Participation in mathematics post-18: Undergraduates' stories

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Abstract: This paper reports on some of the social and emotional complexities young people negotiate, consciously or otherwise, when applying to study at university and presents reasons for why good candidates for mathematics degrees may not opt to study mathematics. The research comes from one strand of the UPMAP project which is seeking to understand profiles of participation in mathematics and physics. Data analysed come from narrative-style interviews which were conducted with first-year undergraduates who had A level mathematics and who were studying a range of subjects at university.

Keywords: higher education, affect, participation

Introduction

This paper reports on one of the three 'Strands' of the 'Understanding Participation in Mathematics and Physics' project (UPMAP) that is funded by the ESRC and other providers as part of their 2007 science and mathematics education call. The funders' intention was to commission research that could provide evidence for policy proposals that would encourage a technically proficient new generation given that post-16 participation rates in mathematics and physics were not considered sufficient from an economic-modelling perspective (e.g. HM Treasury, 2004) to sustain desired economic growth, (ESRC webref). In 2008 the Higher Education Funding Council for England injected a £350 million rescue plan to attempt to counteract the decline in the number of students taking science and mathematics. In recent years there has been a growing concern in the declining number of school-leavers continuing with mathematics and physics after the age of 16 (RSA, 2007). The gender gap in post-16 uptake of physics is larger in England than it is in Scotland, Ireland and Wales (RSA, 2008).

The UPMAP project

The principal focus of the UPMAP project is to understand better what determines student attitudes towards mathematics and physics and the reasons for student subject choice. We are particularly interested in making sense of the phenomenon in which many of those who do well in mathematics and the sciences do not opt to pursue science, technology, engineering or mathematics (STEM) - related study at higher education (e.g., Reiss, 2000). In this paper, we report on undergraduates' retrospective explanations of why they decided, or not, to study mathematics at university.

The findings presented in this paper sit within those of an overall larger project (i.e. UPMAP) of three 'Strands', where Strand 1 employs quantitative methods to map trajectories of engagement and disenchantment of high school students in mathematics and physics by analyses of large scale and longitudinal statistical data (N≅20,000 student datasets), Strand 2 investigates subjectivities and school cultures by working ethnographically in twelve high schools chosen for their

range of staying-on rates post-16, and Strand 3 investigates young peoples' higher education degree choices through analysis of individual narrative interviews. This paper focuses on our preliminary Strand 3 results; that is, we report on undergraduates' reasons for participation, or otherwise, in mathematics at university.

The outline of the rest of the paper is as follows: the body of this report starts with a brief explanation of the rationale and methodology of the higher education aspect of the UPMAP project then presents analyses and findings, concluding with the discussion where we draw out some points from the project as a whole.

Strand 3, rationale and methodology

UPMAP Strand 3 consists of 51 interviews from first year undergraduates under the age of 21, all of whom have mathematics or physics A level (or equivalent), about half of whom are reading STEM subjects. The interviews were narrative style and interpretation employed the psychoanalytic notion of the 'defended subject' (e.g. Waddell, 1998) as well as a form of grounded theorising we have called 'face value'.

The undergraduates we interviewed were recruited from four UK universities (referred to as 'University A', 'University B', etc.). The universities represent a range of institutions: two Russell group institutions in different regions of the country, one pre-1992 non-Russell group university and one post-1992 university. Recruiting the undergraduates for interview involved challenges in negotiating access, peculiar to each institution. In two of the four universities, we received an order of magnitude more applications from students than we were able to interview, so we had to have selection procedures. The main organising principle for the selection was that we should have comparable numbers in each cell of the table below. Numbers in cells give the breakdown from University A:

	STEM	Non-STEM
Female	8	5
Male	5	4

The ratios in the table above are representative of the responses overall with more female and more STEM undergraduates presenting for interview. The sample represents undergraduates with a range of stories, which was what was sought, but we do not claim that the sample is all-inclusive or statistically representative.

Data gathered in Strands 1 and 2 of the UPMAP project are being used to construct trajectories of participation in mathematics and physics of school students in the 12-17 age group and Strand 3 data are used to construct detailed understandings of reasons for participation (or not) in mathematics and physics from individuals in the 18-20 age group. The central research question for Strand 3 is "What are the 'narratives of choice' that undergraduates tell?". Our 'choice narratives' (i.e., our interpretations of the interview data) will be used to inform Strand 2 interview schedule design (e.g. the time we spend in the Strand 2 interviews exploring the relative influence of school, family and other out-of-school influences on mathematics) and themes extracted from the Strand 3 data analysis will be used to interrogate the longitudinal Strand 1 data (e.g. the importance of the utility of mathematics as opposed to its intrinsic appeal).

Methodology

In Strand 3 the aim is to find out about how or why first year (under 21 years of age) undergraduates got to be on the course that they are enrolled in. Our method involved interviewing them and then analysing the resulting transcribed text. Each of the

undergraduate interviewees was informed about the project: their invitation was via a website or an email which explicitly said "please come and talk to us about your choice of course". In part because the undergraduates knew why they were being interviewed, asking questions like "why did you choose study mathematics?" might produce rehearsed, standard responses like "I enjoy it" or "It's my best subject" and, thus, underlying reasons for decision-making that arise from the individuals' subjectivities might remain hidden. It was these reasons which we aimed to uncover and make sense of. We took as a theoretical underpinning a Kleinian-based psychoanalytical model (e.g. Waddell, *op. cit.*) that theorises that all persons defend against anxieties, thus taking as a principle that there are unconscious and subconscious influences on individuals' decision-making about critical life events. These influences, while not separable from the cultural, gender and socio-economic positioning people experience, are not as well-defined as these sociological categories of 'race, class and gender'. We aim to uncover complexities of decision-making that go deeper than the contextual background of students, recognising that individuals are not consciously aware of all of the reasons for decisions.

Furthermore, there are mathematics-specific anxieties that we anticipated detecting (Nimier, 1993; Black et al., 2009). Hence the approach we have used is based on a narrative approach to interviewing (e.g., Hollway and Jefferson, 2000) which aims to elicit a story from the interviewee in which they reveal not merely the rehearsed and public face of their decision making, but also positionings, whether by themselves or by others, they've experienced (due to gender, class, ethnicity, etc.). A narrative approach also elicits memories of critical events and 'random' occurrences that have brought the person to where they are. The aim is to allow each interviewee to tell a story that includes details they were not fully aware of or, at any rate, did not necessarily consider relevant to their choice of university course.

Our interviews were conducted as follows: we had established mobile or email contact with the undergraduate prior to the interview and welcomed them to the room in their university where the interview was to take place. After a few minutes of helping them to feel relaxed and telling them orally about the project, we generally started the interview by asking each student to talk about their education, encouraging them to start from wherever they wanted. The interview then proceeded from what the undergraduate offered, but with the interviewer's aims of finding out about their early childhood experiences both in and out of primary school, their secondary school years and any out-of-school activities they were involved in. We also wanted to find out about any family, cultural or community influences on their decision making and we were alert to opportunities for asking students if there were any critical events they could remember where decisions about subject choices were made.

In practice, interviewing 'defended subjects' by means of conducting such narrative style interviews requires the interviewer to manifest skills similar to those used in a counselling interview: we aimed to bond with the interviewee, so they'd be relaxed enough to tell their story, and we aimed to remember details within the approximately 50 minute interview so that we could pick up on an interesting thread at a later point in the interview, encouraging them to tell their story of their choices. Nevertheless, there is a fine line between a question that 'follows' a previous point and a direct question. Although asking formal, direct questions tends to elicit rehearsed or 'defensive' replies and is generally to be avoided, in conversational (narrative) interviews, a curious and engaged interviewer, having established a 'working bond', will not always adhere to this protocol (e.g., humour sometimes gets the upper hand and in such a case, typically, the subsequent conversation has an improved emotional tone). The resulting conversation is thus a co-construction

between the undergraduate and the researcher: an audio text that was subsequently typed up to form the written text, 'the transcript'.

A post-interview pro-forma explained about how the undergraduate's interview would be used and also provided the interviewee with the opportunity of making a comment on how the interview process had felt. Several interviewees were explicit in making a comment that indicated that the process of talking about their choices had brought to mind things they had not been aware of, validating the methodological process; for example: "I found it very interesting as it offered self-reflexivity which I had not considered before" (Becky – all names are pseudonyms that indicate gender); "It was a nice relaxed atmosphere – and the questions asked were actually insightful for me in analysing my own education" (Peter).

'Face value' and defended subjects

Analysis of the interview texts is still on-going and we are employing different lenses to interrogate the data (Black, Mendick & Solomon, 2009). We refer to the different lenses we are using as: 'face value', 'defended subject', 'discourses' and 'Strand 1 constructs'. At the time of writing we have analysed interview texts from University A in the first two of these ways, 'face value' – where a grounded approach to the text was used to extract themes – and 'defended subject', and these analyses are the basis of this report.

The brief 'face value' account, which is presented first, gives the reader a glimpse of the sort of things the undergraduates said in interview about their relationship with mathematics and their choices; it is not a quantitative presentation of categories of views but a background to the more detailed analysis that follows. Then, in the discussion of Dan, below, we indicate why a 'face-value' approach is not sufficient to understand these young peoples' decision-making and yet is useful to foil a 'defended subject' interpretation. This is because the defended subject analysis proceeds by first locating indicators of defence – for example, inconsistencies, exaggerations, avoidances and silences are typical of ways that feelings are revealed, whether or not the person is aware of the revelation – and then by interpreting these indicators of defence in terms of the narrative the undergraduate is sharing and developing in the interview.

This interpretative way of reasoning about affects is different to published reasoning in mathematics. In this interpretative work we read into the text, locating indicators of defence 'between the lines', as well as reading face value data from the text; in mathematics, of course, inference is strictly from premises via set rules of inference. A mathematician may well say that there are logical alternatives to the given interpretations and yes there are! The justification for the claim is not based on a closed, formal argument but on a holistic and intuitive appraisal, prepared for by study and experience of psychoanalytic methods and literature, and presented as a narrative itself which has also been adapted in the light of critical interrogation by others.

Analysis and findings

This section gives an overview of undergraduates and their reasons for course of study from University A[1], and then looks in detail at an indicative case. Our central aim is to better understand what has steered these students to the course on which they have embarked. In particular, for this BCME context, we examine the research question focussed on mathematics: "What are the 'narratives of choice' that undergraduates tell concerning mathematics?".

On 'face value' reasons for doing or not doing mathematics

Of the 13 interviewees who were studying STEM subjects, predictably, those doing science or engineering considered mathematics as a tool, whereas those doing single or joint honours mathematics did not give reasons for choosing mathematics that included its usefulness – except at a meta level of it being a degree you could do other things with. Of the four reading mathematics, as joint or single honours, each of them expressed the intimacy of their relationship with mathematics; for example, "I always wanted to do mathematics and only mathematics" (Vera), "I couldn't have lost my maths" (Chloe).

Eight of the nine interviewees not studying a STEM subject had A level mathematics and six of them had grade A in it. These undergraduates' stories of their choices frequently referred to 'enjoying' mathematics at school, but employed opposing discourses like 'lack of relevance' or 'difficulty' to explain why they had not applied for a mathematics-related degree; all of the six A-grade non-STEM interviewees used the discourse of being 'good at' mathematics to explain their reasons for their choice of A level mathematics. Discourses of challenge-and-interest and enjoyment-and-creativity were used to explain non-mathematical choices:

> Maths was the easiest of A-Levels for me by far … I liked maths because I was good at it, and I found it challenging but I didn't find it interesting. But English, … I just found … more interesting and I'd rather do something that I find interesting and challenging than something I find easy and less interesting.
>
> (Becky, reading English, other A levels English and history; all A grades)

> And maths, which I did to A-Level, I didn't really enjoy as much. … I suppose to say I didn't enjoy it is a bit extreme but I didn't get the same enjoyment out of it as I did with English and History. I sort of liked the creativeness, like writing essays. … I sort of saw [maths] as a job to be done, so I suppose that's the reason that I didn't enjoy it as much.
>
> (Peter, reading history, other A levels English and history; all A grades)

These undergraduates expressed their reasons for their choices, we have to assume, genuinely. Nevertheless, we can learn more about their decision making when we interrogate their interview text further. For example, early on in Dan's interview he tells of switching from sociology to mathematics A level within the first few weeks of Y12. His reason being that "with maths I knew I knew stuff". At face

[1] We have completed our interviewing at University A and have 22 interviews from first year undergraduates who have at least one of mathematics and physics A level. Twenty one of these interviewees had mathematics A level, and 17 of these achieved grade A. Of the 21 with A level mathematics, 11 attended a maintained comprehensive school or post-16 college, 7 attended a maintained selective school and 3 attended fee-paying (i.e. private) schools (one of whom was a scholarship student).

value this is a rational decision by a young man who has the option of continuing with sociology or switching to mathematics. But even his utterance that communicates the reason for his switch is open to other interpretations: from the 'defended subject' perspective, a reader could ask, for example, 'why does he have the need to know stuff at the beginning of a course?'. This 'I know I know' aspect of Dan's relationship with mathematics is then threatened later on in his Y12, producing anxiety:

> I found the, the very last, the very last exam that we did for the further maths AS was FP1 and it was really, really tough

and he did not continue to A2 further mathematics. In the interview he had said that when he was younger:

> I was always quite good at [maths] I guess. And then I don't know I just like found it quite interesting like kind of got it quite easily as well and did it quite well easily so, I just found it interesting I guess.

Yet:

> I didn't really enjoy maths like as I got older, like it was quite, it just got to a level where it got too complex and just stuff I could never see myself ever using in my day-to-day life.
>
> (Dan, reading English and drama, other A levels English and chemistry, all A grades, further maths AS grade B)

A defended subject reading of Dan's story is that Dan's relationship with mathematics is through performance, so when performance is perceived as weak – B grade for an AS – the relationship is under threat and defences are evoked. When Dan says "I could never see myself ever using in my day to day life" we see an example of Nimier's 'mathematics is remote' defence against mathematics (Nimier, *op. cit*.).

Robin: studying history with economics

The following discussion of Robin shows that defences themselves are interwoven in complex ways. The claim is made that Robin does not choose to read mathematics at university because of certain anxieties which he seems to defend himself against outside his conscious awareness. This report starts (1) by presenting background information on Robin. Then in (2) we present extracts concerning being 'good at maths' and in (3) indicate the importance of history and engineering to Robin while explaining how he was construed as a defended subject *vis à vis* his choice of course. The section concludes (4) by justifying the claim above.

(1) Robin is from a town in the North of England where he went to a middle school, high school and post-16 college. He has one sister six years his junior, his father is an accountant turned manager in the NHS, and his mother was a journalist, then became a full-time mum, and is now a teaching assistant. He was at the beginning of his second term, aged 19, studying history with economics at University A when he was interviewed. His A levels (grade) were: mathematics (A), further mathematics (A), physics (A) and history (A) and he has an AS in economics (B).

(2) Early in the interview Robin says: "I've always been good at maths from basically whenever I could start thinking". He also tells that he got National Curriculum level 8 when in Y7, was in an express GCSE mathematics class on starting high school in Y9 and took the GCSE in Y10; he adds that he "only" got an A for GCSE, had his paper remarked but did not get it upgraded to A*.

Mathematics is the subject chosen by a close peer group with which Robin identifies: At post-16 college, he studied maths entirely within a 'further maths' class;

there were 11 students in the class, three of whom who went to read mathematics at prestigious universities had been 'maths class-mates' with Robin since Y6:

> It's weird because all this time with them doing maths even when I was doing engineering they were suddenly like we came back at Christmas and they all had work for the next semester and stuff and I was kind of interested to know what it was and suddenly this was stuff that I couldn't do because obviously they'd been taught.

After saying this he says that recently "[I]found all my further maths stuff but I didn't want to throw it out because I don't want to get rid of maths".

(3) While at school, Robin had been involved with two engineering enrichments: one in the summer between Y8 and Y9 when he won a prize for making a robot. The other was a longer project, Engineering Education Scheme in Y12 ('EES' – organised by his history teacher), with three other students from his college; all four of these EES students started engineering courses at University H straight from school, but Robin left there after a term, to do history and economics at University A. University H was Robin's second choice for engineering after Cambridge – where he was rejected after interview. He was also rejected (at an engineering careers event) by the RAF to train as a pilot as he had asthma. Robin's history teacher is closely linked to his engineering as well as his degree choice:

> And I had a brilliant history teacher again at both AS and A2 years and she really got me involved with history so … She was really an enthusiastic person and she was as enthusiastic about engineering as she was about history. Her profession was history, she had a history degree from York but she really enjoyed, in a sense she's quite a lot like me, she enjoys history but she enjoys working out how things work and stuff like that. So, yeah, I enjoyed the last year of history at A-level.

Thinking of Robin as a defended subject, we note two rejections related to engineering: no place for him at Cambridge nor in the RAF. So Robin, initially groomed for engineering, to defend himself, has to look elsewhere. Towards the beginning of the interview he spontaneously says:

> Quot. B: I really enjoyed maths. Which is why I didn't want to do a straight history degree, my ideal would have been history with maths but obviously you can't do that. So economics was the closest thing to it basically.

(4) How come he's not doing mathematics? Short answer: because it is too risky; thought of failure elicits anxieties from which Robin has to defend himself. Robin has a mathematical self-identity going back to early awareness of "thinking", yet he was not quite an A* and could not follow his former classmates' mathematics degree work, so failure is imaginable. He experienced rejection by engineering, despite having been positioned to participate in that field and he defended himself against further rejection by avoiding continuing with engineering. His history teacher inspired hope in a different arena; he fantasises identification with her and follows her path.

Discussion

The extracts from the analysis of Robin's narrative exposes complexities around decision making, like choice of university course, that is central to young people's lives. We have shown that certain defences of the self (where defences are theorised as a normal part of personhood), can disrupt a potential career. Adolescent concerns do not sit comfortably with a rational, 'flow chart' model of decision making. Indeed, the very discourse of 'Choice' (Salecl, 2009) that demands individuals' attention to their 'life-making' provokes anxieties. Ultimately, withdrawals and approaches are

emotional acts: Robin is attracted to his history teacher and withdraws from feared failure in his primal intellectual domain (mathematics).

There are some features of mathematics as experienced in education that could be changed and, although we will never know whether this would have been enough to keep Robin in the fold, issues that might not have provoked the defences that resulted in his a-mathematical path are:

- Believing that 'good enough' is, indeed, good enough;
- Having an imaginative projection of doing mathematics in the future;
- Developing a personal, emotionally salient, view of mathematics.

These three items will be developed in other writing. Briefly, the discourse of having to be the 'best' in mathematics to continue is still pervasive and puts many young people off. Continued careers development, while on-going, is needed to seed a personal fantasy that can turn accountants into lion tamers (youtube webref) and recent developments in illustrating opportunities a mathematics degree may offer are very encouraging (mathscareers webref). And, as our Strand 1 preliminary findings already reinforce, students' mathematics-specific 'self concept' and confidence in conceptual tasks, are key psychological factors that have an influence – independent of gender, ethnicity and class – on intention to choose mathematics. Thus, as these mathematics self concepts are experienced differently, honouring the notion of 'student diversity' requires a range of approaches into conceptualising, learning, enjoying and becoming inspired by mathematics.

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