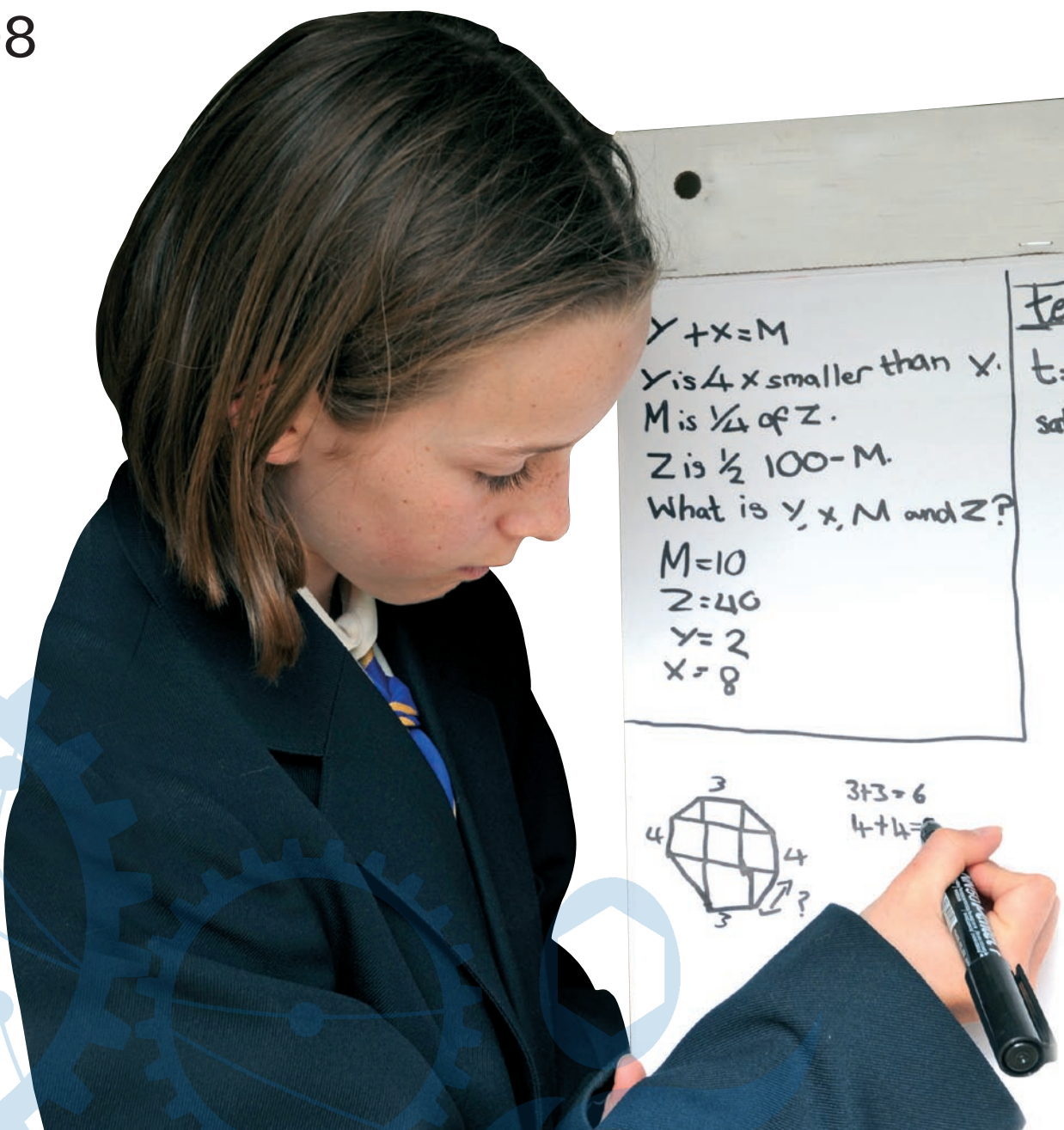
Research Report Series
for UKRC No.6

Mathematical Images and Gender Identities

A report on the gendering of representations of mathematics and mathematicians in popular culture and their influences on learners

Heather Mendick, Marie-Pierre Moreau and Sumi Hollingworth.

July 2008



uk resource centre for women in science, engineering & technology

Mathematical Images and Gender Identities
A report on the gendering of representations of mathematics and mathematicians in popular culture and their influences on learners

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First Published July 2008

ISBN: 978-1-905831-23-4

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Acknowledgements

In doing this research we had a great deal of help and support. Thanks go to Debbie Epstein who worked on the Mathematical Images and Identities project which gave rise to this one. Many of the ideas in here started life as conversations with her.

We are very grateful to the UK Resource Centre for Women in SET (UKRC), and to the Economic and Social Research Council (ESRC) before them, for taking a punt on a rather unusual sounding project and giving us the financial and other backing to enable us to undertake this work. In particular it has been good to work with Pat Morton and Anna Zalevski at the UKRC. We are grateful to them and to Hilary Povey, Jeff Evans, Michael Reiss, Nigel Steele and Yvette Solomon for reading and commenting on a draft of this report.
Bill Richardson, Brian Stewart, Helen Lucey, Hilary Povey, Jeff Evans, Marcus du Sautoy, Nigel Steele, Pam Wain, Pat Morton and Paul Andrews were an encouraging and thoughtful advisory group for the original ESRC project. Our colleagues at the Institute for Policy Studies in Education have provided much day-to-day support, suggestions and entertainment. In particular, Teresa Carbajo-Garcia administered both projects with care, and Nicola Rollock and Katya Williams took on emergency focus group duty when required.

Finally, huge thanks go to the participants in this research, and to those who helped organise the fieldwork at its many sites, for giving of their time and their opinions so generously. Making sense of what they said continues to be both fascinating and daunting. We hope that they will be happy with the outcome.

Executive Summary

This report details research into the following questions:

- How are representations of mathematics and mathematicians in popular culture gendered?
- How are the effects of these representations of mathematics and mathematicians in popular culture on learners gendered?

To address these questions, we draw on detailed analysis of the following data, collected as part of an earlier Economic and Social Research Council funded project:

- About 50 popular cultural texts including films, websites, books, radio and television programmes.
- Over 500 questionnaires from 14-15 year-old GCSE students and 100 questionnaires from undergraduates in mathematics and media studies.
- 15 focus groups with 15-16 year-old GCSE school students and 12 focus groups with undergraduates in mathematics and social sciences and humanities.
- 26 individual interviews with 15-16 year-old GCSE school students and 23 individual interviews with final year undergraduates in mathematics and with undergraduates and postgraduates in social sciences and humanities.

The main findings in relation to the gendering of representations of mathematicians and mathematics in popular culture are that:

- Mathematical representations are both invisible and ubiquitous in popular culture. And whether something is seen as mathematical depends upon context and upon the reader's understanding of and relationship with mathematics as well as on their other cultural resources.
- Popular culture texts strongly support the association of mathematics with masculinity, and also with Whiteness, middle-classness and heterosexuality. This gendering happens through: the dominant representations of mathematicians being men, the disappearing of women's mathematical contributions and the ways that women doing mathematics are subordinated in a range of ways including their youth and their positioning as appendages to 'greater' male mathematicians.
- Representations of male mathematicians combine features that ally them with heroic and powerful men and also features that present them as other, including: mental health problems, obsessiveness, fragility, and social incompetence. Their 'genius' is seen to mark them out from others and all other aspects of the self are subjugated to this.
- There is an emerging group of cultural texts featuring women mathematicians, several of which are part of a growing trend of young, attractive 'smart girls'. While encouraging, there are questions to be raised about the low proportion of adult women mathematicians, the

dramatised tensions between feminine heterosexuality and mathematics and the hyper-attractiveness of these characters.

- Both the representations of women and of men mathematicians, in different ways, present their mathematical abilities as 'natural' and as something people are born with rather than something that is acquired.
- Associated with the last point, representations of mathematics generally present this in ways that support ideas of its inaccessibility to the majority of the population.
- Popular representations of processes of doing mathematics show it as being about sudden and individual moments of inspiration that are accessible only to 'geniuses'. This creative process is aligned with masculinity.
- There are some trends in popular mathematics that offer alternatives to the clichés, notably mathematics incorporating aspects of beauty, creativity, empathy and accessibility. In particular, much popular mathematics is contestable rather than set in stone.

The main findings in relation to the gendered influence on learners of representations of mathematicians and mathematics in popular culture are that:

- There are very strong default images of mathematicians that are easily called up; these default images of mathematicians are of old, White, middle-class, heterosexual men and are associated with markings onto and into the body, including states of clothing, posture, mental health and social awkwardness or geekiness. These images reflect those circulating in popular culture. They are shared by men and women.
- Most participants were unable to identify attractive but unknown women as mathematicians while being aware that this was problematic. There were mixed feelings about the use of such images to sell mathematics, particularly when they were overtly sexual.
- Mathematics is constructed through a series of gendered oppositions such as numbers vs. words, technical vs. emotional and everyday vs. esoteric. These make mathematics something that is less attractive to women than to men.
- Discourses of mathematicians are also characterised by oppositions, for example between 'normal' mathematicians and 'real' mathematicians, people with 'natural' ability and those who just cannot get it or who need to work hard to do so. These discourses link to distinctions between everyday and esoteric mathematics. Again, these images reflect those circulating in popular culture and were shared by men and women but have gendered effects.
- Women are less likely to self-identify as having mathematical ability than men and this makes it more difficult for them to choose to continue with the subject. Both men and women's sense of their mathematical ability derived largely from external factors, prominent among these were assessment results and positions within teaching groups that are setted by 'ability'.
- The ways that people read images of mathematicians and mathematics depend on the understandings or resources people bring to them. For

example, participants who identified with feminism more often read mathematical ability into feminine bodies and participants who identified with mathematics more often read examples of creativity as mathematical.
- Popular mathematicians and mathematics can provide a resource for developing positive relationships with mathematics. In particular, popular mathematicians can provide points of identification and popular mathematics can provide a space to explore 'alternative' understandings of mathematics that cut across some of the oppositions.

Based on our findings, we make recommendations for producers of popular culture, for policymakers and practitioners in mathematics education and for researchers in mathematics education.

The recommendations for producers of popular culture are that we need:

- More representations of women doing mathematics and particularly more adult women whose abilities are independent of the men in their lives.
- Representations of women doing mathematics who are classically attractive, feminine and engaged in heterosexual relationships *and* of those who are not.
- A greater diversity of people doing mathematics, in particular, people from different ethnicities, nationalities, sexualities, ages, social class backgrounds and with different bodies. And, particularly, we need ones that go against the clichés.
- A range of ways of engaging with mathematics happily and successfully, including presenting mathematics as a hobby, an incidental part of a character's life and involved in a range of occupational areas, so that mathematics can be seen as part of someone's life rather than as all consuming.
- Representations of mathematics that present it as accessible to all and that do not obscure the mathematics.
- Representations of the process of doing mathematics that present effort as part of ability and show the process as creative and collaborative.

The recommendations for practitioners and policymakers in mathematics education are that we need:

- To address with learners the question of 'what is mathematics?' by including this within the National Curriculum, within examination syllabuses and within the associated assessments. Alongside this we need to develop teaching materials, initial teacher training and continuing professional development programmes to support this.
- To make mathematics, in its broadest sense, visible in other subjects, especially in those such as humanities, languages and social sciences that are often seen as opposed to mathematics and that are characterised as 'feminine'. This kind of work could happen both within and across disciplines.

- To teach and assess mathematics through activities which cut across the oppositions and present mathematics as creative, collaborative and *un*certain. Coursework, while initially offering such opportunities had undoubtedly become formulaic and so no longer did this in most classrooms, however, its elimination from GCSE and near elimination from A level leave no spaces at all for such work.
- To present mathematics as a human activity carried out by women and men and one that requires work, is ongoing and is affected by experiences of discrimination and other aspects of biography and politics. Work on the histories of mathematics and using accounts from a range of contemporary mathematicians would be a way of doing this. However, it is important to support the use of such available material through both teacher training and development and through its inclusion within curricula and assessments.
- To create space within the curriculum for looking critically at representations of mathematicians in popular culture.
- To offer learners a range of ways of identifying with mathematics in the classroom, for example, as a hobby, as something used in another subject and as something done by a mathematician. For example, teachers could remark on and celebrate different students' attraction to and success in different mathematical activities.
- To encourage the use of 'all ability' teaching in mathematics both at primary and secondary level. This would include reviewing the current Key Stage and GCSE testing regimes which clearly support ideas of 'natural' ability and practices of setting.

The recommendations for researchers in mathematics education are that we need:

- Work looking at how other groups of learners read popular mathematics and mathematicians. Primary school age children and adult numeracy students would be useful groups to work with since research shows both that primary school is an important space for developing relationships with mathematics and that adult numeracy students have varied and changing relationships with the subject.
- Work comparing the figure of the mathematician with other disciplinary identities such as historian, sociologist, chemist and musician, both in terms of how these are constructed in popular culture and how they are read by learners. The relation of discourses of genius to different subject identities should be a focus within such research.
- Work looking at a range of bases for identification with mathematics and mathematicians and particularly at ones that this research suggests could allow a wider range of people to develop positive relationships with the subject. Our findings suggest that biographical research with mature mathematics undergraduates would be a good place to start this.
- Work developing pedagogies that are effective for teaching 'all ability' groups in mathematics.
- Work developing pedagogies that make use of popular cultural resources in the classroom.

- Work developing and evaluating processes of teacher training and development that support the recommendations for practice in mathematics education listed in the previous section.
- Work developing and evaluating systems of curricula and assessment that support the recommendations for practice in mathematics education listed in the previous section and that avoid the pitfalls of coursework.

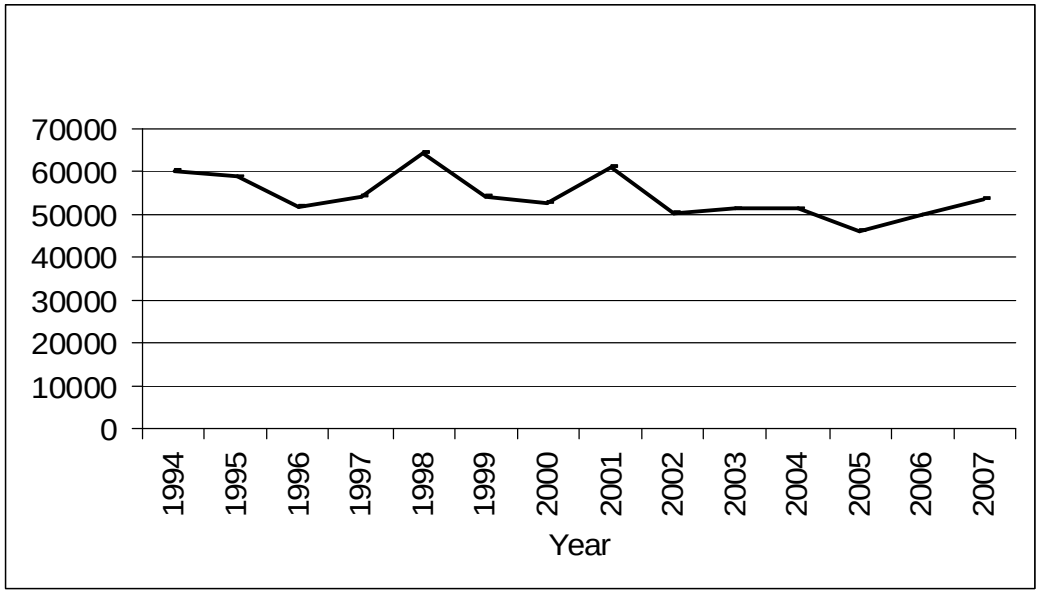
Chapter 1: Introduction

The research reported here explores the ways that mathematics and mathematicians are represented within popular culture, the processes through which these influence people's engagement with the subject, and the ways that these representations and processes are gendered. The research was commissioned by the UK Resource Centre for Women in Science, Engineering and Technology - the government's lead organisation for policy advice and services regarding gender segregation in science, engineering and technology. This opening chapter sets the context for the research.

1.1 Participation in mathematics and gender

In recent years there has been concern about the decreasing engagement in mathematics beyond compulsory schooling in England and Wales (Smith, 2004). Figure 1 shows that, notwithstanding increases in the past two years, entries for A level mathematics dropped by 12% between 1994 and 2007.

Figure 1: Total A level entries: 16-18 year olds: 1994-2007

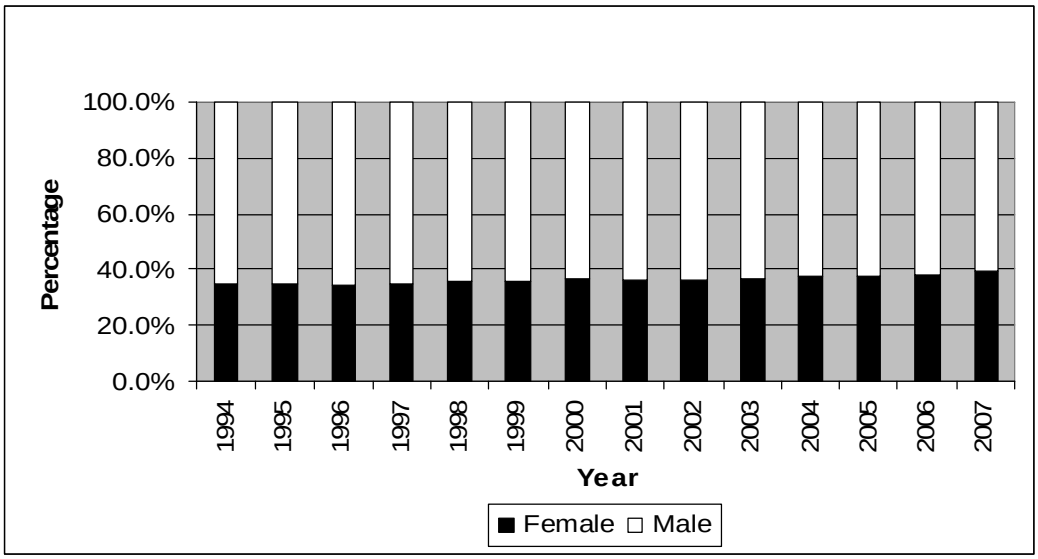


(Sources: DCSF, 2005, DfES, 2004, 2005, 2006, 2007, Government Statistical Service, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2003)

Within higher education, in the decade to 2007, there was an 8% reduction in the number of single honours mathematics degree courses offered by UK institutions (University and College Union (UCU), 2007). However, as with the A-level data, the last few years have seen a small rise in numbers.

There has been persistent evidence of women's lower level of participation in mathematics in comparison to men's. At A level "girls are opting out of mathematics *despite* their advanced performance in secondary school" (Boaler & Sengupta-Irving, 2006, p.210). Figure 2 shows that the proportion of those entered for A level mathematics that are female changed little in the period from 1994 to 2007, rising only slightly from 35% to 40%.

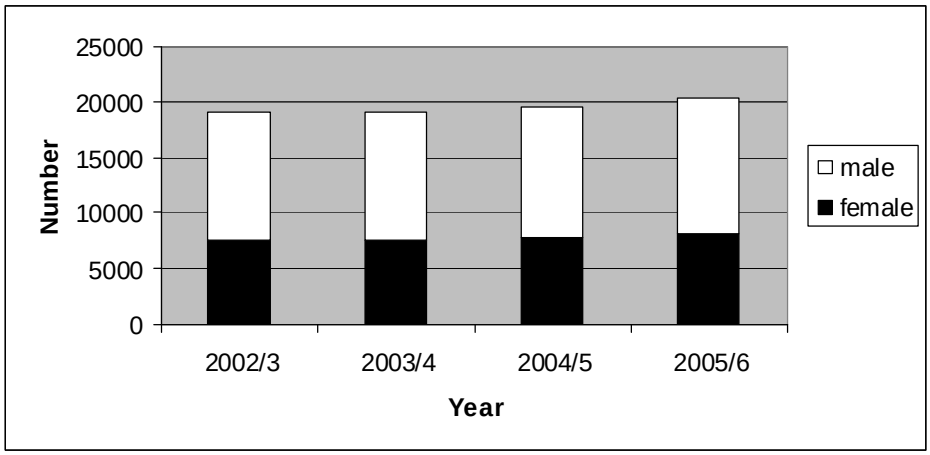
Figure 2: A level entries by gender: 16-18 year olds: 1994-2007



(Sources: DCSF, 2005, DfES, 2004, 2005, 2006, 2007, Government Statistical Service, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2003)

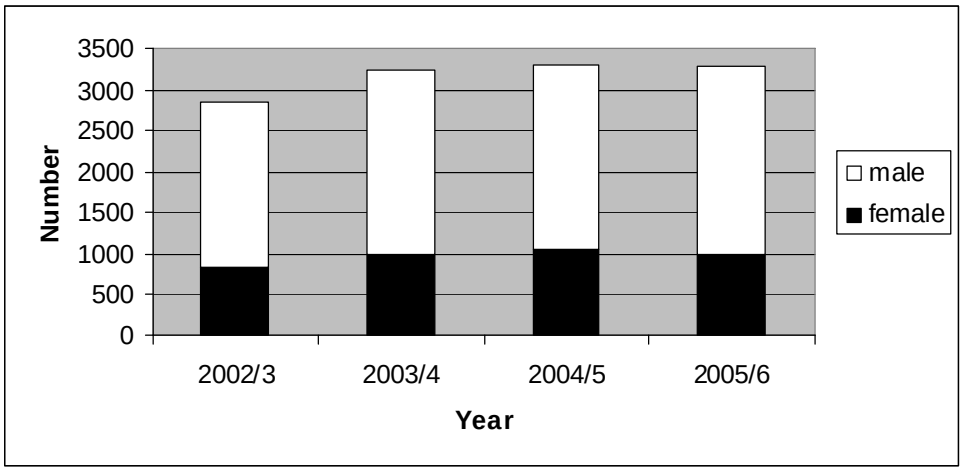
Within higher education women are also under-represented. Between 2002/3 and 2005/6, the proportion of full-time mathematical sciences undergraduates that are female remained fixed at around 40% and the proportion of full-time mathematical sciences postgraduates that are female remained fixed at around 30% (see Figures 3 and 4). The proportion of women among part-time postgraduates dropped during this period from 41% to 34% (see Figure 5).

Figure 3: Full-time mathematical sciences undergraduates by gender: 2002/3-2005/6



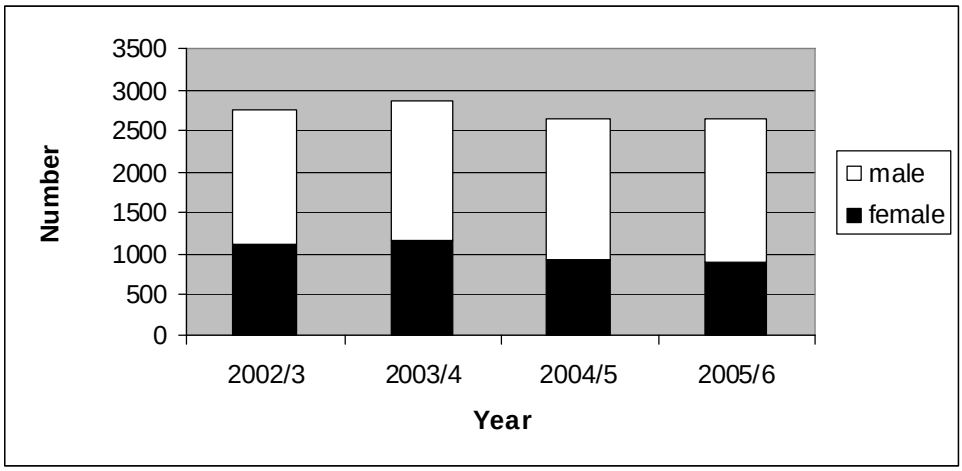
Source: http://www.ukrc4setwomen.org/html/research-and-statistics/statistics/students-in-higher-education/

Figure 4: Full-time mathematical sciences postgraduates by gender: 2002/3-2005/6



Source: http://www.ukrc4setwomen.org/html/research-and-statistics/statistics/students-in-higher-education/

Figure 5: Part-time mathematical sciences postgraduates by gender: 2002/3-2005/6



Source: http://www.ukrc4setwomen.org/html/research-and-statistics/statistics/students-in-higher-education/

Mathematics acts as a 'critical filter' into a range of occupational and educational fields and, in particular, is seen as an underpinning discipline for studying nearly all areas of science, engineering and technology. Thus, women's under-representation in mathematics contributes to their under-representation in other areas.

1.2 Mathematics in popular culture

Alongside the decreasing interest in mathematics there has been an increasing engagement of people with popular culture - including magazines, newspapers, television, films, books, advertising and the internet (Kenway & Bullen, 2001). And, particularly relevant to this project, there has been a

proliferation of popular representations involving mathematics – from *A Beautiful Mind* to *Runescape*, from Sudokus to *The Da Vinci Code*.

There is evidence of the influence of these representations. For example Susan Picker and John Berry (2000) asked 12 to 13 year-olds in the United States, the United Kingdom, Finland, Sweden and Rumania to draw a mathematician. When UK children drew twice as many women mathematicians as their US counterparts, they ascribed this to Carol Vorderman's presence as the vital statistician on television game show *Countdown*:

> There is no equivalent program to *Countdown* on television in the United States, but there has been an increasingly well-funded gender equity movement, which initially arose from such reports as *A Nation at Risk* (1983) and the *National Council of Teachers of Mathematics (NCTM) Standards* (1989). Yet for all the programs and money being spent in the United States, it appears that one television program in the United Kingdom, *Countdown*, has been able to accomplish more, showing the effect the media tends to have on children and society. (p.90)

Social research on popular culture can be crudely divided into three sorts (Buckingham, 1993), all found in the mathematics education literature:

- Production studies: Singh (1999) describes the limitations and opportunities in making the *Horizon* programme about mathematician Andrew Wiles.
- Textual studies: Appelbaum (1995), Damarin (2000), Evans (2003, 2004, Evans & Tsatsaroni, 2007), Greenwald and Thornley (2007) and Mendick (2004) analyse specific representations of the subject matter of mathematics, the processes of doing mathematics and the people who engage in these processes, making connections with teaching and learning.
- Audience research: Eastaway (1999) deals with the use of mathematics in games shows, Lerman (1999) with whether mathematics has cool associations or not and Leach and Mudry (1998) with the use of mathematics within cosmetics advertising. All three are interesting but small-scale studies.

The above list contains the extent of the research done on mathematics leaning and popular culture. The production and audience studies were presented at a series of seminars on the construction of a public understanding of mathematics during 1998/1999. Participants argued that Public Understanding of Mathematics "activities, like those of PUS [Public Understanding of Science], need to see these contexts of consumption as a primary site where 'attitudes' 'behaviours' and 'identities' are constructed" (Leach & Mudry, 1998). This argument was powerfully made there but has not since been taken up by researchers in mathematics education, in stark contrast to the important and productive work done in other curriculum areas on the interaction of popular culture with formal education, for example on literacy (Marsh, 2005). The UKRC has commissioned several other projects on media influences on gender and science, engineering and technology but

mathematics has been largely absent from these (Haran *et al.*, 2007, Kitzinger *et al.*, 2007a, Kitzinger *et al.*, 2007b, Whitelegg *et al.*, 2007). The research reported here addresses these absences.

1.3 Research questions

It is against the backdrop sketched above that we set out to explore:

- How are representations of mathematics and mathematicians in popular culture gendered?
- How are the effects of these representations of mathematics and mathematicians in popular culture on learners gendered?

Within this we investigated the ways that conceptualisations of mathematics and mathematicians in general are gendered and attention was paid to the ways that gender intersects with social class, race/ethnicity and sexuality.

The research built on an earlier Economic and Social Research Council funded project (RES-000-23-1454). It included a survey, focus groups and individual interviews with young people in the final two years of compulsory schooling and with university students in mathematics and in humanities and social sciences. It also involved an analysis of a range of cultural texts featuring mathematics and mathematicians. In this report, Chapter 2 describes the research methods used; Chapter 3 draws on our analysis of cultural texts to discuss gendered patterns in popular representations of mathematics and mathematicians; Chapter 4 draws on our survey, focus group and interview data to explore the ways that women and men make gendered meanings from these; and, Chapter 5 contains recommendations for policy, practice and research.

Chapter 2: Research Methods

The research discussed in this report developed earlier work on mathematics and popular culture carried out by Heather Mendick, Debbie Epstein and Marie-Pierre Moreau and funded by the Economic and Social Research Council (Mendick *et al.*, forthcoming). Specifically, it involved a gendered analysis of the dataset generated in the earlier project. This chapter outlines the research methods used in the collection and analysis of this dataset.

The research used a mixed methods approach, collecting four forms of data: a quantitative survey, cultural texts, and qualitative semi-structured focus groups and individual interviews. The cultural texts were selected both from those suggested by our survey respondents and from those that we became aware of that prominently featured women doing mathematics. The survey, focus groups and individual interviews involved two participant groups:

- **Year 10 - 11 school students:** drawn from three mixed comprehensive schools: Franklin, a rural South West school with a mainly White middle-class intake but a number of rural poor; Shelley, a London school with a diverse intake in terms of social class and ethnicity; St Joan's, a Catholic school in a large South-England town with a mainly White intake but a mix of middle-class and working-class students.
- **University students:** drawn from three Russell group universities (Wollstonecraft, Meitner and Herschel) and three post-1992 universities (Gillespie, Charlton-Moore and James' Park). About half had chosen mathematics and about half had chosen social sciences and humanities subjects. Most were second or third year undergraduates. However, three of the final interviewees were postgraduates.

All the names of the participating people, schools and universities have been changed to preserve their anonymity. Participants chose their own pseudonyms. Since some chose cross-gender or gender-neutral names we have identified them as male or female when we have quoted them.

2.1 Survey

556 Year 10 students and 100 mathematics and humanities undergraduates completed the survey. Respondents completed closed questions on:

- Their feelings about mathematics: Likert scales were used to measure their enjoyment, confidence and anxiety in relation to mathematics and to measure their opinions on the difficulty and importance of mathematics and of its utility for their future career and their daily life; questions were asked about their choice to continue studying or not to continue studying mathematics, the influences on this choice and how capable they felt themselves to be at mathematics.
- Their uses of popular culture: Multiple response questions were used to collect information on the frequency of their interaction with particular forms of popular culture.
- Their engagement with popular culture mathematics and mathematicians: Questions were asked about within which media they had seen mathematics and mathematicians in popular culture and

about whether they had engaged with 11 specific mathematical texts (*Numb3rs*, Tetris, sudoku, cryptic crosswords, chess, Othello, *New Scientist*, *A Beautiful Mind*, *Pi*, *Proof* and *Good Will Hunting*).

- Their families' relationships with mathematics: Questions were asked concerning which members of their families they talk with about mathematics, whether their mother and father use mathematics in their work and what is their highest level of educational qualification in the subject.
- Their gender, social class, ethnicity and age: Data on social class were collected through both parents' occupations and through their highest levels of educational qualifications; data on ethnicity were collected using the census categories.
- Their educational and employment aspirations.

We analysed the results question by question for the overall sample, for each respondent group (Year 10, undergraduates) and for each institution. Using a combination of cross-tabulations and chi-squared tests, we explored:

- Differences in relation to representations of mathematics and mathematicians between those who had continued or were intending to continue with mathematics and those who had/were not.
- Differences in relation to representations of mathematics and mathematicians between those GCSE students seeing themselves as 'good at maths' and those who did not.
- Relationships between speaking about mathematics with family members and the following factors: choosing the subject, seeing oneself as 'good at maths' and awareness of popular representations of mathematics/mathematicians.

Analysis by gender was transversal to the analysis. We also analysed the data by social class and ethnicity where size of categories allowed. Social class was categorised by parents' occupations since the data on parental educational qualifications was unreliable in many cases.

There were two open questions included in the survey. The first followed up the closed question on their capability at mathematics, asking them to classify themselves as very good, good, ok, bad or very bad at mathematics, by asking how they had found this out and how old they were at the time. The second asked them to recall two examples of mathematics or mathematicians in popular culture and, for each example, to say what it was, where they had seen it, what they remembered about it and what their feelings and opinions of it had been. These responses were coded into broad categories arising from the data. For example, the age at which they found out how capable they were at mathematics was classified into: always, pre-school, infant, junior, Key Stage 3, Key Stage 4, sixth form, university and adult. The data from these questions were then analysed by phase and by gender.

2.2 Texts

Data from the open survey question, asking for two examples of popular culture mathematics or mathematicians, were used to build up an archive of 'texts'. These texts included films, television programmes, advertisements,

newspaper and magazine articles, websites, books, games, radio programmes, computer games, puzzles and music.

For the 22 texts that came up more than twice, we constructed a detailed written description. These descriptions included information about musical, visual and verbal material as relevant. For books they ran chapter by chapter, for films and one-off television shows they ran scene by scene. For television series we carried out a detailed analysis of one or two typical episodes supported by a less in-depth analysis of a range of others. Sections of texts relating directly to mathematics were described in the most detail.

These descriptions were entered into a dedicated qualitative data analysis package, NVivo, and coded for sets of 'discourses'. These discourses are collections of ideas about a subject. For example we looked at discourses of mathematics that constructed it as useful for particular purposes, as a sign of intelligence, as the language of nature, and so on. We also looked at discourses of people doing mathematics and of differences of gender, class, 'race' and sexuality. The codes were used flexibly and we added to them as the work progressed. In addition to the texts themselves, we collected 'satellite' resources, or associated texts, including reviews, online feedback and fansite information. These were also entered into NVivo and coded in the same way as the main text descriptions.

For a sample of 20 of the 60 texts that came up once or twice, we compiled summaries of the main discourses circulating in and through them in relation to mathematics, mathematicians and difference. We then looked across the texts. As an extension, specifically for the UKRC research, we also did this for six additional texts that featured women doing mathematics (some of which had come up on the survey and some of which had not).

2.3 Focus groups

129 participants took part in 27 focus groups. In each school we did five groups (one all-female, one all-male and three mixed). These generally had five or six participants, but one had four and one seven. The 12 undergraduate groups were split equally between mathematics and the contrasting subjects of social sciences and humanities, and between Russell group and post-1992 universities. The undergraduate groups generally had between three and six participants; however, due to our struggles to persuade students to attend, one had only two people and another only one. These latter do not strictly qualify as 'focus groups' but we have included them in the analysis because we used the same schedule.

We asked participants for:

- Their feelings about mathematics and on what makes some people want to continue studying the subject and some not.
- Their images of mathematicians, including their physical appearance, work, lifestyle and relationships with family and friends.
- Their responses to clips from the film *Stand and Deliver*, the film *Good Will Hunting*, the gremlins adverts and the TV programme *Deal or No Deal*.

- Their engagements with sudokus and their views on whether these are mathematical and, more generally, on what mathematics is.

The focus groups lasted from about 45 to about 75 minutes in length and were audio-recorded and transcribed.

Because of the nature of the discussions in these groups, with much overlapping talk and one person quickly responding to and building on the contributions of others, it was difficult to ascribe a view to a particular individual. Thus we saw the views as belonging to the group and did not directly compare male and female views. Although we generally did not attempt to map views to individual group members, we did look at the function that particular people played within the talk when this was significant. We analysed the groups thematically by coding them using the computer package NVivo in the following areas: *teachers and pedagogy*, *school and university mathematics*, *images of mathematicians*, *reasons for choosing and liking mathematics*, *responses to particular texts*, *what is mathematics?* Each of these broad areas was broken down into sub-areas. For example, 'what is mathematics?' was divided up into numbers, logic, problem solving, absolute, comparisons with science, comparisons with music, and so on.

2.4 Individual interviews

We carried out 49 semi-structured individual interviews with 26 Year 11 students, 11 final year mathematics undergraduates and nine undergraduates and three postgraduates in social sciences and humanities. These were spread across our participating schools and universities. We asked participants to:

- Discuss the place of mathematics in two imagined worlds: a world 100 years into the future and a world where mathematicians appear regularly on television.
- Talk about their relationships with mathematics, any changes in these and any associated memories.
- Give the reasons for their educational and employment choices and, in particular, the part played by parents, teachers and popular culture in these.
- Arrange a series of images of mathematical people in order of likeability. The mathematical people consisted of: Russell Crowe as John Nash in *A Beautiful Mind* scribbling mathematical symbols on a window, Albert Einstein writing $e=mc^2$ on a blackboard, Carol Vorderman in a sexually provocative pose in front of a blackboard covered with formulas, US actress and mathematics graduate Danica McKellar posed amidst mathematical symbols, a *Time* magazine cover with a woman dressed in a white coat with callipers above her head and the strapline "THE MATH MYTH: the real truth about women's brains and the gender gap in science", and cartoon father and daughter Homer and Lisa Simpson sitting together with a thought bubble coming from Lisa's head showing π and one from Homer's head showing a piece of pie.
- Arrange a series of images of mathematical artefacts in order of 'maths-ness'. The mathematical artefacts consisted of: a surreal art work by Justin Mullins bearing the sum 1+1=3 and beneath this the

words “for large values of 1”, a Romanescu cauliflower, the Mandelbrot Set, a sudoku puzzle on the net of a cube, a blackboard showing a series of networks and phrases, and part of the Alhambra mosque.

- Discuss whether anyone can do mathematics and whether there are any differences related to gender, social class or ethnicity.

Our methodological approach, drawing on fantasy scenarios, memory and visual stimuli was innovative within mathematics education; it gave us a way of accessing the relationship between the mathematical and the popular, one which we knew from the focus groups is difficult to explore directly.

We entered summaries of all the interview participants’ responses onto a spreadsheet. We then carried out a thematic analysis across all of the interviews looking at each issue we had asked about in turn. For this thematic analysis we divided the participants into eight groups splitting them by phase, by gender and by choice towards or away from mathematics. We looked for patterns of similarity and difference within and between the groups. We embedded this thematic approach in a narrative analysis of selected interviews. The narrative analysis allowed us to pay more attention to details of individual biography than was possible when working thematically.

2.5 Relating images and identities

Throughout this research, we have been concerned to develop an approach that allows us to look at the intricate ways that people interact with cultural texts. As early as 1973 Stuart Hall (1973:5) cautioned:

> Though we know the television programme is not a behavioural input, like a tap on the knee-cap, it seems to have been almost impossible for researchers to conceptualise the communicative process without lapsing back into one or other variant of low-flying behaviourism.

More recently Valerie Walkerdine (2007) attempted to avoid the polarisation of debates on media effects between those who claim a direct causal relationship between representations and behaviour and those who seek to deny all such effects. We too sought to cut across the oppositions within debates about the relationship between *images* and *identities*: for example, between active makers of meaning and passive recipients of media messages and conscious and unconscious responses to texts.

We analysed the texts as part of collections of meanings or discourses that circulate within society. In this report, we look at them first in isolation in Chapter 3. Then, in Chapter 4, we embed this analysis in the ways that people make sense of cultural texts and of themselves as mathematical, or not, in relation to them, drawing on the survey, focus group and interview data.

Chapter 3: Gender and Representations of Mathematics and Mathematicians in Popular Culture

It is often difficult to find mathematics in popular culture. For example, the UKRC funded *(In)visible Witnesses* (Whitelegg *et al.*, 2007) research surveyed two weeks' of television and found 403 examples of science, technology, engineering, and mathematics (STEM). Of these only 20 or 5% featured mathematics compared with 68% for science, 16% for technology and 11% for engineering. Most of the references to mathematics were found in the sub-sample of programmes for children and young people. In fact only 2% (6/249) of the 'adult' references to STEM subjects were to mathematics. Thus very little mathematics was found that was not linked to its part in the school curriculum. This limited number of examples can be seen as deriving from the definition of mathematics that was operationalised within the research:

> Mathematics: These programmes should include significant explicit mathematical content, namely a reference or references to mathematical concepts and formula, mathematics research, mathematics as an intellectual activity, or mathematicians. (Whitelegg *et al.*, 2007, p.8)

In contrast, by allowing participants to define mathematics and mathematicians, our research generated a much wider range of images. Taken together these present a complex picture of the ways that people's ideas about mathematics and mathematicians and their relationships with the subject are assembled.

This chapter begins with a discussion of where to find the mathematical within the popular, it then looks in more detail first at what mathematicians look like in popular culture and then at what mathematics looks like.

3.1 Where is the mathematical in popular culture?

As we said above, it is often difficult to find mathematics and mathematicians in popular culture. And, this was the experience of the participants in this research. When asked in the survey to recall two examples of popular culture representations of mathematics or mathematicians, 24% of respondents left the first example blank and 50% left the second blank. However, as discussed below, this signals not an absence of mathematical images but their *invisibility*. Mary Harris (1991) argued similarly that mathematics in work is invisible rather than absent.

Only ten texts occurred more than five times (see Table 1). This list includes two 'edutainment' texts, bitesize and mymaths, that use popular forms to deliver the school curriculum (Buckingham, 2001). It also masks considerable differences between the two respondent groups; only one undergraduate selected bitesize, while only one Year 10 student selected *Pi*. For each of these texts, the feelings they provoked ranged across pleasure, enthusiasm, boredom and distaste; this range of readings is the focus of the next chapter on the influence of these texts.

Table 1: Mathematical texts occurring more than five times in the survey of Year 10 students and second year undergraduates

Text	Media	Frequency
BBC bitesize	Website/TV	117
Countdown	TV	85
A Beautiful Mind	Film	58
Sudoku	Puzzle	54
Mymaths	Website	32
Good Will Hunting	Film	20
Magazine quizzes, horoscopes, articles	Magazine	12
The Curious Incident of the Dog in the Night-time	Book	12
Deal or No Deal	TV	7
Pi	Film	7

A remarkable 71 texts came up five or fewer times, 47 of these being noted by only one respondent each. Some we had anticipated but had expected to come up more often, including: *Rainman* (film), sport, *The Da Vinci Code* (book), Tetris (computer game). Others took us by surprise, including: *Mission Impossible* (film); Russ Noble (comedy); *Friends* (TV); Mambo Number 5 (music). Still others opened us up to whole new worlds, including: Dr Kawashima's Brain Training (NintendoDS game), DJ Shadow/Cut Chemist (music); Johnny Ball (theatre); Wolfram (website). This multitude of diverse images suggests both the *invisibility* of mathematics in popular culture and its *ubiquity*: from Doctor Who explaining happy numbers to Martha Jones and bemoaning the lack of recreational maths in the Earth's curricula (Harper, 2007) to police officers Fraser and Ray discussing Gödel's theorem whilst stranded in the ocean in *Due South* (Mendick, 2007b) and AJ (male) using talk of manifolds and doughnuts to attract Joey (female) in *Dawson's Creek* (Williamson, 1999).

Both male and female participants came up with the same set of common texts in broadly similar proportions. There were a few minor gender differences. GCSE girls came up with more of the references to magazines than GCSE boys, but by no means all of them; male participants came up with more, but again not all, of the references to sport and music. Female participants were somewhat less likely to leave both examples blank but it is difficult to draw any conclusions from this.

In addition to the survey respondents, focus group participants were also asked to provide examples of popular culture mathematics and mathematicians. People produced significantly different examples in the two

settings. For example: because focus group participants were asked to imagine a mathematician they mentioned examples of 'geeks' (for example, TV's *Saved by the Bell*), scientists (for example, cinema's *Flubber*), and geniuses (for example, cinema's *Phenomenon*); because focus group conversations often began with talk about everyday mathematics, participants mentioned examples of shopping, budgeting and gambling. All of these examples had been absent from the survey data. This dissonance between survey and focus group responses (repeated in the interviews) shows that there is no simple absence of popular mathematical images. Reading something as mathematical or someone as a mathematician depends on the context and on your ideas about what mathematics is. As discussed in the next chapter, these ideas are always shifting and up for negotiation.

3.2 Popular mathematicians and gender

The majority of popular culture representations of mathematicians are male, White, middle-class and heterosexual. However, there is an emerging group of representations of women doing mathematics. In this section we look first at the dominant male representations and then at the emerging female representations.

3.2.1 Dominant male representations of mathematicians

Representations of mathematicians combine the attributes of privileged groups - generally, they are male, White, middle-class, heterosexual and heroic - with attributes that position them as 'other' - such as mental health problems, ranging from obsessional behaviour to schizophrenic disorders, lack of social skills and austerity of lifestyle and personality.

A detailed look at three popular culture texts will be used to illustrate this:

- *A Beautiful Mind* (Goldsman, 2001), a film based on Sylvia Nasar's (2001, first published 1998) biography of the same name, features the life of John Nash (played by Russell Crowe), from his time as a student at Princeton University through to old age, when after being diagnosed with schizophrenia he wins the Nobel Prize for economics for his earlier work on game theory.
- *Good Will Hunting* (Affleck & Damon, 1997) focuses on the figure of a mathematical genius: Will Hunting (Matt Damon), a young working-class Irish-American who works as a janitor at Massachusetts Institute of Technology (MIT), and whose huge mathematical abilities are discovered by MIT mathematics professor and Fields medal winner (a sort of Nobel Prize for mathematics), Gerald Lambeau (Stellan Skarsgård).
- *Numb3rs* (Gansa, 1997), an ongoing TV drama (which is broadcast on ITV1, ITV3 and Five US in the UK), is centred on two brothers collaborating to solve criminal cases: Charlie Eppes (David Krumholtz), a young and brilliant professor of mathematics at the fictional California Institute of Science 'CalSci', and Don Eppes (Rob Morrow), his older brother and a special agent at the Los Angeles office of the FBI.

These texts are used as: they are mainstream products which each feature mathematicians as central to the plot; they were mentioned by survey respondents when asked to recall particular examples of mathematics or mathematicians in popular culture; and they are typical of the texts that we analysed. *A Beautiful Mind* and *Good Will Hunting*, in particular, were the most mentioned pieces of popular fiction (see Table 1 above). Although *Numb3rs* got less mentions, it attracts a wide and growing audience in a number of countries including the UK, and has inspired both the development of a mathematics education programme in the US based on the series (www.weallusematheveryday.com) and a huge number of verbal and visual fanfictions on youtube and other websites. Our analysis of the films *Enigma* (Apted, 2001), *Rain Man* (Levinson, 1988)and *Pi* (Aronofsky, 1998), the TV programmes *Horizon* on Andrew Wiles (Singh & Lynch, 1998) and *Beauty and theGeek* (http://en.wikipedia.org/wiki/Beauty_and_the_Geek_%28UK_TV_series%29) and the book *The Curious Incident of the Dog in the Night-time* (Haddon, 2003) support the patterns discussed here and we make occasional mention of these.

As in most pieces of popular culture featuring mathematicians, these three texts contain images of mathematicians which are overwhelmingly male, thus reproducing the traditional association between mathematics and masculinity (Mendick, 2006). These images also associate mathematics with Whiteness, middle-classness and heterosexuality. The only notable exception is Will Hunting, an Irish-American from a working-class background. Yet, *Good Will Hunting* is very much the story of his 'middle-classification', as, in becoming a mathematician, he is required to embrace the values of the middle-class and to leave his working-class neighbourhood, friends and job behind. John Nash's bisexuality, first family and divorce (Nasar, 2001) are disappeared from the film of *A Beautiful Mind* in order to construct a conventional heterosexual love story and Alan Turing, the gay real-life codebreaker of Bletchley Park, is replaced in *Enigma* with the fictional figure of Tom Jericho in order to enable, once again, the telling of a conventional heterosexual love story. However, it is worth noting that while the mathematicians are all White they are often also minority ethnic: Charlie Eppes is Jewish (as is the mathematician in *Pi*) and Will Hunting is Irish.

A recurrent feature in these fictional accounts of men mathematicians is that they are not just any mathematician: they are figures of 'genius'. *Numb3rs*, puts much emphasis on Charlie's precocious ability to solve complicated mathematics problems, on the fact that he was five years ahead of his age at school, entered Princeton at 13, and got his first journal article published at 14. *A Beautiful Mind* narrates the life of a mathematician of extraordinary ability who goes on to win a Nobel Prize. Despite his lack of formal education, *Good Will Hunting*'s main character promptly solves a problem which Professor Lambeau hoped to see only his best MIT students solve, and after weeks of work. When Fields Medallist Lambeau asks his students to tackle an even harder problem which took him and his team two years to resolve, Will settles it swiftly too. This role as genius often casts them as heroes, changing or even saving the world with their abilities. However, this extraordinary 'gift'

for mathematics comes at a price. In particular, they are positioned as Other and their mathematical abilities are closely associated with mental health issues, social awkwardness, autism and obsession.

John Nash in *A Beautiful Mind* presents symptoms of schizophrenia, paranoia, and some form of social anxiety disorder, as do the mathematicians in *Pi* and *Enigma*. There are also some suggestions of mental health issues in relation to Charlie Eppes and Will Hunting. Charlie reacts to events in a very emotional way with a suggested lack of control over his emotions, for example spending the last three months of his mother's life, while she is dying of cancer, working on a mathematical problem he knows to be unsolvable. With working-class Will Hunting, there is a scene when he loses control reacting with severe violence when he meets a man who abused him as a child. The element of physical violence in the way Will expresses his emotions contrasts with Charlie's more middle-class ways. This incident happens prior to Will entering the mathematical community, embarking on a course of therapy, and falling in love with a wealthy Harvard student, thus suggesting that the story of Will is also one of redemption through becoming middle-class. These mathematical men are constructed as fragile and so as in need of being protected, rather than as being protective, in sharp contrast with dominant masculinities (Williams *et al.*, 2007).

Mathematical men also lack social skills. In some cases there are direct links made with aspergers and autism, notably in *The Curious Incident of the Dog in the Night-time* and *Rainman*. However, more usually mathematical men are simply presented as 'geeky' or 'nerdy'; geeks (as epitomised in shows like *Beauty and the Geek*) are socially incompetent and usually expert in some field of science, technology or mathematics. In *A Beautiful Mind*, John Nash is described as a loner with few friends. Will Hunting may have a small fixed group of friends, yet he finds it difficult to manage the closeness that his relationship with girlfriend Skylar (Minnie Driver) involves. He initially denies his love for her and runs away when she asks him to follow her to Stanford where she has been accepted at Medical School. In *Numb3rs*, Charlie's best (and initially his only) friend is a theoretical physicist at Princeton, Professor Larry Fleinhardt (Peter MacNicoll), who has in common with Charlie an obsession for his work (in theoretical physics) and a certain level of awkwardness in social situations.

This supposed lack of social skills is indeed often explicitly related to their obsession for mathematics, as is the case both in *A Beautiful Mind* and *Numb3rs*, where the main characters see the world through the spectrum of mathematics. This obsession with mathematics interferes with relationships, resulting in mathematicians' private lives being often constructed as non-existent or in conflict with and secondary to their mathematical identities. A particularly dramatic example of this can be found in *Pi*, when mathematician Max is seen drilling into his own head, metaphorically excising the mathematical ability from his brain, before he can go on to a happier and more relational future. The ending of *Good Will Hunting* provides another example, when Will leaves behind high-level mathematics to 'go see about a girl'. In this

respect, an underlying message may be that a life dedicated to high-level mathematics is antithetical to a fulfilled private life and domestic happiness.

In these texts, mathematicians' lives are read as if everything in their life, personality, practices and beliefs is subjugated to their mathematical self and is leading to them becoming great mathematicians. This not only suggests that mathematics takes over their life, but also that it takes over their identity. Such accounts are also characteristic of biographies which, because of drawing officially on 'facts', can be very powerful in establishing ideas of truth and authenticity. Sylvia Nasar's (2001) biography of John Nash, or Andrew Hodges' (1983) of Alan Turing are typical in this respect as they read small details in the lives of these men as evidence of their mathematical genius. Having established the association of mathematics with masculinity and the key features of popular cultural representations of mathematical men, we go on, in the next section, to look at how the increasing number of images of mathematical women compare to these more traditional images.

3.2.2 Emerging representations of women doing mathematics

The majority of mathematicians in popular culture are male, however, there are also a growing number of popular representations of female mathematicians and other women doing mathematics and these are the focus of this section. For the UKRC funded research, the texts analysed for the earlier ESRC funded project were supplemented with additional texts featuring women doing mathematics. These were selected to allow a greater understanding of the patterns in these representations. The ones analysed for this section are listed below:

- *Proof* (Madden, 2006): a film telling of mathematician Catherine's (Gwyneth Paltrow) attempts to deal with the death of her father, Robert (Anthony Hopkins). Robert, who was also a mathematician, died after years of mental health problems throughout which Catherine was his carer. She attempts to deal with her own possible mental health problems and to get her work recognised as her own rather than her father's by young mathematician and love interest Hal (Jake Gyllenhall).
- *Numb3rs*: a TV series (see above) featuring mainly male mathematicians but also one less central female mathematician Amita Ramanujan (Navi Rawat) who begins as Charlie's doctoral student and then becomes his love interest.
- *The Da Vinci Code*: a global phenomenon as first a book (Brown, 2003) and then a film (Howard, 2006), in which academic, Robert Langdon (Tom Hanks), and cryptographer and descendant of Jesus and Mary Magdalene, Sophie Neveu (Audrey Tatou), battle and puzzle their way to the Holy Grail.
- *Digital Fortress* (Brown, 1998): a thriller novel in which an attractive and intelligent female cryptographer Susan Fletcher works to stop all the national security data kept by the US becoming accessible to the world via the web.
- *Countdown* (http://en.wikipedia.org/wiki/Countdown): a long running daily Channel 4 television game show consisting of numbers and

letters games. Engineering graduate Carol Vorderman features both in the hostess role and as the resident numbers expert or 'vital statistician' who is turned to for a solution to the numbers games when the contestants fail.

- *Mean Girls* (Waters, 2004): a film telling of Cady Heron's (Lindsay Lohan) entry into high school at age 16 after previously being home-schooled in Africa. Encouraged by her friends she enters the most powerful clique in 'girl world' and becomes absorbed into boys, fashion, popular culture and bitchiness. She pretends ignorance in her advanced calculus class in order to attract a boy in the group. Eventually she comes clean and, on instruction from her mathematics teacher, Ms Norbury (Tina Fey), she joins the mathletes team.
- *High School Musical* (Ortega, 2006): a musical in which Gabriella Montez, star scholastics team member, and Troy Bolton, basketball team captain, break free of their stereotypical roles by auditioning for their school musical. This move at first challenges and then gains support from their friends.
- *Matilda* (DeVito, 1996): a film (based on the Roald Dahl children's book of the same name) about Matilda (Mara Wilson) who is a child with remarkable mathematical and verbal abilities and magical powers. Matilda manages to use her powers to escape her unappreciative family, and to help her benevolent teacher and school mates.
- *Cube* (Natali, 1997): a cult science-fiction horror film in which seven characters are imprisoned inside a cube-like device consisting of inter-connecting rooms. Their escape involves a young school girl and an autistic man having to do 'astronomical' mathematics quickly in their heads in order to escape torture or death.

The women in these texts occupy a range of positions. However before looking in detail at these, it is important to note that in several of the examples, while women are present, their contributions are downgraded, they are positioned as subordinate to men and they or their contributions are rendered invisible in key ways. This is not a new phenomenon. An overview of biographical volumes on mathematicians (for example, Ashurst, 1982, Bell, 1986, Morgan, 1972, Turnbull, 1962) reveals their focus on 'men of mathematics', as E. T. Bell puts it in his book of the same name. The contributions of the likes of Emmy Noether, Sophie Germain, Ada Lovelace, Hypatia and the many contemporary female mathematicians are disappeared or downgraded (with the exception of those feminist-inspired books dealing 'specifically' with women mathematicians, such as: Henrion, 1997, Osen, 1994, Perl, 1978). The subordination of women mathematicians is multifaceted and materialises in the side-lining of women in the plot and in materials 'satellite' to those fictions and in the positioning of women as dependent on men as students, partners and daughters.

In *Numb3rs*, Amita is Charlie's doctoral student (although she switches supervisor and specialty at the end of season one in order to pursue the possibility of a romantic relationship with him). Further, as Alice Silverberg (2006) observes, only three characters in *Numb3rs* do not have a character profile on the official CBS website, including the two main women in the series

(Amita Ramanujan and Megan Reeves). In the same vein, the website never gets Amita's surname right, calling her variously Ramanjuan or Ramajuan. In *A Beautiful Mind*, Alicia Larde, although a Physics graduate, is a student of John Nash, and later his wife. In addition to this multiple subordinate positioning (daughter-student-wife or girlfriend), these women are frequently positioned as 'assistants' to more senior mathematicians. As student-wife (Alicia Larde/Nash) or student-girlfriend (Amita Ramanujan), they provide all forms of support. This is apparent in *A Beautiful Mind*, where Alicia Nash goes to great lengths to support her husband through schizophrenia, and in *Numb3rs* where Amita is seen providing emotional, intellectual and domestic support to Charlie, for example, helping him to solve FBI cases rather than solving them in her own right. This downgrading of women's abilities can also happen in the transition between one medium and another, as in the disappearing of Sophie Neveu's abilities in the move from page to screen; the puzzles and anagrams solved by Sophie Neveu in *The Da Vinci Code* book are either left out or ascribed to the workings of Robert Langdon's mind in the film.

These practices of disappearing the mathematical contributions of female characters and of subordinating them to male characters support the associations of mathematics with masculinity discussed above. However, in some of these texts women are the stars and it is these that are the focus of the rest of this section.

Like the texts in which men are at the centre, these representations generally support the associations of mathematics with Whiteness, middle-classness and heterosexuality. However, there is a little more 'difference' with the women than the men: Amita Ramanujan and *High School Musical*'s Gabriella Montez are from minority ethnic backgrounds, being Indian and Hispanic respectively, and Sophie Neveu, as French, occupies the 'White Other' category like several of the men discussed earlier.

However, unlike the figures of male mathematicians, these women are not generally figures of genius who have mental health problems, are socially incompetent and whose obsession for mathematics has colonised their entire personality. Only Catherine in *Proof* fits this figure. Although she may be described as pretty by common standards, she is not very groomed, appearing mostly with messy hair and wearing jeans and a T-shirt. She is defensive and neurotic in relationships with others and breaks social codes, for example, at her father's funeral she interrupts the orchestra to accuse people of having let her father down in the last years of his life and to detail the hallucinations and schizophrenic episodes that happened during that time. Mathematical skills are a characteristic that permeates all aspects of her identity; with Hal, her love interest and her father's ex-student, she discusses how to "prove" that her dress fits, while Robert is seen in her imagination telling her "you knew what a prime number was before you could read". Crucially she dropped out of her mathematics degree to care for her father. However the film does not simply reproduce the opposition between domesticity and mathematics, for Catherine found a way to continue doing

mathematics alongside her caring role, although she struggles to get her work taken seriously as her own after her father's death.

Of the other seven women, four are young. These characters need to be understood as part of a broader trend of proliferating 'smart girls' in contemporary popular culture (Inness, 2004, Paule, 2007), that also includes, for example, the general science-computing-mathematics-whiz Willow Rosenberg from *Buffy the Vampire Slayer* (Battis, 2003), the graduate physicist Fred Burkle from *Angel* (Greenwald & Thornley, 2007) and Lisa Simpson from *The Simpsons*, who dresses up as a boy in one episode in order to gain access to 'hard' mathematics (http://www.mathsci.appstate.edu/~sjg/simpsonsmath/). Their youth and student positioning can be read as a further example of women's subordination. They are not (yet) mathematicians and questions can be raised about whether they will be able to grow into them. Perhaps like tomboyism, mathematical ability in girls "is tolerated as long as the child remains prepubescent; as soon as puberty begins, however, the full force of gender conformity descends on the girl" (Halberstam, 1998, p.6). *Mean Girls* and *High School Musical* dramatise the struggle between femininity and mathematical ability and have happy resolutions. These texts are discussed further below.

Even within the adult representations there is an important pattern of 'generational' subordination, as these women are frequently the descendants of celebrated male mathematicians. A striking example of this is Catherine in *Proof* who is the daughter of a 'mathematical genius'. This idea of mathematics as a heritage from the father is central to the film, as Catherine's struggle with her father's inheritance - his mathematical skills and his, possibly related, insanity - is integral to the storyline. Similarly, Sophie Neveu, in *The Da Vinci Code*, 'inherits' her mathematical interests from her grandfather, Jacques Saunière, who brought her up:

> Sophie's passion and aptitude for cryptography were a product of her growing up with Jacques Saunière - a fanatic himself for codes, word games and puzzles. *How many Sundays did we spend doing the cryptograms and crosswords in the newspaper?*
>
> At the age of twelve, Sophie could finish the *Le Monde* crossword without any help, and her grandfather graduated her to crosswords in English, mathematical puzzles and substitution ciphers. Sophie devoured them all. Eventually she turned her passion into a profession by becoming a codebreaker for the Judicial Police. (Brown, 2003, p.113)

This patrilinear transmission of the mathematical 'gift' to gran/daughters has no equivalent when it comes to male mathematicians, suggesting they do not need to owe their mathematical skills to a forefather. Indeed, in the three texts subjected to in-depth analysis in the last section, none of the male central characters doing mathematics seem to have 'inherited' it. The same cannot be said of the one woman mathematician given some form of importance in these three texts, Amita Ramanujan, whose name precisely suggests some kind of descent from Srinivasa Ramanujan, the self-taught Indian mathematician.

Although Will Hunting is supervised by Professor Lambeau, there is no symmetry whatsoever as Will vehemently challenges Lambeau's authority (and finally breaks from him), and as the film clearly sends the message that, despite his lack of formal education, Will's mathematical abilities are superior to Lambeau's. In a striking contrast to the relationship between Charlie and Amita, Will is never positioned as an 'assistant' to Lambeau.

Unlike the male mathematicians, and with the notable exception of Catherine in *Proof*, women doing mathematics are socially skilled and comfortable. It is difficult to imagine a series of *Beauty and the Geek*, in which beautiful men teach geeky women how to be comfortable in social situations and how to interact with the 'opposite' sex. However, these women's mathematical abilities are presented as in tension with their social position: Matilda's mother tells her that "a girl does not get anywhere by acting intelligent", while joining mathletes is described repeatedly as "social suicide" in the High School based 'girl world' of *Mean Girls*. This film dramatises the tensions between mathematics and feminine hetero/sexuality as the central character Cady hides her mathematical capabilities to appeal to the best looking boy in her calculus class. It is her feigned ignorance that precedes their first kiss. This stands in stark contrast to the scenes in *Good Will Hunting*, *A Beautiful Mind*, *Numb3rs* and *Enigma* where the leading man's intellect and his fascination with mathematics are presented as attractive to, at least some, women.

There is much research documenting the tensions for girls between intelligence and femininity (Hey, 1997, Renold, 2001, Walkerdine, 1990). It is an open question whether these new representations will change this. It is encouraging that the tensions are being dramatised and that happy, albeit exclusively heterosexual, resolutions are imagined in both *Mean Girls* and *High School Musical*. One important reservation is the way that these women are all classically attractive and conventionally feminine. This applies equally to the adult women mathematicians. Carol Vorderman through the hostess role on *Countdown*, her diet, exercise products and a range of sexually provocative publicity material reminds us all that she is a body as well as a mind. And cryptographers Susan Fletcher and Sophie Neveu are seen more than once in Dan Brown's novels as the object of the male gaze – the latter being described when we first meet her through the eyes of a male detective as "an attractive young woman [who] always drew eyes [of male colleagues] away from the work" (p.78). So while it is helpful to show that hyper-femininity is compatible with mathematics, it would be useful to also have some representations that suggest that it is neither essential nor compulsory (Kitzinger *et al.*, 2007b). This is an issue to which we return in the next chapter where we look at how these images were read by participants.

We have focused so far on the points of difference between the popular culture representations of men and of women doing mathematics. There is one important point of similarity: the ways that their mathematical abilities are presented as in-built or 'natural' as opposed to something that is acquired. In the case of male mathematicians this happens through the associations between mathematical skills and mental health problems and the ways that their whole personality becomes subjugated to mathematics. For women, this

more often happens through suggested links between mathematical and other abilities. Matilda and Willow have magical powers while Sophie Neveu as a descendant of Jesus is very much special (Picker & Berry, 2000, found a link between figures of mathematicians and magicians for school students). Magic and madness are both ways of writing mathematics into and onto the body as a 'special' and 'natural' ability. In this way they persist in constructing the mathematician as something you are or are not 'naturally' and mathematical ability is not seen as something that is accessible to all. So while literacy is seen as an essential part of being fully human, "in contrast to this framing, arithmetic is not naturalized as genetically human, but as *genetically determined within humans*" (Damarin, 2000, p.76, original emphasis), hence the common stories of the mathematics gene. This, like all the discourses discussed in this section, is part of wider social stories about mathematics and mathematicians. However, as we explore further in the next section, it is gendered through the opposition between effort and ability. And, as we argue in the next chapter, it has particularly problematic consequences for women's relationships with the subject.

3.3 Popular mathematics and gender

In this section, we extend the previous analysis of the gendering of mathematical representations in popular culture. We do this by looking at the ways mathematics is gendered not just through the differences between the images of the men and women doing it but also through the discourses that construct the subject itself and the process of doing it.

Mathematics in popular culture is in many ways even more invisible than are mathematicians. Particular symbols do act to call up mathematics: numbers most obviously, but also blackboards, the letter *x* and formulas (best of all are blackboards covered in formulas involving many numbers and *x*'s). There are also instances of Fibonacci spirals, prime numbers, fractals and multiple dimensions which produce yet more examples of the same in circuits of self-reference. However, it is questionable how far one is supposed to or is even able to engage with the mathematics in these examples. Often this is treated fleetingly and the symbols are there to suggest the intelligence and value of particular characters (such as in the examples from *Dr Who* and *Dawson's Creek* mentioned in section 3.1) or, in advertising, of particular products (Evans & Tsatsaroni, 2007) or to conjure up associated emotional responses as in the *X files* movie strap-line: "Take your greatest fear and multiply it by x." Fear, panic and anxiety are common emotional responses to mathematics (Buxton, 1981, Evans, 2000) which are exploited by the Gremlins advertising campaign (http://www.dfes.gov.uk/get-on/gremlin.shtml) which is designed to draw people into adult numeracy classes.

There is a further complexity to looking at the mathematics in cultural texts which is, as pointed out in the previous section, that whether and how something is read as mathematical depends hugely on the resources that someone brings to the text. This can be seen by comparing the engaged way in which mathematician Sarah J. Greenwald interacts with the mathematics in the show *Futurama* in her website *Dr. Sarah's Futurama Math: Mathematics in the Year 3000* (http://www.mathsci.appstate.edu/~sjg/futurama/) with the

single reference to it from our survey respondents which perhaps unsurprisingly picked up on none of the programme's 'sophisticated' mathematics references but instead on the way that one of the characters "was doing his taxes". However, with all those provisos we still think that it is useful to analyse how mathematics is presented within popular cultural texts. This section should be read in conjunction with section 4.2 where we look at how our participants made sense of these representations.

Mathematics is often associated with, or even synonymous with, school work in these texts. The dominance of 'edutainment' texts was noted earlier. As well as BBC bitesize and mymaths the CGP revision guides were mentioned by survey respondents. All of these texts borrow styles and techniques from popular culture to deliver the school curriculum and, in particular, to provide support in preparing for high-stakes assessments such as GCSE examinations and End of Key Stage Tests. It is worth noting that the way these resources break up mathematics into bitesize pieces and present it as a series of meaningless techniques is unlikely to attract more girls to study the subject (Boaler, 1997, Burton, 1994). Turning away from teaching materials, examples such as *Mean Girls* and *High School Musical* are full of classrooms, chalk/whiteboards and formal lessons with all the paraphernalia of homework, tests and lots of sums. However, while mathematics is tied to school in these two films it does go outside the formal curriculum through mathletes and scholastics competitions. This idea of mathematics as competitive is supported more broadly, for example, in *A Beautiful Mind*, *Good Will Hunting*, *Numb3rs* and the *Horizon* documentary on Andrew Wiles where the practice of mathematics is associated with prizes and with internal competition between mathematicians. Interestingly, this competition is combined with the presentation of the figure of the lone male mathematician discussed earlier.

Mathematicians do not generally do a great deal of mathematics within the popular accounts of them. When they do it is usually presented as mystifying in a pace and manner which make it difficult to understand. Further, the process of doing mathematics is constructed as masculine. Claudia Henrion (1997) identifies a series of myths about doing mathematics that maintain the association with masculinity: one is that mathematicians work in complete isolation and a second is that mathematicians do their best work in their youth. These cultural texts support these myths about mathematics by presenting it as individual rather than collective, as the result of sudden revelation rather than ongoing effort and work, as something associated with youth and precocity and as close to madness and so being enacted by the kinds of male mathematical geniuses discussed earlier. There are frenzied scenes in which Will Hunting, and John Nash are seen scribbling uncontrollably on all available surfaces – including mirrors and windows; Charlie Eppes keeps a huge number of blackboards in the attic of the house that he shares with his father and is often seen making use of them for a bout of frenzied mathematical activity, covering one after the other, hanging them on walls and laying them on tables.

It is useful to look in more detail at the ways that men and women are positioned within this mathematical creativity. We do this by focusing on the

one scene in *A Beautiful Mind* where John Nash comes up with some new mathematics: the game theory result that eventually won him the Nobel Prize.

> The scene begins in a bar with upbeat music playing, the camera focuses on one tall blonde and then on a group of mathematics graduate students all staring at her. The exception is John Nash who is seated working, surrounded by papers and books piled haphazardly and with a pint of beer. His fellow students draw his attention to 'the blonde'. They look at the group of young women, who then look back at them. Nash looks uncomfortable. Martin makes a reference to Adam Smith's theory that "in competition, individual ambition serves the common good". 'The blonde' looks at Nash. His fellow students joke about Nash's lack of success with women. There is a change in Nash's posture and a change from upbeat jazzy music to light, repetitive piano music. He smiles, as if in reaction to 'the blonde', and says "Adam Smith needs revision". He then explains that if they all go for 'the blonde' they block each other and will upset the other women; however, if they cooperate and none of them go for 'the blonde' then they will all be successful. During this exposition the images get surreal and blur slightly, as if the characters are becoming puppets to illustrate Nash's conjectures. We get an aerial view where, in a geometrical pattern, we see all men going for 'the blonde', then all going for the other girls. The camera pans from a close-up of Nash to his mathematical 'visions'. This happens alongside changes of music and in Nash's tone of voice from nervous to authoritative and in the loss of his bodily twitches. This sequence ends with Nash saying "That's the only way we win, that's the only way we all get laid", the music goes back to jazzy and he turns to his fellow students to discuss his ideas on Adam Smith's theory. Their attention is clearly on the girls and one fellow student suggests that Nash is trying to find a way to get 'the blonde'. Hastily, Nash gathers his paper and leaves. He pauses by 'the blonde' and he says "thank you" and rushes out, she looks puzzled.

We can look at the ways in which women are positioned within this narrative. 'The blonde' acts as the silent muse for the creativity of the great male genius. This relates to the subordinate positioning of women doing mathematics within narratives analysed earlier. This positioning of women as handmaidens to and inspiration for creativity but not as creative agents in their own right is common in texts; it speaks to the ways in which our very notions of creative (mathematical) thought are gendered (Thomas, 1990, Walkerdine, 1990). We offer a second example in a passage of dialogue from the film *Pi* in which Max discusses his mathematical progress with his mentor Sol. Sol is using a story about Archimedes to encourage Max to slow down:

> Sol: The king asks Archimedes to determine if a present he has received is actually solid gold. Unsolved problem at the time. It

> tortures the great Greek mathematician for weeks. Insomnia haunts him and he twists and turns in his bed for nights on end. Finally, his equally exhausted wife, forced to share a bed with this genius, convinces him to take a bath, to relax. While he's entering the tub, Archimedes notices the bath water rise. Displacement - a way to determine volume, and thus a way to determine density. Weight over volume. And thus Archimedes solves the problem. He screams "Eureka!" and he is so overwhelmed, he runs dripping naked through the streets to the king's palace to report his discovery. Now, what is the moral of the story?
> Max: That a breakthrough will come.
> Sol: Wrong! The point of the story is the wife. You listen to your wife, she'll give you perspective. Meaning, you need a break. You have to take a bath or you'll get nowhere. There would be no order, only chaos. Go home, Max, and you take a bath.

Again the woman is positioned as the necessary support to male genius. Within the one documentary we looked at Andrew Wiles is depicted as someone who wrestled with the problem of Fermat's Last Theorem in his mind for years while his wife looked after his material interests. In contrast, Cady Heron in *Mean Girls* has to literally and metaphorically see past the object of her desire, Aaron Samuels, if she is to get her mathletes question right. He is a distraction from mathematics rather than an inspiration and support for it; he also gets both a name and a voice unlike 'the blonde' and 'the wife' in the examples above.

We can understand the gendering of mathematics itself, by looking further at the scene from *A Beautiful Mind*. This style of this scene shows that much work must be done to turn the everyday into mathematics, we have, to use Valerie Walkerdine's (1998, p.60) phrase "to leave the world behind the better to control it". This scene is followed by one of frenetic activity in which the seasons are shown changing from winter to spring outside Nash's room, with the implication that he is in there feverishly doing mathematics, oblivious to the world. This depicts mathematics as something that is outside of the everyday and that takes you out of the everyday. When we think about the way that many feminists, from Simone de Beauvoir (1988, originally published 1949) on, have shown how women are constructed as tied to the everyday, then we begin to see how writing the process of doing mathematics in this way further ties it to masculinity.

In fact, there is a recurrent juxtaposition in all these texts between the everyday usefulness of mathematics and the esoteric abstraction of mathematics. We are continually shown or told that mathematics is useful or even necessary for familiar everyday practices such as calculating profits (*Matilda*) and counting calories (*Mean Girls*) or for unfamiliar but important ones such as winning wars (*Enigma*, *Dambusters* and *A Beautiful Mind*), criminal activity (*Ocean's 11*) and crime-fighting (*Numb3rs*). The most blatant and pedagogic example is the voiceover during the credit sequence for *Numb3rs*, the season 1 version is:

We all use math every day:
To forecast weather;
To handle money.
We also use math to analyse crime:
Reveal patterns;
Predict behaviours.
Using numbers we can solve the biggest mysteries we know.

Alongside this we are continually presented with mathematics as esoteric in the scenes where Charlie Eppes does mathematics. Like in the scene from *A Beautiful Mind*, these take you out of the normal run of the drama, they are in black and white and often feature speeded up images that move around as if choreographed in time with the overwritten formulas and with Charlie's voiceover. This is mathematics as mystical, esoteric and inaccessible to all but the lone, usually male, genius. *The Da Vinci Code* and *Pi* use similar visual and sonic techniques in attempts to convey the process of doing mathematics, whilst leaving the mathematics obscure. This tension between mathematics as everyday and accessible and as esoteric and inaccessible is something that recurs in learners' talk about the subject and that we return to in the next chapter.

In this section we have looked at the ways that mathematics itself is gendered. While it can feel obvious to say that mathematics is aligned with masculinity because the majority of people who do it are men, we have been trying to make a somewhat different point here, that is, that mathematics itself is constructed as masculine. This works through tying mathematics to a binary framework, so that it is certain rather than uncertain, rational rather than emotional, and so on. We will come back to this in Chapter 4 and show how these binaries are used by learners to develop their relationships with mathematics.

However, there are several trends within popular mathematics that challenge this oppositional framework. Since it is this oppositional framework that ties mathematics to masculinity, discourses that offer alternatives to this - writing mathematics as beautiful, empathic, accessible - have the potential for changing how we think about mathematics. In particular, they offer possibilities for disrupting the links between mathematics and masculinity and so for more women to develop positive relationships with the subject and to choose to study it.

- There is a strong notion of mathematics as beautiful, often linked to pattern and nature; sound- and vision-scapes are used to show mathematics. In these ways there are discursive links between the process of doing mathematics and artistic, musical and other forms of creativity.
- There is a notion of mathematics as empathic when, in the *Mean Girls* mathlete competition sudden death, Cady has a revelation. Her internal monologue during this runs:

> Calling somebody else fat won't make you any skinnier. Calling someone stupid doesn't make you any smarter. And ruining Regina George's life definitely didn't make me any happier. All you can do in life is try to solve the problem in front of you.

- There are some serious attempts to present mathematics in a way that can be engaged with and that frame it as accessible to all. The 2006 Royal Institution Christmas Lectures were on mathematics. BBC Radio 4 broadcast a dedicated show (*More or Less*) about the subject and also features mathematics occasionally in a range of other shows, most notably *In Our Time*. There are also a number of recreational and popular mathematics books. Games shows, most obviously *Countdown* and *Deal or No Deal* but also *The Price is Right*, *Who Wants to be a Millionaire?* and *The Weakest Link*, present mathematics as part of 'general knowledge' and humanity, rather than being the province of only some. The success of sudokus and of Dr Kawashima's Brain Training also bring mathematics into people's lives as do computer games like Tetris and Runescape and people's interactions with mathematics in magazine quizzes and in sport.

This is not entirely unproblematic. Many newspapers have felt the need to reassure people that sudokus are not mathematics. Melvyn Bragg, the presenter of Radio 4's *In Our Time*, talks knowledgeably about all the topics covered in the show with the exception of those that are mathematical. In the two shows that we analysed for this research he described himself as "blinking in the face of this [mathematical] assault" and described the listeners as "hanging on here … by their fingertips, as I am doing, completely intrigued by this out of space thought that you mathematicians go in for". However, there is an openness and contestability about popular mathematics which makes it a different kind of object to school mathematics with a different set of possibilities. One can reasonably discuss whether and in what ways each of these cultural products is mathematical and this is evident in the ways that people read popular mathematics as we shall see in Chapter 4.

3.4 Conclusions

The main findings reported in this chapter are that:

- Mathematical representations are both invisible and ubiquitous in popular culture. And, as is explored in greater detail in Chapter 4, whether something is seen as mathematical depends upon context and upon the reader's understanding of and relationship with mathematics as well as on their other cultural resources.
- Popular culture texts strongly support the association of mathematics with masculinity, and also with Whiteness, middle-classness and heterosexuality. This gendering happens through: the dominant representations of mathematicians being men, the disappearing of women's mathematical contributions and the ways that women doing mathematics are subordinated in a range of ways including their youth and their positioning as appendages to 'greater' male mathematicians.

- Representations of male mathematicians combine features that ally them with heroic and powerful men and also features that present them as other, including: mental health problems, obsessiveness, fragility, and social incompetence. Their 'genius' is seen to mark them out from others and all other aspects of the self are subjugated to this.
- There is an emerging group of cultural texts featuring women mathematicians, several of which are part of a growing trend of young, attractive, 'smart girls'. While encouraging, there are questions to be raised about the low proportion of adult women mathematicians, the dramatised tensions between feminine heterosexuality and mathematics and the hyper-attractiveness of these characters.
- Both the representations of women and of men mathematicians, in different ways, present their mathematical abilities as 'natural' and as something people are born with rather than something that is acquired.
- Associated with the last point, representations of mathematics generally present this in ways that support ideas of its inaccessibility to the majority of the population.
- Popular representations of processes of doing mathematics show it as being about sudden and individual moments of inspiration that are accessible only to 'geniuses'. This creative process is aligned with masculinity.
- There are some trends in popular mathematics that offer alternatives to the clichés, notably mathematics incorporating aspects of: beauty, creativity, empathy and accessibility. In particular, much popular mathematics is contestable rather than set in stone.

Chapter 4: Gendered Influences of Representations of Mathematics and Mathematicians in Popular Culture

Tracing the influence of popular culture is difficult. As has been observed in other research, popular culture is just one among many influences on people's choices and relationships with subjects such as mathematics (Kitzinger *et al.*, 2007a). In fact, in the survey neither male nor female participants, neither GCSE students nor undergraduates, identified "images of maths and mathematicians" as a major influence. Within this, phase differences were greater than gender differences. Only 4% of GCSE students said that popular cultural representations had affected their decision on continuing with mathematics post-GCSE (cf. 'career plans'-70%, 'being good at it'-60%, 'enjoying it'-44%) The figure for undergraduates was 11% (cf. 'being good at it'-68%, 'enjoying it'-66%, 'career plans'-39%). However, they are simultaneously aware of a generalised presence of mathematics within popular culture (while often, as noted in Chapter 3, struggling to come up with specific examples): for example, asked where they have heard about mathematics in popular culture, 88%, of GCSE students mentioned the internet, 82% TV and 74% puzzles; 96% of undergraduates mentioned books, 89% the internet, and 82% puzzles.

This chapter focuses on unpicking the gendered influences of popular representations of mathematics and mathematicians. We do this by looking first at participants' ideas about mathematicians and then at their ideas about mathematics. It is clear that people have strong images of both mathematicians and mathematics that these images draw on the constellations of meanings circulating within popular culture that were identified in Chapter 3, and that these images are one of the ways in which gender inequalities are reproduced.

4.1 Gender and learners' ideas about mathematicians

This section discusses the images our participants had of mathematicians and the ways that these are gendered and connects these to the patterns identified in popular representations in Chapter 3. The following data from GCSE and university students are drawn on: the focus group responses to the invitation to imagine a mathematician (including imagining their appearance, lifestyle, work and family life) and to discuss a short extract from the film *Good Will Hunting*, and the individual interview responses to the question of who can do mathematics and to the request that they place a series of six images of 'people and mathematics' in order of their likeability.

In general, participants' default images of mathematicians closely match the dominant clichés of mathematicians in popular culture identified in Chapter 3. These imagined mathematicians were overwhelmingly White, heterosexual, middle-class, old and male, as Bernice, a female sociology undergraduate at James' Park, put it: "Old guy, grey hair, glasses, Einstein." There was a strong association between doing or being good at mathematics, masculinity, and higher forms of intelligence, as well as between higher forms of intelligence and middle- and upper-classness. We begin by unpicking these associations.

The links from mathematicians to masculinity were often implicit, for example, being established through mentions of Albert Einstein and/or Stephen Hawking, facial hair and clothing, as in this extract:

> Researcher: What are they wearing these mathematicians?
> Jesus: Suits.
> Chantz: Shirt and tie.
> Ashley: Gotta be a shirt hasn't it? [GCSE students, St Joan's, male/female/male]

Men were sometimes seen as doing better at mathematics, and women as doing better at English and humanities, and these differences being seen as 'natural'. In one focus group of mathematics undergraduates, participants divided mathematics specialisms into "female" ones and "male" ones. The divisions between masculine and feminine subjects shifted between and within groups but what remained fixed was the holding of these as oppositional categories and that those areas designated as masculine were constructed as more intellectual than those designated as feminine. These ways that mathematics is understood through gendered oppositions are discussed in more detail in the next section.

Social class associations were often made by drawing on categories which negate the political dimensions of class, for example, when students refer to mathematicians wearing a suit or tie as in the extract above, being wealthy or not swearing, or when they talk about 'posh' people or 'chavs'.

> Researcher: What kind of family like they'd have?
> JD: Posh.
> Researcher: Posh, OK.
> Sarah: Probably quite wealthy, yeah.
> …
> Researcher: Why's that? Is that because,
> Sarah: Because they might be a lot higher than say a maths teacher or like the highest possible sort of thing. [GCSE students, Shelley, male/female]

In this and other cases, students operate a hierarchy on the scale of 'poshness' and mathematics, between their mathematics teacher and mathematicians, the latter being seen as posher and with higher forms of intelligence (and 'geekiness'); this is part of a construction of mathematicians as an elite, both in relation to intellectual and economic capital. In the schools containing students from working-class backgrounds, this led to oppositions between 'us' and 'them'.

> Maya: Yeah, I think they're [mathematicians] quite middle-class. It depends actually, in the, not in this school.
> Candi: Because I reckon, you know, to kind of gain that, very kind of level, that level of intelligence you'd have to go to university. I imagine it coming quite easily to them being brought up in a kind of good family. [GCSE students, Shelley, female]

The default White image of a mathematician sits alongside the inscription of Indian and Chinese pupils as naturally and remarkably able. In their research

on British Chinese young people, Louise Archer and Becky Francis (2007, p.52) have identified the associations of natural cleverness with Asian people as a "negative positive" that reinforces their construction as Other (Said, 1995)

> In particular, the stereotype was felt to homogenise or distort young people's academic experiences, misrepresent their efforts and achievements and created a pressure of expectation that was experienced as oppressive. Moreover the notion of cleverness was also pathologised and formed the flip side to a more overtly negative discourse of 'Chinese geeks'.

Mathematicians are overwhelmingly seen as being "nerdy" or "geeky", even in many cases by mathematics undergraduates (who sometimes attempted to redefine those terms in a positive light), in opposition to being cool. This is strongly embodied. When asked to imagine a mathematician, most participants had very precise ideas of what mathematicians look like. In one of the Shelley school focus groups this was reflected in a discussion about differences in hair length between mathematicians and scientists: the former having short hair, the latter long hair. This discussion also took in mathematicians' "scrawny" bodies (Maya, female) and their "glasses" (Maria, female). In this case, as in the others, their descriptions were implicitly of male not female bodies. This embodiment is so strong that several participants believe that you can say whether somebody is a mathematician or not, just from how they look. In one case, mathematics was literally written on the body, when a sociology undergraduate described how her friend the "maths geek" had tattooed π on his wrist.

Students also had a very precise idea of mathematicians' personalities, and saw them as nervous, hyperactive and socially awkward. This is linked to the way that many participants associated mathematicians with mental health issues.

> Luigi: In *A Beautiful Mind*, Russell Crowe, he was like amazing at maths, solving numbers and stuff. He could just like see numbers and he could solve, like, really complex things, but then he was like schizophrenic.
>
> …
>
> Bob: I am not sure if it is a disease, it's called Asperger's Syndrome most people that do have Asperger's syndrome are actually amazing at maths but they have like side effects like schizophrenia and things like that that stop them going out. [GCSE students, Shelley, male]

In the interview discussions about the selected images of 'people and mathematics', a photograph of Einstein and a still of Russell Crowe as the mathematician John Nash from the film *A Beautiful Mind* were often met with comments about their "weirdness" or eccentricity. For Einstein this was epitomised by his appearance: "crazy hair" and the "mad" look in his eye, and for John Nash, by his battle with schizophrenia. Both pictures attracted discussion about the boundary between genius and madness. For example Chantz (GCSE student, St Joan's, female) mused about John Nash, "is he crazy or is he just clever?" This raises identity issues. Those participants not

choosing mathematics tended to position these attributes negatively as something with which they would not identify. Women and girls presented more negative perceptions of this - as “disturbed” and “nuts” (Saba, humanities undergraduate, James’ Park, female), and as “weird” and “mental” (Jeff, humanities undergraduate, Herschel, female). However, those choosing mathematics (at A-level or degree) were more likely to frame this positively as “skill”, “commitment” or “devotion” and less likely to be frightened by connotations of mental illness. Thus, some mathematics undergraduates, more male than female, gave positive value to ‘geek’ status; however, several went to considerable lengths in the interviews and focus groups to claim ‘normality.

Some participants think mathematicians can have ‘normal’ lives, some not. However, the fact that they need to state this suggests that it is far from being obvious. Many believe that mathematicians’ lifestyle is dominated by mathematics, as they are obsessed with it. In one Franklin school focus group, participants imagined mathematicians as “working endlessly at a desk trying to work out a formula or something” (Leslie, male), as spending “their spare time … doing extra maths questions” (Louise, female) and as “dedicated to what they do” (Bobby, male). Thus, mathematicians are seen as leading lonely lives. Their relationships are permeated by mathematics and they only relate to people who share their interests. Those participants who think that mathematicians can have ‘normal’ lives and relationships generally see this as possible only for ‘normal’ mathematicians or mathematics teachers as opposed to ‘real’ mathematicians or geniuses. Mathematicians were overwhelmingly constructed as geniuses. This figure of the mathematical genius was constructed in opposition to those using mathematics. In this way, links were made between the type of mathematics done and the type of mathematician one was. We explore these further in the next section where we discuss participants’ views of mathematics.

All of this constructed mathematicians as belonging to dominant groups in terms of gender, class, ‘race’ and sexuality, but also as something other. In this way the views reproduce the patterns in the dominant popular culture representations of male mathematicians identified and examined in Chapter 3. Thus, they support the associations of mathematics with masculinity. In particular, they implicitly support the idea that mathematics is something you either can or cannot do – ‘naturally’.

> The people that you know sat in their rooms and thought about things that no one would ever even’ve, like, how did even someone even start to think about Pythagoras’s theorem and stuff, what on earth? How? It doesn’t make sense. So you just think of them as something, I don’t know, elite, you know, different from everyone else. [Annie, GCSE student, Franklin, female]

This idea of ‘natural’ ability at mathematics was also discussed explicitly by both male and female participants across all groups: GCSE students, mathematics undergraduates and humanities and social sciences university students. This idea circulated in a range of ways, for example, through

freakish stories, such as of Nelle's (GCSE student, Shelley, female) uncle who "like proved Pythagoras' Theorem when he was 10", through 'commonsense' statements, such as Ashley's (GCSE student, St Joan's, male) that "everybody has their talents", and through tales of students who get by without working hard at mathematics, as when Margaret (GCSE student, St Joan's, male) said, "there are still some people that misbehave but they've got the image that they can coast through all the work". They also clearly circulated through popular cultural representations as people mentioned examples of documentaries on child geniuses and asserted that someone such as Will Hunting, while rare, could exist. While all participants felt that most people, through effort and/or good teaching could improve at mathematics, this was combined with the idea that your 'natural' ability set limits on how far you could improve and that this was needed to be a "real" mathematician. The next extract illustrates the ways that people held together the tensions between the role of effort and teaching on the one hand and 'natural' ability on the other:

> But if you just teach them … then they learn maths but it doesn't mean that, you can't produce mathematicians. You know you have to born as a mathematician, real. [Alice, mathematics undergraduate, Gillespie, female]

While these ideas about 'natural' ability affect both male and female learners of mathematics, our research suggests that they have greater impact on girls and women. One of the most striking gender differences in this research was the gendering of mathematical ability. The question 'how good are you at maths?' showed marked differences between males and females, with male GCSE students over three times as likely to self-identify as 'very good' at maths (33 people or 11% of males; 7 people or 3% of females) and slightly more likely to say they are good at maths (39% compared with 35%) ($p=0.002$). This relationship was also classed though the differences are not statistically significant, partly due to small sample sizes; 27 people or 8% of middle- and intermediate-class students, and 4 people or 4% of working-class students self-identify as 'very good' at maths. This reproduces earlier research on gender and mathematics ability (Mendick, 2007a) and sits alongside statistics showing little difference between girls' and boys' attainment at mathematics (Boaler & Sengupta-Irving, 2006).

When we looked at how they had found out whether they were good or bad at mathematics, the answers of both male and female participants were very similar. They were overwhelmingly dominated by external judgements, with only about one in five relying on their own sense of self. Predominant among these external factors were systems of assessment and selection, including End of Key Stage tests, GCSE examinations, ongoing class tests and 'ability' grouping. Secondary schooling, and especially Key Stage 4 leading up to GCSEs, was the main period identified by both the undergraduates and the GCSE students when they found out whether they were good or bad at mathematics.

Participants showed a critical awareness that the images they held of mathematicians were clichés and often both used them and distanced

themselves from them. For example John (GCSE student, Franklin, male) said a mathematician is: “a very sort of stereotypical geek type of person, but obviously they aren’t all like that.” However, they were unable to produce alternative ideas about mathematicians because of the lack of these available within their experiences of school mathematics and popular culture. As Wilbert (GCSE student, St Joan’s, male) put it: “If you have always seen it on the telly, you haven’t seen anything else of what that person or what that thing is then you’re going to think that when you think of it.” In particular, many noticed the ways that the gender (and ethnicity) of popular mathematicians did not fit with their own experiences:

> Annie: If you look in films and TV series like *Saved by the Bell* and stuff you don’t see geeky girls.
> Phoebe: That is true but there is very many, there’s quite a lot of geeky girls. But they, in lessons they just do their work, they don’t speak to, they don’t socialise. [GCSE students, Franklin, female]

However, this critical awareness did not extend to the ways that they read images, as can be seen from the analysis of participants’ responses to specific images of people and mathematics in the individual interviews (see section 2.4 for a list of pictures used). Turning to the two unknown images of women used in the interviews, participants found it easier to imagine that a woman dressed in a lab coat and posed formally on the cover of *Time* magazine was good at mathematics than a young informally dressed and posed actress Danica McKellar (http://www.danicamckellar.com/) depicted surrounded by mathematical symbols (belying the reality that the ‘cover girl’ was most likely a model while McKellar has a mathematics degree). This struggle was particularly apparent among the GCSE students. Leslie (Franklin, male) said of Danica: “you don't really imagine mathematicians to be like, I don't know, casually dressed”. Candi (Shelley, female) both allying herself and distancing herself from the cliché said, “as much as I kind of hate to admit it myself, she just doesn’t seem, doesn’t seem like the type I’d imagine would be good at maths.” Interestingly, it seems that it is partly her identification with entertainment that precludes Danica from being read as mathematical by these young people. Typically, Elizabeth (St Joan’s, female) said she looks unintelligent because she “looks more like a popstar” and Pisces (Shelley, male), on being told a little about her, said, “maybe I’m being stereotypical, but I don’t consider actors as that clever.” Similar views were expressed by most of the mathematics undergraduates. Only the female social sciences and humanities students expressed different views with all but one of them being positive about Danica despite, like the other participants, not knowing who she is. Grace (Gillespie) and Donna (Gillespie) described her as “confident” and Mansa (Gillespie) as a “very intelligent” and “nice young lady”. Mansa, Sam, Louise, Ellie and Maria all liked the way she breaks the stereotype of mathematicians as male and shows that you can be clever *and* attractive, as Ellie (Meitner) put it: “it’s saying you can be attractive and intelligent and study maths and it’s not a bad thing.” Although Louise (Herschel) seems surprised that Danica takes care of her appearance and looks fashionable as well as being into mathematics, she is - unlike the mathematics undergraduates and the GCSE students - able to read her in this

way. All of these social sciences and humanities students have taken courses on gender as part of their degrees and many have a commitment to feminism. It is likely that it is these resources that allow them to read Danica's image positively and as mathematical.

Participants were more comfortable with identifying intelligence in women who they knew from the media. This was shown in their responses to a picture of cartoon character Lisa Simpson discussing mathematical pi with her pie-minded father Homer and to a picture of Carol Vorderman posed in front of a blackboard covered with formulae. Lisa Simpson was met by a largely positive identification. Most found the show amusing and entertaining and liked Lisa's character, seeing her as a "bright", "clever", "intelligent" young woman (which they set in contrast to her father), though Dave RG (mathematics undergraduate, Herschel, male) was critical that her character is a stereotypical mathematics "geek".

Views on Carol Vorderman were more mixed as some GCSE and university students objected to the image as an attempt to 'sex up' mathematics. For some this was a rejection of the portrayal of women as sexual objects while for others it was about the incompatibility of sexuality and mathematics, such as when Sam (social sciences undergraduate, James' Park, female) said: "that's not what maths is about, it's got nothing to do with that." However some of the female social sciences and humanities students praised the way that she challenged the stereotypes: "an attractive young woman who is highly intelligent as well … Who says you can't do maths in stockings?" (Louise, Herschel), and "why not use your sexuality when you can?" (Donna, Gillespie). The tensions between having images of women that cut across oppositions between mind and body and images which do not over-sexualise women has been noted in other research on media representations of women scientists: "our research suggests that what people wear can be an important site through which gender politics are enacted" (Haran *et al.*, 2007, p.32). All of this suggests that we need a diversity of representations, a point we to which we return in our recommendations in Chapter 5.

Thus, while we can see the effects of the dominant male representations of mathematicians discussed in Chapter 3 it is more difficult to identify any influence of the emerging female representations of women doing mathematics. These representations do not seem to allow many to generalise the idea that you can be intelligent *and* female, and in particular intelligent, female *and* attractive, beyond the examples they know. This can be related to research showing that the oppositions between rationality and femininity, discussed in Chapter 3, are very entrenched (Lloyd, 1993, Oakley, 2000, Walkerdine, 1990).

This has effects also on who can identify with mathematicians and we can see this by looking at the 40-strong and 83% male group of GCSE students who identified themselves as 'very good' at mathematics in the survey. Members of this group generally have a different relationship to mathematics within popular culture, being significantly more likely to play tetris and chess and do sudokus and cryptic crosswords. This relationship also applies to those who

are most likely to continue with mathematics post-GCSE. For this group, it seems that popular culture provides significant resources for developing identifications with the subject. This is supported by evidence from the interviews and focus groups that some images come to take on particular significance for males choosing mathematics with characters representing something they want to be/come. For example, Dave (mathematics undergraduate, Charlton-Moore, male) spoke at length about *Jurassic Park's* Ian Malcolm as a "New Age mathematician" and "the first cool mathematician, ever," and Nathan (GCSE student, St Joan's, male) talks about remembering a mathematician featured years ago in the cartoon series *Recess* who was "seen as really cool … and like he went to work for NASA." Only one woman expressed a similar identification but she did not go on to study for a degree in mathematics. Grace (social sciences undergraduate, Gillespie, female) spoke passionately about cryptographer Susan Fletcher in *Digital Fortress*:

> She was the woman in a man's world. She did so well … I actually started thinking about it that way. If she is that good, you know, then [Laughs], I can do it too. Yes, I did, because I like that character.

The lack of women with whom to identify is an issue given that we found that particular people can serve to counter dominant clichés about mathematicians as inevitably male, as in Grace's reading of Susan Fletcher's character. These particular people may be 'real' teachers, peers or family members or 'fictional' characters in media texts, a finding that resonates with Joshua Meyrowitz's (1985:119) argument that for fictional characters, "although the relationship is mediated, it psychologically resembles face-to-face interaction." In many ways, one could argue, the relationship can be more powerful because the possibilities for fantasy are greater.

4.2 Gender and learners' ideas about mathematics

This section discusses the images our participants had of mathematics and the ways that these are gendered and connects these to the patterns identified in popular representations in Chapter 3. The following data are drawn on: the focus group discussions on the question of what is mathematics and on sudokus and a short extract from the TV game show *Deal or No Deal*, and the individual interview responses to the request to imagine a world where mathematicians appear on TV regularly and that they place a series of six images of mathematical artefacts in order of their maths-ness.

There were no clear differences between the ways that the male and female participants in our research understood mathematics. However, what we want to argue is that both the men and women in our study held views of mathematics that aligned it with masculinity and so are more likely to deter women than men from continuing with mathematics within education and employment (although they are actually quite likely to put off the majority of people - both male and female). We develop this argument below by looking at a series of gendered oppositions through which people construct mathematics:

Numbers / Letters and Words
Mathematics / English and Humanities

Rule-based / Creative
Technical / Emotional
Education / Entertainment
Esoteric / Everyday
Real mathematics / Calculation
Masculine / Feminine

In this way, we build on earlier work in a range of countries (Palmer, 2007, Pechtelidis, 2007, Vermeulen, forthcoming, Walkerdine, 1998, Walshaw, 2001). In a detailed study of the gendering of the choice to study mathematics at A-level, by one of the authors of this report, it was pointed out that:

> Although binaries move and shift, their overall structure does not. The important things, from a gender point of view, are that:
>
> - The two terms are seen as mutually exclusive.
> - In each pair the two terms are unequally valued.
> - The term with the higher value is associated with masculinity. (Mendick, 2006, p.21)

The dominant understanding of mathematics expressed in the focus groups and interviews was of **numbers** or doing something with them. This clichéd image of mathematics was reproduced easily by all of the focus groups and is tied to both school mathematics and popular mathematics. Participant talk is complex and frequently shows a critical awareness of the problems with seeing mathematics as numbers. As Laura (social sciences undergraduate, James' Park, female) said about sudokus: "when people see it, they see it's numbers, they're like, 'Because it's numbers.' And you associate maths with numbers." As part of this there was a strong opposition between numbers on the one hand and **letters and words** on the other; for example, no focus groups, where this came up, could read cryptic crosswords as mathematical. Saba (social sciences undergraduate, James' Park, female) said that she would do sudokus if they used letters instead of numbers, while still feeling that this would not stop it being mathematical:

> If it worked the same way, if you had to do, you know, I would do that. … It would be maths, but I'd choose to ignore the fact that it's maths and just look at the letters. … As soon as I see numbers, I don't see anything.

Often people made sense of **mathematics** by comparing and contrasting it with other subjects. Commonly it was seen as similar to science subjects and different from **English and humanities** subjects. These oppositional constructions position mathematics against subjects which are less **rule-based** and hierarchical, and which involve words and **creativity**. The most striking binary inscriptions come from social sciences and humanities undergraduates who posited oppositions in which their own subjects, and their own selves, are set:

> I felt like my brain didn't really work in that way … I mean I felt like I am a bit more sort of waffly and a bit more sort of floaty and artsy. [Mary, social sciences undergraduate, Meitner, female]

> I think that there is kind of like the intelligence where you would make up an argument and you rationalise like different arguments. And then there is kind of intelligence where you would solve a problem and there is a distinct answer. [Ellie, social sciences undergraduate, Meitner, female]
> I know it's a bit over simplistic, but like if people do have areas of their brain that they are more sort of successful with. Just like looking between like sociology and maths like we are better at sort of constructing an argument and that sort of thing, better at theorising. Or maybe just because we have to be but maybe you could argue that we are more used to engaging our emotions and things like that. And so I suppose you could say with some people if their main focus in their brain is on the like mathematical technical side then that might be at the cost of the like emotional. [Sky, social sciences undergraduate, Meitner, female]

Many participants, like these three, adhered to the idea that there is something called the 'mathematical mind' and that this is more **technical** and less **emotional**. And, as discussed above there was a recurrent tension between being good at mathematics because of 'natural' ability and becoming good at mathematics through effort, and a recurrent opposition between being a hard worker and being 'naturally' able. Since we only interviewed one male social sciences or humanities undergraduate, it is impossible to say whether this talk is related to these participants' gender, to their area of study or to both. However, several of the male GCSE school students invoked such oppositions, albeit less starkly than did the university students. It was the mathematics undergraduates' talk that was most likely to cut across these binary inscriptions.

There was a related discourse that associated mathematics with **education** and opposed this to **entertainment**. This was apparent in the last section where we discussed participants' views of Danica McKellar, rejecting the possibility that she was mathematical in part because of her associations with the entertainment business. When asked to imagine a world where mathematicians appear on TV regularly, a number of participants resisted this idea. Most commonly they did this by arguing it was impossible or unimaginable or by saying that they and/or others would not watch TV there. Some of those who were able to, at least, partially imagine this world resisted it in other ways. In particular eight participants (out of 49) saw it as a world overtaken by education. For example, one GCSE student Dominic (Shelley, male) imagined, "that's a world where like everybody's learning constantly … there're like little babies, progressing academically, they already know how to spell." When asked if he would like to live in this world, he said:

> Out of all the people that would like to live in that world, I would probably be the one to rebel against it. Because I, I, I like, I like maths and I like learning but, um, I like my playtime as well. Yeah. I'm really a playful person. I hate giving up my time to study. … I want TV to, just to entertain me. That's not learning, coz that's the one place, that's the one world you want to live in

> where there's no maths or English. There's just, fantasy, opera and drama, and supernatural, flying and yeah.

Here television is associated with entertainment, play and fantasy and is opposed to the realm of education, learning and mathematics. Such reactions foreclose the possibility that entertainment and education can exist together, transforming each other. Instead one side has to consume or colonise the other. Similarly, most participants were unable to imagine people being concerned both with their intellectual development *and* with their physical appearance, their mind and their body.

In nearly all the focus groups there was a distinction set up between basic, **everyday** mathematics on the one hand and complex or **esoteric** mathematics on the other. This opposition is tied to notions of utility with much of mathematics being classified as useless; it is also tied to ab/normality through various processes of othering including the naming of esoteric mathematics as "gay" (GCSE student, Franklin, male). There is much anger among GCSE students and social sciences and humanities university students at having to study useless, esoteric mathematics:

> I think a lot of it personally is a waste of time and a lot of it is, there's no way that regardless of what job or what career you choose to go into after school there's no way that you're going to use half the stuff we learn in school. … I know for a fact that my dad works with cars and my mum's a hairdresser and they've never used any of that. My mum's never come in and said, 'oh I had to do some algebra today.' [Ashley, GCSE student, St Joan's, male]

Although a minority counter this position by arguing that mathematics is everywhere, these divisions of everyday vs. esoteric mathematics were very strong. They are gendered and classed divisions and relate to the academic vs. vocational divide that underpins much of the UK curriculum (Dowling, 1998). As well as being supported by discourses in popular mathematics, they are reproduced in some of the divisions within school mathematics such as that of mathematics vs. numeracy and the planned division of GCSE1 vs. GCSE2 (see Vermeulen's (forthcoming) work on the gendered divisions between core mathematics and mathematical literacy in the new South African curriculum).

These two types of mathematics can be related to two types of mathematician. As one GCSE student Firefly said:

> There's different types of maths, there's like genius maths, which is working out these equations and winning big prizes. … Then there's loads of different other sorts of maths like the sort of maths that apply to engineering or apply to accountancy or anything. … So I think there's, like there's maths maths, like working out complex equations and stuff, is more a thing that you see as someone who just sits at home with a desk, staying up till two o'clock working out this equation. Whereas applied

> maths you just think someone, just like a more normal person in a job, even though the maths might be similar. [Franklin, male]

So we can see how the two gendered oppositions - between 'normal' mathematicians and 'geniuses' (discussed earlier) and between everyday and esoteric mathematics - are connected through the idea that 'normal' people engage with everyday forms of mathematics, namely calculation, while other and othered mathematicians engage with its esoteric forms.

A fascinating example of this was the mathematics undergraduates' responses to an image of Carol Vorderman within the interviews. Ten out of eleven reacted against her. Four of them target her mathematical abilities. Sophie (Herschel, female), Joanna (Herschel, female), Bridget (Wollstonecraft, female) and Mr 37 (Gillespie, male) did not like the fact that she represents mathematics in the popular media arguing that just because she is good at 'mental arithmetic' does not mean that she is good at mathematics. Bridget pointed out that she only got a third class degree. Mr 37 said:

> I don't know how much of a good mathematician Carol Vorderman is, I just know she's a good, she's good at arithmetic. … I think a lot of mathematicians I know state plainly that they actually can't do arithmetic. [laughter] … it's not necessarily about sort of deep mathematical ideas.

These reactions can be understood as drawing on gendered oppositions between activities of **calculation** and of **real mathematics**, between calculating and reasoning, between surface and depth:

> To be thought of as calculating is not complementary. Calculating is often what the other is: women; scheming; wheeling, and dealing bargainers. The refined mind reasons, but does not calculate. Indeed, witness the oft-told joke that mathematicians cannot add up. (Walkerdine, 1997, p.57)

These oppositions and their projection onto people are important for maintaining the elite position of mathematician (Mendick, 2005).

As we said, our research and that of others suggests that all students, but particularly women and girls are put off studying the subject by these binary constructions. These are constructions which exclude emotion, creativity, fantasy and so on from mathematics and present it as rigid, certain and absolute. These are best countered not by positing a "sense of the importance of feminine attributes against masculine reason precisely because we think that gender differences are fictions with no firm basis in reality" (Walkerdine, 1998, p.164) but by alternatives that cut across these oppositions. Thus, we end by looking briefly at such alternatives where they occurred.

These alternatives most often mobilise ideas of mathematics as logic and ways of thinking. Less often they mobilise ideas of mathematics as problem solving and as about pattern, beauty and creativity and in one case as empathic, as exemplified in these extracts:

> It's about modelling real world situations in a way that people can use, [John: problem-solving] yeah, solving problems and stuff. Most of it boils down to like theories or you know, patterns, that sort of thing and you can use them to explain things in the world. [Dave, mathematics undergraduates, Charlton-Moore, male]

> When you understand mathematics, the why and the how, then you can understand life. … Your idea is right but I have to understand I have to know why you are telling that, why you are doing this, why you are doing this. If you are explaining very well I won't be angry. That is why people have told me that I am so quiet, that is right, because I am always thinking. [Thierry, mathematics undergraduate, Gillespie, male]

> You know everything that it's about just by looking at it [a picture of a Romanescu cauliflower]. … It's maths in the world we live in and it's, I don't know, it looks, maths really it's about perfection and you can't, it's either the right or wrong answer. And with that it's like, it's just so right, it's just perfect, the symmetry and the way it fits together. It's more natural as well, as opposed to just being put down. [Pisces, GCSE student, Shelley, male]

Participants draw on a range of resources to support these 'alternatives'

- Mathematics GCSE coursework - in one GCSE and one mathematics undergraduate group.
- Work in other subjects - such as studying Fibonacci in art.
- Things people have said - 'someone told me maths is …' including teachers, parents and friends.
- Popular culture - particularly sudoku, gambling and sport.
- University mathematics - particularly the emphasis on proof.

The discussions on what is mathematics within the focus groups were often animated and involved a number of discursive shifts. Focus group and interview talk support the conclusion in Chapter 3 that popular mathematics is more open than school mathematics, there is more room for discussion and so more spaces for people to shift their ideas about what mathematics is and to find a way of relating to it. Part of this relates to the way that emotion is visible within popular mathematics and less visible but very present in school mathematics - from pleasure to anxiety to anger (Bibby, 2001, Evans, 2000, Walls, 2003). For example, interaction with sudokus (http://en.wikipedia.org/wiki/Sudoku) provoked one GCSE student to reflect:

> Before I came to like this meeting I just thought that maths was a like thing that has divide, times and plus and minus and all that stuff. … The question 'what is maths' I don't think it will ever be answered because it just goes on and there are so many different things and I think you have to spend like at least I don't know, more than a life time thinking about what maths is. [Dominic, GCSE student, Shelley, male]

This fluidity of ideas about the nature of mathematics, together with an openness and enthusiasm for discussing this were surprising.

This research suggests that popular culture can be an important resource for opening out ideas of mathematics. Returning to the ubiquity and invisibility of the mathematical in popular culture noted in Chapter 3, this can be understood as an instance of what Ole Skovsmose (1994:42) calls the formatting power of mathematics. This names the way:

> That mathematics produces new inventions in reality, not only in the sense that new insights may change interpretations, but also in the sense that mathematics colonises part of reality and reorders it.

The formatting power of mathematics gives us the paradox of relevance that "on the one hand, mathematics has a pervasive social influence and, on the other hand, students … are unable to recognise this relevance" (1994:82) and so supports the everyday vs. esoteric opposition discussed above. Skovsmose argues that we need to teach mathematical archaeologies that make mathematics visible through the process of "uncovering the mathematical roots of an activity" (1994:96) and highlighting the role of mathematics in structuring our understanding of the world. Our research shows that archaeologies of popular mathematics would be an important and accessible approach to these (Greenwald & Nestler, 2004a, b).

Thus there are pedagogic possibilities for using popular culture texts to make available more positive relationships with mathematics to a wider number of people, and in particular, to more women. They create spaces for learners' own views and so give people alternatives to the current limited range of ways of relating to mathematics. The patterns of emotional investment and identification with characters and stories make these potential ways of doing mathematics differently.

4.3 Conclusions

The main findings reported in this chapter are that:

- There are very strong default images of mathematicians that are easily called up; these default images of mathematicians are of old, White, middle-class, heterosexual men and are associated with markings onto and into the body, including states of clothing, posture, mental health and social awkwardness or geekiness. These images reflect those circulating in popular culture. They are shared by men and women.
- Most participants were unable to identify unknown but attractive women as mathematicians while being aware that this was problematic. There were mixed feelings about the use of such images to sell mathematics, particularly when they were overtly sexual.
- Mathematics is constructed through a series of gendered oppositions such as numbers vs. words, technical vs. emotional and everyday vs. esoteric. These make mathematics something that is less attractive to women than to men.
- Discourses of mathematicians are also characterised by oppositions, for example between 'normal' mathematicians and 'real'

mathematicians, people with ‘natural’ ability and those who just cannot get it or who need to work hard to do so. These discourses link to distinctions between everyday and esoteric mathematics. Again, these images reflect those circulating in popular culture and were shared by men and women.

- Women are less likely to self-identify as having mathematical ability than men and this makes it more difficult for them to choose to continue with the subject. Both men and women’s sense of their mathematical ability derived largely from external factors, prominent among these were assessment results and positions within teaching groups that are setted by ‘ability’.
- The ways that people read images of mathematicians and mathematics depends on the resources people bring to them. For example, participants who identified with feminism more often read mathematical ability into feminine bodies and participants who identified with mathematics more often read examples of creativity as mathematical.
- Popular mathematicians and mathematics can provide a resource for developing positive relationships with mathematics. In particular, popular mathematicians can provide points of identification and popular mathematics can provide a space to explore ‘alternative’ understandings of mathematics that cut across some of the oppositions.

Chapter 5: Recommendations

In this final chapter we sketch out the implications of our research findings by making recommendations for the following groups:

- Producers of popular culture
- Policymakers and practitioners in mathematics education
- Researchers in mathematics education

5.1 Recommendations for producers of popular culture

In terms of representations of mathematics and mathematicians in popular culture, this research indicates that, although people do not simply absorb images, it is useful for them to have a diverse range to draw on. In particular the research suggests that we need:

- More representations of women doing mathematics and particularly more adult women whose abilities are independent of the men in their lives.
- Representations of women doing mathematics who are classically attractive, feminine and engaged in heterosexual relationships *and* of those who are not.
- A greater diversity of people doing mathematics, in particular, people from different ethnicities, nationalities, sexualities, ages, social class backgrounds and with different bodies. And, particularly, we need ones that go against the clichés.
- A range of ways of engaging with mathematics happily and successfully, including presenting mathematics as a hobby, an incidental part of a character's life and involved in a range of occupational areas, so that mathematics can be seen as part of someone's life rather than as all consuming.
- Representations of mathematics that present it as accessible to all and that do not obscure the mathematics.
- Representations of the process of doing mathematics that present effort as part of ability and show the process as creative and collaborative.

It would be helpful for producers of popular culture to liaise with researchers in the field and for organisations working in this area such as Public Awareness of Science (PAWS) to facilitate this. However, although there may be some scope for working with individual artists, it is very difficult to influence the production of popular culture representations directly. The majority of these are generated in North America and are governed by the dictates of global capital. This is likely to remain so despite some democratisation of cultural production through the internet and digital technologies. Thus we turn to our recommendations for UK policy and practice in mathematics education, where greater influence is possible.

5.2 Recommendations for policymakers and practitioners in mathematics education

Debra Hayes and her colleagues (Hayes *et al.*, 2006) who worked on the productive pedagogies research in Australia emphasise that for educational change to be effective all three of Basil Bernstein's message systems of

schooling - assessment, pedagogy and curriculum - need to be coordinated. This is something we strongly support. Teachers can act independently to change their pedagogy but this will be much more effective if they are supported by a curriculum that creates spaces for and legitimates different types of teaching activities and by systems of assessment that value and give credit to the performances produced through these activities.

The main finding reported in Chapter 4 in relation to gender and mathematics is that oppositional ways in which mathematics is constructed create problems for the majority of learners but particularly for girls and women in terms of identifying with subject and so wanting to study it. To tackle this we recommend that policy and practice on mathematics education develop approaches that are based in and encourage understandings of mathematics as emotional as well as rational and creative as well as rigid. In particular the research suggests that we need:

- To address with learners the question of 'what is mathematics?' by including this within the National Curriculum, within examination syllabuses and within the associated assessments. Alongside this we need to develop teaching materials, initial teacher training and continuing professional development programmes to support this.
- To make mathematics, in its broadest sense, visible in other subjects, especially in those such as humanities, languages and social sciences that are often seen as opposed to mathematics and that are characterised as 'feminine'. This kind of work could happen both within and across disciplines.
- To teach and assess mathematics through activities which cut across the oppositions and present mathematics as creative, collaborative and *un*certain. Coursework, while initially offering such opportunities had undoubtedly become formulaic and so no longer did this in most classrooms, however, its elimination from GCSE and near elimination from A level leave no spaces at all for such work.
- To present mathematics as a human activity carried out by women and men and one that requires work, is ongoing and is affected by experiences of discrimination and other aspects of biography and politics. Work on the histories of mathematics and using accounts from a range of contemporary mathematicians would be a way doing this. Much material to support this already exists (Greenwald, 2005, Povey *et al.*, 2001). However, it is important to support its use through both teacher training and development and through its inclusion within curricula and assessments.

The main finding reported in Chapter 4 in relation to gender and mathematicians is that people's images of mathematicians follow the clichés found in popular culture, for example, drawing heavily on geek discourses. In particular, success in mathematics is generally ascribed to 'natural' ability and the effects of this, while problematic for all, are gendered since girls and women find it more difficult to think of themselves as 'good at maths'. To tackle this we recommend that policy and practice on mathematics education develop approaches that engage learners critically with popular

representations of mathematicians and that counter damaging notions of 'natural' ability. In particular this research suggests that we need:

- To create space within the curriculum for looking critically at representations of mathematicians in popular culture.
- To offer learners a range of ways of identifying with mathematics in the classroom, for example, as a hobby, as something used in another subject and as something done by a mathematician. For example, teachers could remark on and celebrate different students' attraction to and success in different mathematical activities.
- To encourage the use of 'all ability' teaching in mathematics both at primary and secondary level. This would include reviewing the current Key Stage and GCSE testing regimes which clearly support ideas of 'natural' ability and practices of setting.

5.3 Recommendations for researchers in mathematics education

This research has been important in helping us understand the ways that representations of mathematicians and mathematics influence learners. However, it constitutes the first large scale research into this. As such we would recommend that further research be carried out to follow up some of our findings and recommendations. In particular the research suggests that we need:

- Work looking at how other groups of learners read popular mathematics and mathematicians. Primary school age children and adult numeracy students would be useful groups to work with since research shows both that primary school is an important space for developing relationships with mathematics (Bibby, 2006) and that adult numeracy students have varied and changing relationships with the subject (Swain *et al.*, 2005).
- Work comparing the figure of the mathematician with other disciplinary identities such as historian, sociologist, chemist and musician, both in terms of how these are constructed in popular culture and how they are read by learners. The relation of discourses of genius to different subject identities should be a focus within such research.
- Work looking at a range of bases for identification with mathematics and mathematicians and particularly at ones that this research suggests could allow a wider range of people to develop positive relationships with the subject. Our findings suggest that biographical research with mature mathematics undergraduates would be a good place to start this.
- Work developing pedagogies that are effective for teaching 'all ability' groups in mathematics.
- Work developing pedagogies that make use of popular cultural resources in the classroom.
- Work developing and evaluating processes of teacher training and development that support the recommendations for practice in mathematics education listed in the previous section.
- Work developing and evaluating systems of curricula and assessment that support the recommendations for practice in mathematics

education listed in the previous section and that avoid the pitfalls of coursework.

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Communication of the research

Below is a list of outputs from the both the UKRC and the ESRC funded research. Further details are available from the project website: www.londonmet.ac.uk/mathsimages

Epstein, D., Mendick, H. & Moreau, M. P. (2007) Absolute cultures: mathematics education meets cultural studies, paper presented at *Cultural Studies Now*, London, 19-22 June.

Epstein, D., Moreau, M. P. & Mendick, H. (2007) Imagining the mathematician: young people talking about popular representations of maths, paper presented at *British Educational Research Association*, London, 5-8 September.

Mendick, H. (2008) Imagining mathematicians: issues of gender, invited talk to the *Conference of the Heads of Department of Mathematical Sciences*, 7-8 April.

Mendick, H. (2008) GCSE students imagining maths, invited talk to the *University of Manchester Mathematics Teaching Away Day*, 23 May.

Mendick, H. (2007) Undoing mathematics? Fantasies of gender and mathematics, keynote paper presented at *Mathematics, Science and Technology in the Body of Education*, Volos, 18-19 December.

Mendick, H. (2007) 'I could always just play': gender and mathematical ability, keynote paper presented at *Promoting Equality in Mathematics Achievement*, Barcelona, 25-26 January. (forthcoming in proceedings)

Mendick, H. (2007) Moving Images of Maths, workshop at *Mathematical Association Conference*, Keele, 11-14 April.

Mendick, H. (2007) Popular Mathematics?, workshop at *Association of Teachers of Mathematics Conference*, Loughborough, 2-5 April.

Mendick, H. (2007) Mathematical Images and Identities, workshop at *Critical Mathematics Education Group*, Sheffield, 27 March.

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Moreau, M. P., Mendick, H. & Epstein, D. (forthcoming) 'Terrified, mortified, petrified, stupefied by you' … and gendered? Constructions of 'mathematical man' in popular culture, in: E. Watson & J. Kille (Eds) *Contemporary Mediated Masculinities*.

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ISBN 978-1-905831-23-4