Report – "Introduction to Mathematics at University"

With the generous support of the Newton Trust Widening Participation & Induction Fund we were able to run a residential Mathematics outreach programme for Black, Pakistani and Bangladeshi students aiming to study Mathematics, or a related subject, at University. This programme, run during 29th July to 1st August 2024, was a joint endeavour by the Faculty of Mathematics, Newnham College, and Churchill College, based on an online programme run by the Faculty since the summer of 2020, which the INT grant enabled to become residential, thus offering participants the opportunity to experience live classes in the Faculty and life in a Cambridge College, and interact more meaningfully both with each other and with the Cambridge students who helped throughout.

The programme was advertised on the CAO event listing page, to Target Oxbridge, and to Churchill College and Newnham College area link schools. Teachers and Target Oxbridge could nominate students in Yr12 who self-identify as Black, Pakistani and Bangladeshi (including mixed race), who were studying Mathematics and Further Mathematics at A Level or equivalent (Mathematics Analysis and Approaches for IB students). Priority was given to applicants according to the following WP flags: Care experienced, Refugee status, Free School Meals, IMD, and attending a maintained sector school. Of 40 applicants selected, 2 dropped out because of illness close to the start of the programme, so eventually only 38 attended. To my knowledge, no students who had experienced care or were refugees applied, but all admitted met at least two of the other criteria.

Unlike the previous incarnations of this programme, which started online in 2020 because of COVID restrictions, and remained so until this summer 2024, attendees were not roughly evenly split by gender, but followed the more usual pattern for Mathematics outreach events in Cambridge, with a female cohort of about 32% of the total. This may well be a consequence of requiring students to be studying Further Maths (or equivalent), since the percentage of female students taking Further Maths at A level in 2024 is only about 27% (and in fact down from about 29% in 2020). Previously, whilst we recommended that students should be studying Further Maths, we did not make it a requirement. We may reconsider the value of changing requirements, in order to attract more female students and possibly persuade them of the value to engage with Further Maths in Yr13.

The programme was quite academically intensive and included two 'mini courses', with exercises, one on a pure maths topic, one on an applied maths topic; interactive problem-solving sessions designed to support students to develop their mathematical thinking and their confidence; a supervision in groups of two students, on a problem sheet with STEP-style questions; two mathematical talks by Cambridge mathematicians, a talk about Mathematics at University and a Q&A session about applying to Cambridge and what interviews are like; a games evening with student mentors, and a film evening. The full timetable is attached.

Two main aims of the programme were:
- To help students develop their mathematical thinking and their confidence in tackling STEP questions and new mathematical topics, and to encourage them to engage with

the STEP Support Programme and other online resources for mathematics. We hope that this will increase their success rate in application to highly selective universities, especially those which require additional tests such as STEP, TMUA or MAT, and contribute to decreasing the awarding gap once they are admitted.

- To help students have a positive perception of a university such as Cambridge, which is often perceived as a place which is not 'for people like them', and feel a 'sense of belonging' in a highly academic environment.

We conducted two surveys, one before the start of the programme and one after it ended, to gauge the success of our aims and to obtain feedback that would help us improve what we offer in the future. We asked the following questions in both surveys:

Q1: I am confident in my ability to understand challenging topics
Q2: I am confident in my ability to solve complex mathematical problems
Q3: I am confident in my ability to discuss my thought processes with other Year 12 students when solving mathematical problems
Q4: I am confident in my ability to discuss my thought processes with student ambassadors when solving mathematical problems
Q5: I am confident in my ability to discuss my thought processes with a professor/lecturer when solving mathematical problems
Q6: I will apply to university
Q7: I will apply to study Mathematics or a related course at university
Q8: I will apply to one or more Russell Group universities
Q9: I will apply to Cambridge
Q10: I have a clear understanding of Cambridge's undergraduate application process
Q11: I have a clear understanding of what the University of Cambridge is looking for in prospective applicants
Q12: I have a clear understanding of how Cambridge applicants are assessed
Q13: I have a clear understanding of how to prepare for an interview
Q14: I have a clear understanding of the importance of STEP
Q15: I have a clear understanding of how to prepare for STEP

with replies on a 6 point scale ranging from 'Extra unconfident' (0), 'Unconfident' (1), 'Somewhat unconfident' (2), to 'Extra confident' (6)' (or equivalent, according to the question).

The response rate was high enough to be meaningful and useful for measuring the effect of the programme in some of its aims: 28 students completed the pre-event survey and 26 students completed the post-event one. Further, we know that around 50% of the attendees have applied to Cambridge, mostly to study Mathematics, but also NST (Physics), Computer Science, and Engineering. This meets beyond expectations our initial aim that at least 30% should apply to Cambridge. Judging from the responses, we expect almost all the rest to apply to other selective University. We will be able track outcomes eventually from the HEAT database.

The results from Q1 to Q15 are summarised below in two charts, to compare attitudes before and after attending the programme. It is immediately apparent that all attendees already had high expectation of applying to a selective university, and many of applying to Cambridge. This remained largely unchanged, with only a marginal decrease in those intending to apply to Cambridge (19 out of 28 'Confident' or 'Extra confident' beforehand, compared to 15 out

of 26 afterwards). Such small decrease in those wishing to apply should be seen as a positive result, probably reflecting that those who feel that the very intense and fast-paced nature of the Mathematics Tripos is not something they would enjoy or thrive in have been able to make a choice that is likely to lead to better satisfaction and eventual outcomes for them.

The rest of the questions show a marked positive shift, with the post-event survey chart almost completely devoid of responses in the (0) to (3) range. The most striking changes are in the students' confidence in their ability to understand challenging topics and to solve complex mathematical problems (Q1 & Q2), in their understanding of how Cambridge applicants are assessed (Q12), of how to prepare for an interview (Q13), and how to prepare for STEP (Q15). This clearly meets our initial aim that at least 70% of participants should report increased confidence in tackling challenging problems.

Pre-event survey - questions 1 to 15

Post-event survey - questions 1 to 15
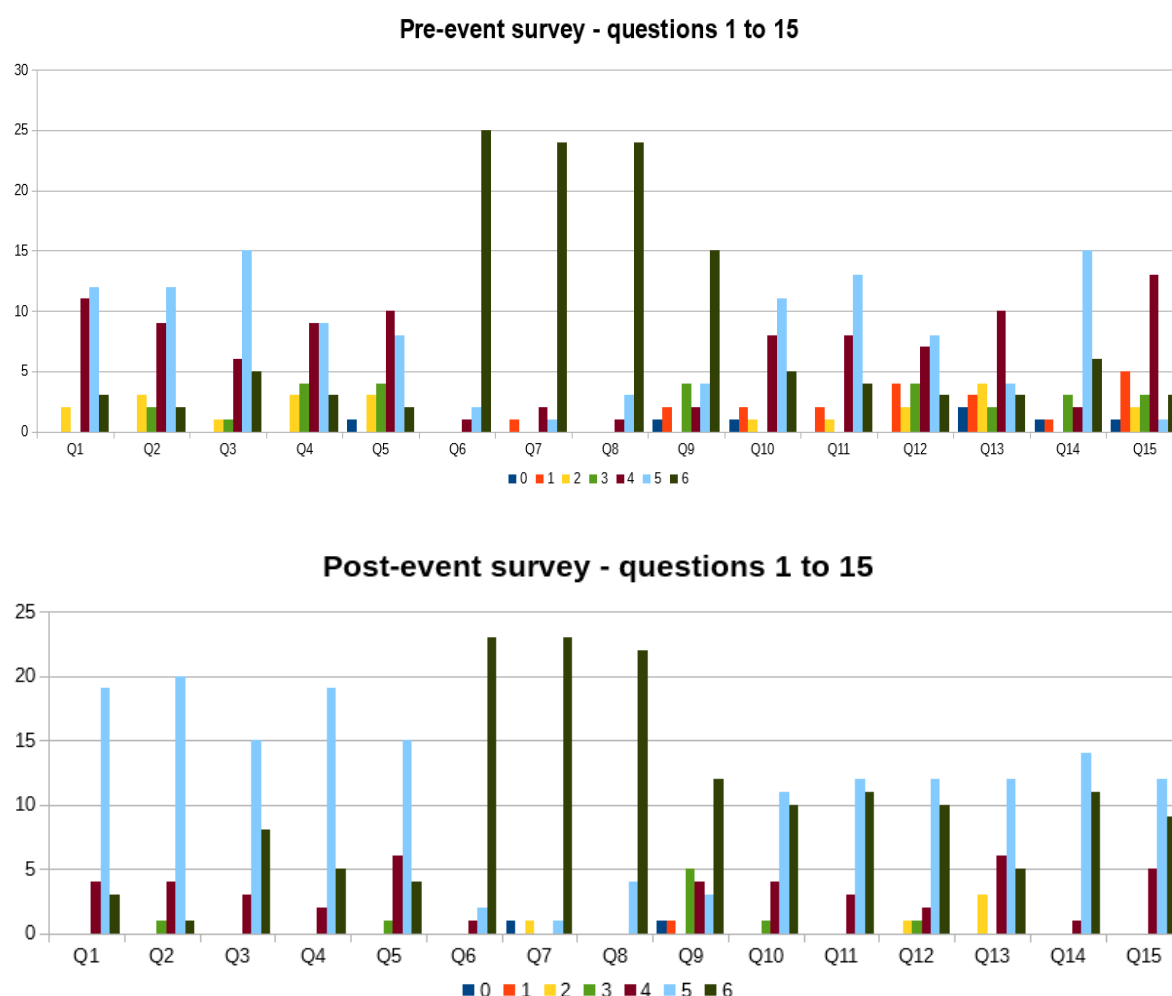
The post-event survey also had additional questions, with replies on a 4 point scale ranging from 'Very poor' to 'Excellent', to help us gauge how the different parts of the programme were perceived, and a number of free field questions to help us understand what work best and what could be improved. Results for these are summarised below.

Post-event survey - questions 16 to 18
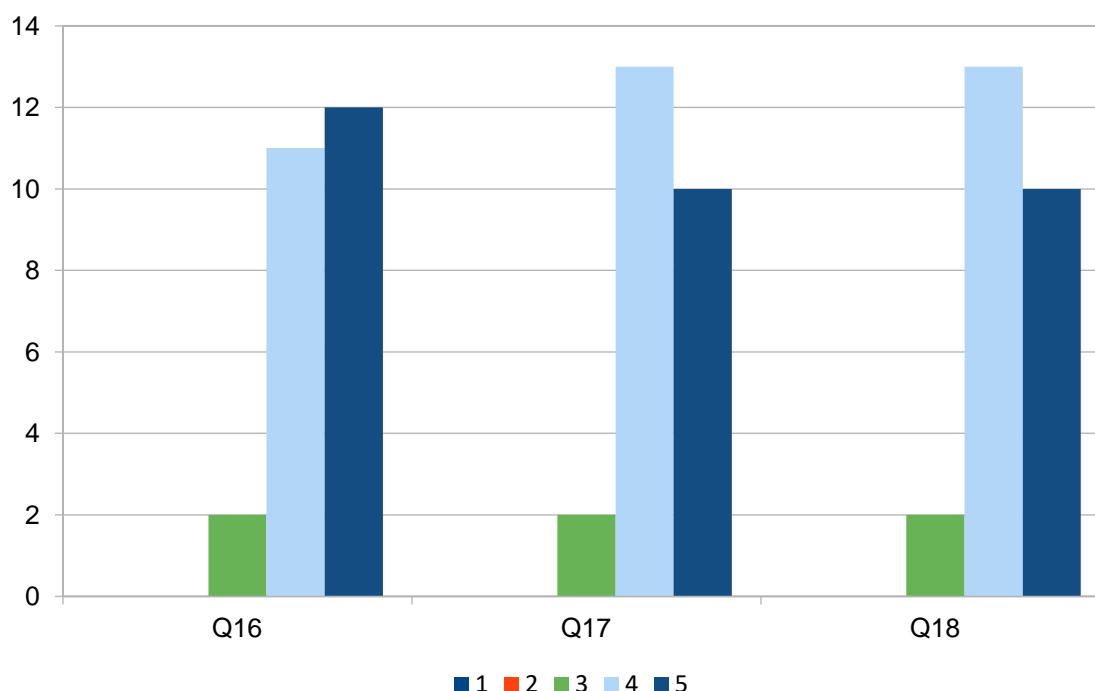
Q16: How would you rate the Maths lectures?
Q17: How would you rate the STEP session on Monday?
Q18: How would you rate the session on admissions and making applications on Thursday?

The additional free-field questions were:

Q19: What did you enjoy most about the residential?
Q20: What did you find most useful about the residential?
Q21: Is there anything you think we could change about the residential to make it better for future?
Q22: Is there anything else you'd like us to know?

From these, we learned that the students particularly enjoyed and appreciated interacting with other students, both current Cambridge students and students from other schools in the UK, and being taught by Cambridge mathematicians.

Particularly appreciated was also the academic content, which gained high scores both for enjoyability and for usefulness, especially so the supervisions and STEP preparation. Participants also appreciated the non-academic parts of the programme, and particularly the Formal Hall.

Overall this proved highly successful in meeting its main objectives and reaching the target audience, and was well received. One potentially beneficial change might be to return to recommending, rather than requiring, applicants to be studying Further Maths, as this requirement may have contributed to the drop in percentage of female applicants. Some students mentioned that they would have liked to experience a mock admissions interview, and this is something which we will also consider.

Intro to Maths at Uni 2024:

Start Time	Mon 29 July	Tue 30 July	Wed 31 July	Thu 1 Aug	
		Breakfast- packed lunch collected Walk to Department for sessions to start at 9:30am			
		MR5 (1.5hrs)	MR5 (1.5hrs)	Central Core	Central Core
09:30		"Introduction to mathematical reasoning" Lecture and student exercises *Owain Salter Fitz-Gibbon*	"Introduction to mathematical reasoning" Lecture and student exercises *Owain Salter Fitz-Gibbon*	Supervisions (1 hr)	Supervisions (1 hr)
10:00					
10:30					
11:00		Break	Break	Break	
11:30		MR5 (1hr) "A serious approach to the zombie apocalypse using differential equations - an introduction to applied mathematics and modelling" *Alison Ming*	MR5 (1hr) "A serious approach to the zombie apocalypse using differential equations - an introduction to applied mathematics and modelling" *Alison Ming*	MR5 (1hr) Admissions & STEP, making a University application, with Q&A *Orsola Rath Spivack & current students*	
12:00	TRAVEL				
12:30	*Arrival and registration (in College)*	Lunch		TRAVEL	
13:00					
13:30		MR5 - (1hr) "Tiling Problems" *Mansur Boase*	MR5 - (1hr) "Voting, and Arrow's impossibility theorem" *Kweku Abraham*		
14:00	*walk to CMS*				
14:30					
15:00	MR5 (1hr) STEP workshop	Break	Break		
15:30		MR5 - (1.5hrs) Problem solving/ Team work	MR5 - (1.5hrs) Problem solving/ Team work		
16:00	*Icebreaker / Games*				
16:30					
17:00			*Walk back to Colleges (and free time in College)*		
17:30	*Walk back to Colleges (and free time in College)*	Walk back to Colleges, get ready for dinner			
18:00					
18:30	Dinner		Dinner		
19:00					
19:30	Film	Fornal dinner at Churchill College	Work on Maths problems		
20:00					
20:30					
21:00					
21:30					