# Invisible and Special: young women's experiences as undergraduate mathematics students

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This paper reports on young women students' participation in their undergraduate mathematics degree programme: their gendered trajectory is characterised in terms of their being both 'invisible' in the dominant university mathematics community and yet 'special' in their self-conception.
It draws on data collected from a three year longitudinal project investigating students' experiences of undergraduate mathematics at two comparable traditional universities in England. Specifically, students' narratives are interpreted as providing insights into their defensive investments in their particular ways of participating.
An interpretive feminist perspective is used to claim that these young women are involved in the ongoing redefining of the gendering of participation in mathematics, and conveys how they manage to choose mathematics, and achieve in university mathematics, whilst in many respects adhering to everyday views of femininity.

## Leitmotif

> No one could see [the witch] Serafina from where she was; but if she wanted to see any more, she would have to leave her hiding place. …There was one thing she could do; she was reluctant because it was desperately risky, and it would leave her exhausted; but it seemed there was no choice. It was a kind of magic she could work to make herself unseen. True invisibility was impossible, of course: this was mental magic, a kind of **fiercely held modesty** that could make the spell worker not invisible but simply unnoticed. Holding it with the right degree of intensity, she could pass through a crowded room, or walk beside a solitary traveller, without being seen. (Pullman 1998)

## Introduction

Mathematics is a troublesome subject: it has an aura of being important, hard, boring, high status and challenging. It is also troublesome in that not enough young people choose to study mathematics at university even to satisfy the demand for graduate mathematics teachers, let alone the interest in employing numerate graduates in other professions. This background opened up research questions about the people who do choose mathematics (and also sustain their studies) and led to our being members of a project team charged with reporting on the development of a cohort of undergraduate

mathematics students from two comparable universities as they progressed through their degree.

The project, 'Students' Experiences of Undergraduate Mathematics' (SEUM), was a longitudinal study running from 2000 to 2003 that investigated the progression of a cohort of undergraduate mathematics students' at two comparable universities in England. The main aim was to understand better the reasons why students experience undergraduate mathematics programmes in different ways and why some maintain or develop more positive attitudes than others to the subject. Data in the form of questionnaires, examination results, interviews and observations were collected and analysed by the research team.

Findings from the research included, for example: that students' attitudes to their academic work could not be separated from their attitudes to their social and emotional lives—all impacted on and influenced each other; that a disproportionate number of the most successful came from graduate families; that without exception, students reported that they were greatly helped in their learning by enthusiastic lecturers and tutors; that more support is needed to help retain students. Several outputs from the research have already been published and references or downloadable copy can be found at the project website (http://www.education.leeds.ac.uk/research/mathseducation/seum.htm). In this paper we focus on the experiences of women studying mathematics at university, and in particular, on their characterisation as 'invisible yet special'.

The position of girls and women with respect to mathematics has changed significantly over the past few decades and continues to change. What we report here is a snap-shot view of their participation in undergraduate mathematics taken from our

particular project. Our aim is to document aspects of the female experience of studying mathematics, and in particular, to consider some of the ways in which the young women we studied negotiate a path through undergraduate mathematics *as women*. Thus while some gender comparisons are inevitable in a paper such as this, our primary intention is not to compare the actions, experiences or attitudes of the male and female students. Although we acknowledge that the young men with whom these women studied have their own complex trajectories and modes of participation, it is the women on whom we focus and we do not discuss the men's experiences in any detail here. We begin by describing our interest in the topic, and then turn to theoretical and methodological considerations. Following that we give a give a brief overview of existing literature in the field. Finally we offer interpretations from interviews with some female students and observations of lectures, developing the twin themes of *invisibility* and *specialness* in greater depth.

## Gender emerging

Gender was not initially an explicit focus of the study, but individual students were always coded F or M and some statistics were routinely calculated. All of the women in the cohort were 18 or 19 years old at the beginning of their course. In terms of achievement, there was little variation between the women and the men although the men whose initial attainment placed them in the top half made slightly greater gains than women in the same group (Bartholomew and Rodd 2002). Thus while female students outperformed male students in their first year (the difference in the attainment of men and women was small but statistically significant), a slightly higher proportion of men graduated with first class degrees. Furthermore, students attaining an upper second or

better had the option of studying for a fourth year and graduating with a masters in mathematics, but of those qualified to do so, fewer women than men opted into this programme; at one of our universities only 2/20 women with upper second degrees, compared with 9/21 men with upper seconds, elected to stay on for a fourth year to do the 'MMath' course.

National trends are broadly consistent with this picture. While it remains the case more men than women study mathematics at advanced levels, the proportion at degree level is now almost the same as the proportion taking mathematics A level (the necessary school leaving qualification for HE mathematical studies). The ratio of 1:2 of female to male students in our cohort is in line with female participation rates across UK mathematics departments (University and Colleges Admissions Services 2001).

These figures indicate the continuing disparity in the uptake of advanced mathematics, but this was not what initially prompted us to look further at the experiences of the women on the course. We were working in a team which was predominantly women, all of whom had been mathematics teachers or were mathematics graduates. During team project meetings we often worked together on data analysis, discussing interview transcripts and fieldnotes from lectures or tutorials. At these meetings, discussions about class, culture or ethnicity were initially taken more seriously than those of gender; we became interested in the working class lad who wanted to be a mathematics lecturer, and the Asian student who found little with which he could identify in the very white community of his university mathematics department. Nevertheless, as time went on, we—Hannah and Melissa—started to discuss the project outside of meetings in social settings. And then between the spaces of efficient analysing of data,

routine calculation of statistics, individually and jointly, but in the context of relaxed shared attention, we became aware of gender discomforts, and began to focus on a number of key incidents that struck us as significant, and led us to develop the theme of female invisibility: the woman's answer that was not heard by the man who was giving the lecture; a man who was described by other students as the 'best student in the year' though in fact the best result was achieved by a woman who remained silent when hearing the conversation; the (male) lecturer who invariably gazed towards the back of the room, the 25% of students who were women sitting near the front so he never met their eyes while teaching. As observations like these came into focus we realised, with some shock it has to be said, that we were furthermore complicit in compounding this female invisibility; within our interview analysing meetings a disproportionate amount of time was spent on talking about male students; they appeared colourful and interesting and were easier to position in terms of stereotypical 'effortless achievers', 'boffins' or as being from a different culture. Where did the women students fit in?

## Methodology and methods

Part of the original brief of the project was to track students' attitudes as well as behaviours and academic outcomes as they progressed towards their degree, and a grounded theory (Glaser and Strauss 1967) approach was adopted for data collection and analysis. The interviews in particular provided a rich dataset, and the notion of 'belonging' emerged as an important theme for us. Members of the project team drew on Bourdieu's concept of 'habitus' (Bourdieu and Passeron 1990 cited in; Macrae and Maguire 2002) and Wenger's concept of 'community of practice' (Wenger 1998, cited in; Rodd 2003) to help us interpret our data and capture some of the ways in which students

did or did not belong in the community of mathematics students. We were also increasingly drawn to the post-structuralist notion of discourse (for example Walkerdine and Girls and Mathematics Unit 1989; Davies 1993; Mendick 2003a) as a way of theorising students' presentation of particular versions of themselves.

As with the majority of research in the social sciences, our initial analyses grew out of the basic premise that we could take our data at 'face value', yet as we immersed ourselves in the interviews that had been conducted with students we found that often what struck us as most significant was that which was left unsaid, or the contradictions occurring in students' narratives, rather than the face value of what we were being told. It seemed to us that many students were telling us (and themselves) stories to which they were highly committed and which they held to be 'truths' about themselves, and we increasingly viewed ourselves as *interpreters* of the interviews, noting omissions and gestures, rather than *distillers* of truths. During the discussion following a presentation we gave at the Centre for Interdisciplinary Gender Studies in Leeds (Bartholomew and Rodd 2002) it was suggested that Hollway and Jefferson's (2000) narrative interview method might offer us a useful framework. Drawing on ideas from psycho-analysis they posit the psychosocial subject (that is, the subject who is simultaneously psychic and social), taking as their starting points:

> All research subjects are meaning-making and defended subjects who:
>
> - may not hear the question through the same meaning-frame as that of the interviewer and the interviewees;
> - are invested in particular positions in discourses to protect vulnerable aspects of self;
> - may not know why they experience or feel things the way they do;
> - are motivated, largely unconsciously, to disguise the meaning of at least some of their feelings and actions. (Hollway and Jefferson 2000 p26)

They outline an approach to interviewing and data analysis which aims to elicit stories which reveal something of an individual's psychic investments in particular subject positions. With these guidelines in mind, we interviewed five of the young women participating in our study while they were about halfway through their third year, and these data supplemented the 'main' project interviews. In approaching potential interviewees we sought a balance of students who had been previously interviewed and those who had not, and we were particularly motivated to talk to some of the high attaining students who had been so invisible to us before.

We saw part of our job, within this project on students' experiences, as being to tease out the subtle ways that undergraduate mathematical experience was gendered. We had already noted the invisibility – referred to above – underlying an espoused liberal equal opportunities ethos which works towards greater female participation but stops short of challenging the terms in which they are expected to participate. However, we began to regard this invisibility not simply as something that was imposed upon the young women we were studying (though this is undoubtedly part of the story), but also as something they actively took up as a defence. This is the 'fiercely held modesty' of Serafina Pekkala, and it is manifested in these women's positioning of themselves in ways which render them invisible. In the final sections we illustrate and explore further this invisibility, and a twin theme of 'specialness', in greater detail. We draw mainly on data from the five 'narrative' interviews, but also refer to other interviews from the project (mostly conducted by Sheila Macrae the project's full-time researcher), as well as from observations and test results. Before that, in the next section, we give a brief overview of the literature in the field of gender and mathematics education.

## Gender and mathematics literature

The mathematical priesthood is more than 3000 years old, and, according to Margaret Wertheim's analysis, throughout these ages mathematics has been the tool for the quasi-religious controlling of nature, and the priesthood has systematically excluded female participation (Wertheim 1997). It is not surprising then that mathematics has had an image as a male activity.

The image of mathematics being masculine has persisted in feminist as well as other quarters, even though females have made rapid gains in achievement and in participation where blatant barriers have been removed (Burton 1986; Rogers and Kaiser 1995). Yet this image is changing, and the position of young women studying mathematics is very different today from that of past decades. Indeed, in a study of girls and boys in London comprehensive schools, Becky Francis (2000) found that girls and boys did not consider mathematics and science to be boys' subjects. Both the boys and the girls voted for English as their favourite and mathematics as their second favourite subject, with more girls listing mathematics as their favourite subject than boys. The students overwhelmingly considered that the sexes have the same ability in all school subjects, though tended to attribute female superiority in academic subjects, due to 'boys' problematic behaviour'.

Nonetheless, the extent and nature of gender differences in mathematics has attracted considerable research interest, and it is possible to trace the trends in the way 'the problem' has been conceptualised through the research outputs that have been generated at various times (Rogers and Kaiser 1995; Ernest 1998). The field is dominated by work which looks for differences in the attainment or attitudes of women and men (or more often, of girls and boys), and then seeks to account for them, either in terms of

innate differences between males and females or in terms of differences in socialisation. Yet as Valerie Walkerdine and colleagues have shown, this work is underpinned by an unquestioned assumption that there is a 'problem' with girls and women as far as mathematics is concerned, and that the task of the researcher is to identify its nature so that an effective solution can be found (Walkerdine and Girls and Mathematics Unit 1989). The veneer of objectivity granted by the predominantly quantitative methods adopted masks the fact that the *answers* produced are a product of the *questions* that were asked, and are at best partial truths. So for example, the findings that girls more often lack confidence in their ability (Hyde, Fennema et al. 1990; Terwilliger and Titus 1995) and are inclined to rule-following behaviour (Scott-Hodgetts 1986) and rote learning (Ridley and Novak 1983) all contribute to the image of boys 'taking risks' when doing mathematics, and demonstrating 'flair' that is absent in girls. Yet the possibility that the learning environment may make it easier for boys to take risks than for girls to do so, and that what is constructed as a risk is itself gendered, is not raised. Such research has been criticised for its tendency to 'blame the victim', by locating the problem with the girls themselves without considering the wider context which produced the behaviour identified (Kaiser and Rogers 1995; Boaler 1997b).

Although there is relatively little research into the experiences of women studying mathematics at degree level, some important contributions to the literature have focused on this sector. Rogers (1995) and Burton (1995) both argue that the presentation of mathematics as a complete (and inert) body of knowledge is disempowering for learners, and that this is likely to be particularly acute for women. This work is valuable in that it shifts the 'blame' from women and girls and onto mathematical epistemology and

pedagogy, and highlights the ways in which mathematics education reproduces inequalities within society (Dowling 1997). However, our focus in this paper is different, and we are primarily concerned with the actions and motivations of the young women in our study.

Despite the difference in emphasis, work which has focused on mathematical pedagogy speaks to many of the issues that we wish to raise in this paper. Stimulated by a concern with social justice, and a desire for gender equity, a number of researchers have documented the ways in which classroom norms frequently serve to exclude girls and women by denying their experiences and valuing speed and competition over in-depth understanding (Boaler 1997a; Bartholomew 2001). While we do not wish to argue that women are 'naturally' less competitive than men, or that they need to understand material in greater depth than do men before they feel confident or comfortable, we concur with Walkerdine's argument that the cultural referents of mathematics achievement are discursively constituted as masculine (Walkerdine and Girls and Mathematics Unit 1989). While for boys and men the experience of succeeding on these terms is likely to be affirming of their masculine identities, it is often more problematic for girls and women (Bartholomew 2002).

## Interpretations from the data

*Special girls*

A strong theme to emerge from the narrative style interviews—confirmed by evidence from the previous ones—was that it was *special* to be a woman studying mathematics. Several of the women made reference to this specialness existing since early childhood. For example Lucy says "*everyone's called me strange ever since I was*

*like a little kid I've always liked doing maths*" and Susan speaks of having a "*maths gene*". Such expressions occurred in several more of the women's narratives. We went through the interviews with the men and found no example of an analogous boyish 'specialness'. They talked instead about the quality of the subject or their confidence in being good at it now rather than their mathematical competence being part of their identity from an age of innocence. Is this because it is easier for young men to own their continued mathematical ability rather than having to identify this talent with a pre-sexual past? It certainly appeared difficult for the women we interviewed to claim current successes for themselves (Bartholomew and Rodd 2003).

Among the 5 women participating in narrative style interviews, Lindsey, Jessie and Tessa each got first class degrees, an achievement of 23% of the women students and 24% overall at their university in mathematics. They each express this specialness from when they were younger:

> I can remember in year four at primary school we used to do times table tests … and they'd time you and you put your hand up when you finished and I was always the first to finish. And I don't know if it was the fastest time but I know once I did it in nine minutes something. That's funny, I can remember that nine on my paper. … I was always the first to finish it. (Lindsey)

> [Maths is] my favourite. It's always been my favourite. Even at primary school, … on my reports … it's like maths, maths, maths. … The maths teacher [at middle school] was the first one that kind of really said to me—you should do it. You know? You could do it. I remember him. I liked him. (Tessa)

> Yes (I have always liked maths). Always. Even when I was in the infants. I used to finish my maths books first. … I used to like to learn my times tables at school. I got a little badge. (Jessie)

These women students' early identity was embossed with a self-conception as mathematically superior, special, chosen. Their particular self-images as mathematical little-girls were spontaneously communicated in interview, in a tone of pride and with a sense of touching base. The feminist philosopher, Morwenna Griffiths, has written about

issues of ‘belonging’ and tells her story of being a special mathematical girl too, albeit referencing her identity at an older age:

> At 16, when only a few of us in my all-girls’ school chose to specialise in maths and science, we told endless stories to ourselves about the group who took maths, and the kind of people we were. We were the ones who enjoyed the puzzle about the existence of imaginary numbers, and we were special, being such a close-knit group. (Griffiths 1995 p21)

Griffiths illustrates how a developing identity includes telling ourselves stories about what it is to be a woman, or a man, where we want to belong, how we want to straddle boundaries, to belong and not belong (Griffiths shares a vivid anecdote about being reprimanded for wearing nail varnish on the same day as coming first in a chemistry exam). It is no secret that university mathematics departments are peopled principally with men; no moderately aware young woman will be surprised that her lecturers are mostly male. Her gender identity and her mathematical identity cannot rest on being in the gender-majority in the mathematicians’ domain. These very academically successful students have polished their respective childhood images of being mathematically special, which is part of how they achieve being mathematical women. Griffiths’s anecdote is as an older girl than our students report. And this prompts the question of whether a community of ‘mathematical girls’ developed at university. There was no ‘women’s maths society’ or similar defined grouping that declared the women students ‘other’ but with a right to be there. A former generation’s feminist anger has dissipated. But we do find they have an interest in each other, for example, Lindsey (who achieved a first class mark in every exam she took at university) says “*one of my friends, Martha, she’s top girl … it’s nice to have other people around me that are as good*” and when she speaks of her circle of friends they are all female names. In fact, at times over the three years, Martha was not just ‘top girl’ as perceived by Lindsey, but top student, as

calculated from assessment results. As we remarked above, in the first year the top students (by examination mark) in both institutions were young women, though neither in our conversations in the research team nor in the observed students' conversations was this initially apparent.

*A lads' environment*

'Homotopy and Surfaces' is a level 3 module referred to, in a light-hearted way, as 'homo and surf' by the lecturer, a relatively young British man and one of the tenured faculty. He is interested in educational issues, and is keen to teach in an egalitarian manner. While around 100 teaching sessions were observed overall, one of us (Melissa) attended 25 of the 33 Homotopy and Surfaces sessions, primarily to get information about concept development in a final year pure mathematics option. Although gender was not an explicit focus of these observations, gender issues emerged from the start. Of the 44 students registered for the course in 2003, 11 were female and 33 male, a lower F:M ratio than the third year cohort overall. 35 of these (7 female, 28 male) were in the third year cohort which we were following (the others were exchange students or masters students). The women taking the course had higher performance than the men: for our cohort students 4/7 (57%) of the young women taking this course got a first class degree overall and 5/7 (71%) achieved a first on this module. In comparison, 6/28 (21%) of the males taking this course got a first class degree overall and they were also the 6 to get a 1st for this module. It seems, therefore, that the women taking this module were a particularly high attaining group, and indeed, more 'elite' than the group of men choosing it.

In lectures the women generally sat together. The room was arranged in 6 rows of 7, and the female students sat in row 2 and row 3. One exception was Tessa who often sat amongst the males towards the back. They also had a far higher attendance record than the male students: there were never *less* than 8 (73%) female students at a session and more than half the time observed they were all there or just one missing, but there were never *more* than 28 (85%) males. Male attendance was at 73% or more (≥24 students) for only 30% of sessions recorded, compared with the 100% for the females. Of the two (out of a total of 6) 'examples classes' (where students work on their mathematics problems with the assistance of peers or lecturer) observed one had 8 females and 8 males, the other had 8 females and 6 males. Again, Tessa was unusual among the women in that her attendance was somewhat erratic.

However, 'participation' by the female students was disproportionately less than would be expected from their attendance-rate. Early on in the course the lecturer said that he was "*keen on people asking questions: proper maths questions*" and he frequently stopped, asked a question and waited until some student response was given. Occasionally he invited students to chorus a reply to questions like "*what's the fundamental group of a circle?*" otherwise students could interrupt if they felt like it. Several male students, particularly Oliver, Charlie, Patrick and Sam, interjected and engaged the lecturer in conversation on the topic. The only female students to have been heard to comment were Lindsey and Tessa. Lindsey always sat second row first right; she answered questions posed by the lecturer and asked a few closed questions of her own. On one occasion when she gave a correct algebraic simplification there was an audible "*oooh*" from the class (suggesting she was being unattractively clever).

This apparent 'policing' of Lindsey's behaviour by her classmates 'feels' to us to be highly gendered and is perhaps symptomatic of the endurance of a view of active participation in mathematics as being at odds with an acceptable feminine identity. While the lecturer encouraged questions—and in particular 'proper maths questions'—from students, the evidence of the relative contributions in lectures of the men and women taking the module suggests that this was not an invitation that empowered all to participate. While not all men rose to his invitation, it is notable that the students who participated most were all men. These observations resonate with findings from research carried out in upper secondary 'top set' mathematics groups, where boys have been found to dominate proceedings (Bartholomew 2002; 2003). In particular, the pally relationship that the lecturer established with the group was most inclusive of those students who were most 'like him', and the light-hearted banter that accompanied lectures (for example, referring to the course as 'homo and surf') created a lads' environment in which it was difficult for the women to participate. Like the high attaining top set girls who were careful to locate themselves on the margins of their mathematics group (ibid.), Lindsey downplayed her contributions in lectures:

Interviewer : do you ask the lecturers?

Lindsey: no I don't tend to ask questions

*High Achievers*

Although Lindsey appears relatively comfortable discussing her success, it is interesting how she accounts for it. Describing the process of revising for exams, she says: "*I'm cutting down the notes, and cutting them down more. I always leave the learning process actually, to almost the last minute*" and when asked whether the condensing of her notes is part of the learning process she responds, "*No. It's the build*

*up to the learning process. … It's setting aside the things that you need to learn*". What is notable here is that the only part of the process which she discusses in any detail is the final stage of committing her condensed notes to memory. As she talks more she develops the theme of her excellent memory at length—"*People say I've got a photographic memory*"—and proudly recites a list of ten words she memorised as an exercise when she was in year 7 at school. Having an outstanding memory is clearly something that she holds to be a truth about herself, and is presented as an explanation for her success in mathematics. She does not talk at all about her mathematical ability, and in this respect appears to be tapping into discourses about mathematics learning which place 'real understanding' in opposition to 'memorisation', and generally associate 'flair' with boys. Given the response of her classmates when she did demonstrate her ability, it seems likely that this stance affords her some invisibility and is more comfortable.

Tessa, the other woman on this course to speak up in lectures, and another of our 5 interviewees, contrasts with Lindsey in that she appears more able to acknowledge her 'flair', though she expresses some surprise at discovering it in herself:

> I had no idea how I was doing and it was after the first exams I thought—oh God, I can do it

Yet even Tessa, who says her experience at university has been wholly positive, and who appears to have found ways of being publicly successful, reveals during her interview that, despite always having wanted to, she almost didn't study mathematics at university, and she too qualifies her own achievements by referring to nameless other people 'who can just do it':

> I always wanted to do maths but I just thought I couldn't do it. Didn't think I was good enough. Because I'm not like a. … you know there are some people who can just do it. I'm not one of those. So that's why I always thought, well, you know, I can't do it, it's maths, it's too hard. And then there was a girl in the year above me at school and I overheard her saying to one of my

> teachers that she was going to do maths at university. And I thought—oh, if she can do it so can I. So I did.

She describes going to a careers interview when she was at school and telling the careers adviser that she wanted to study French and Geography, and adds "*I don't know why I wanted to do that*". Later she says: "*I think if ... that girl who I'd heard, if I'd not heard that I don't think I'd be here doing maths*".

Jessie, who did not take the homotopy and surfaces courses, was another highly successful student. She was typical of many of the women we interviewed in that her sense of specialness as a mathematical girl stands in contrast to her presentation of herself as a young women studying mathematics at university. Interviewed during her third year, she appeared nervous and uncomfortable throughout, and seemed to be particularly uneasy when talking about successes she had experienced at university. Indeed, she presented herself as barely coping with the course, saying "*nothing's easy. It's all like, constantly struggling to understand it*", and it is only at the very end of the interview that she made reference to the fact that she was on course for a first (which she got); anyone who didn't know otherwise would assume she was barely scraping through. She says that when she doesn't understand something in a lecture she hopes that "*somebody in the class asked what it was. Not me*". However, when asked directly whether she has ever spoken up in a lecture she says that she has, "*because the lecturer was asking us questions and nobody was answering and he wasn't going to give in, so I thought I'd better answer.*" As she speaks more about this, it transpires that in this lecturer's class she has contributed in this way on a number of occasions, yet as she talks about it she becomes palpably less comfortable, laughing nervously as she talks. Crucially, she at no point acknowledges any sense of achievement or pleasure in contributing in this way.

Rather, she says that she "*got it wrong half the time. Which is quite embarrassing*", and refers to "*this one lecturer*" who "*wouldn't give up asking questions*" in an exasperated voice which is clearly meant to convey that she had no choice but to answer.

The story that she is telling doesn't seem to correspond to a reality in which she does contribute in lectures (or at least, it puts a particular spin on it, casting her contribution as something she is forced into). Indeed, she seems embarrassed, almost ashamed, by her contributions in lectures, and seems to shrink from anything that might draw attention to herself, even as she achieves her first class degree.

At another point in the interview we are talking about times when she has felt successful while at university, and again her nervous laughter betrays something of how uncomfortable she might be feeling as she talks about these issues. She is referring to a calculus course that she took in the first year, at which she felt she had a head start as she had covered some of the material while at school. However, it is as she is talking about how pleased she was that she could do it while others couldn't that her reticence becomes most marked; when pressed about the fact that it felt good to be one of the best she erases the part of the story that was about her doing *better* than others—it becomes simply that everyone else found it difficult *as well*:

> HB So the fact that everybody else was struggling with it … boosted your confidence did it? …
>
> Jessie Yeah. It's actually when it comes to exams because you sort of know that if everybody does badly they are going to bump up the marks, so you sort of hope when you are doing exams, if I've done badly I hope everybody else thinks it was difficult as well.

While these women all have different stories about studying mathematics at university, the themes of specialness and invisibility feature in all of them. Lindsey seems to retreat into a stereotypically feminine role for self protection, just as others protected themselves from the limelight in various ways, and they seem to draw on a sense of

'specialness' stemming from their early childhood to get them through. But these women don't retreat from the mathematics; however they choose to present their performance, they are clearly engaging meaningfully with the subject. They have been highly successful at university, and it is apparent from the way they talk that they derive a great deal of pleasure, and even a sense of protection, from the study of mathematics itself; Lindsey remarks, "*when I'm in the zone (doing mathematics) nobody touches me*".

*In comparison: Ann's story.*

Ann's story contrasts with the other students we have mentioned in that Ann has not been a particularly successful student. She graduated with a third class degree (after achieving upper second level marks in year 1 and then lower second level marks in year 2). She lives at home with both parents in a picturesque village 12 miles from the university. Her father has a mathematics degree and she acknowledges that "*he tries to help motivate*" her.

Ann first took A level mathematics a year early in Year 12 of high school, having been selected for a fast track class of eight students who were to study the course for one year rather than two. However, she did not get a good grade. So she took A level mathematics again in her final school year, repeating the lessons in the 'ordinary' class. Her descriptions of being in the chosen few for her fast track A level followed by her repeating the year with the ordinary students in Year 13, illustrates some of the issues of invisibility and specialness that we are asserting are gendered within the mathematics learning domain and also the way contradictions arise within a narrative of self.

Right at the beginning of the interviews Ann tells the interviewer that she is special:

> A level I found not easy but I enjoyed A level. Because our school had a thing where they did, they took sort of a handful of people, say eight of us, and tried us to do our A level within twelve months instead of two years. And I did that but I got a C and I wasn't happy.

When prompted , she reasserts that the course she took was right for her:

> The second academic year was all revision for me. Sort of clarifying the little niggly things that I never understood before and then it's like—oh yeah! And for some reason it all slotted together, the second year, when I was going through it. It all made more sense. It was good for me to do it in that way.

Later on in the interview, when invited to tell about her pre-university experiences of doing mathematics, Ann says:

> I did [GCSE] in year 10 instead of year 11 and got an A*, which spurred me on in maths, you see. I was always good at maths

and she traces her success to primary school

> In year 6 they started to split us up into different levels of groups, and I was always in the top group and I was sort of striding on. So it was probably as early as that."

She refers to her teacher from Year 9 (in high school) as the head of the mathematics department who "*liked the people that were good*" and she confirms that she was one of his 'star pupils': "*Yes. Oh yes, I was!*"

Then Ann has her set-back—getting a C at A level in Y12; her teacher had commented that she'd do "*wonderful things*" but she'd "*come out with a grade like that*" and was subsequently "*back with everyone else*" not with "*those eight people*" who had been chosen to do their exam early. But even though it was "*a bit strange*" she soon mixed in, because "*it was your friends anyway, it was your year*". Ann refers to the A level material "*clicking*" the second time round and even enjoying the A level exam "*that everyone else was saying was really hard*". She also remarks: "*I tried not to say anything because I knew I'd found it really easy*", exemplifying a form of the invisibility and female *fierce modesty* to which we are drawing attention. Ann goes on to say that she did not speak in class (in her retaking year)

> because I knew it was sort of unfair… because I knew it already. …I'd kind of sit and do something else for a bit while they learnt the basics and then we all mucked in together

Ann has the power to wait and the confidence to let her knowing be a silent complicity between herself and the teacher.

When Ann talks about university mathematics, her first response is "*very hard*". The metaphor 'hard' is used by Ann at a rate of about one per 150 words of her speech while talking about university mathematics.

It seems that Ann achieves the *fierce modesty* of a female seeking knowledge at school but does not achieve it at university. After all her final degree result puts her in the bottom 6% of the third year mathematics students at her university. Furthermore in her narrative-style interview, she does not spontaneously talk about actual incidents within the mathematics community at the university (although several stories about school were shared) which together with other comments she made suggests a lack of engagement with university mathematics. And she never did leave home. Somehow Ann, at university, did not do what Serafina did: walk right up to knowledge.

## Discussion

Thinking about these issues, and writing this paper, has raised some tensions for us, and we wish to acknowledge these rather than attempt to iron them out entirely. We want to tell a story of these women's success, yet we also recognise some of the ways in which their actions appear to be constrained. We note the dramatic advances in recent decades that have made studying advanced mathematics possible for many more women, but have seen the continuing privileging of masculine ways of being in relation to mathematics, resulting in defensive responses from female students such as those discussed in this paper. We recoil at the 'equal but different' mantra, and want to resist essentialist accounts of gender differences, yet want to posit a positive female-mathematical and

celebrate some of the distinctively feminine ways in which these women negotiate the demands of undergraduate mathematics.

Through the ages, a few women have studied academic mathematics on the sufferance of sponsoring men: Hypatia's and Emmy Noether's fathers, Mary Somerville's cousin-husband. Today, in societies with which we are familiar, liberal democracies sponsor 'others', like girls and women, to study mathematics. Celebratory initiatives of the 1980s, like 'Girls into maths can go' (Burton 1986) or 'GAMMA' (Girls (then 'Gender') and MatheMatics Association) have been absorbed into a culture of 'inclusion'; girls have been normalised as potential mathematical beings, though the normative is still, by observation, male. At university, 'female mathematicians' may be introduced to encourage the girls and teach respect to the boys, but they are 'other': no gender epithet is needed for the majority of mathematicians.

Grappling with the under-representation of women in advanced mathematics, Heather Mendick (2003b; 2003a) argues that 'doing mathematics is doing masculinity' and that this raises particular tensions for those who front female bodies:

> That people whose bodies are socially marked as feminine do things that are socially marked as masculine and vice versa is not surprising. However, that the marking of the body as male or female impacts on one's possibilities for acting is apparent; not all positions are equally available to all people. (Mendick 2003b)

This idea arises from her post-structuralist interpretations of her interview data from 16-19 year old mathematics students. These students' utterances illustrate the same sort of contradictory gender-work that Griffiths (above) has discussed as the identity-building work of "wanting and not wanting to belong: deciding how to belong" (Griffiths 1995 p21) in the business of growing up female.

We wish to echo Mendick's call for more subject positions to be made available to more people regardless of, in her terms, social markers and for

> gender reform work that rejects the fashionable polarised 'Mars and Venus' versions of gender that naturalise dominance as difference, and that does not dictate to girls or try to change them, but works with both boys and girls acknowledging the complexities of their lived identities. (Mendick 2003a, p184).

However we also call for more ways of being, including those which can be identified with contemporary femininity, to be recognised as mathematical.

A framework for interpretation that confounds the 'othering' of females with respect to mathematics is that of 'queer theory'. Queer theory deals with the interplay of the 'other' enjoying the 'normal' on their own terms. In our study, where the domain is undergraduate mathematics, the women (who are 'other' in this domain) enjoy academic mathematics (normality) as women. And our notion of female fiercely-held modesty can be viewed from this perspective. In our brief foray into this theoretical territory, we make particular reference to Deborah Britzman's psychoanalytic take on queer pedagogy (Britzman 1998) as it explains the unsatisfactory nature of the liberal desire for 'inclusion', which is at the heart of current policies in mathematics education at the post-compulsory level.

Queer theory makes sense of difference without subsuming the different, i.e. without normalising the deviant:

> Queer theory proposes to think identities in terms that place as a problem the production of normalcy and that confound the intelligibility of the apparatuses that produce identity as repetition. (*ibid*. p81)

She goes on to ask "how can difference be different? And different from what?" (p86). So we acknowledge that the young women mathematics undergraduates in our study did present differently from the 'normal' young men. (Though not always so different: for example, Tessa, in her skipping lectures and sitting other-than-with-the-girls

behaviour, signalled gender transgression from the norm in this regard (but not in her dress which was standard teen (hetero)sexy); another example echoing Griffiths' story of wanting and not wanting to belong.)

Our point is that one of the ways the women students can be different is in the way they come close to knowledge: quietly and in control, rather than in the (patriarchal) constructivist ideal of an interacting neophyte engaging with the knowledge of his mathematical family by gazing, questioning and being a replica of the teacher/father. We are arguing that a learning persona does not have to be an imitation of the masculine model. These women students' invisibility is not biddable. It is intentional. Their self-identification as 'special' is not masculine. It is protective. And some are finding ways to participate.

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## References