Gender and Programming: What's Going On?

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ABSTRACT

The learning (and teaching) of programming in Higher Education is a perennial problem, and is the subject of much attention and innovation.

One way in which the problem can be addressed is for instructors to investigate and thus better understand the ways in which students learn to program.

We present the results of investigations carried out at the Universities of Kent and Leeds into the ways in which *gender* influences the learning approach of students in programming. The research shows that gender is a significant factor in determining the way in which students approach learning to program. A better understanding of the issues raised would lead to more effective teaching and thus better learning.

Keywords

Gender, programming.

1. INTRODUCTION

The teaching (or perhaps we might more accurately say the *learning*) of programming is a problem. Few teachers of programming in higher education would claim that all their students reach a reasonable standard of competence by graduation. Indeed, most would confess that an alarmingly large proportion of graduates are unable to "program" in any meaningful sense.

The School of Computer Studies at the University of Leeds is no exception to this. Staff are all too familiar with students who approach their final year project work determined to avoid programming at all costs, presumably because they either cannot program or *believe* that they cannot.

The School teaches introductory programming to approximately 250 students every year, about half of whom are registered on single subject degree programmes (the rest are studying various joint honours combinations). These students come from a wide variety of backgrounds, and have a range of pre-existing programming ability, ranging from complete novices to professional programmers. In an average year about 120 of the students are novices.

As regards the achievement of a reasonable standard (ideally we would hope that the novices will attain the same standard as those who approach the module with some prior experience), this group of novice programmers is obviously where most effort is focussed. Work over several sessions ([12], [13]) has focussed on innovative approaches to supporting these students. At the same time (session 1997/98) a further change was also introduced - additional resources were made available so that extra tutorial classes were provided for those students who approached the staff and asked for additional support. We were insistent that these classes were available only to students who applied - we had no desire to attract students who were in difficulty because of having neglected their studies (although there was no reason why such students could not ask to join), and we wanted to keep the class sizes as small as possible. Students were made aware of the classes, and were told to approach a member of the teaching staff if they wished to join; in this way we hoped to limit the take-up of the classes to motivated students who were in difficulty.

This additional class was seen as a success. The staff saw a significant number of students who had clearly been struggling attend these classes and eventually achieve creditable, if unspectacular, results. It was apparent, though, that the vast majority of the students attending these classes were women - in the first year sixteen out of twenty attending were women. This trend continued, and in the 1998 session once more the vast majority were women - this time seventeen of twenty one.

This was surprising given that the cohort shows the usual gender profile of computing undergraduate classes in the UK. On average about twenty per cent of the cohort are women, with the majority coming from various joint honours programmes.

A worrying aspect of this phenomenon was that a small minority of (presumably male) students reported in the end of module questionnaires that they believed that the staff were willing to help only the women students.

Even though the staff knew that this was certainly not the case, this is obviously not a pleasant comment to read in student feedback. The comments have reappeared each time the module has been presented since, and even appeared to have percolated into students' attitudes in other modules. It was also exasperating to see that many students continued to fail the module - these were students who might well have benefited from the extra classes. It was noticeable that all 14 of the students re-sitting the programming module at the end of the 1997/98 session were men.

In the 1998 session it was planned to run the same classes - a reasonable decision since they were clearly of great benefit to the students who attended them. At the same time, the decision was taken to investigate students' attitudes and approaches to the learning of programming so that we might understand why mainly women attended the classes. This investigation would be complemented by a similar exercise at the University of Kent, where there were no such additional classes available.

A comparison with a different institution seemed preferable to a comparison with a different module at Leeds. We were particularly interested in how students approached *programming*, and there was no suitable alternative programming module at Leeds. It also seemed that the attitude that the staff were more willing to help women was starting to be reported in other modules at Leeds - presumably this had its roots in the programming module.

2. THE STUDY

The University of Kent at Canterbury recruits from much the same pool of applicants as Leeds. Entry requirements are similar, and the gender profile of students is comparable. The only difference that may be of relevance is that the Computing Laboratory at Kent has rather more female teaching staff (12 out of 44) than are to be found at Leeds (6 out of 40). The programming languages taught are C++ at Leeds and Java at Kent.

The study involved a simple questionnaire, which was presented to students in a lecture. The lecture was in a programming module, and took place in the eighth week of a ten week module. The students were presented with a series of seven statements, and were asked to respond on a scale of "1" meaning "strongly disagree" to "5" meaning "strongly agree".

The main analysis would be the calculation of average "opinions" and comparisons of the responses from Leeds and Kent. The students also asked to indicate their gender and whether they were "mature" (which we defined as aged over 21 on entry to the University).The statements used were:

1. I find programming easy.
2. I prefer to work alone.
3. When I get stuck I will always approach a lecturer for help.
4. When I get stuck I prefer to ask my friends for help first.
5. When I get stuck I prefer to work out the answer myself.
6. In general, men are better than women at programming.
7. The lecturers are more willing to help female students than male.

Obviously, our main interest was in the answers to the final question and, in particular, whether students of both gender agreed with this.

3. RESULTS

The responses were collated, and averages from the Leeds and Kent samples were calculated. They are summarized in the table at the bottom of this page.

The most striking feature of the answers to the first six questions is the closeness of the averages from the students at the two universities. In no case do the differences appear to be significant (at the 5% level). There are some apparent differences which can be understood as differences between the cultures of the two departments. The salient difference in the figures is, of course, in the answers to the final crucial question (*The lecturers are more willing to help female students than male*). It is clear that students at Kent in no sense agree with this statement, but their counterparts at Leeds certainly do. It is also clear that it is the male students aged less than 21 at Leeds that most strongly believe this.

The only obvious difference between the way in which programming teaching is organized at the two universities is that Leeds provides the additional classes that are available only on application.

It seems reasonable to suppose that it is these classes that are causing the differences we see. There are, of course, many other possible causes. The possibility that the staff teaching the module are in some way biased towards the female students (perhaps because they are a minority) cannot be discounted, but they would certainly vehemently deny this. It is also possible that news of the usefulness of the classes is spread between friends, and we might

	Male>21		Male<21		Female>21		Female<21		All	
	Kent	Leeds	Kent	Leeds	Kent	Leeds	Kent	Leeds	Kent	Leeds
Sample	8	7	50	29	8	1	6	19	72	56
Q1	2.8	2.4	2.8	2.5	1.5	1.0	1.3	1.8	2.5	2.2
Q2	3.5	2.9	2.9	2.5	2.5	3.0	2.0	2.3	2.8	2.5
Q3	3.0	2.0	2.9	2.6	3.8	2.0	2.7	2.4	3.0	2.4
Q4	3.5	4.7	4.1	4.0	4.0	2.0	4.7	4.4	4.1	4.2
Q5	4.0	3.0	3.7	3.3	3.0	3.0	3.3	2.8	3.6	3.1
Q6	2.0	2.5	2.4	2.9	2.5	2.0	2.3	1.8	2.4	2.5
Q7	1.5	2.9	2.3	2.9	1.3	1.0	1.3	2.8	2.0	3.3

Table 1. Comparison of student responses by age and gender

expect first year women students to have made more female friends in their first weeks. Another possible issue would be that some men would find the prospect of joining a class that was almost exclusively female rather intimidating. Nevertheless, the key underlying issue is the provision of the extra classes, and the way in which they were organized.

A further interesting fact is apparent from the Leeds sample. Responses were received from only 56 students at a class that should have been attended by some 110 (the class takes place on a Friday afternoon - a very unpopular time). Of these 56, 20 were women. In the whole class there are 31 women registered, so 65% of the women attended. The equivalent attendance figure for the men is 46%, which is significantly lower. This seems to point to a difference in *motivation* between the genders, or perhaps to a difference in the way the genders approach learning.

4. GENDER AND COMPUTING

This analysis has highlighted to us a difference in the way in which men and women approach learning. At the heart of the situation at Leeds is the growing perception that female students are weaker at programming than their male counterparts. Previous studies have shown that female students lack confidence in this domain [16], [18], and that one significant corollary of this is often an underestimation of their own ability [1], [2], [11]. The roots of this lack of confidence stem from long before arrival at university. Proponents of social learning theory argue that all school curriculum subjects are stereotyped as either male or female (with Computing falling into the male category) and that this causes an almost automatic lack of confidence when girls attempt subjects which are branded as male. Research has also shown that female students are genuinely less fascinated by computers than their male counterparts - they prefer to take a much more pragmatic approach to the subject [8]. Spender [17] suggests that the main reason for this is that male centred materials such as computer games create a culture in which male students are encouraged to participate outside the classroom, thus giving them more hands-on experience, which in turn leads to increased confidence. Because female students are not targeted by this culture they are more likely to do only the work which is required [14].

Another important factor in addressing the issue of why more female students are seeking help is that of different learning styles. Most of the research into how gender affects how people learn is based upon secondary (11-18) schooling, but it is transferable to any age group. It has been observed that institutional change can play a significant role in polarizing gender stereotypical behaviour [15]. Further work has shown that there are some broad generalizations which can be made [5].

Davies [6] observed that female students show a tendency towards working more consistently, and stamping out difficulties before they become real problems, whilst male students show more of a tendency to refuse to admit that there is a problem, often ignoring the issue until it has become much more serious. Students map their own values onto others and then find it difficult to reconcile, what is to them, unexpected behaviour. Other research has found that these differences are most strikingly demonstrated when single sex schools are merged to form a co-educational establishment [9]. Although this is not the case here, the Kent admissions officer has noted that a high proportion of CS undergraduates previously attended single sex schools.

The provision of extra tutorials at Leeds was intended to help all students equally, but this has not been the effect. The female students have used them as a means to receive extra tuition, and the male students have interpreted this in their own terms: staff preferring to help female students. Positive discrimination was not the intention, and as we are not able to address the underlying causes, a more *male friendly* approach is also required to redress the balance, and to actually help the male students who are struggling.

5. CONCLUSIONS

The additional programming classes were introduced with the best intentions in response to a serious problem. They have been a success, but it is clear that the way in which they have been introduced has succeeded in targeting only a subset of the class. That subset happens to be coincident with the female students.

An examination of gender-related differences in attitudes to study, and in attitudes to study in computing in particular has shown us why this might be so. The phenomenon is not unique to Leeds. A qualitative attitude survey carried out at Uppsala University has produced similar findings [3]. In retrospect, this is not surprising. Previous work at Leeds [4] had unearthed differences in the ways in which men and women performed in an innovative highly participation-based module. It was shown that women performed significantly better than men in this setting. This is the same effect that we are now seeing in the programming modules.

The final grades in programming for students of each gender are comparable. It is noticeable, though, that the women students seem to have recently started performing rather better than their male counterparts. The figures (on a scale of 0 to 100, where 37 is a pass and 70 is first class) are:

	Female		Male	
Year	Number	Av. Grade	Number	Av. Grade
1991	41	59.4	136	62.0
1992	49	60.7	141	61.4
1993	65	57.1	177	66.8
1994	27	59.3	160	59.4
1995	27	56.9	180	55.7
1996	35	60.2	187	59.0
1997	46	60.7	188	58.7

Table 2. Final programming grades by gender

This mirrors the trend in GCSE (age 16) examinations [10], where girls have now started to perform better than boys. The same trends are seen at Leeds in many other modules, including final year projects. The trends we notice here have, in fact, been apparent for some years - the introduction of classes has merely highlighted them. Instructors on the programming modules at Leeds have long reported that female students (and, to a lesser extent, mature students) are much more likely to approach staff for help. An informal count kept during the 1998 session showed that over three-quarters of the times staff are approached is by women students. An interesting side issue is that most male students seem to prefer to raise their problems via electronic means - email or bulletin boards.

In other areas of the degree programmes at Leeds, staff report that the female students appear to be more motivated and more

determined to succeed. The only subjects in which this is not seen is in mathematical areas, and particularly in areas where computers are not directly used. This seems to be borne out by the final degree results, where women are now starting to out-perform the men.

For the programming modules, it is clear that changes must now be made. We now have an insight into the way in which our students choose (or perhaps "are conditioned") to study, and it is clear that we must devise a way to give more support to the male students. This must, of course, be done covertly. For the remainder of the programming modules, and in future sessions, it is planned to take a far more pro-active role in approaching the male students who appear to be having difficulties. It remains to see if this will be successful.

6. POSTSCRIPT

Preliminary findings from the end of course evaluation shed more light on the findings set out in this paper. In this evaluation, students were asked to rate their responses to a number of questions using the same scale as was used in this study. It was possible to separate student responses by gender, and the averages were calculated. The results showed that:

1. Female students were much less confident in their abilities in C++ (*I am competent in C++* - Male average 3.6, Female average 2.9);
2. Female students found small group tutorials (not the extra classes described here) much more useful (*The tutorials were useful* - Male 3.7, Female 4.2):
3. Female students *enjoy* the programming module much more than their male counterparts (*I enjoyed this module* - Male 3.0, Female 4.1);
4. Female students consider that the module was harder work (*This module was hard work* - Male 3.8, Female 4.1).

These results will be the subject of further study [7].

7. ACKNOWLEDGEMENTS

Dominique Attwood, Jenni Meehan and Kate Page for once again proving how difficult programming can be.

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