VICTORIA UNIVERSITY OF WELLINGTON

Department of Computer Science

PO Box 600
Wellington
New Zealand

Tel: +64 4 471 5328
Fax: +64 4 495 5232
Internet: Tech.Reports@comp.vuw.ac.nz

Women in Introductory Computer Science: Experience at Victoria University of Wellington

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

Technical Report CS-TR-96/18
1 November 1996

Abstract

This paper documents efforts that the department has made to support women students between 1991 and the 1996. Our major goal has been to reduce the high withdrawal rate of women students in our entry level course in computer science. We describe the approaches that have been taken to address this concern, and present the data which has been collected to track the results of our efforts. Our data suggests that providing a gender neutral content is not enough to ensure that men and women will retain similarly. In this paper we suggest policies which we feel may be beneficial in achieving similar male and female retention rates.

Publishing Information

This report will be presented at the *Twenty-Eighth ACM SIGCSE Technical Symposium*. San Jose, CA, USA. February, 1997

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 is unique in several respects:

- it focuses on retaining students rather than increasing participation
- all our changes are applied to the entire class, rather than targeting women
- more than one staff member has been involved
- the course itself has been under the control of just one person
- it has gone on for a long period of time

In this work, we have tried a number of strategies to deal with the problem. We have determined that these strategies are not sufficient by themselves. In this paper, we describe these strategies and our results.

Our focus is on retention rather than participation. Retention refers to the level at which a group succeeds within a course. Participation refers to the level at which a group is represented in the course. Our focus is on retention for several reasons. Firstly, it is more under the control of the department. Secondly, we anticipate that solving the retention problem will have positive ramifications for participation. Thirdly, we feel that students who express an interest in a subject should be supported in their desire to study that subject.

This paper is organized as follows. In the next section, we present the background material needed to evaluate our work. In section 3, we discuss the methodology we used and in particular the hypotheses that we based our work on. In section 4 we describe our efforts with COMP102, and in section 5 we present our findings to date. Finally, we give our conclusions in section 6.

2 Background

The computer science introductory courses taught at VUW follow ACM curriculum guidelines. COMP102 is an entry level course for students wishing to major in computer science. It covers most aspects of programming in Pascal, except the use of pointers and dynamic data structures.

While the exact details of the course structure have changed since 1990, as described in section 4, the following structure has been common to all the years. The course consists of approximately 13 weeks of 3 one-hour lectures per week. There are weekly assignments that students are expected to work on in the computer laboratories. Some of the assignments are marked and contribute a small amount towards the final grade. There is also an mid-term test and a final exam.

The retention problem was identified in the late 1980s, and resulted in various efforts, both within the department and in conjunction with the Sociology department at VUW.

Investigations into equity issues in COMP102 by the Sociology department was carried out mainly by Toynbee [4], who did a study comparing the background and experience of women and men in COMP102. The conclusions from this work were that women:

- did withdraw or fail at higher rates than men
- were less likely to have had prior programming experience
- were less likely to have home access to a computer
- were socialized towards doing “soft” computing and men were socialized towards doing “hard” computing.

- were probably more anxious, less confident and have a poorer attitude towards computers in comparison to the men as a result of gender-stereotyping that has occurred prior to their arrival at University.

Toynbee also criticized the course as being male-oriented. The three factors that seemed significant were: the subject of the examples and assignments, the visibility of women in the subject, and the environment:

- Until 1991, the programming assignments tended to be numerical or money oriented problems. The literature indicated that women were more likely to be motivated by problems that involved constructing programs that would be useful in the real world.
- Byrne reports that when the proportion of women in a course is below 33% ("gender normal") the impression is that it is not normal for women to be in that course [1].
- The environment in 1990-1991 was large, unsupervised, poorly-equipped labs. In such an environment, those with more experience, typically male, tended to be more visible. There was also a tendency for some men to behave poorly, making the environment an unpleasant place for some students.

3 Methodology

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), hypothesized 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.

Our approach was not purely observational, since we constantly made changes to the course in response to our observations. Nor has it been strictly experimental; professional ethics meant we could not have control groups, and, to provide the best course we could conceive of, we frequently changed a number of factors at once.

Based on the observations from within the department and the work by the Sociology department, we developed the following hypotheses to guide the development of the course:

- A strongly mathematical approach differentially disadvantaged women students.
- Assignments based around useful applications were important for motivating women students.
- The low visibility of women, especially as role models and mentors, discouraged women from continuing in computer science.
- The social and physical environment of the laboratories is significant to women students.
- Little prior experience with computers would make the course difficult and women students were more likely to have little prior experience.
- Students who find the course difficult are intimidated by seeing other students who have prior programming experience completing the assignments very quickly.

Our evaluations of the course are based primarily on the success and failure rates for men and women. In this report, "failure" includes not completing the course. However, there are many points at which students can drop out. At the very beginning of the course, many students are changing their program, and dropping out of the course may have little to do with the course itself. All our statistics have therefore been based on students who were still in the course after two or three weeks, (after the date at which they can obtain a refund if they withdraw). We assume that these students really do intend to complete the course, and so refer to them as "committed" students.

4 Changes to the Course

The observations by the teaching staff and the reports by the Sociology department have prompted a number of changes in the way COMP102 is presented and taught. There have also been changes made to the course as part of the on-going process to keep the curriculum up-to-date.

4.1 Textbook and Course Content

In 1991, the textbook was changed to Graham [2]. Following Graham's "procedures early" approach, the course was significantly changed, replacing a substantial amount of computer organization issues with an increased emphasis on top-down design with procedures and Abstract Data Types. The assignments were also changed completely as described below.

4.2 Entrance Requirements

Since its inception 1984, there was a greater student demand for COMP102 than there were resources, so that the course had restricted entry. In the late 80's through to 1991, students needed good high school marks or a good record at university to gain entry to COMP 102. As the resources for the department were increased and the demand for computer science weakened, the entry requirements were loosened. By 1994, no students were being turned away, increasing the number of academically weaker students in the course.

4.3 Range of Experience

We have attempted to address the range of experience of the students taking COMP 102 in several ways:

- In 1992, we began introductory lab sessions in the first two weeks, to "jump-start" inexperienced students.
- Since 1994, we have delayed introduction of topics known to cause problems for inexperienced students (such as recursion).
- In 1995, we introduced (self-selected) streamed lab groups consisting of students without much previous programming experience and students with previous programming experience. This meant that inexperienced students were less likely to see the apparent easy success of the experienced students.

4.4 Providing Help

To reduce the time inexperienced students spent on minor problems, we have tried to optimize the help given to students.

- Since 1991, the lecturer has run optional tutorial sessions targeted at the weaker students.
- In 1992, we reduced the number of assignments that were marked and redeployed the tutor time to provide "in-lab" help.
- In 1993, we reduced the length of the scheduled lab sessions from 3 to 2 hours to free up more tutor time for additional help sessions.
- More tutor time was provided for the "inexperienced students" lab stream.

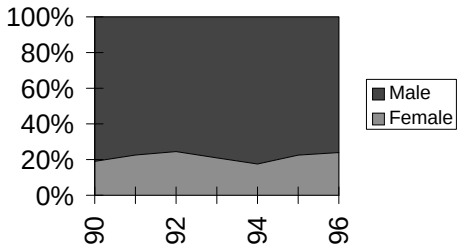

Figure 1: COMP102 enrollment, 1990–1996.

4.5 Reducing the Male-Orientation

We tried to reduce the apparent male-orientation of the course by addressing each of the factors:

- In 1991, we completely changed the programming assignments to be more graphical tool oriented assignments.
- While we could not change the proportion of women, we have attempted to increase the visibility of women by actively recruiting female lab tutors.
- In 1992, new accommodation and equipment meant we were able to significantly improve this environment. We have also found that having tutors in-lab tended to reduce the rowdy element.

4.6 Assessment

We have tried to improve the timing of feedback to students in the following ways:

- In 1992, we split each assignment into a “Core” and an “Extension” to let the weaker students know when they could stop, knowing they had covered the central material of the assignment.
- In 1995, we introduced two terms tests (with the first test counting towards their final mark only if it helped) to give students feedback earlier in the course. Unfortunately, the resources required to set two tests were such that we returned to just one test in 1996.
- We have been reconsidering assessment in the course, and have adjusted standards to make better grades more attainable.

5 Results

5.1 Enrollment Data

Total enrollment in COMP102 from 1990 through 1996 has changed little over the seven years, varying between 240 and 280 students. Figure 1 shows the number of committed women as a fraction of the number of committed students. This also has varied little: the percentage of women has been between 17% and 23% for seven years.

5.2 Enrollment Data Interpretation

There is no observable pattern of changes over the seven years. It is not surprising that overall enrollment varies little between 1990 and 1993 since we restricted enrollment during that period. It is somewhat interesting that the decline in demand that led to the restrictions being lifted did not seem to continue after 1993 — it appears that the demand has been roughly constant at the level of our previous restrictions.

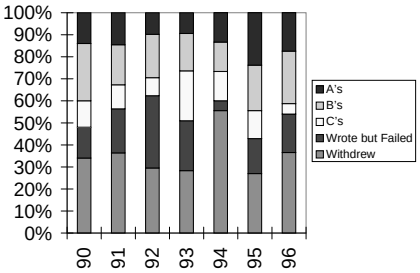

Figure 2: COMP102 result category sizes for women, as a percentage of the total female population, 1990–1996.

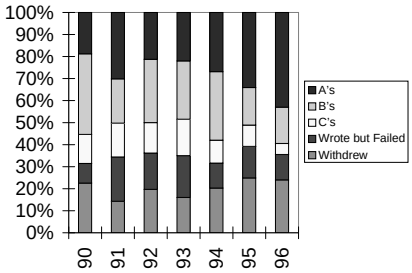

Figure 3: COMP102 result category sizes for men, as a fraction of the total male population, 1990–1996.

The restrictions on entry during 1990–1993 were implemented on academic grounds (looking primarily at mathematics). The percentage of women we declined was not consistently larger or smaller than the percentage of men we declined. Because our focus was on increasing the retention of women, we did not attempt to change our recruitment practices. It is therefore unsurprising that the fraction of women has varied little, although this is despite a global trend of decreasing number of women in computer science [3].

5.3 Course Results Data

Figures 2 and 3 show the final results of the same set of committed COMP102 students shown in figure 1. The categories shown are as follows:

- A: passing grade (in 75% – 100% mark range)
- B: passing grade (in 60% – 75% mark range)
- C: passing grade (in 50% – 60% mark range)
- Attempted final examination, but failed course.
- Either formally withdrew from course, or did not sit final examination.

Figure 2 shows the result category fractions for women, and figure 3 shows the result category fractions for men.

For both men and women, there is variation from year to year in the results. Some variations in the data may be explained by particular events. For example, a particularly difficult terms test (as in 1994) may discourage less confident students from continuing with the course. This may explain the high number of women withdrawing in 1994.

In spite of the variations, there are a number of consistent differences between the two sets of data. The principal differences are:

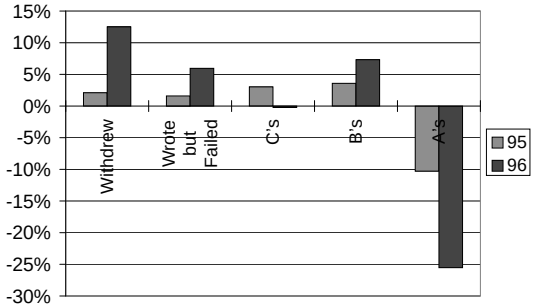

Figure 4: COMP102 result category male/female differences for all students, 1990–1996.

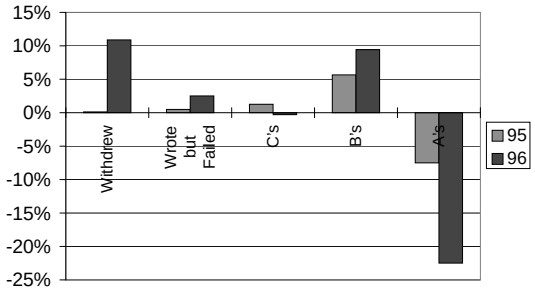

Figure 5: COMP102 result category male/female differences for inexperienced students only, 1990–1996.

- The proportion of women who pass the course is consistently much smaller than the proportion of men who pass the course: the proportion of women passing varies between 40% and 55%; for men it varies between 60% and 70%.
- The proportion of women who get A grades is consistently smaller than the proportion of men who get A grades. The difference is similar, though not as marked, for B grades.
- The proportion of women who either withdraw from the course, or who do not sit the exam, is consistently greater than the equivalent proportions for men.

These differences all seem to be diminished in 1995, where the proportions in all categories for men and women become more similar.

In 1995 and 1996, we asked students sitting the exam how much previous experience of programming they had before they began the course, and then correlated this with their eventual results. As we expected, there were significantly more male students with a lot of programming experience, and students with more programming experience generally achieved higher grades.

Figures 4 and 5 show the *differences* between females and males for each of the result categories in 1995 and 1996. A high value indicates that the proportion of female students in that category is higher than the proportion of male students in the same category. Figure 4 shows the differences for all committed students; Figure 5 shows the differences when the students with significant experience are removed.

The data shows that prior experience may account for a little of the difference between male and female, but most of the difference exists even for the students with little programming experience. Note that although inexperienced males and females withdrew, failed, and obtained C's equally in 1995, there was still a significant difference in the proportions who obtained A's and B's.

5.4 Course Results Interpretation

The main implication of the data seems clear: despite our efforts to improve the quality of COMP 102, particularly to improve the retention of female 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 cannot be certain whether we have been doing the wrong things, not doing enough of the right things, or doing the right things but not well enough.

The data from 1995 and 1996 on previous experience suggests that although more experienced students do better, and more males than females have such experience, we should not lay the blame for the differing performances of males and females on their experience of programming prior to the course.

It is possible that there are other factors at work over which we have little control. For example,

- Social conventions may influence good female students to enroll in subjects other than computer science, leaving our course with an unrepresentative sample of female students.
- After enrolling in our course, female students may be swayed by social influences that suggest that computer science is unsuitable for them.

We may be able to determine if such factors are significant by further study, but we have no conclusive results so far. If factors of this kind are dominant, it will take a different kind of effort, and a different scale of effort, to make any impact.

The 1995 results were encouraging in that the difference between males and females was small for that year. In particular, their withdrawal and fail rates were almost identical, once the experienced students were discounted. One of the changes we made in 1995—separate labs for those with and without previous computing experience—was continued in 1996. Although we believe that this change was a good one, the poor retention results of 1996 strongly suggest that this change was not the sole cause of the better results in 1995.

The other change in 1995—an additional, early, optional terms test—was not repeated in 1996. Our current hypothesis is that the early feedback to students is particularly critical for women students. This is in spite of the fact that the feedback from the test was often negative: students frequently do worse on the first test than they expect to. However, the test results were available early in the course, and only counted towards the final grade if they increased the grade. We hypothesize that students were able to use this early feedback as an incentive to work harder, whereas the negative feedback in the later, non-optional test of 1996 was such a discouragement that women students withdrew or gave up. We intend to reinstate the early test in 1997 and look forward to reporting on the results.

6 Conclusions

This paper has discussed our efforts between 1990 and 1996 to improve the retention of women in our introductory computer science course. We have made a variety of changes to the content of the course, the organization of laboratories and help facilities, and the assessment. To determine the success our efforts, we have collected and analyzed the student results for seven years, and have more recently analyzed the effect of prior experience.

We would like to be able to report that our efforts have been successful, but our data does not support this conclusion. The data suggests that providing a gender neutral content is not enough to ensure that men and women will perform similarly. Nor is it sufficient to improve the laboratory environment, and the help facilities, though we believe that all these changes have improved the course. There is some evidence that the nature of the assessment and timing of feedback has a differential effect on men and women, affecting whether they are likely to withdraw from the course. We intend to investigate this factor further in 1997.

It also appears that the differences in previous programming experience does not account for all the difference between the performances of men and women.

Our experience is that single changes to a course may not make a significant impact by themselves, and that careful data collection and analysis over a long period is necessary to identify where real progress is being made. We recommend that other equity programs take a similar long term view of the problem.

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