ENCOURAGING GIRLS TO STUDY COMPUTER SCIENCE — SHOULD WE EVEN TRY?

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Female students are under-represented in both secondary and tertiary computer science courses. Open-ended data were collected from interviews with (a) male and female tertiary computer science students, (b) professional women working in computer science, (c) Australian and Asian female students enrolled in tertiary computer science courses, and (d) professional women using computers in a wide range of occupations. Collectively these data suggest that (a) the underrepresentation of women is partly a cultural factor and (b) that student perceptions of computing careers are generally inaccurate. Drawing on the interview material the later part of the paper identifies the characteristics of careers using computers and makes recommendations for attracting more girls to those careers.

LITERATURE REVIEW

In most Western countries the low female participation rate in computer science courses is of concern to educators at both secondary and tertiary levels. Participation rates of females in computer science classes generally are considerably below 50% and the rates continue to decline as the level of education increases (Leveson, 1989; O'Rourke, 1992). Victorian secondary education enrolments suggest that the problem is restricted to computer science, rather than to computing in general. Slightly more than half of the students enrolled in the 1991 Victorian Year 11 Information Technology units were girls (Taylor, 1992a). In the following year girls comprised only 26% of the Year 12 Information Systems class, the subject with the greatest computer science component. In the predominantly applications based Information Processing and Management subject the proportion of girls was 56%, and in Information Technology in Society it was 67% (Taylor, 1992b).

In the tertiary sector the percentages of females enrolling in computer science are even lower. In 1990 approximately 25% of Australian enrolles in first year tertiary computer science courses were women (Kay, 1990) and, consistent with that figure, in 1992 28% of first year enrolments in the BSc computing course at Deakin University were women. However, in the corresponding 1992 second year class only 20% were women, in the third year class it was 16% and in the fourth year it was approximately 10%. Thus, the percentages of women are decreasing at each level of the course, a trend generally consistent with data from previous years and findings from other Western countries. Recent USA data show a steady decline in female participation in computer science from a high of 50% at high school level, through 36% at undergraduate levels and 13% in doctoral programs (O'Rourke, 1992).

The current approach to teaching computer science suits many males, but frequently does not provide the relevance which females require. Whereas males are often happy to tinker for the sake of tinkering (Whyte, 1984), females seek social interaction (Maccoby & Jacklin, 1974), relevance and often an external justification for completing a task (Linn & Hyde, 1989; Lovegrove & Hall, 1987). In addition, females frequently are disadvantaged by entering a course with less computing experience than their male classmates (Clarke, 1992). The acquisition of computing skills requires a considerable expenditure of time and effort, often working alone with a computer. Many girls may be reluctant to give up opportunities for sharing activities with other girls, or to jeopardise their popularity with their peers to spend time tinkering with a computer.

In Australia computing careers are financially rewarding and provide good job opportunities. A comparison of 120
trades and professions listed in the Melbourne Age Careers Guide supplement (Careers Guide '93, 1993) indicates that only six occupations, including the traditional female professions of teaching, nursing and secretarial work, employ more people than are employed as computer programmers and systems analysts. Salaries paid to programmers and analysts are the highest of these top six employing occupations, and are higher than most of the other 120 occupations listed.

REASONS FOR LOW FEMALE ENROLMENTS

Data we have gathered from a series of related studies over the past three years suggest some reasons for the disproportionately low ratios of girls and women in secondary and tertiary computer science classes. Four separate studies involved interviews with tertiary computer science students, interviews with professional women working in computing, and interviews with Australian and overseas tertiary female computer science students, and further interviews with professional women in computing.

Study A — Interviews with university computer science students

Method

Members of an undergraduate social psychology class each interviewed one female and one male computer science student, giving a total of thirty-four male and thirty-four female interviews. The psychology students were provided with a set of open-ended questions. Although this study has been reported previously (Teague & Clarke, 1991), the report below represents a more detailed analysis of the aspects of the data relevant to the present paper.

Results and Discussion

From these interviews the following five major categories of reasons for enrolling in a computer science degree were identified:

- **Career.** Reasons related to computer science as a career, e.g. good job prospects, high salaries.
- **Encouragement.** They were encouraged, supported and/or motivated by family, teachers and/or friends.
- **Second choice.** It was their second choice when their first choice became unavailable, e.g. because they did not reach the required entry score.
- **Likely/good at it.** They stated that they liked and/or were good at computing.
- **Influenced by previous results.** They had achieved good results in a previous computing course, and consequently had decided to continue their computing studies.

The responses have been graphed in Figure 1. The percentages exceed 100% as students were able to supply several reasons. This graph shows that: (a) encouragement, support and motivation are twice as likely to be mentioned by women as by men as reasons for enrolling in computer science, with more than half of the women responding mentioning these factors as one of the reasons they enrolled in computing; (b) liking and/or being good at computer science are reasons given by only seven women, and almost three times as many men; and (c) computing was a second choice was mentioned by almost 30% of women, but only 6% of men. Overall there is a tendency for women to enrol in computing for extrinsic reasons (career prospects, encouragement from others) and for men to enrol for intrinsic reasons (they like computing).

The students were asked why they thought girls did not choose to study computer science. Sixteen percent of female responses and 10% of male responses specifically mentioned lack of encouragement for girls to study computer science and/or mathematics and science. Another 28% of female responses and 32% of male responses mentioned factors relating to the stereotyping of computing as a male domain. Many of these responses indicated that in some secondary schools girls are not receiving as much encouragement to study computing as is given to boys.

When the undergraduate interviewees were asked what they thought could be done to encourage more girls to consider computer science as a possible career, approximately one third of responses suggested including computing in the curriculum at secondary or at primary level, and another third suggested encouraging interest in a variety of ways, including providing more female role models, and providing more information on the nature of computing careers. The remaining one third of responses was divided fairly evenly between changing courses and changing stereotypes. The percentages of male responses and female responses in each category were remarkably similar.

Study B — Interviews with female computing professionals

The comments provided by the undergraduate students focussed almost wholly on programming, and sitting at a terminal in isolation, activities which rarely reflect current workplace practices. Their image of computing is consistent with the common stereotype of the hacker, but how closely does this reflect the workplace environment? To identify the characteristics of working environments seven women with formal computer science qualifications were interviewed.

Method

The seven women were contacted by 'phone by one of the researchers and asked a similar series of open-ended questions to those asked of the students. Relevant aspects of the findings are summarised below.

Results and Discussion

Responses to interviews with seven professional women working in computing indicated that they loved their jobs; that they spent relatively little time working at the computer alone; that most of that time was spent writing reports rather
than programming; and that the job features which they most enjoyed were the challenge, the variety and working with people (Teague & Clarke, 1991). These interviews portrayed a completely different view of computing careers to the perceptions of computing that were held by the students. A report on the education and training needs of computing professionals and para-professionals in Australia (Department of Employment, 1990) identified ‘reading ... to keep up to date’ as the most common task of computing professionals, followed by: determining clients/users needs; identifying problems in the system; providing advice to management; and assisting users. (p. 78). Clearly, good communication skills are essential for most of these tasks, while computer programming per se is a lesser task for many computing professionals.

When the women were asked for their suggestions on methods of encouraging more girls to study computing not one suggestion involved the teaching of computing in schools. Of eleven different suggestions, nine related to the need for more female role models and to educating girls about the true nature of computing careers. Most of these women had found that working in computing was quite different to studying computer science at school and university. Although the students may have accurate perceptions of tertiary computing courses, their responses when interviewed revealed little awareness of the true nature of careers in computing. The professional women believed that computing was a very fulfilling career for women, and that women generally were better than men at many of the tasks required of a computing professional.

Study C — Interviews with Australian and foreign (Asian) students

The female participation rates in computer science classes suggest that the academic interests of males and females are different. However this may not be solely a gender issue, but rather it may be due to cultural factors which are influencing girls’ choices. The Deakin University undergraduate enrolment data, presented earlier, are for Australian students only. A very different picture emerges on examination of the gender balance of the non-Australian students enrolled in the course. Approximately half of the third year Bachelor of Science computer science class at Deakin is composed of full fee paying Asian students, the majority of whom are from Singapore. Most of these students have already completed a diploma in computing and are upgrading their existing qualification to a degree. University places are limited in many Asian countries and graduates with degrees are paid substantially more and have better career opportunities than graduates with diplomas, hence the desire of many diplomates to upgrade their qualification to a degree. In 1992 65% of these students (forty-five students) were women. It seems that attracting women to computing courses is not a problem in Singapore. This observation of the class composition suggests that it is not gender differences that cause girls and women to avoid computer science, but rather it is social and cultural effects. Possible reasons for cultural differences between British and Singaporean tertiary computing students have been reported by Uden (1991).

Method

The method was similar to the study interviewing undergraduate computer science students. Twenty-six psychology students each interviewed one Australian and one Asian female tertiary computing student. Many of the questions were identical to those asked in the earlier interview study.

Results and Discussion

Responses to a question asking why students thought there were so few Australian women studying computer science are summarised in Table 1. They fell into four categories: (a) attitudes and expectations, including different work and achievement ethics; (b) societal influences, including gender differences and stereotyping; (c) encouragement, or the lack of it, and familial expectations; and (d) other reasons.

The first three reasons each suggest that if more Australian girls are to enrol in computing classes they need greater encouragement. The messages they are apparently receiving are that computing is not something which girls do; it is a masculine occupation; there are more suitable occupations for women.

Study D — Further interviews with female computing professionals

The studies above suggest that both schoolgirls and their advisers do not have accurate information about the true nature of computing careers. The stereotyped view that computing is essentially technical and more suited to boys than girls discourages girls and their advisers from considering a computing career. Further data were collected to identify the main characteristics of computing careers and computing-related careers from the perspective of women working in the field.

Method

Seventeen women were interviewed by the researchers about their jobs. As with the previous studies, a list of questions was used as a guide. The definition of computing was broadened to include women without formal computer science qualifications, including some women who used computers extensively, but whose primary training was in another field.

Results and Discussion

From these interviews a list of the characteristics of computing careers was derived. The list has been divided into (a) those aspects relating to study requirements and entry into the field, and (b) the main characteristics of many computing jobs.

A. EDUCATION AND ENTRY

Levels of knowledge. In future, almost everyone will be required to make some use of computers, whatever their jobs. Four levels of computer use were identified:

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<tr>
<th>Reason given</th>
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<tr>
<td></td>
<td></td>
<td>Number</td>
<td>%</td>
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<tr>
<td>Attractives and expectations</td>
<td></td>
<td>12</td>
<td>34%</td>
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<tr>
<td>Societal influences</td>
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<td>11</td>
<td>31%</td>
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<tr>
<td>Lack of encouragement</td>
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<td>Family expectations</td>
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<td>Other</td>
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Table 1 Reasons given by Australian and Asian women for Australian women choosing not to study computer science.
• Computer scientist: Jobs where a tertiary qualification in computer science is the normal entry requirement. These include jobs as programmers, systems analysts and project managers. For this level, tertiary mathematics is desirable.

• Experienced computer specialist: Many computing jobs are held by people who have learned 'on the job.' Typically, they know how to use a range of packages and have some knowledge of computer programming. In this category may be user support consultants, computer-based training developers and sometimes programmers and systems analysts. Often these people will have seen a need to obtain formal qualifications in computing after working in the industry for some time.

• Computer users: These people spend the greater part of their working day utilising a computer. Some computing studies are advantageous and secondary school mathematics to Year 12 is highly desirable, although it may not be used explicitly in the job. Examples of occupations in this category are desktop publishers and computer pattern drafters.

• Computers as tools: Computers are used in most jobs. One or two computing subjects may be taken at senior or post secondary level. Experience is often gained on the job. Mathematics is not required, but may be useful. Practice and knowledge develop confidence and a comfort zone with computers.

Entry. Very few of the seventeen women interviewed had left school with the intention of studying computer science. Many did 'something else' then decided on a career change and retrained in computing. Others moved into computing when they worked with computers and 'discovered' they were good at computing. Some found they enjoyed computing after studying one unit as part of another course. It is likely that in the future it will become more difficult to enter the computing field without formal qualifications in the area.

Choice of secondary subjects. The women all suggested keeping options open, but also doing at least some subjects that are of interest. Most suggested that all students, both male and female, should be encouraged to complete as much mathematics as possible, even if they find mathematics boring and/or difficult, as it is a prerequisite to so many careers. While mathematics may not be used directly in most computing jobs, a knowledge of mathematics helps give people the confidence that they have the technical competence to tackle any aspects of the job which might arise.

Computing skills. Everyone needs to be empowered with sufficient technical knowledge to feel that, at all times, they are in control of the computer at the level at which they need to use it.

Tertiary studies. Most practitioners emphasise the need to combine computing with something else. The choice of the 'something else' depends upon the individual's interests and abilities and the areas in which they plan to work. Recommendations from the women interviewed included business, media studies/communication studies, journalism, psychology, fashion, science, education, electronics and art.

Continual study. Most practitioners state that they are always learning. Some enrol in formal courses to develop skills in new areas, or in areas where they have had 'on the job' training, others read and attend exhibitions and conferences to keep abreast of technological changes.

Work compared with earlier study. Working as a computer scientist is much more enjoyable than studying as the study involved (mostly individual) class assignments while the job involves more inter-personal interaction. Most courses focus on programming while the job provides a broader view of systems development.

B. THE NATURE OF COMPUTING CAREERS

Skills. The skills that the professional women considered necessary for a computing career include: logical thinking and problem solving abilities; communication skills, especially listening skills; organisational skills; research skills: the ability to write clearly and especially technical writing skills; and creativity. Note that mathematical ability is not mentioned in this list.

Features. The job features which were mentioned most frequently were working with people, variety and challenge. Future potential was obvious, as computing is a growth industry. Many jobs allow flexibility of working hours and working location, which is an advantage for both leisure and for combining work with family responsibilities.

People-orientation. Generally, the women interviewed spend the greater part of their time helping people solve problems with computers, working with people at all levels, from senior management to junior employees. They are continually meeting new people. Some suggest that on each project they work intensively with a small number of people, but that the group changes from project to project.

Helping-orientation. Many girls choose a career where they are helping people (teaching, nursing, speech pathology) and later find that they are not suited to that type of career, which may not be sufficiently challenging for them and may be limiting in the numbers and types of people they meet. All of the women who were interviewed particularly enjoyed those aspects of their jobs that involved helping solve users' problems.

Social interaction. In most computing jobs team work is far more common than working alone.

Satisfaction. The women found most satisfaction in their jobs from helping people and from seeing a finished product, be it a completed system or a trained user.

Problems and dislikes. The majority of the women had difficulty thinking of anything that they did not enjoy about their jobs. The main concern was that frequently there were too many demands and not enough time and other resources to meet them all.

Portability. Computing skills are transferable between jobs. Many computing people see themselves as belonging to the computing industry rather than to the company that employs them. Due to the transferability of skills it is easy to move between companies, between sectors (public, private, education), between states and between countries.

Money and potential. Computing personnel can be very highly paid and there is considerable career potential. Starting salaries are approximately equal to the average wage and salaries of twice the average wage are common. Computing jobs frequently lead to management positions.
Why Bother To Attract Girls To Computing?

When the majority of the female undergraduate computer science students do not mention liking computing as a reason for being in the course, why should girls be encouraged to study computing when, for whatever reason, they obviously prefer other subjects? The most obvious answer is that, by avoiding computing, girls are cutting off career options that are both financially rewarding and have better job opportunities than many other occupations. For example, a June 1993 survey of Deakin University Bachelor of Science computing and mathematics graduates who completed their courses in 1992 revealed that 65% had obtained employment because of their degree (Ridgeway, 1993), a substantially higher employment rate than for most graduates in these recessionary times.

It used to be believed that it was more important for boys to aspire to high paying jobs than for girls to do so, as men were expected to be the main breadwinners in the family, but this is no longer the case. Only one woman in twelve is supported by her husband throughout her life (Parves, Woolands, Schwarz, Alan, Deans, & Steward, 1988). With approximately one marriage in three ending in divorce, and illness, accidents and similar unexpected events changing the plans of many families, the woman becomes the primary breadwinner in a large number of Australian families, and will contribute at least partially to the family income in more than 90% of households. There are very few couples where the woman would be financially better off than the man if the relationship broke up, and few where the man would have primary responsibility for the children. The situation of combining work and childcare, either single or married, is considerably easier to organise on a consultant systems analysts’ salary of $80,000 than on a clerical worker’s salary of $25,000. It is as important for girls as for boys to train for a career which pays well and has good employment prospects.

But high salaries and good career prospects are not adequate reasons for encouraging more girls into computing if they don’t enjoy computing. However, the interviews with professional women reported above indicate that computing as practised in the workplace is significantly different to computer science as it is taught in schools and universities, and that these women all found their jobs to be challenging and fulfilling. Women working in the field stressed the communicative and cooperative aspects of their work, features sought by many schoolgirls (Teague & Clarke, 1993). It is likely that many of the young men who choose computing will discover that progress in their chosen field is not leading them along the path they had anticipated. The skills needed for these tasks frequently are lacking in the young men who happily spend many hours each week ‘playing’ with their computers. One female undergraduate student reported that several male students spent considerable time communicating with her electronically, but that they were completely tongue tied when they met with her face to face. In extreme cases a male student sitting on the adjacent chair would use electronic ‘talk’ to communicate with her rather than turn sideways and communicate verbally. Such males will have difficulty following the typical career paths described by the female professional computer scientists.

Computer Science Courses

Does this mean that computer science courses are not preparing students adequately for their future careers? To some extent, yes. In part, this is due to the need to assess students’ work individually, which frequently means that students must work on their assignments alone, without consultation with others. In part it is because there is an emphasis on the theoretical aspects of computer science, and on application of concrete computer science issues, such as writing programs, rather than the more abstract notions of systems development. Computer science courses have prepared students well for their first programming job, and have attempted to provide a strong theoretical foundation for the future, but the skills that are required for more senior positions, such as systems analysis, require the acquisition of a conceptual framework that generally comes with experience in the field.

The application of computer packages, such as word processors, spreadsheets and databases to everyday tasks is likely to be seen as relevant and useful to girls and women, either immediately or in their future careers. In contrast, writing a program to solve a problem that could be solved more quickly with a calculator may be seen as a pointless exercise rather than an opportunity to apply newly learned programming skills to an everyday problem. As an example of this type of problem, a first year undergraduate assignment required the writing of a C program to calculate the minimum distances that the early Vikings would have had to travel out of sight of land if they had sailed to the Americas. The parameters were the latitude, longitude and height of mountains in Iceland, Greenland, etc. Anyone who enjoys problem solving is likely to find this exercise intrinsically interesting and challenging. To those students who are struggling to master programming skills, and are not enjoying the struggle, the point of learning to program to solve such a problem, with its lack of relevance to their present or future lives, will remain a mystery. The literature suggests that such students are more likely to be women than men. Among the students interviewed for the female/male study reported above, far fewer women than men mentioned liking computing as a reason for enrolling in the computing course. The indirect costs of computer involvement may be much greater for girls than for boys. With an incomplete understanding of the necessary skills the problem becomes frustrating, time consuming, and difficult, rather than challenging and interesting.

The developments in computer software over the past few years have changed the nature of computing in the workplace. In many organisations fourth generation languages are replacing third generation languages for developing new applications. Gone are the days when programming is an essential skill for anyone who wants to develop a new application on a computer. While traditional computer science knowledge still provides, and will continue to provide, a framework for computing professionals, new tools are replacing many of the older techniques for design and development.

Recommendations

The research described above has identified several factors which deter girls and women from studying computer science. There are many others (for example, see Clarke, 1992). Factors which can be addressed by schools include:

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Providing greater encouragement to girls to continue with computing and mathematics. The research described above identifies direct encouragement by family and teachers as a major factor in the decision of many girls to enrol in computer science (and mathematics) courses, and lack of encouragement as a reason why girls do not enrol in these subject areas. Girls today have the same rights as boys to the best possible education, and, given the factors weighted against them, require more encouragement than boys to enter what, for them, are non-traditional areas. Hanchey (1992) has accumulated a list of resources for gender equity, including computing resources, and the Australian Association of Mathematics Teachers (1991) has a list of recommendations aimed at achieving gender equity in mathematics, many of them equally relevant to computing. Provide more information on the true nature of computing careers. In common with many professional careers, the nature of computing careers is not understood by most members of the community outside that profession. Unlike other careers, computing also suffers from overexposure in certain areas, particularly clerical work (word processing) and hacking. Thus, computing careers suffer not only from a lack of understanding, but also from misunderstanding. Teachers can provide (and obtain for themselves) greater insight into computing careers by availing themselves of the many resources which are available. Many large organisations, particularly government and semi-government organisations, are willing to send a (female) computing professional to schools to talk about her work.

There are several videos available specifically targeting girls (e.g. Lane, Clarke, & Teague, 1992). Following the interviews with students and professional women reported in this paper it was decided that a high quality video would be one effective way to provide more information about computing and computing careers, including suitable role models, to large numbers of Australian girls. The video ‘Girls, Have You Considered Computing?’ was the result. This video, presented by television personality Tania Lacy, incorporates most of the comments about and features of computing careers discussed by the women who were interviewed. Tania’s presentation style appeals to teenagers and the video has been well received. It can be obtained by sending a cheque for $25 to ‘Girls, Have You Considered Computing?’ School of Computing and Mathematics, Deakin University, Geelong, Victoria, 3217.

Make computer science more relevant to girls. Changes in courses do not always keep pace with the workplace. While there is still a need to teach computer science fundamentals, the emphasis on some of the topics may need to be reduced to allow more time for teaching applications development using packages rather than programs, following the trend in the workplace. Bernstein (1992) suggests that introductory computer science topics can be taught using software packages rather than programming, and that such an introduction lends itself more readily to group work and provides immediate functionality and purpose.

CONCLUSIONS
The low numbers of girls and women in computer science classes appears to be related to societal factors rather than to gender. Inaccurate perceptions of computing and stereotypical roles deter girls from computing studies, as do the nature of traditional computer science courses. Women working in the field are enthusiastic about their work. They identify the need for communication with others as one of the most important aspects of their jobs. Several women stated during the interviews that women are more suited to this aspect of computing than are most men. Greater encouragement from family and teachers is important if more girls are to enrol in computer science classes. Equally important is the need for girls to be educated about the true nature of computing careers.

REFERENCES


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