

SUCCESSFUL UNDERGRADUATE MATHEMATICANS: A STUDY OF STUDENTS IN TWO UNIVERSITIES

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As part of an ESRC-funded longitudinal study, 'Student Experiences of University Mathematics' [1], we followed a cohort of undergraduate mathematics students at two traditional universities with high ratings for research and teaching. This report centres on interpretations of successful students' engagement with their course as gleaned from in-depth interviews, statistical data and questionnaires. We report that these first class' students participate in their undergraduate mathematics community in many different ways and their views about mathematics are diverse. Nevertheless, these students have, in Aristotle's terms, 'flourished' and we point to factors which we hypothesise contributed to 'first class' students' success.

INTRODUCTION

Success at university is multi-faceted. Making friends and having taken extra-curricular opportunities are important, whatever a student's academic profile. Nevertheless, while it is difficult to gauge the success of friendships, the degree classification at the end of the course serves as a standard measure of academic success. In this paper we consider students who have achieved a first class degree at the end of three years of undergraduate study. Data for this paper come from the 'Students' Experiences of Undergraduate Mathematics' (SEUM) project. In this three year, Economic and Social Research Council (ESRC) funded project we focused on one cohort of single honours, undergraduate mathematics students from two, traditional, city based English universities, 'Waverley' and 'Marmion'. We have collected a variety of data: in-depth interviews, questionnaires, statistics, observations of lectures and tutorials.

Statistics

Distributions of degree classifications was as shown in this table:

University	1	2.1	2.2	3	ord.	y/a	fail	total
Waverley	29	38	30	13	4	9	3	126
Marmion	14	9	8	3	-	-	3	37
Total	43	47	38	26	4	9	6	163

Table 1: numbers in each degree class ('y/a' stands for 'year abroad')

As this table shows, a significant proportion (26%) of the students who saw the course through to the third year did gain a first class degree (or its equivalent, for those continuing to a fourth year and M.Math, or equivalent, degree). We have

substantial interview data from 25 of the 43 students with firsts and will draw on representatives of these in this paper. Furthermore, we have data on these students' background from 35 out of the 43, primarily from our questionnaires. From these data we found that 29 out of the 35 had at least one parent who was a graduate. The issue of cultural capital, after their first year, was discussed in (Macrae & Maguire, 2002).

In this paper, firstly, we introduce a set of 'telling cases' who illustrate some extent of the variety in successful experience. Then we aim to explain why these five succeeded by positioning them in terms of participation in the *Community of Practice* (Wenger, 1998) of undergraduate mathematics students at their university. As this theory of social learning of Wenger's did not seem to be sufficiently explanatory, a more general and more ancient notion of human flourishing (Aristotle, *Nicomachean Ethics*) is then mooted as a common feature of these students' experience.

Charlie (graduated 2003)

"it was everything I expected and some more"

Charlie chose to do mathematics at university because it was something he was confident that he could do well in, it was a degree "that showed I could think and learn and had a logical mind and would be employable" and indeed, as he says in his final year, it was "a means to an end"; Charlie has secured himself a good job in a prestigious company in the City of London. His life has been "going well on so many fronts" and he can see himself working in London for "five or ten years... get what I want from London and then move out".

Charlie does seem to know what he wants and can self-regulate successfully in order to achieve his goals. He is both short-sighted and diabetic, so he has tended to sit in the front of lectures and to drink little alcohol. He was determined not to be "undersold", and has managed to "distinguish [himself] from the rest of the crowd". Charlie knows what is important in terms of relationships, is not shy about asking lecturers about maths problems, has participated enthusiastically in the basketball team and will have "very, very good memories" of Waverley which he assesses to have been "very, very good for me". He disdains students that "let themselves" get behind, his advice being "catch up and shut up or stop going to the lectures". He says that mathematics was a degree choice rather than a "particular passion". He does not feel that his view of maths has changed over the three years: "it is a very kind of straight square subject by the nature of it" and it "still has room to evolve".

Charlie is a socially-focused person. In the first year he speaks about "really, really enjoying ... working together, discussing things, getting going with ideas". He reckons, speaking of Oliver, neither of them would have done better than "a medium 2.1 without each other". In the third year he says "I think working on your own is just loveless and a lonely kind of task so you've obviously gotta have some course mates,..., you've gotta have the right ones". Charlie has picked the right ones, picked the right girlfriend, picked the right job; he has had social and academic success.

Oliver (graduated 2003)

“I’ve enjoyed the course as much as I’ve, I’ve got out as much as I’ve put in basically. The more I’ve worked on things the more I’ve enjoyed it, that’s the bottom line, but all the maths is really, really interesting.”

Oliver is one of the big personalities on the maths course at Waverley. He started his undergraduate career at the age of 22 having redone maths A level at night school. He always sits at the front of a lecture and is unhesitant in engaging the lecturer in mathematical discussion during a lecture or around the maths department. He has joined many clubs, for example, juggling, basketball, climbing, yoga and meditation society. He comes from a graduate family where his father and step-mother are teachers and, despite having eschewed teaching at the beginning of his course, he has now enrolled to do a secondary mathematics PGCE as he’s “got into all this meditation and yoga and stuff and become like less career orientated” and “I really enjoy explaining stuff to people and I actually think I’m quite good at it”.

Oliver does see himself as a mathematician “a bit” because he’s going to be teaching maths and he’s “really sort of passionate about the subject”. He considers that he’s “got quite a bit in common with the lecturers in that way. I know I’m older, I don’t see them as like separate things, d’you know what I mean, I just see them as part of the Maths Department.” Indeed he is on first name terms with the younger lecturers and is often to be seen arguing a mathematical point or pursuing a deeper explanation with lecturers, “looking at why they’re doing things and thinking about it rather than just trying to pass the exam.” Oliver does not consider that his view of mathematics has changed fundamentally: “I know, I do understand though there’s something kind of certain about maths, but when you come to apply it really, it’s not, it’s not certain at all, it’s just continuing taking a situation and adjusting it. And even Pure Maths is kind of a bit like that really. Em, it’s just that once you’ve done something it’s kind of fixed.” (On statistics, he “just found it all so boring that [he] didn’t do any of it”). Mathematics is considered a creative subject and Oliver considers the teaching “very good”, “even the not very good ones [lecturers] still have the enthusiasm.”

Oliver has been sharing a house with Charlie for the past two years and they chose the same modules as they can help each other effectively “there’s one module that he’s gonna teach me, and I’m gonna teach him the other three when we revise”. Oliver is “kind of regrettin’ a little bit that I’m not doing a Masters now though. I’m not blaming Charlie, but ... he’s got carried away with [the investment banking idea] and I’ve gone off it completely.” Oliver has had a rich experience overall. Although he is consistently “passionate” about mathematics, he has had his ups and downs socially, and indeed in terms of results (1% in one statistics exam!). He reckons that a Maths degree has taught him “about organisation and stuff” as well as maths, but he’s “learned more from the whole university experience really”. He has changed from a rather ambitious career-orientated youth to someone who is “continually trying to become a better person, which is really important to me.” He attributes this to his

yoga and meditation practice, rather than maths, which has changed him “off the scale”.

Chloe (on four year course)

“I love being a student...I like, I just like this life. There’s no real pressure and it’s just so nice.”

Chloe comes from a small supportive family, she still refers often to her mother, to whom she has continued to be close, and took her father’s advice in staying on for the four year course as “most people have degrees these days”. However, she also says “I don’t want to leave” and “wouldn’t like it” if this, her third year, was her last. Her father has introduced her to some part-time jobs, and she seems to have managed her finances comfortably with the help of some “maturing investments”.

Chloe was one of a small group of students (most of whom seem to be heading for first class degrees) who have gone each year to the departmental weekend at a nearby residential centre for a few days of extra-curricula mathematics lectures. “I’ve been every year. I love it.” She is also involved a departmental scheme “to integrate the first years”. So I go to that party every year, which is good, cos you make a few friends through that”. In the first year she felt she’d “opened up” when she came to university, despite having a self-conception as “shy”. Her grades from school were excellent, and she found “the first year was quite easy... because everything that we covered in Further Maths [advanced high school maths] they went through here really quickly” adding “I was relieved that I knew what they were talking about.”

While Chloe likes to socialise, and did sometimes work in a group of high attaining students in college in her first year, in her third year she says that she is “quite independent”, and she does not generally ask lecturers if she has a problem, because she’d rather “try and work things out for herself”. She also remarked that some lecturers are “quite rude” when you “don’t know what they’re talking about” as they are “just here for research”. It has “never occurred to her to think beyond what is being offered”, but her interests are clearly towards theoretical physics which she speaks about spontaneously and enthusiastically. In the first year she tells the interviewer that her Cambridge-educated engineer father had said to make sure to go to tutorials and “not to worry about those lectures” as “he hardly went to any of the lectures”, in her final year she said, with pride, that she was attending all her lectures.

And she sees herself as a mathematician, despite her reports of being demotivated at various junctures over the three years. A mathematician is some one who has a “special quality” in their “way of thinking” and for whom mathematics is “more a part of them”. As a mathematician “you think outside what you might think is practically possible. An engineer’d just dismiss things if he didn’t think they were practical, but a mathematician can think outside that”. As an undergraduate, Chloe has become an insider, she has accepted the constraints of her environment without perceiving them as restrictions; she is hard-working, socially well-integrated and compliant.

Robert (graduated 2003)

“I’m just passive and as you say just regurgitating everything I’ve been taught”

Interviewed after the first semester of his course, Robert was quite disheartened. He only decided to stay on because his mother pointed out that he didn’t have anything else to do. When asked him where he sat on various spectrums all his answers were “towards the middle”. He is “possibly” doing an MSc, also at Waverley “I’ve got to apply and see whether there’s a place”, having missed the deadline to get on the 4 year undergraduate course. His reasoning is that the MSc will “help me to get a job” which is the same reason he gave in the first year for doing a maths degree. Robert says he’s a “regurgitator”. When asked what he’s got out of a maths degree, he first says that he’s “forgotten a lot of the maths”. However, after floundering a little considers that “time management” has been a new skill for him because

I was useless when I first came to university cos obviously in school the teachers manage everything for you, and I don’t know, er, you know, that’s just the main thing, time management and learning to accept that you’ve got to sit down and do the work and that sort of thing.

Something that has developed since his first year is his notions of memorisation and understanding, he now values the latter, perhaps because he sees it as a means to improved grades: “I’m making sure I understand everything, and, as well as memorising them, and my grades have improved, so, that’s, I don’t know.” When asked about his change in attitude to maths, he interprets this as a question about how much work he now does, rather than a question about his philosophical take on mathematics. However, he does indicate a preference for applied mathematics as it involves “real problems”. In fact, Robert would have rather done a physics degree. He gives a glimpse of his tacit view of maths when he explains “that’s just what maths is, it’s the workings of things, it’s never going to be that interesting to trawl through the last little detail”.

What seemed to keep him going was the fact that he felt a first class degree was within his reach. This was a considerable motivation to Robert, who seems to correlate enjoyment with success very closely. When asked to talk about the modules he’s taken, his response is couched in terms of difficulty and the results he got. His social life revolves around going to the pub with people he shares a house with, and though he says he plays five-a-side football with some maths students, he also reports that he doesn’t “really speak to anyone else in my year”.

Florence (graduated 2003)

“I certainly think that my degree or the majority of the content of my degree will never be useful for anything, and it will just get sort of forgotten within six months of finishing and then never asked for again, which is fine”

Florence, from a graduate family, started her university career by working on her maths each evening and spending each weekend with a boyfriend in a city 50 miles from her university. She felt maths was “the only part of university that’s remained

fairly constant”. Mathematics is satisfying to Florence: “real Analysis 2 in the last semester was just a fantastic course because it pulled together Maths”. She reports that “95%” of the work she does on her own. Although in the first year Florence complained about lectures being boring, she has no complaints about the teaching in the third year, even though there are lecturers she “dreads” as they try and get participation in tutorials. She sees herself as someone with a maths degree, rather than as a mathematician. She would like a job that is ‘9 to 5’.

Florence invested early in study before she integrated socially into the city-university life, she speaks to other people when something is hard but has no interest in speaking in tutorial. Her principal orientations are through her boyfriends and she seems to have little emotional contact with her parents. She has good control over the maths and to keep that advantage, she shares a house with three successful male maths students, two of whom she’s been out with. Her plan after graduation is to move to the town where her current boyfriend will be living, there to be “reconciled to either doing accounts, chartered accountancy training or something like that”.

MATHEMATICS UNDERGRADUATES’ COMMUNITIES OF PRACTICE

Wenger’s ‘social theory of learning and becoming’ is an explanation of how learning involves both *practice* and *identity* (1998:14). That is, knowledge develops for an individual as they engage with the world in a particular fashion: they participate in a *practice*. As they participate, they become part of the community of practice, taking as real (reifying) the tokens of that group and this beginning to belong helps fashion their *identity*, (ibid.:151). The experiences of attending mathematics lectures and sitting exams, giving pet names for modules or courses and being familiar with staff, contribute to a way of being and constitute participation in the community of mathematics undergraduates. In this community, objects of mathematics as well as the mathematics department’s curriculum, exams and assessment procedures are reified.

Participation, is experienced in quite different ways by even this ‘first class’ group of students and, as Wenger’s theory of learning explains, this different participation contributes to their identity: **Robert and Florence** both appear to be on the periphery of the undergraduate mathematics community. Robert has participated by focussing on definite goals and taking a narrow, manageable, view of mathematics as dealing with details. Florence has participated by producing good results and having some social engagement with other students, particularly males, who might be useful for help. Florence communicates a deep satisfaction with mathematics; it is a refuge for her. It seems that Robert needs the structures of mathematics (or physics) to hold him to a viable path: the requirements of being a mathematics student are understood and he has found that he can regulate himself to achieve the well-understood goal of exam-passing. Florence is the opposite – where maths for Robert gives him external structure in the form of exams, for Florence, maths is an internal regulator. For Florence the structures of maths and her capacity to work with them give her an inner

security and satisfaction despite her attachment to relationships which do not seem to enhance her ‘flourishing’.

Chloe and Oliver are both central within their respective undergraduate mathematics community. While Oliver participates by standing out in his behaviours and appearance and uninhibitedly talking mathematics whenever he has an opportunity, Chloe has participated by gaining respect from her efforts in her work and contributing to the social environment of the department. The nature of their respective participation is highly gendered, for what is more, Chloe has the role of a ‘big sister’ to newer students while Oliver associates with the almost entirely male lecturers and will dominate any lecture when he has a point he wants to make or idea he wants to pursue. Chloe does not tend to expose her lack of understanding to lecturers, but Oliver has moved to participation *as a mathematician* where playful delight in all mathematical problems, including those which might be considered elementary, is an aspect of participation in the community of *mathematicians*.

Charlie has participated in order to maximise his advantage in his future, rather than to learn mathematics for its own end or to pass exams. He seems to be able to understand the requirements of the community, and to seek the status of a first class degree, without handing over his heart, as Oliver has done. While Charlie has gained pleasure from doing mathematics, the chances are that he’d have also found the satisfying side to studying economics or chemistry.

FLOURISHING

While Wenger’s theory gives us a way of interpreting the relationship between practice and identity, it does not give us insight into what facilitates these successful undergraduates getting ‘on track’. A theory that fits the observation that these students have ‘done-well-for-them’ is that of Aristotelian ‘human flourishing’ – an aspect of ‘virtuous character’ (Sherman, 1989). This flourishing is not to be understood just in conventional terms, which is exemplified in Chloe’s story: showing round first years, loving the life, being enthusiastic about a particular branch of mathematics and being justifiably critical about a few aspects of provision. Even Robert, whose story was presented as a foil to the enthusiasts, has developed: he has made friends that he lives with, is able to focus on his work well enough to achieve satisfying results and to please his parents, and he has learnt to value understanding in his learning.

The Aristotelian concept of ‘human flourishing’ (*eudaimonia*, Aristotle, *Nicomachean Ethics* from Sherman, *op. cit.*:77-8), seems to pertain to the process of becoming within a social setting, which is also Wenger’s interest. From the extensive data we find that the students gaining a first all did communicate spontaneously some aspect of pleasure to do with doing maths, which contributed to their well-being and their sense of well-being. Another common feature was that they all communicated that they valued understanding, even though their notions of understanding varied from being able to answer exam questions to an engagement with ideas irrespective

of the exams. From what we have found out about the students, these first class students all engaged with their studies, for most of the time at least. Such virtuous activity is integral to flourishing, despite their patterns of engagement being very different and their motivations varying hugely. These commonalities contrast with their views of the subject which were wide ranging: from mathematics as a meaningless game which is fun to do, maths as a source of the processes of following through tedious details, maths as a practical subject/ a beautiful subject, or even, considered on a meta-level, as a high status subject that is character and mind-developing.

This sense of satisfaction, happiness, or ‘human flourishing’ can be contrasted with the frustration, anger and despair of some other students who have not done so well. We have less data from failing students since they have not been as willing to be interviewed, they often miss appointments or avoid the interviewer.

CONCLUSION

The major differences between very successful and failing students, reported in Macrae, Brown, Bartholomew and Rodd (2003), seemed to be greater focus and self-discipline, perseverance and determination, including the determination to sort out a solution when things started to go wrong, and less inclination to self-delusion. Several of these factors can be classified in Entwistle’s terms of managing effort, having a deep or surface approach to learning organising or monitoring their studying (Entwistle, 2003:2). Finally, it has to be said that, the successful students all had social backgrounds which considered a university education normal or prestigious, so the challenge to achieve inclusivity remains.

NOTES

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