations or public bodies and extensively publicised though the media (see answer to question 3 below).
- *Personally-tailored arguments* based on a deep understanding of the abilities of an individual, in order to show her why ICT studies are really her best choice because they offer a good opportunity to combine her rationality and creativity within the complex structure of her talents. Such arguments cannot be adopted passively. On the contrary, each person has to pick them up on her own, e.g. during inspiring problem-solving processes. It is most important to attract and maintain the attention of girls towards ICT during their upbringing. This should start with computer games tailored for little girls and continue with other projects that can ensure rich and motivating experimental environments to encourage talented students to ask new questions and verify their answers. Success in winning the game or in finding the right solution results in building healthy self-confidence and an objective estimation of the quality of the tested talent, leading to a rise in the preference for ICT.

However, first of all there is a lack of inspiring toys, games and more complex tools to support females in the development of *personally-tailored arguments* for ICT choice. The tools that are needed have to be able to attract the attention of an 'average clever girl' who has no sharp professional orientation, yet. Besides, the *universally-valid arguments* for ICT choice should get much more publicity with the support of various public bodies and media.

3. What can professional organisations do to encourage and support women working in computing?

These organisations have to co-operate in raising public awareness about all the arguments supporting ICT choice for women. It is important to present and inform the wider public about:

- success stories of female computer scientists and professionals;

[1] For more on Women in Science in the Czech Republic, see www.genderonline.cz and www.zenyaveda.cz

- examples of good practices in those ICT organizations that have succeeded in creating female-friendly occupational environments where women are happy to work; and
- available (still scarce) tools which schools and parents can use to attract the attention of girls towards ICT.

4. What roles can diverse organisations (such as employers, unions, professional bodies and public policy authorities) play in pursuing this objective, and how can they most effectively complement each other's activities?

Employers and unions have to co-operate to ensure that the best working conditions are available for parents working in ICT. They should support unorthodox solutions, e.g. part-time jobs for parents with small children, the possibility of working partially at home or the opportunity to dedicate some time to continuous education.

Professional bodies and public policy authorities should support the building of all sorts of environments (e.g. the toys and games) that facilitate formation of the personally-tailored arguments for ICT studies which are attractive for girls. This is impossible without considerable grant support because companies producing standard commercial games and toys tend to stick to the traditional gender stereotypes because that is safe from the viewpoint of future sales of their products. The creative ICT learning environment could have the form of, for instance, a 'science museum' with a number of hands-on exhibits complemented by a publicly-available web-based element. Running such an environment is a typical not-for-profit activity, which deserves financial support from public bodies.

5. What particularly effective strategies have you initiated or experienced that could serve as an example to others? What do you see as the main problems involved in developing and implementing effective strategies?

Girls attracted to ICT should gain more experience and self-confidence in ICT projects during their upbringing. If the teams in ICT school projects are mixed, the boys tend to take over the responsibility and leadership. To bypass this, it is advisable to form unisex teams during co-education. Moreover, competition between girls and boys can bring an additional flavour.

6. Is there a role for international action or should we tailor strategies to national need?

Design of all the above-mentioned tools is impossible without extensive international co-operation and grant support. Its female-oriented part could be inspired by an analysis of reasons why some countries (e.g. Portugal, Italy, Sweden, India and Malaysia) have been very successful in reaching a reasonable proportion of female students in Mathematics and Computer Science.

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Widening Women's Work in ICT

In understanding the problem of women's under-representation in computing, and in advancing suggestions for addressing it, I believe the discussion must look closely at organisational practices (employers as well as professional organisations) and their implications for women's inclusion in, and experience of, IT professional work.

I have recently been involved in some European research into women in IT professions. Widening Women's Work in ICT (WWW-ICT) was a study of women in computing in seven European countries: Austria, Belgium, France, Ireland, Italy, Portugal and the UK. In each country, biographical interviews with twenty IT professionals were conducted, and four case studies of organisations were carried out.

The project was concerned with the issue of the under-representation of women in IT professions, with the reasons for this state of affairs, and with making recommendations for change which could be adopted at organisational, member state and EU level. We focussed particularly on the long-term employment trajectories and current working lives of women IT professionals.

In terms of women's entry into the field:

- In general, we found that women are not put off by technological work. Rather, they find it challenging, creative and generally stimulating. Although there is a 'culture of masculinity' in computing, there is equally a feminine culture of computing which is less prominent.
- IT professions are very varied indeed, and there is no single route into IT work. Although most jobs require technical and maths-based skills, other non-technical skills are also emerging as important for the work. Recent developments in IT (e-publishing, multimedia) have widened the content of the work and the skills required to include economic, marketing and management, communications and other 'hybrid' skills.
- People come into IT work through increasingly varied entry routes and often by accident. Many IT professionals have entered the field with arts, journalism and social sciences qualifications.
- Despite twenty-plus years of widespread IT diffusion and use (including in schools), girls and women still tend to have a vague and ill-informed idea of what constitutes IT work, and careers advice remains unclear. A stereotype of IT work as 'nerdy' persists among girls and continues to put them off.

Once in employment, several issues related to the organisation of IT work affect women's entry, retention and promotion:

- IT work is relatively deregulated in several respects: employment relations are highly individualised and collective agreements are not the norm; freelance and contracting work is widely used; and individuals take responsibility for their own career development and advocacy. Women are often disproportionately affected by precarious working arrangements, and this is certainly the case in the newer areas of computing professions such as multimedia work, web design and so on.
- Although maintaining up-to-date skills is vitally important in the computing professions, many companies have slashed their training budgets following the recent downturn in the industry. Professional development has increasingly fallen to the individual, while at

the same time skill certification is becoming increasingly supplier-led (Microsoft's certification system, for example). Skills are maintained through peer groups, the web and computer-based training and learning. Coaching and mentoring have also become increasingly important means of employee development. Women may be disadvantaged by the scarcity of time to invest in self-training and by greater constraints on their mobility.

- Project working is widespread. It often involves tight deadlines and long hours (particularly in the UK), working on clients' sites, working on call or working at home. Yet, at the same time, there is considerable autonomy left to employees in how they organise and manage their work loads, and this in practice often results in 'self-exploitation' of IT workers where they impose upon themselves long hours in order to get the job done (Mermet and Lehndorff 2001). Such working arrangements have particular implications for women (as they do for men with caring responsibilities), and can effectively discriminate against them. Some employers directly discriminate against women in their promotion systems, but women also often opt out of applying for promotion where longer working hours are involved. Work-life balance/family-friendly polices are quite under-developed in the IT sector.

Despite nearly twenty years of public and private initiatives, the representation of women in IT professions remains low and is decreasing in most EU member states, as well as in the US and elsewhere. Initiatives have tended to target individual women, focussing on their training and education, but much less has been done within organisations to address some of the issues which make IT professions unattractive for them. Examples of good practices at this level are still rare, though employing organisations are keen to learn from one another.

Our research suggests that initiatives need to be developed to cover all parts of the 'pipeline', including individual girls and women, schools, higher education, employing organisations, professional associations and trade unions. There is much greater scope for co-ordinated activities which address the issue at individual, organisational and social levels.

Reference

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Increasing Women's Participation in Computing and Technology's Positive Impact on Women around the World

How are computing professions changing with the Internet and mobile technologies, and does this offer new opportunities to women?

The computing profession has changed, and is changing with the Internet. Important changes include the ability to work with a widely geographically distributed group, and the ability to work from almost anywhere. These changes present new opportunities for women, especially those that are juggling different parts of their lives, such as family with work.

What are the main obstacles to women's participation in computing professions?

Many females believe that computing is less interesting than other options and that they won't be as good at it. Computing is not perceived as cool by children, or as desirable by their teachers and parents. Commonly expressed reasons for not choosing computing as a course of study by high-school women include fear of isolation, Computer Science classes being perceived as for really smart kids, and the lack of role models in their family or family structure.

What can professional organisations do to encourage and support women working in computing?

Professional societies are in a unique position to change the overall systems that support and encourage women in the computing profession. Societies can offer their members information about programs that work, and guides about how to change the system. They also have an opportunity to offer change by changing themselves first, including finding a diverse leadership team, and offering program content about increasing gender diversity.

What particularly effective strategies have you initiated or experienced that could serve as an example to others? What do you see as the main problems involved in developing and implementing effective strategies?

I head up a non-profit enterprise, the Anita Borg Institute for Women and Technology, whose programs are all about increasing the participation of women in computing, and about increasing the positive impact of technologies on the world's women.

The Institute is a nationally recognized organization that provides platforms allowing women's voices, ideas and spirits to influence technology. Participants in its are an unusual mix of academics and industry, and include many of the technology thought leaders of today. Its impact is significant on the lives and careers of women who both work in the technology field and are affected by technology. Our mission is to increase the impact of women on all aspects of technology, to increase the positive impact of technology on the lives of the world's women, and to help communities, industry, education, and government benefit from these increases. We have demonstrated success in a number of our programs, including:

- *The Grace Hopper Celebration of Women in Computing Conference* is the premier event for technical women in computing. The Grace Hopper Celebration of Women in

Computing is designed to bring the research and career interests of women in computing to the forefront. Presenters are leaders in their respective fields, representing industrial, academic and government communities. Leading researchers present their current work, while special sessions focus on the role of women in today's technology fields. Past Grace Hopper Celebrations have resulted in collaborative proposals, networking and mentoring for junior women, and increased visibility for the contributions of women in computing.

- *The Systers Online Community for Women in Computing* is the first and largest such online community. It has been in active use since 1987 and now engages and supports nearly 3000 women in 38 countries. Systers is a place for women to find answers to the issues that they deal with in their lives as both a woman and a technologist.
- *The new Leadership Initiative* brings together leaders from academia, industry, and government to share leadership strategies that work, allow participants to network and to learn from others. This, in addition to providing leadership skill building, allows participants from academia and industry to develop more fully their personal leadership at a time in their career when many of them are leaving or making other choices.