VICTORIA UNIVERSITY OF WELLINGTON
Te Whare Wananga o te Upoko o te Ika a Maui

School of Mathematical and Computing Sciences
Computer Science

PO Box 600
Wellington
New Zealand

Tel: +64 4 471 5341
Fax: +64 4 495 5045
Internet: Tech.Reports@mcs.vuw.ac.nz

Computer Science Retention and Recruitment at VUW

Amy Gale, Peter Andreae, Robert Biddle,
Judy Brown, and Ewan Tempero

Technical Report CS-TR-97/4
July 1997

Abstract

This paper recounts our experience in addressing recruitment and retention of women in our introductory Computer Science course for intending majors. In the past we have concentrated on retention, and present the background to these efforts, together with our results. We then relate our experience in recruitment over this period and currently, and discuss the possible relationships between recruitment, participation, and retention.

Publishing Information

This paper appeared in the proceedings of *WIC'97: Fourth Australian Women in Computing Workshop*, Melbourne, Australia. 1st July 1997.

Computer Science Retention and Recruitment at VUW

Amy Gale, Peter Andreae, Robert Biddle, Judy Brown, Ewan Tempero
Victoria University of Wellington,
Wellington, New Zealand
http://www.mcs.vuw.ac.nz/comp/Research

Abstract

This paper recounts our experience in addressing recruitment and retention of women in our introductory Computer Science course for intending majors. In the past we have concentrated on retention, and present the background to these efforts, together with our results. We then relate our experience in recruitment over this period and currently, and discuss the possible relationships between recruitment, participation, and retention.

1 Introduction

The Department of Computer Science at Victoria University of Wellington (VUW) has been concerned about the success rate of women in COMP102, our first course for Computer Science majors. Proportionally more women than men were dropping out or failing the course. The department has been trying to address this problem since 1989 and has been collecting statistics to support this work since 1990. Our work has focused on retention, and all our changes are applied to the entire class, rather than targeting women. We have worked in conjunction with the Sociology department at VUW.

Recently we have begun to look at relationships between recruitment and retention. Retention has been our main focus to date, and although we have run recruitment activities, we are now concentrating more effort, and gathering information via our recruitment efforts to improve our understanding of our potential students. Many of our activities specifically target under-represented groups, including women, Maori, and Pacific Island students. We hope that this new approach will both improve our recruitment activities, and allow us to understand how we can address retention more effectively.

The remainder of this paper is organised as follows. The next section describes the background to our work, and especially involves research relevant to identifying the causes of the retention problem. We follow that with a summary of the results of our efforts to date in improving retention. Section 4 describes our early efforts at recruitment, and Section 5 describes our more recent efforts, and suggests how we plan to proceed. Finally, we summarise our experience, and present some conclusions.

2 Background

This section briefly describes the work done by Toynbee, Forder, Davies (Sociology, VUW) and Brown (Computer Science, VUW) in the late eighties and early 90's into retention of female students. This work included: a literature review, a survey and interviews of withdrawing students.

In 1989 Forder[4] did a literature review on women in computer science. This provided valuable information on the role of society in determining who *participates* in introductory computing courses such as COMP102: 'Introduction to Computer Program Design' (a course designed for our majors) and COMP130: 'Introduction to Computers and Applications' (a computer literacy course that the department runs for any university students). Forder wrote about social construction theories and how women were socialized towards doing 'soft' computing and males were socialized towards doing 'hard' computing. This theory explained very nicely why we have roughly equal numbers of males and females in the course 'Introduction to Computers and Applications' which is a 'soft' computing course geared to applications, where roughly half of the 300 students are female, and many fewer women (about 20%) in 'Introduction to Computer Program Design' — our 'hard' computing course. This early work explored the area of social influences on our student body.

The degree to which social influences impact on our work on *retention* is not known. There is some evidence to suggest that this stereotyping has a significant impact on women beyond whether or not they participate in 'hard' computer science courses. Colley [3] reported that with her data, when gender-stereotyping and prior experience were removed, no significant gender differences were observed in anxiety, confidence and attitude to computers. This research and others like it, indicates to us that the women in our course are probably more anxious, less confident and have a poorer attitude towards computers, in comparison to the men, as a result of gender-stereotyping which has occured prior to their arrival at university. We also believe that these differences result in poorer retention as well as participation rates. Our action plans for improving retention attempt to take these probable gender differences in anxiety, confidence and attitude into account. Toynbee [8] discusses the social factors which contribute to different attrition patterns in the males and females in COMP102.

A questionnaire of committed COMP102 students in 1990 and 1991 helped to gather background information about our students. In 1992 Toynbee produced a report describing the findings of this questionnaire [7]. In it she made recommendations to the Computer Science Department. Toynbee noted distinguishing characteristics of female students including that they were: slightly older, more likely to be in part-time employment, less likely to have had computer courses available to them at school, less likely to have had a computer at home, less likely to have had a computer bought especially for them, less likely to have done programming and less likely to participate in computing clubs. She recommended that COMP102 should take the more novice background of women into account if the department wanted to retain more women students.

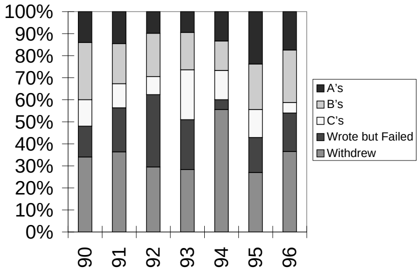
In 1992 Forder [5] reported on interviews of 37 students (both male and female) who withdrew from COMP102 after the first two weeks of the course . Although not yet properly analyzed, the interviews appear to show that withdrawing students hold stereotypical and generally negative views about computers and that those who withdrew had insufficient previous programming experience to keep up.

In general, our early investigations revealed differences in the males and females in our population which were similar to those being found elsewhere. We used insights derived from these investigations to modify COMP102 in an attempt to retain more of our female students.

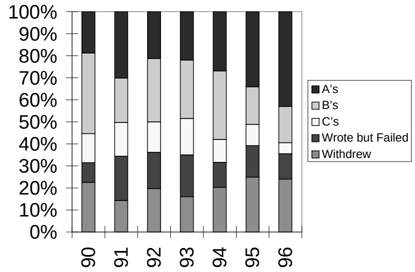
3 Attempts to Improve Retention

The methodology underlying our work is best described as "action research". In each of the past seven years, we have evaluated the results of the course (using a variety of methods), hypothesised possible causes for the poor pass rate and the differentially worse retention rate for women students, then modified the course in an attempt to resolve the problem. At the end of the course, we collected data on how well the students did or when students dropped the course.

The changes we have made include: changing the textbook, allowing more open entry to the course, experimenting with special "jump-start" labs, introducing special lab sections for those with little prior experience, providing increased help both in supervised labs and outside of lab times, attempting to reduce the male orientation in examples and lab exercises, more actively recruiting female tutors, and experimenting with changes in our assessment procedures.



Course results for Women



Course results for Men

The achievements of men and women in the course are summarised above. Of course, this is not a controlled experiment, and we must be cautious in our interpretation of this data since many factors could be influencing results (such as changes to our enrolment policies over this period, and world-wide trends). However, the main implication seems clear: despite our efforts to improve the quality of COMP102, particularly to improve the retention of women students, retention was not significantly improved from 1990 through 1996. This is disappointing, and we are keen to understand why this is the case.

We present further details about our retention efforts elsewhere [2].

4 Past Recruitment Effort

In this section we will review our undergraduate recruitment practices over the period in which we have presented retention results, from 1990 to the present.

In 1990 we began an activity we called the "Young Computer Scientists Club" (YCSC), modeled on similar ventures we were familiar with in Israel and in Canada. We chose three nearby secondary schools, one of each single-sex school, and one mixed school, and invited them to nominate ten good sixth-form (penultimate year) students (we asked the mixed school for a balance of female and male students). We then organised at least one evening activity every month, consisting of a talk by one of our staff, and a related activity; we also sent them a newsletter every month. We used the club to promote interest in computer science in general, and in doing computer science at VUW. In particular, we were keen to distinguish computer science from computer literacy courses at secondary school.

We ran the YCSC for two years. There were successful aspects to the club, and several students we first saw as sixth-formers appeared later as first year students (one of these students has just recently completed an MSc). However, the costs to us of running the scheme seemed large, especially in time and coordination, and we felt the results were not on a scale that justified the effort. The YCSC just involved three schools, and increasing this number seemed likely to increase coordination difficulties. Coordinating with schools was not easy, and the commitments of the students to school activities, sports, and clubs often made attendance at YCSC sessions disappointing. While the schools themselves generally approved of what we were doing, coordination and communication with the schools was not easy. Moreover, we found that many teachers did not understand the key distinction between computer science and computer literacy courses.

Another recruitment program we have participated in for five years is an annual "Women into Science Day". This targets sixth-form female students, and is organised across our Science Faculty. While this targets an audience we are very interested in reaching, we are only one part of the exercise. We give a talk to the full group, over a hundred students, but the short activity we organise attracts only about ten students.

Throughout the years, our main recruitment activities have been done in conjunction with the VUW Liason Office, who are the main connection between the university and secondary schools. In particular, they organise an annual "7th Form Open Day" at mid-year to assist students in understanding the university. On this day, we always give a talk explaining what computer science is all about, and highlight some key issues that interested students should consider when enrolling. (In particular, we point out that students may choose to "major" in computer science, or may take one or two courses in conjunction with another programme, or may just take our own literacy course.) In recent years we have also opened some of our labs on this day, and run sessions where students can see some of the lab activities done in first year courses.

Later each year, the liason office follows up the open day with visits to schools to assist students in selecting programmes and enrolling. Liason request academic staff to volunteer to come along on these visits, and we manage to have someone go along for several visits every year.

While we have always regarded both the open day and the school visits as worthwhile, we have begun to realise they are not necessarily worthwhile as recruitment activities. Probably even at the time of the open day, and certainly by the time of the visits, these students have already decided what subject area they want to focus on at university. In fact, some anecdotal evidence suggests that students who attend the open day sessions with wrong ideas about computer science (e.g. they see it as computer literacy) still persist in these ideas even after our talk.

The paragraphs above discuss two of the main approaches we took to recruitment: our YCSC and "Women into Science" Days, and working with Liason with 7th formers. The former seemed highly targeted and effective, but expensive and not reaching many students with our message; the latter seemed to be talking to many students — but too late to change their minds.

We did undertake other recruitment activities, but saw our involvement as largely opportunistic. Where someone else organised an activity and invited us to participate, we did. This usually took the form of a day or so promoting some aspect of the university, or addressing some particular part of the community, and we contributed a session on computer science (e.g. science "Link" courses in the mid 90s which targeted underrepresented 6th and 7th formers; 6th form days organized by the Liaison Office; and University open days for the community at large.

Looking back on our recruitment activities, it seems our efforts could have been greater. However, we must remember that for most of this time we were restricting enrollment into out first year courses, and regularly turned applicants away. In more recent years, we have been persuaded to lift enrollment restrictions. However, as enrollment has increased we have not been resourced accordingly. We are now considering reimposing the limits, and considering whether any increase in recruitment activity is justifiable.

We now realise that one historical weakness in our recruitment efforts has been a lack of data gathering. It would have been useful to have surveyed students in secondary schools to find out how well they understand what computer science is, and how aware they were of our programmes. It would have been useful to survey students we talk to, to see if their understanding and awareness improved.

5 Current Recruitment Effort

The major problem that retention efforts do not address, and that "good" recruitment efforts should be able to address is this: *the majority of people do not know what computer science involves.*

The problem has two main consequences. Firstly, a number of students take computer science courses when what they really want are computer literacy courses. Secondly, and less easily remedied (students in a course they do not want to take can always withdraw), students who might have enjoyed and achieved well in computer science are not taking the courses at all.

This can partly be traced to the fact that most high school computing courses are heavily biased toward computer literacy. There may be some programming component, but it is usually slight and taught with no theoretical background. Additionally, in many schools the "Computer Studies" course offered at 6th form level is regarded as a weak option academically, with strong students not expected to take it, so that these students are left with the impression that "computer studies" is not a challenging discipline. Combined with the misplaced belief that computer studies and computer science are synonymous, this leads to a misconception that needs to be overcome if these students are to have the opportunity to make an informed decision about whether to study computer science.

A major goal of any recruitment effort, then, should be to inform students about the nature and content of the computer science discipline. If recruitment is considered important, then some attempt should also be made to determine whether or not students have in fact gained the increased understanding of the nature of computer science that was hoped for.

Not unrelated is the fact that by 6th or 7th form, the majority of students have already formed some decision about whether they will be continuing to tertiary level, and what subjects they plan to study there. Since the most intense wide-scale recruitment efforts (7th form open day, school visits) tend to be aimed at 7th form students, we are left with two options:

- present computer science in a manner sufficiently dazzling as to change the minds of the senior students

- design our own recruitment efforts to target younger students

Clearly, the first of these options is considerably more difficult than the second.

In the remainder of this section, we will discuss current and planned future efforts to address recruitment by addressing these issues.

5.1 The 6th Form Activity Programme

At the end of 1996 we were approached and asked if we would provide a programme of Computer Science activities to a group of 6th form students from a local public girls' high school. This was to be part of a week of activities offered by various academic departments of our university, and the students were to be self-selecting.

This provided a useful parallel to the case of students electing to take a computer science course at university. The students had nearly completed their secondary schooling (some students go directly from sixth form to university). They might have encountered computer studies at school, but not computer science. They had elected to participate in the computer science programme, but not necessarily with a full understanding of what computer science involved.

With this in mind, we planned not only a programme of activities, but questionnaires to be completed both before and afer the programme, in order to attempt to determine what the backgrounds of these students were and what their already-formed assumptions about computer science were.

The programme outline sent to the school included the paragraph:

"One of our prime objectives will be to establish that computer science bears little or no resemblance to 'computer studies' as taught in high school, but is instead a broad area with interesting problems and great potential for creativity."

The programme itself took place over two days. We were given the option of taking up to five days, but resource and staffing constraints meant that two days was the most time we could take. The activities in the programme fell into three categories: computer-based activities, classroom-based (no computers) activities and lectures. Thirteen students attended.

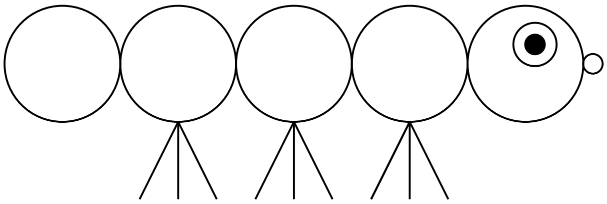
The computer and classroom based activities involved a high level of staffing, with a ratio of about 1:3. Undergraduates already trained as tutors for our first year courses were invited to participate. It was hoped that we would be able to have most or all of the tutors for the programme be women but due to the timing of the programme this was only possible for one of the two days.

5.2 Computer Based Activities

The computer based activities fell into two categories: programming and World Wide Web. Each took around one hour.

The programming activities involved adding code to working Pascal programs in order to alter their functionality. In both cases, the programs were ones that students in our first computer science course, COMP 102, have to write during the course. The graphic/application focus reflects the department's effort to design assignments around the research [4] that suggests women much prefer programming activities with an application focus over those with a numerical focus.

The first program drew a simple insect on the screen. The program code was analysed with the students, and they were then encouraged to extend it to make the insect's body one segment longer. All students succeeded at this task. Many then further modified the program, for example to draw multiple insects and to colour body segments.



The second program was based on a more advanced laboratory assignment - a simple paint program based on a main command loop with subroutines for each drawing command. For this exercise, the students were given a working version of the program with the aim of adding a new tool. The program was tried out, its code was analysed and then the students chose a new tool to add (some suggestions were given - a big brush, a circle-drawing tool, shading for the shapes). Based on this choice, they went through the process of deciding what information was needed from the user, what calculations, if any, were needed and which built-in commands were needed. Finally, they wrote a short procedure implementing their new tool and added lines to the main command loop to allow the tool to be selected and used.

The Web activities reflected much less the content of a typical computer science course. They more closely resembled the laboratory exercises of our computer literacy course, COMP 130. Bearing in mind our stated aims, we took great pains to explain this distinction to the students. We had felt that the students would enjoy these activities. On reflection, however, because the aim of the programme was to emphasise the distinction between Computer Science and computer literacy, the inclusion of literacy based activities may not have been wise.

The first activity was a simple browsing exercise, designed to introduce the students to the range of information subjects and formats available on the Web.

The second involved creating their own Web pages to be put together on a page for the activity programme. Students were provided with digital photographs of themselves and used an HTML authoring tool to create pages about themselves. Those who preferred not to write about themselves were encouraged to create a fictitious person instead.

5.3 Classroom Based Activities

The "Be a Robot" exercise described by Rodger and Walker[6] was reproduced with great success. The exercise attempts to give students some insight into the problems involved in robot instruction by assigning each member of a group of four a different task (eyes, brain, left actuator, right actuator), blindfolding all but the "eyes" and letting the "brain" direct the construction of various block configurations on a table. Each student had a turn in each position.

An exercise exploring the nature of various sorting algorithms was also tried. Each student was given an identical set of numbered pieces of paper and a "sorting competition" was held. The first to finish explained their sorting strategies, as did the last to finish. The idea that some methods are "better" than others for certain sorting situations was explored, with introduction of some of the better-known sorting algorithms for illustration.

5.4 Lectures

There were three lectures. The aim was to give students some background on a few of the fields in computer science. While we described them as lectures, there was more interaction with the students than might be expected in a typical university lecture. Each was given by a member of academic staff with research interests in the relevant area.

A lecture about "the Future of Computing" involved a video[1] followed by a discussion of the future depicted in the video. Students discussed what they found credible, what they found incredible and what they would find useful of the computing advances shown. Some concepts in HCI were discussed and related to the computers shown in the video, and to technology existing today.

Following the Robot activity was a talk about some of the problems explored in AI. Natural language processing was given particular focus, using the Eliza program as illustration.

A lecture on "the Limits of Computing" introduced the Halting Problem as an example of a problem that computers simply can't solve, and included an informal proof of its unsolvability. Also discussed was the idea that some problems, while computable, are sufficiently complex as not to be considered feasible.

5.5 Survey and Results

The survey questions were designed with three main areas of interest in mind:

- What is the student's academic background and what, if any, are their tertiary education aspirations?
- Why did they choose to come to the Computer Science programme?
- What did they think of the programme activities?

At the beginning of the programme all but one of the students indicated that they intended to attend university. Seven of them intended to include some computer science. These numbers were unchanged in the end of programme survey.

Their subjects being studied at school and favourite subjects covered a wide range, with science and commerce subjects strongly represented. Just under half the students cited computer studies as a favourite subject.

The reasons for choosing the computer science programme were along the lines of "it sounded interesting", "I am interested in computers", "to find out more about the subject".

In response to questions about how they rated their own competence and attitude toward computers, the mean group response was in the "above average" range. Everyone in the group had done "some" or "lots of" wordprocessing, all but one had played "some" or "lots of" games. Just under half had done "some" or "lots of" programming.

In the after-programme survey, the mean response to the questions about attitude toward and competence with computers was not significantly different.

Questions about which activities were enjoyed determined that the most popular were Web browsing and the Robot activity, with the two programming activities and the talk about the future of computing also scoring highly.

A final question asked if there were any activities that the students hoped for or expected that were not in the programme. Answers to this question varied. Some students answered in the negative with comments like "my expectations were met". Several did not answer at all. Of the two responses that indicated activities the students had expected or hoped for, one referred to email and one to spreadsheeting.

The number of students intending to take computer science at university did not increase.

5.6 What Does This Mean?

It is not entirely surprising that the mean self-reported attitudes toward computers did not change to a statistically significant degree. The programme was very short, and even if it had an impact on the thinking of the students involved, it would not necessarily be an immediate one. This question is useful in that it gauges the attitudes of students toward computers, but taking before-and-after snapshots of attitudes and expecting a change is perhaps only worthwhile for a programme of considerably longer duration.

The fact that one of the thirteen students, even after the programme, suggested that spreadsheeting was something that could have been part of the programme perhaps indicates that our quite strenuous attempts to distance computer science from the computer studies courses many of them had done at school had not been completely successful.

This is somewhat disappointing, although the fact that only one student gave such a response may mean that it is not significant.

5.7 Future Direction Indicated

- The survey should be carefully redesigned, in particular to attempt to more accurately gauge student preconceptions about computer science at the beginning, and to see if they have changed at the end.
- Wider surveying should be investigated. Surveying large groups of students from different age groups and different schools to determine their proconceptions about computer science will be very useful.
- The programme could be redesigned for the future, using the results of the activity popularity questions asked.
- Work with even younger students may be needed.

6 Conclusions

This paper has outlined our efforts to address participation and retention rates of women in our first course in Computer Science. We have discussed the background to our approach, presented our efforts to improve retention, and their results, and then discussed recruitment.

The relationship between our recruitment practices and the impact on participation rates and retention rates for women is uncertain. We have for some years been careful to avoid bias in our presentations, and have been generally aware of various related issues. We have organised some recruitment activitied directly targeted at prospective female students. However, we regularly observe that about 80% of COMP102 is male, and about 20% female at the start of every year.

Of course, many factors are beyond our control. However, it seems possible that how well we communicate with prospective students may be involved. For example, if we are not effective in our recruitment communication, then we may see effects on both participation and retention resulting from informal communication about computer science involving friends, the popular media, and so on. It seems possible that a lack of equity can then be introduced by this informal communication, or even by the degree to which there is informal communication on this subject. Accordingly, it seems reasonable to consider better communication for recruitment to have a positive effect on participation and retention rates.

References

[1] Steve Anderson, Shiz Kobara, Barry Mathis, Dustin Rosing and Ev Shafrir. Synergies: A vision of information products working together — Video Presentation. In *Proceedings of CHI 95*. ACM, 1995.

[2] J. Brown, P. Andreae, R. Biddle and E. Tempero. Women in introductory computer science: Experience at VUW. In *Proceedings of SIGCSE 1997*. ACM, 1997.

[3] Ann Colley, Matthew Gale and Teri Harris. Effects of gender role identiy and experience on computer attitude components. *Journal of Educational Computing Research*, Volume 10, Number 2, 1994.

[4] Sue Forder. Computer equity and education: A review of the literature. Department of Sociology & Social Work, Victoria University, Wellington, New Zealand.

[5] Sue Forder. Strangers in a strange world. Department of Sociology & Social Work, Victoria University, Wellington, New Zealand.

[6] Susan H. Rodger and Ellen L. Walker. Activities to attract high school girls to computer science. *SIGCSE Bulletin*, Volume 28, Number 1, 1996.

[7] Claire Toynbee. Why women drop computer science. Department of Sociology & Social Work, Victoria University, Wellington, 1992.

[8] Claire Toynbee. Hard disk failure. In *Celebrating Women in Science*, PO Box 184, Wellington, New Zealand, 1993. The New Zealand Association for Women in the Sciences Inc.