A-level Further Mathematics uptake: barriers for underrepresented young people

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# **Summary**

This study explores the uptake of A-level Further Mathematics (also known as Further Maths), and sets out the context and barriers which contribute to inequalities in participation in the UK. The Outreach Department at Imperial College London currently runs the ‘Further mA\*ths Online Programme’, which is supported by the Hg Foundation and aims to assist A-level Further Mathematics students who are considering studying a maths-related degree at university. We would like to gain more understanding of why, even when it is an option, students are not taking Further Maths. We are interested in ways to support raising attainment at GCSEs to enable more students to have the option of studying Further Maths at A-level.

Advanced mathematics qualifications are a vital requirement for studying STEM degrees at university and for the wider economy. Most STEM degree entries require good Maths grades at A-level, and some courses, such as Maths, Physics and Engineering at Imperial College London and other selective universities, also require/ prefer good results in A-level Further Maths. Performing well at Further Maths is also known to ease the transition from A-level into a range of STEM degree courses, setting up students to succeed.

However, participation and attainment in A-level maths qualifications are both unequal. Along with existing research on outreach work and Maths education, findings from this study, also funded by the Hg Foundation, will be vital to inform the plans for future maths outreach intervention. The findings can also provide better understanding of challenges relating to advanced Maths (non)participation in England.

## The main questions that were explored

1. Why do students who are interested in STEM subjects choose to/not to study Maths and Further Maths A-levels? What are the main factors that encourage students’ progression to advanced maths?
2. What are students’ views, experiences and perceptions of studying maths at advanced levels, including A-levels and university (potentially in the future)?
3. What are participants’ perceptions of useful strategies which could support raising students’ GCSE attainment and facilitate progression to Further Maths A-level, particularly for those from disadvantaged backgrounds and/or underrepresented groups?

## Statistics graphic. In 2021 of all students in England. 4.7% of A level students at state schools took Further Maths verses 10.1% at independent schools. In 2022 of the 18 year old in UK who sat the exam 40.7% achieved an A* in A level Further Maths, and 22.8% achieved an A* in A-level Maths.A-level Further Maths in context

A-level Further Maths is taken with A-level Maths; it could be taken as one of the standard three A-level subjects or sometimes is taken as an additional qualification. Historically it has been taken by a relatively small minority of students studying A-level Maths. Further Maths students study maths in greater depth by studying further and more challenging mathematical content as well as broadening study by additional study of mathematical applications (Boylan et al, 2016). Further Maths can also be studied as an AS level qualification. In 2022, there were 15,146 students in the UK who sat the A-level Further Maths exam, while 95,635 students sat the A-level Maths exam (JCQ, 2022). From earlier research (Noyes, 2013; Noyes & Adkins, 2016; Boylan et al, 2016), it is clear that students’ school/college attended, gender, ethnicity and social class impacts upon participation. Demack et al (2019) found that the pattern of A-level Maths participation rates is similar to that for A-level generally – for most Black and Minority Ethnic (BAME) groups of students (with the exceptions of Black Caribbean and mixed Black Caribbean and White students) rates were higher than White British students. However, for Further Maths, the rates were higher for Chinese, White Other, and Indian compared with White British students, and relatively high participation rates were also observed amongst students from Sri Lankan Tamil or mixed Asian and White ethnic groups. Students from other BAME groups were found to be less likely to take this subject. Demack et al’s (2019) analyses also found a female disadvantage in terms of participation and attainment in both A-level Maths and Further Maths. And after taking Key Stage 4 attainment into account, students at independent/fee paying Key Stage 5 institutions were around 1.27 times as likely to take A-level Further Maths compared with state school/college peers. Boylan et al (2016) found that schools with higher numbers of Further Maths students tend to have fewer students from socially disadvantaged backgrounds (e.g. students eligible for FSM, students with SEN). Recent research (Boylan et al, 2016; Hodgen et al, 2020) all strongly points to attainment at Key Stage 4 in Maths and overall is a key determinant to future participation and attainment in A-level Maths and Further Maths. This study aims to gain further understanding of some of the barriers to participation and explore ways to support raising students’ GCSE attainment and facilitate progression to Further Maths A-level.

# **Methods**

The main focus of the study was conducting focus groups with 62 Year 10-13 students from 22 state schools/colleges during Spring and Summer term 2022. We also spoke to four maths teachers to provide some additional information for our study. The study required a more purposeful sampling to get depth and focus to better understand (non)participation in advanced Maths qualifications among students under-represented at Imperial. We targeted students who had expressed interest in STEM or were seen as interested in STEM by gatekeepers, as they are more likely to consider studying (or to be studying) advanced Maths qualifications and to have aspirations to study STEM degrees. We attempted to reach a range of schools and participants from different regions and different contexts, especially students from backgrounds under-represented at Imperial. We have also linked data collected with the external data source, the Higher Education Access Tracker (HEAT) database, which provides additional information on participants based on students’ postcodes and schools. 70% of the students were from the Greater London area, and 82% of the student lived at home postcodes in high levels of deprivation. The majority of students were from BAME backgrounds.

Ethics approval for the project was gained from the College. All participants have been assigned pseudonyms. The research team acknowledge limitations to this project. It is possible that participants who view maths positively were more likely to take part, while those who were less engaged did not.

# **Results - Understanding Further Maths Uptake and Non-participation**

The findings from the study confirms certain patterns from existing literature and provides further insights on certain issues.

## Reasons for Choosing Further Maths

### **A requirement or preferred choice for their university course.**

Among the Further Maths students, many described that Further Maths is a requirement or a preferred subject for their chosen degree courses, particularly at highly selective universities.

“When I was checking universities, their requirements for Computer Science, normally they say Further Maths is an extra thing that you can do, but I know from experience that everyone is going to do the extra if they want to go to university. Imperial ask you to do Further Maths, UCL ask you to do Further Maths, Cambridge ask you to do Further Maths, so if you don’t do it you’re going to be behind everyone else.” **Ade (Year 12)**

### **Benefits to their Maths A-level and/or future study.**

Some students also described that studying Further Maths would be helpful to their Maths A-level and/or their chosen university course, whether it was a requirement or not.

“I knew I wanted to do Engineering at university, and I know it’s very Maths-heavy. So, I thought, it wasn’t required for any of the unis I was looking at. But I thought, if I was studying that, I would be really good at the normal Maths which is required. And if when I get there, even if I don’t get an A\*, the stuff I’ve learnt for that will be helpful in the actual uni course itself.” **Tim (Year 13)**

### **Appreciation of maths**

Some students spoke about the enjoyment they got from doing complex maths.

“I think it’s quite satisfying when you are given a challenging problem or a challenging question, regardless of whether it’s Pure, Stats or Mechanics. Obviously, people have their preferences, but I think the whole concept is that if you do something hard, and you get it right, it’s quite satisfying. So, I enjoy that.” **Kamal (Year 12)**

## Reasons for Not Choosing Further Maths

### **Not meeting the course requirement; course unavailability; competing demands or wanting more options.**

There were a range of reasons why some students did not study Further Maths A-level. Some students did not meet the course requirement at their school/college, and some students were at institutions where Further Maths was not an option. Some eligible students chose to prioritise other demands or preferred to explore more/other subjects.

“I chose not to do further maths because I felt like I was dedicating, not that I didn’t like maths, I just realised I didn’t like maths as much as I liked science. I felt it was too much calculations and I wanted to apply my knowledge more. I mean, I don’t know how it is in Further Maths, but I wanted to spread out my options a bit more. I feel like if I did Further Maths and I didn’t like it, I wouldn’t be able to experience other subjects.” **Joanna (Year 12)**

### **Negative perception and reputation of Further Maths**

Further Maths was being seen as too challenging and out of reach for some students.

“No, I never thought about doing it. Honestly, I kind of thought it was in the name, Further Maths, I don’t know, it was too much for me. And I felt like a lot of the people that do it, I’m not as motivated as them. And I feel like they’re, I don’t know, because I got an Eight as well, so I was like, I feel like loads of people who do Further Maths only get 9s, so I was like, it’s kind of out of the picture for me as well.” **Melis (Year 12)**

### **Workload**

Some students were concerned about the heavy workload and pressure to perform well.

“I would actually be totally okay with doing Further Maths. Only thing is, I want to make sure that I can get the grades because I don't want to be barely scraping it and then already have three topic heavy subjects, and then just continue to just destroy myself mentally if I do Further Maths. Because I know… Have a friend that does Further Maths and he, for him, he doesn't have a lot of free time.” **David (Year 11)**

### **Gender related issues**

The study confirmed that generally there were fewer girls than boys are in Further Maths classrooms. Female participants described that girls sometimes lack confidence or are ‘more careful’, and the male dominant environment might not always be welcoming to some. One of the participants also explained that her cultural background discouraged girls from pursuing ambitious career goals.

## Reasons for Dropping Further Maths

There had been virtually no information on why some students drop out of Further Maths A-levels.

### **Managing workload**

The decision to drop Further Maths could be a strategic one for some students. Some just took Further Maths to improve their Maths A-level grade, and some dropped it as a way to better manage their studies.

“I feel like people drop Further Maths because you do Maths, the whole of A-level Maths in one year (Year 12). So, then the second year, if you drop Further Maths, you can just relax on that Maths side and concentrate on the other two subjects that you’ll have.” **Christina (Year 12)**

### **Decision made by the school**

However, our participants revealed that some students were forced to drop the course if they did not meet a high standard. This contributes to the results of Further Maths A-level having significantly more top marks compared to other subjects.

# **Conclusion – Further Maths capital + habitus?**

We would like to apply a conceptual framework to help us to better understand uptake of Further Maths and to find ways to remove or lessen the barriers to participation. Bourdieu’s[[1]](#footnote-2) theory of social reproduction provides a useful conceptual toolkit to examine relations of different advantages and inequalities, particularly with respect to education. The theory looks at how social relations and practice are produced through the interaction of habitus and capital within field.

**Bourdieu’s ‘thinking tools’**

* **Capital:** The range of cultural, social, and economic resources you have that support engagement in a particular context, and allow you to navigate rules and expectations – the ‘hand’ you can play in the game (e.g. higher education). These capitals are unevenly distributed among different groups in society. The more a person has of capital valued in that particular context, the more likely they would succeed.
* **Habitus:** The ‘feel for the game’ - a sense of what is normal for ‘people like us’. Habitus can be described as embodied dispositions, skills, habits that a person develops through socialisation and experiences, both past and present. Habitus is not fixed and can be both individual and collective (e.g. middle-class habitus). Habitus produces both ‘a sense of the game’ and ‘an ability to play the game’.
* **Field:** The context in which an individual is operating and making decisions, for example in A-level study or Higher Education. The value of capital is determined by the field. For example, the conjunction of working-class habitus and the middle-class field of highly selective university might make some working-class students feel like ‘fish out of water’.

So what kind of resources or capital would support students to choose and succeed in A-level Further Maths? How can we support students to feel like Further Maths is an option for them? What are things the Outreach Department can do to support the uptake of Further Maths, and what are constraints in the education system we have to consider?

## Further Maths Habitus?

“They [people who don’t do Further Maths] might see a couple of integral signs and someone who hasn’t seen an integral sign before in their life, they go oh, what is this? And then, they might think, you must be a genius. You work on this all the time. But once you get introduced to it, it’s kind of second nature to you”. **Jedrick (Year 13)**

Jedrick describes doing complex maths problems becoming second nature to him, which made him feel at ease and normal in a Further Maths classroom, feeling like ‘fish in the water’.

How can we support more students to feel like ‘fish in water’ in Further Maths? From this study, we identified some shared clusters of attitudes and dispositions among Further Maths A-level students, which we interpreted as signalling a potential form of Further Maths habitus. Further Maths students overall have a high level of appreciation of maths (and its applications), and often enjoy the ‘beauty’ or complexity of more advanced maths, as well as overcoming the challenges to find answers. The construction of Further Maths as a difficult or hard subject is longstanding, and difficulty (and difficulty to achieve a high mark) is a strong reason given by some students for decisions not to pursue the subject. Although Further Maths students might not describe themselves as exceptionally intelligent, the general perception from other students is that Further Maths students are ‘clever’ and ‘smart’, which might affect high attaining students who lack confidence and come to see the subject as ‘not for me’. However, it is strongly agreed by everyone that hard work is a major and necessary component for studying Further Maths. There is also an expectation to be challenged and overcome struggles to find answers. Resilience, self-motivation, capacity for independent study and a strong work ethic appear to be crucial to successful Further Maths participation.

However, there is also an expectation (and pressure) to achieve top results, as there is heavy gatekeeping on who could study or continue through a Further Maths A-level. Further Maths students tend to have clear goals for their higher education and career plans, generally in Maths, Physics, Engineering or Computer Science – this also includes students who strategically drop Further Maths after studying it for one year to help their Maths A-level and/or concentrate on their other subjects in the second year. It is also generally the case that fewer girls are studying Further Maths, and the male-dominated environment could reinforce the situation and discourage more girls from pursuing the subject.

## Further Maths Capital

The concept of ‘Further Mathematics Capital’ discussed here is an extension of the concept of Science Capital (Archer et al., 2015) and recent Further Maths research (Boylan et al., 2016). The idea of Further Maths Capital provides a way to understand and organise all the Maths and Further Maths-related resources that a person may have or can develop. The Further Maths capital ‘bag’ holds all of your Further Maths-related interests, knowledge, relations, behaviours and resources, encompassing:

* ***What you know about Maths and Further Maths*** (e.g. GCSE Maths attainment, knowledge of Further Maths curriculum content);
* ***How you think about Maths and Further Maths*** (your Maths and Further Maths-related attitudes and dispositions, e.g. knowledge about the transferability of Maths and particularly Further Maths, understandings of the exchange value of maths qualifications and degrees with high mathematical content);
* ***What Maths/Further Maths-related activities you do outside of lessons*** (e.g. consumption of maths related media, maths related extracurricular activities, tutoring);
* ***Who you know*** (e.g. family, friends or people in your networks with maths related qualifications and degrees; people who talk with you about maths-related topics, others who encourage you to engage and/or continue with Further Maths).
* ***Access to support and provision from education organisations*** (e.g., availability of Further Maths courses and teachers at school, positive maths culture at school, additional support to aid students to attain higher grades).

“Mathematics opens doors (Noyes, 2016).” However, not all students are given equal opportunities to access high-level mathematics qualifications and subsequently high-status commercial, technological and scientific careers. When students have high Further Maths capital (i.e. have been given a ‘good hand’ of maths related resources) and have developed Further Maths habitus (i.e. they ‘just know’ how to carry on and feel at ease in a Further Maths classroom), they would be more likely to participate and succeed in Further Maths A-level. When more students are given the option to choose Further Maths, they are given opportunities to pursue STEM or other numeric degrees or careers. Performing well at Further Maths is also known to ease the transition from A-level into a range of STEM degree courses, setting up students to succeed and potentially lessen the existing attainment gap between White British and BAME students at university. Ultimately, the unequal access to Further Maths is strongly linked to structural issues in the wider education system. However, there are a number of things university outreach departments can do to support students from under-served communities to build Further Maths capital and to develop a Further Maths habitus to enable them to engage and succeed in the subject and beyond.

# **Project conclusions and recommendations**

| **Conclusion** | **Recommendation** |
| --- | --- |
| **Prior/GCSE attainment is a strong predictor for participation in Further Maths A-level and future attainment** | Support to raise prior/GCSE maths attainment (i.e. improve mathematical knowledge, develop skills to tackle complex problems, improve students’ confidence and enjoyment in maths) to give more students the option to choose Further Maths.  This is particularly the case for socially/economically disadvantaged pupils with high prior attainment levels, where achieving a top grade at GCSE could greatly affect their chance of progressing to Further Maths. |
| **The prospect of studying Further Maths is not positively perceived or well understood by many, and some high attaining students might view it as too challenging** | Most students do not have access to GCSE Further Maths or Statistics courses. Further Maths taster sessions or more information about studying Further Maths A-levels (e.g. in-school and extra-curricular activities/ programmes) would be useful to help students to make informed decisions – students can evaluate their interest in the topics they would meet at A-level and to experience the challenge and success with this material in order to reduce the perceived risk of committing to a difficult A-level subject. |
| **There is a gender bias with fewer girls taking Further Maths** | Foster inclusive teaching and learning to help tackle gender and other bias in maths and STEM in general (e.g. meaningful representation of women and girls and people from other underrepresented groups in curricula, educators, and role models); support students in developing a more accurate match between performance and maths self-concept. |
| **Students from schools/colleges with fewer resources (often from more deprived backgrounds) receive no or limited support on choosing A-levels and future pathways, as well as preparing for university applications and additional subject specific exams for selective universities** | Provide more information on the potential benefits of studying Further Maths, including the transferability of the qualifications and high-level mathematical skills, to students and parents to aid them to make more informed decisions; raise awareness of subject requirements for the application process and expected mathematical knowledge required in different STEM degree courses.  Upskill teachers and careers advisors particularly in 11 to 16 schools where knowledge about Further Maths and the progression routes it unlocks may be limited. |
| **Students from schools with a strong maths culture and larger A-level Maths and Further Maths cohorts are more likely to choose and succeed in the subject** | Support schools and teachers to increase the organisational Further Maths Capital at school level to improve access (i.e. more support for teacher CPD to enable more offerings of Further Mathematics, more funding to support more provision of Further Maths in lower participation areas).  Embed maths and the enjoyment and appreciation of maths across the curriculum and school life, not limited to maths lessons. |
| **There is heavy gatekeeping at school/college on who can take and continue Further Maths; the Further Maths results are more skewed than other subjects** | Facilitate conversations with schools and teachers to challenge the less helpful discourse around aspirations, emphasising the importance of high expectations for young people and from their teachers.  School/college and university to examine their current highly selective policies and practices relating to Further Maths and higher education admissions. |

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1. Pierre Bourdieu is a renowned French sociologist and public intellectual who made significant contributions to theorizing the link between education and culture. [↑](#footnote-ref-2)