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Progression through a mathematics specialist school

A case study of trajectories of the first two cohorts through King's College London Mathematics School

Dr Jennie Golding
UCL Institute of Education

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Jennie Golding October 2019
j.golding@ucl.ac.uk

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EXECUTIVE SUMMARY

King's College London Mathematics School was, when founded in 2014, one of only two state-funded specialist mathematics schools in England, with key purposes of enhancing equitable access to competitive mathematics-intense course in universities, and enhanced retention in mathematical pathways of young people with significant mathematical aptitude. In 2019, the first students from the initial cohort graduated from university. This study sampled KCLMS alumni from the first two cohorts to capture their reflections on their pathways to, through and beyond KCLMS to Spring 2019. It used a googlesurvey open to all such alumni, which netted 26 responses, together with slightly more in-depth interviews with a stratified sample of 6 alumni then at each of Oxford and Bristol universities, as a cluster sample. In both cases, alumni were overwhelmingly generous with their time and the depth of reflection offered. We do not know how representative the sample achieved is. However, findings suggest:

Pre-KCLMS

- A mixed level of contact with the school of KCL pre-enrolment or pre-admission.
- School or KCL outreach activities were key motivators for about half, with other enrichment opportunities also key motivators in building awareness of, and commitment to, mathematics as more than routine GCSE mathematics.
- Application to KCLMS was often linked to critical enrichment experiences, from whatever source – or else was via an influential teacher or parent.
- 'Switching on' to mathematics appears usually to have stemmed from enrichment, and especially, mathematically challenging additional experience, though 'being unusually good at' more standard school provision was also instrumental for some.

In-KCLMS:

- Early days at KCLMS were daunting for most, but students appreciated induction provision.
- Most found the concentrated mathematical community surprisingly 'normal' and affirming, though for a small minority it remained unhelpfully niche or aspirational. The restricted nature of the curriculum was acknowledged as a challenge for targeting entry more widely. 'Other' subject support was important and had perhaps been less effective than for mathematics.
- Most alumni had developed deeper, more rigorous and satisfying relationships with mathematics through KCLMS core deep, rigorous, problem-solving focused provision, akin to, but different from, the satisfaction gained from enrichment opportunities.
- Teacher and visiting expertise was highly appreciated, while respondents also talked about the pedagogic limitations of some inexperienced teachers, including academics unused to communicating with 16-18 year olds.
- Students largely felt they had been well-supported in finding appropriate aspirations/university pathways, although some still regretted limited encouragement to apply to Oxbridge. Those who had taken, or studied for, additional university entrance papers had enjoyed the experience but students were clear they needed to prioritise optimum performance in A Levels.
- Participants offered a range of relatively small ideas to enhance experience further, focused around broader experiences and skills to better support long term whole-person development (Section 4.2.7 in this report).

Post-KCLMS:

- For most, transition to university had been a socially and academically relatively smooth process, perhaps via a refreshing 'gap year'. In HE, small Oxford cross-discipline collegiate communities, and small-group tutorials, were particularly appreciated. All seemed content with the pathways followed to this point.
- HE conversations had increased participants' appreciation of the quality of the mathematical and learning experiences they had experienced at KCLMS, and the mathematical confidence endowed.
- The rigorous and problem-solving approaches privileged at KCLMS had supported participants well in transition to university mathematical expectations, as had the work ethic and community inter-dependence, though some thought the development of more independent study skills would have been useful.
- Although not directly alluded to, it was apparent from much of what was said that KCLMS had, probably with one exception, supported development of a robust and well-founded mathematical (or mathematics-user) identity and confidence that had been helpful in adjusting to university.
- Inevitably, individuals' relationships with mathematics had changed, and often fluctuated, over their time at university, depending in part on their course. For those studying courses with high mathematical content, relationships with mathematics had often become highly fulfilling.

'The Big Picture':

- Participants overwhelmingly thought KCLMS had, in their time, fulfilled its mission of enhancing equitable access to mathematically-rich HE courses. Some were sceptical of the potential for maintaining that once outstanding examination and HE entry results were established.
- In terms of retaining students on mathematical journeys, participants felt effective provision had supported an inclination to persist in mathematical engagement, but none reported feeling pressured to continue in pathways other than those to which they were at that stage best suited.
- At the stage of data collection, some clearly felt ready to move out of education while others were keen to progress into research. Beyond-university career aspirations were varied and often ambitious, but these young people all appeared confident, and well-prepared, for their planned pathway, with many effusive about the foundation for that given by KCLMS.

1. Introduction

In 2011, as vice-chair of the Advisory Committee for Mathematics Education, I was invited to an exploratory meeting at the Department for Education at which international provision of specialist mathematics schools, primarily in Eastern Europe and Russia, was discussed, with a view to possibly setting up such schools in England. As a classroom-based teacher I had for a long time worked on trying to expand the quality of provision available to young people in ordinary circumstances and ordinary schools who showed signs of unusual aptitude for mathematics, so this for me was an exciting move. An invitation to propose suitable collaborations and locations for a related initiative in England was duly issued, and as a result, England's first two specialist mathematics schools, sponsored and supported in particular by King's College London and by Exeter University respectively, were launched, with their first intakes in September 2014. They are very different from their counterparts in eastern Europe and Russia, not least in that they offer fulltime provision only for students aged 16-18, rather than the much earlier and more extended provision offered elsewhere. Key aims were to increase equity of access to high quality and aspirational mathematics education, and to better support continuation in richly mathematical post-school pathways of those young people deemed to have high mathematical potential.

These two 16-18 mathematics 'free schools' have operated in very different contexts and circumstances, subject to the standard Ofsted inspection regime evaluating their in-school provision. But at a time when their first cohorts are graduating from university, and several other new mathematics schools are, not without controversy, set to join the original two[1], it seemed appropriate to ask, looking beyond schooling, '*What are these specialist mathematics schools in England offering for mathematically-rich student progression?*'

Quantitative data on these young people's progression is in the public domain, but while the school had been regular in soliciting feedback during students' two years at the school, the more nuanced qualitative perceptions of longer-term student progression attitudes, motivations and engagement, particularly as presented to an outsider, were comparatively untapped. We therefore set out to harness the lens of some of the young people who had participated in early provision of this sort, taking our sample from those in the first two cohorts at the King's College London School – hereafter referred to as KCLMS. We frame the following account as an interpretivist one: any such data collection is subject to participants' selection and presentation of their experiences, and to its interpretation by the researcher, no matter how hard the researcher attempts to adopt 'distance' from the situation. The account presented here is, therefore, co-constructed by the participants with me; it has, however, been offered to all participants who shared their email addresses, for their validation via the pseudonyms adopted here. The approach harnesses the voice of KCLMS alumni, in line with recent approaches in education research that privilege 'student voice' as one of underlying respect for the key beneficiary of the specialist mathematics school project – but it is only one of several voices that need to be considered in education policy terms. Related issues, including the status of the knowledge acquired through these approaches, are discussed further in Chapter 3 (Methodology).

[1] https://www.gov.uk/government/news/top-universities-urged-to-open-new-maths-schools
https://emps.exeter.ac.uk/mathematics/news/archive/2013/title_319679_en.html
https://www.tes.com/news/all-students-should-receive-excellent-maths-teaching-not-just-those-specialist-maths-schools

We asked about critical mathematics- and pathway-related experiences and influences pre-KCLMS, during their time at the school, and since then, and about their plans for the future. KCLMS is a unique educational institution in England, and very different from Exeter Mathematics School which, rather than drawing on KCLMS's densely-populated multicultural, aspirational and thriving city and its surrounding area, has as its catchment area a sparsely-populated, economically challenged region where aspirations are typically low. Similarly, the curricula adopted at the two schools are quite different one from the other. Consequently, the findings here are indicative of those from early cohorts of KCLMS, and not necessarily more widely generalizable. Nevertheless, the thrust of many responses is not dependent on the details of situation or of curriculum; responses have something to say about the quality of mathematics education to age 16 of those who have particular mathematical aptitude, they detail some of the opportunities and constraints associated with the KCLMS initiative, suggest that the first two years were widely successful in meeting its aims for the medium-term, and are broadly very encouraging for the future of such schools, at least in relation to the students concerned.

In the medium-term, these findings should be situated in the wider literature surrounding provision for young people with particular mathematical aptitude, pre-university. We engaged with the wider evidence base before, during and after the study, and will harness that more deeply when writing for an academic audience, but offer a bibliography to the interested reader as Appendix 3.

In what follows, the substance of evidence lies in chapter 4. Chapter 2 presents the background to KCLMS's existence, and outlies the motivation for the research questions adopted, and chapter 3 the methodology, including the approaches adopted in relation to ethics. Chapter 4 is organised by phase of experience (before/at/after KCLMS, and 'the big picture'), and within that, by research sub-question. Finally, chapter 5 offers a brief overview and discussion of the findings, including in the light of the constraints and affordances exposed in chapter 2.

2. Background and Research Questions

It is important to realise that the KCLMS curriculum, core and wider, available to the first two cohorts has changed somewhat over time. From its inception, all students study for Mathematics and Further Mathematics A Levels; almost all historically, and at present all, study for Physics A Level. Other options over time have included Computer Science and Economics to AS Level, and sometimes one or both of those has been available at A Level. Beyond the core curriculum, there have always been a number of enrichment opportunities in both year 12 and year 13, and the early students below comment on both the experimental and transitory nature of some of their additional opportunities, inevitable in a new model of institution.

Widespread mathematics enrichment, including from visiting speakers and postgraduates, and preparation for additional university entrance papers in mathematics and physics, whether eventually taken or not, for the UKMT-run Senior Maths Challenge and maths and physics Olympiad papers, have been offered from early days in the school. KCLMS currently offers all these, support for the Informatics Olympiad, 'Curriculum X' that takes students well beyond A Level in each or any of their study subjects, and the 'King's Certificate' for all, a substantial collaborative research-based project undertaken in year 12. Some year 13 students also take the AS-equivalent Extended project Qualification.

Sport and wider physical education are now more systematically provided for than in the early days reported here, and there are a wide variety of clubs and societies ('Robotics Club, where students build and programme Lego EV3 robots, Drama Club, Board Games Club, Philosophy Club, Cryptic Crosswords Club, Chess Club, Anime Club, Art Club, Book Club, Film Club, Latin Club, Astronomy Club..'). Students also enjoy a now well-developed pastoral and 'futures' support structure. Some of these developments build directly on those experienced by alumni in the first two cohorts; others address some of the reservations evidenced below.

For some years prior to the inception of KCLMS, KCL itself provided mathematics enrichment classes for students in years 10 and 11. From its early days, KCLMS set out to complement those with a range of 'outreach' and enrichment opportunities for local students, including those who might eventually apply to come to the school. For the two cohorts studied her, such opportunities were of course limited, though below participants evidence the impact of 'taster days', weekly problems, and even specimen entrance tests. Current provision is much more extensive, described on the website as:

GCSE enrichment for students: An extensive programme of enrichment for GCSE students from numerous partner schools, with classes running on weekday evenings for students in years 9 to 11. Applications for 2019-20 will open soon.

Mathematics Circle: Our mathematics circle is a group of young mathematicians who meet fortnightly to engage collaboratively in mathematical thinking. Applications for 2019-20 will open soon.

SEVEN+: A 3-day Easter GCSE revision course for Year 11 students focusing on problem solving and exam preparation which will make the difference between a high GCSE grade and a very high GCSE grade.

Mathematics Summer School: A week-long summer school at the start of July for students in year 10 who attend our GCSE enrichment, and anyone else we have room for!

PHYSICS+: A summer school at King's College London for Year 11 students who want to study Physics A-level. The summer school is for students who are from backgrounds currently under-represented in the study of Physics.

There are also outreach opportunities for teachers, described at https://www.kingsmathsschool.com/activity/outreach-for-teachers: important since many mathematics teachers, while largely meeting DfE requirements that they have a nominal 50%+ of their first degree course in mathematics, are under-equipped for teaching school mathematics at the highest levels – or with challenge and engagement for those with most aptitude for mathematics (Ofsted, 2012); it is also the case that in general, teachers in advantaged schools are more experienced – and often more effective – than those in deprived schools (Sutton Trust, 2018).

Aspirations to equity of access are clear in the dissemination of such opportunities, e.g. for GCSE enrichment: 'If you are coming to the end of year 9, you can apply to join us in year 10. If you are coming to the end of year 10, you can apply to join us in year 11. Since our mission is to widen participation in mathematical degrees and careers, we'll prioritise places to students who: – do not have parents(s) or carer(s) who have studied at university – have been eligible for Free School Meals in any of the past 6 years – live or have lived in local authority care, are a young carer, or are disabled'. The extent of achieved participation, both in outreach and in KCLMS entry, by particular characteristics, including by gender and by SEND , is harder to find. It is important to understand the impact and effectiveness of such outreach activities – in time not only on those young people who eventually study at KCLMS, but on the others who take part and then complete their school education elsewhere.

In terms of student attainment at the school, Ofsted evaluation of the quality of educational provision, and student access to the most competitive mathematics-intensive university courses, there is no doubt that KCLMS has been successful in its first five years: Appendix 2 reproduces attainment summaries for the first four graduations, as well as headlines from the first (and to date, only) Ofsted report. Implicit in those attainment summaries is information about the changing nature of the available curriculum, although Mathematics and Further Mathematics A Levels remain at the heart of that. Importantly, since most entrants to the school are high-attaining, and are selected largely on the basis of their mathematical potential, those attainment summaries also point to unusual 'value added' attainment, that is, attainment that is better than would nationally be expected on the basis of students' prior attainment.

That state-funded mathematics education in general in England is not in the healthiest state is evidenced by successive Ofsted subject reports (Ofsted, 2008, 2012), and for some years there has been robust debate within the mathematics and mathematics education communities about the scope and nature of provision for the most mathematically inclined, in particular[2]. Even if young people who have been relatively successful in school mathematics choose to pursue mathematics-intensive course at university, the experience is often far from successful, and retention rates are not good. Solomon and Croft (2016) evidence significant challenges in supporting young people's engagement with mathematics through university:

- School mathematics teaching often produces alienated relationships with mathematics
- University students comment on a shift from calculation to theory as a shock.
- Many embrace change and describe a desire for greater ownership of mathematics
- But there is little evidence of support in either school or university for developing access to mathematical meaning-making
- Disengagement reflects failure to reverse alienation from the activity and product of mathematics[3].

[2] Borovik, A.V. & A. D. Gardiner (2012) Mathematical abilities and mathematical skills, The De Morgan Journal 2/2, 75{86. ISSN 2049{6559. http://bit.ly/2jTYy4r.

[3] Solomon, Y. and Croft, T. (2016). Understanding undergraduate disengagement from mathematics: addressing alienation. *International Journal of Educational Research 79*, 267-276

Such challenges are not unique to England: indeed, much of the western world[4] reports similar 'leakage', superficial engagement with mathematics, and other threats to participation at the school-university interface.

Taken together, it is clear that KCLMS has developed in ways that are distinctive to their mission and context, though these are not always fully supported by those who are influential in the field: for example, Borovik (2017) argues such young people would be better provided for with tuition by university lecturers, in classes drawn from the wider area – and that such tuition should start from the early teens.[5] In the light of KCLMS's claimed key purposes, then, it was important for this research to address and understand each stage of alumni's journeys, from pre-application engagement with mathematics, though and beyond KCLMS. At the time of the study, almost all participants were in their last or penultimate year of study as an undergraduate.

In England, but also widespread internationally, the 'pipeline' in the supply of mathematically well-equipped graduates, is leaky at both the school-HE interface and in retention through university courses (di Martino and Gregorio, 2019; Gueudet, 2008; Koichu & Pinto, 2019; Rach & Hinds, 2017).Possible causes and pre-emptive approaches to addressing those have been explored in the literature, but without many clear conclusions, certainly in terms of necessity and sufficiency (Alcock et al, 2020; Biza et al, 2014; Davis et al, 2009). We anticipate that this study will have a contribution to make to that knowledge base.

In consultation with the school's Headteacher, then, the following research questions were adopted:

What can a specialist mathematics school in England education offer for mathematically-rich student progression?

- *What have been the pathways and critical incidents/experiences for the first cohorts of graduates in relation to progression to, through and from KCLMS since they left in 2016 or 2017, and in what ways did their experiences at/with the school impact those?*
- *What are their perceptions of*
    - *Impact of KCLMS outreach activities,*
    - *KCLMS's role in broadening equity of opportunity (social and economic agenda)*
    - *impact of KCLMS's concentrated mathematical community*
    - *impact of KCLMS teacher expertise*
    - *their own affective development in relation to mathematics*
    - *their transitions from school to university*
    - *their own and their peers' retention on the 'mathematical journey'*
    - *other features of their mathematics school experiences that students perceive to have been distinctive?*

[4] Gueudet, G. (2008). Investigating the secondary-tertiary transition *Educ Stud Math 67*/237-254. https://doi.org/10.1007/s10649-007-9100-6; Koichu, B. &Pinto, A. for EMS Education Committee (2019). *The secondary-tertiary transition in mathematics: What are our current challenges and what can we do about them?* https://euro-math-soc.eu/sites/default/files/STT-survey-%2015-02-2019.pdf

[5] Borovik, A. (2017). What can specialist mathematics schools give to students that mainstream schools cannot? *The De Morgan Gazette 9*/4

3. Methodology

The vast majority of KCLMS alumni go on to Russell Group universities. Since the experiences of the first cohort were clearly unrepresentative of later cohorts, it was decided with the Headteacher that the sample for in-depth interview would be from all students in the first two cohorts, looking to achieve a stratified sample across students who had progressed to either Oxford or Bristol, as representative of Oxbridge or other Russell Group universities, so affording a stratified sample of typical KCLMS graduate destinations. Similarly, it was decided to invite all alumni from the first two cohorts (~120-130 in all) to participate in an online survey. For manageability, it was agreed interviews would be restricted to about six from each target university, recruiting probably the first six to volunteer, unless that produced a clearly unrepresentative (for that university) sample.

For ethical reasons it was felt that research tools should be developed jointly by the researcher (JG) and the headteacher (DA), and that all email contacts would be initiated by the school administrator (MM). For the googlesurvey students were given the option of providing name and/or contact details, if they wanted to be notified of research outcomes, and for participant validation purposes, but otherwise, could remain entirely anonymous. The googlesurvey was under the editing control of the researcher, again for ethical reasons, so that the school has not seen original responses. In the case of potential interviewees, the Headteacher forwarded positive responses to the researcher. In that way, the researcher, although DBS-checked, would only have access to student names and contact details when students opted into that. The administrator transcribed interviews with an understanding of confidentiality, and reports here are under pseudonyms; they were offered to participants for validation, giving the individual access to his or her pseudonym. However, the details given are such that it is possible that other staff or students from the school will recognise the interviewee concerned, and interviews were undertaken with participant knowledge of that possibility.

Interviews were arranged in a neutral venue in Oxford or Bristol as appropriate, and at a time mutually convenient to interviewee and researcher. In fact, because of train failures on the line to Bristol, most Bristol interviews had to be conducted by Skype rather than, as planned, face to face. Received wisdom is that responses by those unknown to the interviewer tend to be more superficial when conducted remotely than in a face to face interview as planned. Our experience was that students interviewed in this way were very forthcoming, perhaps because rapport had been built up with the interviewer over a number of emails, though their responses were overall more concise than those achieved from a face-to-face encounter.

Study research activities therefore took the following form:

- **November/December 2018:** JG drafts googleform (GF) and email contact content, and JG makes ethics submission; DA and JG develop GF and contacts jointly.
- **January 2019:** MM approaches all 2016 and 2017 KCLMS alumni a by email asking them to participate in a googlesurvey which would both inform and justify future planning and suggest possible 'stories' that would be of interest to current students. *Deadline:* end of January.
- **February/March 2019** In parallel, MM contacts all from those cohorts attending Bristol or Oxford asking if they'd be prepared to share their stories in more depth in a face to face (audio recorded) interview lasting ~20-25 minutes, at a time and in a place convenient to them on a given day from a choice (say 5/6 interviews per university). Design detail of interview informed by initial survey outcomes.

- **March 2019:** Interviews conducted (one day in each of Bristol and Oxford was planned), then transcribed by the school administrator. Given low response rate to date, DA reminds alumni about google survey.
- **April/May:** transcription of interviews.
- **Summer 2019:** analysis, interpretation and communication of outcomes.

The study resulted in 12 recorded interviews and 26 completed Googleforms from other KCLMS graduates. 26 Bristol or Oxford undergraduates offered an interview; those not accepted for interview were encouraged to complete the survey instead; in fact only 3 did. With one exception, where communications were not sustained, those accepted for interview were the first six volunteering from each university, as that also gave a balance of gender and of cohort, and a spread of mathematics and other degree courses, so comprising a purposive sample. The study is therefore based on responses from a total of 38 KCLMS alumni.

Interview transcriptions were from 6 undergraduates from each of Oxford and Bristol, in each case 3 females and 3 males, and in each case 3 alumni from the first cohort and 3 from the second. The Bristol sample included 4 studying mathematics, sometimes with another subject, and the Oxford sample, 3. The other 5 interviewees were study Computer Science (2), Engineering, Physics or Economics, so were heavy 'users' of mathematics': below, they reflect on how that influenced their developing relationship with the subject.

The 26 completed Googleforms were in 16 cases from the 2016 graduation and in 10, from the 2017 graduation. Gender is not always known, but all bar two were at the time of completion based at a Russell Group university: 1 more from Oxford, 5 more from Bristol, 2 from Cambridge, 5 from Warwick and 2 from Bath. 13 of these 26 were studying mathematics and all respondents, for degrees with a high mathematical content. It will be seen below that some of the responses given were quite extensive, with undergraduates obviously keen to share their experiences and reflections in some depth: this again points to the possibility of atypicality of respondents. In places, the punctuation or spelling (but not content) of quotations given are 'standardised' for ease of reading. Survey respondents are identified as S7, S18 etc, whereas interview participants are referred to by pseudonym that might or might not align with an individual's gender or ethnicity. We often refer to participants as an inaccurate plural 'they' rather than the more awkward English 'he/she' – again, for ease of reading.

Analysis and interpretation

Above, we have broadly described the motivation for our research questions. Initial thematic analysis was, therefore, by research sub-question as in Chapter 2, with sub-themes then identified in a grounded way. Resultant development of interview schedules from survey responses was less extensive than anticipated, partly because response was slow – much slower than for interview request – and window for iteration limited by the ethical requirement to complete fieldwork before the Easter break and so end of year examination preparation. However, survey responses when they did arrive tended to be far more extensive than is typical in education research where the participants are unknown to the researcher (though known to the requester), so that it was easy to use those as prompts at appropriate places in interviews. Subsequent analysis involved visiting and re-visiting all data in an attempt to bring alternative lenses to it.

However, such analysis is deeply selective and subjective, as in an interpretivist paradigm: 'Who is speaking to whom turns out to be as important for meaning and truth as what is said; in fact what is said turns out to

change according to who is speaking and who is listening' (Alcoff in Fielding, 2004a, p. 300[6]). This is particularly pertinent for this study since, as evidenced below, staff at KCLMS very actively solicited students' views during their time at the school – but this is now, and to an outside listener. So what is said or heard is different – not better - and selective on both sides, and represents how these young people choose to portray their experience at one point in time, to one outsider. The nature of that outsider is also a consideration: in order to begin to understand the worlds of these young people, it was necessary to use a researcher familiar with the education system in this country, with higher education and policy in relation to the mathematically inclined, and with mathematics itself at university level. Inevitably, this placed the researcher in a position of power relative to participants, derived from experience and an enhanced overview of these areas, if a novice in terms of their in-KCLMS experience. As one with such a knowledge base, messages and implications of the voices used might have been lost though research selection and interpretation – even if not screened out by participants.

However, it will become clear that even allowing for participant selection for the specific listener, there was among the participants a multiplicity of such voices, with no widespread unanimity among these young people but a variety of lenses, ….and critiques. Further, those who chose not to participate, for whatever reason, leave a 'voice of silence' which is not represented here.

It is also necessary to voice a further note of caution about the words used in different contexts and transferred here: they also represent just a snapshot in time, and in alumni's responses to a request for validation of the use made of their words, there was already a shift in positioning from some, including from one who positioned himself as 'adopting the voice of my teenage self and now trying to adopt a more mature view' – although his voice as reported here is the original voice of Spring 2019. In other words, this report would read differently again if the views of KCLMS alumni were being sought now. Further, we were only soliciting the views of students who were successful in applying to KCLMS (and to self-selecting alumni within that). What they say has implications for the further development of KCLMS, but not in a robust way for those young people who chose not to apply, or who applied and were not admitted – or for the students and teachers at the institutions they would otherwise have attended. Nor do findings from these KCLS alumni necessarily transfer unproblematically to other mathematics specialist schools: a considerable corpus of work testifies to the 'London effect' of comparatively well-resourced schools, densely situated so that many young people in the London area have genuine choice of school or college at each stage, and enrolling a large proportion of second or third generation 'Brits' whose families are aspirational for them, and confident in the power of education to effect social mobility. That density of post-16 institutions also protects from undermining of viability of mathematics teaching groups elsewhere, and from unreasonable impoverishment of richness, of peer challenge, of community, and of viability, of the remaining mathematical A Level groups, or of mathematically-capable students who while committed to mathematics, feel strongly about pursuing a broader curriculum than that available at KCLMS: these are all threats to mathematics schools developed in some other contexts.

Generalisability

These 39 sources of data represent 39 KCLMS graduates from two cohorts with a combined total of 120, so a 32% response rate, fairly typical of cold requests for feedback to unknown researchers, though the personal

[6] Fielding, M. (2004a). Transformative approaches to student voice: Theoretical underpinnings, recalcitrant realities. *British Educational Research Journal*, *30*(2), 295–311.

initial response from the school might have been expected to result in a greater response; however, there were 26 offers of interviews from undergraduates at just Oxford or Bristol, a much higher response rate. Researcher capacity limited the number of these that could be followed up, to the first 12, as that gave a comparatively powerful sample as described above. Those volunteering their thoughts in the survey might well be atypical of the cohort as a whole, perhaps feeling particularly strongly about their experience, or unusually KCLMS-community-conscious. Some areas of exploration were particularly susceptible to sample bias: for example, given the decision to exclude Cambridge undergraduates from the sample, students taking STEP papers 2 and 3, arguably the most demanding additional university mathematics assessments, were under-represented in the interview sample. Similarly, although it is thought that all graduates from the first two cohorts initially proceeded to university, some after a 'gap year', those small number who have not completed the planned study were excluded by the methodology adopted.

Given the combination of these constraints, and the near-universal progression of KCLMS graduates to competitive universities, usually to read mathematics-related degrees, the findings are likely to represent the range of those held by active undergraduates, though perhaps not in representative proportions or to representative extents. The research methods adopted, though, offer nuanced and rich data that help us to understand the views of these young people at this stage in their pathways. To represent that richness, we have included here numerous quotations from transcriptions or googleforms, always endeavouring to indicate its typicality among the data collected. The perceptions and experiences of subsequent cohorts might of course be different, and the graduates represented here, as will be seen, perceived changes in characteristics of cohorts as the school became established.

Approach to ethical tensions

Contact details are already held by KCLMS with permission for use for purposes which include follow-up of student trajectories: that is interpreted to include the present study. All initial approaches will go via the school, as described above. The researcher needed contact details for those who agreed to an interview, for purposes of organisation of interviews, thanks, and offers of participant validation; thereafter they are only held on the consent forms of interviewees, in a locked cabinet. Anonymity has been adopted for survey participants ('S1, 2…'), and pseudonymity for interviewees, although given the size of each cohort and the distinct pathways taken, it cannot be guaranteed: for that reason, the course studied, or student background, is only referred to when perhaps relevant to the remarks being made. Note that a student referred to as 'year 2' at university was not necessarily in cohort 2 at KCLMS, since some students took an additional year 'out' between school and university. Anonymity is, though, particularly important for interviewees since more in-depth responses were sought. Students completing a googleform could opt into giving their email address for purposes of receiving both a full version of this report to validate accounts via their 'student number', and to receive a one-page summary of findings in due course; interviewees were offered participant validation of interpretation of their contribution as in this report, and also offered access to a summary of findings. Unusually for such work, a significant proportion of participants both engaged with the 'findings' sent and returned reflective comments, often with requests to edit quotations to better reflect their considered position, or to re-frame phrases they felt might conceivably threaten anonymity. Others, again usually, said they thought that they were probably identifiable to key KCLMS personnel from the quotations and background given, but were content for that to be so.

Confidentiality within these bounds was assured, including any problematic mention by name of individual teachers, except that any disclosure that reported or might be indicative of any safeguarding issue would be followed up in line with school and UCL professional protocols.

The timing of the googleform in January and interviews in February/March was to balance impact on preparation for Finals or end of year examination preparation while also accessing as complete a picture as possible of KCLMS graduate trajectories and perceptions to that point. Interviews took place in a public, accessible, but reasonably quiet location of the interviewees' choosing, with the researcher documenting time and place with a colleague for security.

Consent was integral to the googlesurvey, and was established via e- or paper consent forms then securely stored, for interviewees, as in Appendix 1.. UCL ethics regulations require consent to store recordings and digital responses for validation purposes for up to ten years from the research, but in a secure depository. Interviewees, and survey respondents opting in, were offered the opportunity to validate or withdraw any use made of their interview or responses, with four weeks allowed for them to do so. Consent included students' right to withdraw their data from the study any time to late July 2019: as indicated above, at least a third of participants engaged actively with validation of their data in September/October 2019, and requested or suggested various edits. None, though, requested total or even majority withdrawal. Topic foci in survey and interview were not expected to be sensitive, but participants in any case opted in to answering any particular question.

This, and any other, reports produced will be the property of the school as funder, and their dissemination and publication at the school's discretion. Any related academic papers/presentation with the researcher as sole author will be the intellectual property of the researcher but publication will only be sought with the permission of the school's Headteacher; publication of any joint papers again will only be sought with the Headteacher's permission.

This report, then, addresses each of the sub-research questions in some depth, drawing first on googlesurvey returns (with participants identified as S1, S2, etc) and subsequently, following iterative development of prompts in the light of survey responses, on interview transcriptions. Interviewees with pseudonyms Otis, Dan, Carly, Fabio, Lizzie and Amandeep were in Spring 2019 undergraduates at Bristol and Kim, Michael, Noreen, Bill, Ettie and Grace undergraduates at Oxford.

4. Findings

Interview questions were developed slightly from those used in the survey particularly in terms of probes used. As evidenced below, though, some survey responses were so full that their richness compared well with that achieved in interviews: both survey and interview respondents were amazingly generous with the time they devoted to the study and the effort invested in reflection on the questions posed. We deal in turn with students' journeys to, through, and beyond KCLMS, finally relating those to key aims of the school.

4.1: Student experiences and critical incidents pre-KCLMS

Key Findings

- Mixed level of contact with school pre-enrolment or admission.
- School or KCL outreach activities key motivators for about half, with other enrichment opportunities also key motivators in building awareness of, and commitment to, mathematics as more than routine GCSE.
- Application often linked with critical enrichment, from whatever source – or else via an influential teacher or parent.
- 'Switching on' to mathematics appears usually to have stemmed from enrichment, and especially, mathematically challenging additional experience, though 'being unusually good at' more standard school provision was also instrumental for some.

- Enrichment and outreach
- Application to KCLMS
- 'Switching onto' mathematics

Pathways into KCLMS

4.1

We first focused on critical experiences and influences in students' journey to KCLMS: what experiences did they have of enrichment beyond standard GCSE provision, when and why did they decide to apply to KCLMS, and what had switched them on to mathematics sufficiently that they decided to commit to a relatively specialised focus and restricted curriculum? It will be seen that these varied, although a key parental or teacher influence was often apparent.

4.1.1 Pre-application enrichment or outreach activity

Since 'standard' school provision aimed just at GCSE benchmarks can be uninspiring for those with a particular aptitude for mathematics, we wanted to know what in-class, extra-curricular or external enrichment or extension experiences had been engaged in by participants. In particular, we wanted to know if they had participated in any KCL or KCLMS enrichment or outreach activities before application to the school – and if so, at what stage, and what impact that had had. Since the study participants were thinking about progression at age 16, school and KCL provision for enrichment has developed, but some, particularly that organised by KCL, was already well-established for the first tow cohorts.

Of the 26 completed surveys, only 8 were from students who had taken part in such KCL or KCLMS-provided enrichment or outreach – but for each of those, the experience had proved formative:

> *Yes: the taster days: they got me excited about the school (S9);*
>
> *The open days which convinced me that KCLMS was where I wanted to go, (S11);*
>
> *I attended after school enrichment classes (at KCL) one evening a week with a few other kids in my class. Through this I was able to explore higher level mathematics which developed my interest, but also it made me aware of the opportunity at Kings Maths School (S13);*
>
> *Outreach at KCL, enjoyed it so applied to the school (S17);*
>
> *Outreach at KCL, the level of maths was interesting and I looked forward to these extra curricular lessons (S23);*
>
> *KCL Maths Summer School, 2012. It was a fantastic learning experience. I really enjoyed all the classes taught by the KCLMS teachers and I was motivated to study the subject at a higher level (S24);*
>
> *Further maths enrichment classes – really got me hooked (S25);*
>
> *GCSE Further Maths Outreach. It made maths fun again. In year 9 I really didn't like maths, in year 10 I was ambivalent but by going to outreach sessions maths became more interesting and challenging and more like a puzzle (S26).*

Some of the interviewees had experienced small-scale outreach/enrichment activities, or had responded to opportunities on the newly-developed school website such as the still-active 'weekly puzzles', but none of these was at any scale: 'one after-school activity before the school existed, so it wasn't in the school' (Kim); 'I was online and looking for 'maths puzzles and I found their weekly challenges' (Michael); 'I went to a taster day' (Carly); 'in April before the course started there were some taster sessions so that was after you'd been accepted but before you had decided that was the one you were going to go to' (Lizzie).

At least half the interviewees, though, had experienced extra-curricular enrichment via the quite extensive network of opportunities more widely available in England, and had usually been introduced to that via their school. Of course, a big proportion of such opportunities in England are within travelling distance of London. Sometimes students talked about the promotion of KCLMS opportunities at such events. Additionally, at least 3 students talked about extended opportunities available *in* school for Additional Maths level 3 FSMQ (OCR) or AQA's level 2 Further Mathematics qualifications, with variable degrees of teacher support. Several

talked about the role of the UKMT Mathematics Challenges in whetting their appetite for problem-solving. None of those interviewed referred to general in-class enrichment beyond GCSE requirements, as part of everyday teaching in school – but then 15- or 16- year olds might well not be aware of specification requirements as opposed to embedded enrichment around those:

> *In secondary school because I was interested in the (UK) Maths Trust the school decided to send me to one of these talks at Wilson school, weekly or bi weekly, and they would talk about random things about maths and then eventually I got an email saying as you had attended these talks, there was something, the Royal Institution, and I got an email saying do you want to go to a sort of super class at the institution itself…I wasn't someone who was very impressed by this sort of thing but my parents said 'No, you have to go to this because it's in the auditorium where Faraday did his experiments, Humphrey Davy did his experiments', and I ended up going there and as I was leaving Dan Abramson was handing out leaflets about setting up new school and would you like to apply. I didn't know what to make of it (Ettie);*

> *I went to this maths event, women in mathematics or something, and they were handing out leaflets there (Grace);*

> *Not at school, but I found out through school. I did some out-of-school engineering summer school programmes with the Smallpiece Trust, so it wasn't really maths but I applied for them, it wasn't my school who applied for them. I did some Exotech at Imperial as well. So I didn't really do any maths enrichment per se but I did some engineering type stuff and I tried to do, I did additional maths GCSE as well which was mainly out of school and my own learning other than in school… (Lizzie).*

It appears that KCL and KCLMS enrichment and outreach opportunities are effective in raising mathematical interest and awareness for many potential KCLMS students – but that sensitisation to the possibilities offered is also widely supported by other such extra-curricular opportunities offered ether in or out of school.

4.1.2 Application for KCLMS

We asked students when and why they decided to apply for KCLMS. For almost all who gave a timeline, the decision was made (usually early) in year 11, sometimes as a result of outreach experiences (2 surveys, 1 interviewee), but also because students wanted a 'fresh start' or similar (5 surveys, 3 interviewees). This was sometimes as a result of particularly positive school experiences that had inspired them and left them wanting more (5 surveys, 2 interviewees), or because a particularly influential adult, usually a parent or teacher, encouraged them to do so (6 surveys, 4 interviewees), although there was little evidence of any teacher in an 11-18 school, that is, one in which the student could have stayed to complete A Levels, encouraging application in a significant way. Many KCLMS alumni cited attraction of the particular nature of the KCLMS curriculum and community, and the impressions gained on open days (8 surveys, 4 interviewees) – or a combination of such influences. Of course, KCLMS was relatively new for these first two cohorts, so although some had been involved in KCL outreach earlier in their school career, they wouldn't necessarily have been aware of the forthcoming school. Early impressions were obviously very positive:

> *I applied in 2014. My main motivation was from the unique summer school experience and I really enjoyed all my Maths lessons from school, therefore I thought going to KCLMS would (and it clearly is) the best option (S7);*

After attending the enrichment classes and enjoying the teaching methods at the school (S8).
I really enjoyed the outreach sessions. Maths became more of a puzzle and a challenge rather than just a subject I was good at. I really liked the whole environment and teachers and thought that it would be an awesome place to do a level maths (S17);

Applied in 2013. Wanted to build a strong grounding in maths and was impressed by the care and thought put into the teaching plan (S5);

At the beginning of year 11. The A Level subject options at KCLMS aligned pretty much perfectly with what I liked to study at GCSE and what I wished to study at university, and I liked the idea of studying the same subjects with lots of other students who shared my love of maths and physics (S13);

I applied when applications were open. I decided to apply because the school had a focus not only on the standard curriculum mathematics but the wider applications and implications of the subject (S14);

I decided to apply when I was looking up possible sixth forms I could apply to at the beginning of year 11. I decided to apply for KCLMS because they specialised in maths, which I was very interested in, the staff and students were very welcoming and kind when I went to the insight evenings and also, due to the affiliation with KCL (S18);

Final year of year 11, I attended an open evening for the school and it sounded like an exciting concept (S22);

I was already set on studying Mathematics, and the idea of completing A levels in an environment where everyone was also doing Mathematics was very appealing (S23);

I enjoy Maths, KCLMS seemed like a nice environment, and the grades from the first year of students were pretty amazing (S24);

I was looking on line for maths puzzles and I found their weekly challenge. So I did those and I thought of applying. The idea of being surrounded by people who … at secondary school I was in set 3 for maths and nobody around me was at all interested, and it was extremely exciting, the prospect of being somewhere where everybody actually cares (Michael);

I went to a taster day and an open day…. I was the best in my school at maths, just the methods of teaching made it very uninteresting because it was like 'this is what you need to do for the exam, and if you do that, you're fine'. We never did anything extra. So I knew I was really good at it and I did the entrance exam for King's. After that I realised I was good, but I wasn't great or amazing. When I did the exam and I did well on that, that's when I realised I was actually really good at it (Carly);

As Mr Abramson had really inspired me on the few occasions in which I had met him throughout my applications process for KCLMS, I contacted him - who luckily remembered me - and after an interview I started a KCLMS (S21).

For those citing a 'fresh start', accounts of their mathematical experiences at secondary school were sometimes quite sobering – but others recognised personal characteristics in themselves that suggested a

new beginning might be productive – or family circumstances dictated that, and in some cases the school did not offer the desired A Level choices. Some schools in the Greater London area are for students to age 16 only, and those young people necessarily look for another institution post-16:

I wanted to move school for a fresh start and KCLMS seemed to be the ideal option as I thought it would provide me with a focused environment for studying mathematics and physics, subjects I knew I wanted to pursue. The experience I had with the teaching standard in enrichment classes reassured me that I would get the best education. I believe that without the exposure to KCLMS through the enrichment classes I would have been more sceptical about moving to a new school, especially in the pilot year (S3);

Half way through my GCSE year, primarily because my family could not longer afford private tuition at … school and still wanted a very good maths heavy school (S10);

For a fresh start, with a new crowd of people: my relationships at school were no longer very productive (S25);

I really enjoyed maths and physics and it sounded quite exciting. I liked the idea of going to school in central London and I wanted a break from my school, I didn't want to go into the sixth form (Bill);

Because the school I was at, they didn't offer further maths, I did quite well in maths but I wanted to be in a mathematical environment. Everyone loved maths there and you get a good environment and lots of energy. At …. it was a lot more focused towards arts and English and things like that… My year was lucky because they let us do economics but I think it was just that year (Grace);

My school couldn't necessarily offer Further Maths and I wouldn't know until it was too late to apply elsewhere (Kim);

I wanted a new environment, something more stimulating…. (Otis);

I was very indifferent towards school at that point, so the reason I chose to go to King's and stay at King's was because I only had to apply to one school and then once I got in I didn't have to do anything else (Fabio).

It is important to note that in this study we did not access any of those young people who would have benefited from KCLMS but who, for whatever reason, did not apply. Even for some respondents, there were reservations about the restricted curriculum:

I didn't know exactly, and the range of subjects was restricted. And I knew I wanted to do maths, quite interested in physics. I thought I would end up doing maths, further maths, Spanish, chemistry or something, so I applied to do those at ….College…they promised chemistry and proper facilities and everything was set up with Bunsen burners and phials and beakers and things. It's understandable that you can't deliver absolutely everything, especially where you are brand new, and 60 in a year, but it was a little bit misleading (Ettie).

As indicated, teachers and parents were key influencers in applications, but some careers advisors also seemed well-informed from early days:

My mum heard about it and suggested that I apply since I was good at maths and I had nothing better to do (S11);

After KCLMS being suggested by a career adviser in year 11 (S16);

My secondary school teacher knew I was interested in mathematics, and had a talent for it, so he recommended me to apply for KCLMS (S19);

Dan saw my enthusiasm for maths and was also interested with my Rubik's cube. I initially was planning to apply to my secondary school's sixth form, but with my maths teacher's convincing that Dan was trying to entice me to apply for KCLMS, I decided to go for it (S26).

For interviewees, parents and schools also appeared influential. Some were in 11-16 schools so would have had to transfer to another institution at age 16 in any case, but for those in 11-18 schools there was no awareness of schools being reluctant to lose keen, and largely successful, students:

A teacher at my school gave out some leaflet about King's and that's how I found out about it. Nothing before that … I think mostly it was one of the subjects I was good at, a subject I naturally enjoyed it more, and also considering, we were all thinking what to do at A levels, what to do at university, I thought I would probably want to do engineering or maths at uni, something like that. I just enjoyed it and I was good at it (Dan);

I think when it really hit me that it was where I wanted to be was the entrance exam in December in year 11 and there was a practice exam online. ..I …thought 'OK, I'm just going to do this' and I did it and I looked at the time and it felt like ten minutes had passed, but the time just flew by and I just really enjoyed doing it. That showed me that it was the place for me. I just did it and thought that was really good, and I enjoyed myself (Lizzie);

I knew I wanted to get into a more academic oriented school… Yes, I wanted to do computer science. I knew that from year 11. And I knew that I needed maths for that, crucially, so my school encouraged me (Amandeep).

What we see exposed as salient is a variety of key 'influencers', accompanied by effective school outreach and communication, and, essentially, compelling presentation of who and what the school community is.

4.1.3 'Switching on' to mathematics

However, any 15/16 year old considering application to KCLMS and aware of its very particular curriculum will need to be at least positively inclined towards continued participation in mathematics before taking that step. Sometimes this appeared to stem from being unusually 'good' at it, but often, key motivations stemmed from encounters with mathematically challenging experiences. Many respondents (11 of 26 in the survey, 5 of 12 interviewees) said they had for some time enjoyed mathematics, or a related subject, and linked 'being good' at it with enjoyment:

Being comfortable with numbers, visualising geometries (S7);

Looking forward to math homework in school (S5);

It came quite easily to me, was very rewarding to solve problems which seem impossible at first (S19);

Always enjoyed maths and the challenges you face in maths (S25);

I was initially much more interested in physics pre-A Level, until I learned that the higher the level of physics you do the more deeply integrated it becomes with maths, and that encouraged me to learn the maths behind the physics I already knew (S6);

Interest in engineering and physics, especially aerospace. I found maths easier to understand than the other people at school and it was my favourite subject, it also happened to align with helping me to understand my interests (S10);

One day it just sort of clicked and a problem that I had been really struggling with … for ages, and it was quite a core foundation, so when I finally cracked it, it opened up a whole new world and I realised it's not quite as hard as you actually think. You can work on stuff, and I think the reason I wanted to do maths was that I really wanted to push myself and excel because everyone says maths is hard, and stuff like that, and then I ended up finding it really interesting and taking joy from it (Otis).

Notice, though, that someone has signposted the 'problems which seem impossible at first' or provided 'the challenges you face in maths', and at least 5 survey respondents, and 3 interviewees, credited their school teachers or school provision for 'switching on' their interest:

Loosely put, due to my 'ability' I was able to take Further Maths at GCSE, which exposed me to higher level mathematics concepts such as matrices and more complex integration. I think taking this extra GCSE solidified my choice to take mathematics at A-Level as there was quite a lot of cross-over between this GCSE and introductory AS-level topics. In total I took 3 GCSE's in Maths, (Stats, Maths, further Maths) and alongside triple science I was pretty much as immersed as one could be in Maths at a non-specialized state school. I always found physics interesting and Maths felt like the only way I could properly understand what was going on (S13);

My good teachers before KCLMS in maths and the logic behind it (S18);

Most enjoyable subject at school, excellent teacher (S15);

I suppose my teachers, I don't know, I was good at it, I enjoyed it and they were all very encouraging. I had a very good maths teacher who was very enthusiastic about maths and the same with my physics and biology teacher (Bill).

It was actually the Maths Challenge that made me think maths was at all interesting, and it took off from there…. I think after I liked it, I appreciated my teacher more. She had quite a similar approach to Kings, a sort of meritocratic thing. Which most people hated, people made fun of her a lot because she made people work things out themselves as opposed to telling them the answer, but after I was interested already, that was clearly the best way to do it (Michael).

For some students (at least 5 in the survey, and 2 interviewees), it was KCLMS provision of some sort that kindled, or re-kindled, their commitment to mathematics:

Growing up as a girl …I was never really encouraged to pursue that in school and ended up losing my interest in the subject, and although I was always top of my school in maths, I had lost the sense of

curiosity towards it, only doing the necessary to maintain my grades. This was true even after I moved to the UK in year 10, pretty much until I attended the KCLMS taster day in 2014, where the teaching methods and the maths problems presented to me re-sparked my curiosity (S10);

I had been good enough at maths since I can remember, I'd taken the UKMT and done alright a few times but I didn't enjoy it and wasn't "switched on" before KCLMS. I was very passive about the whole thing (S20);

I'd always been good at maths but it was only really in year 11 that I really began to enjoy it. Between the outreach sessions at King's, starting the FSMQ at school and the recreational maths club at school I really enjoyed maths. I wanted to study A-level maths and KCLMS was the best place to do that (S26);

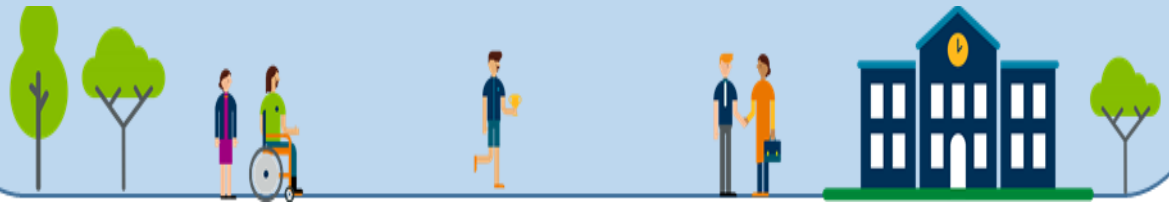
I've always really love puzzles…the Murderous Maths books were a massive influence on me. …And some of the stuff from the KCLMS website like the weekly maths tests and the admissions tests, I really enjoyed (Noreen).

Again, individual 'influencers' including family members, played a part: 'I was always "switched on" to maths, my father made sure it was an essential part of learning through childhood' (S23). What we see, then, is a pivotal role for getting stuck, for cognitive challenge and struggle – and for opportunity for young people who have mathematical potential to have opportunities for those sorts of experiences pre-16.

4.2: Student experiences and critical incidents at KCLMS

Key Findings

- Early days were daunting for most, but students appreciated induction provision.
- Most found the concentrated mathematical community surprisingly 'normal' and affirming, though for a small minority it remained unhelpfully niche/aspirational. The restricted nature of the curriculum was acknowledged as a challenge for targeting entry more widely. 'Other' subject support was important and had perhaps been less effective than for mathematics.
- Most had developed deeper, more rigorous and satisfying relationships with mathematics through KCLMS core provision, akin to but different from the satisfaction gained from enrichment opportunities.
- Teacher and visiting expertise was highly appreciated, while respondents also talked about the pedagogic limitations of some inexperienced teachers.
- Students largely felt they had been well-supported in finding appropriate aspirations/university pathways, although some still regretted limited encouragement to apply to Oxbridge. Those who had taken, or studied for, additional university entrance papers had enjoyed the experience but students were clear they needed to prioritise optimum performance in A Levels.
- Participants offered a range of relatively small ideas to enhance experience further, focused around broader experiences and skills to better support long term whole-person development.



- First experiences
- The community and curriculum
- Relationships with mathematics
- Teacher expertise
- Choice of HE pathway
- Additional papers
- Even better if….

Experiences Through KCLMS 4.2

4.2.1 First experiences at KCLMS

We asked students about their experiences of the first few months at KCLMS, about what had particular impact, and what could perhaps have been done better. Many, of course, contrasted their first term with experiences at their previous school, and it's important to remember that in the English system, transition from a broad programme of study, and the pressure of GCSEs, in year 11, to the comparatively specialised typical 3 or 3.5 A Level programme is a major change for most students. In common with their peers, most KCLMS graduates have no experience of other post-16 provision.

The dominating report, clearly memorable to participants, was that of an initially daunting experience, sometimes amounting to a 'culture shock'. Combined with this was usually the challenge of not only new people, approaches to learning and teaching, systems and routines, but joining a community very different in nature from that known previously, and composed almost entirely of peers who

appeared ‘very smart’, particularly in relation to mathematics. Some students came from schools that were perceived to have focused on how to ‘do’ examinations, or where provision for comparatively precocious students had been a fairly isolating experience, and took time to discover they needed to ‘let go’ of those approaches if they were to make meaningful progress. Whereas many students appreciated the efforts that had been made to develop a socially-cohesive community, there was widespread expression of early reservations about the move, and comparatively few positive comments about individuals’ experiences in the first few weeks. However, these were often then balanced by a longer-term view of the school impact:

Scary, intimidating (Amandeep);

A definite culture shock. I was a little younger than my peers and had taken my Maths GCSE early hence had spent a year doing little Mathematics and felt as if I had gone backwards, combined with the intensity and volume of maths at the school made it a steep learning curve. I feel as though for much of the time, I had been focused on learning with a particular goal in mind, e.g. to solve exam questions, rather than being focused on the context of the skills being taught and some of their applications, and this was a habit that was very hard to unlearn. I often found the homework problems challenging, and some form of 'office hours' to discuss ideas and methods in greater detail would have helped me to be proactive rather than muddle through the sheets trying merely to obtain the answer rather than a strong grasp on the ideas emphasised in the tasks. I fared much better in my second year than my first I feel, partly due to feeling much more grounded as an individual in the school and partly due to the steep learning curve I encountered throughout the entirety of my first year at KCLMS. Looking back, I developed in a way I doubt I could at another sixth form given the culture at KCLMS and the kind of education it offered with extremely competent teachers and pervasive of focus (S14);

At first I felt out my depth. It was the first time academically, where I hadn't been top of my class; and it was different to be around people on the same level. It kept me grounded, and made me want to put more effort in to keep up (S22);

Yes, so initially, the first month or so, I was really unhappy. I can’t remember why but I was seriously considering going back to my old school. I felt out of place socially, I didn’t know anyone, that sort of thing (Michael);

I firstly felt a little out of my depth because I didn't do a further maths GCSE but a lot of other people did, and I did my maths GCSE in year 10 so I hadn’t done a lot of the maths that other people had done recently for a whole year… In year 11… I did statistics. Not a lot, and statistics was my least favourite thing so I didn't pay much attention to it even though I was doing it. So when I started, I found everyone else seemed to have this idea of imaginary numbers and they were new to me and everyone else seemed to know what they were, things like that happened to me a little bit (Fabio);

Firstly, I was very scared, since I was surrounded by super intelligent peers and staff members. Then there was a whole school event/maths challenge (can't recall the name), it was a really good ice-breaker (S24);

The first term was quite a big shock. It was strange going from an all girls’ school to a much more male dominated environment (S26);

It was quite fun, because obviously I was doing a lot more maths than I was doing before but that's just how A Levels work compared to GCSEs and I enjoyed that a lot. It was good. I found it difficult because I find new places and people difficult but it helped that I had maths to talk about (Kim);

Very different environment to come into and found it hard to believe in my abilities when surrounded by such a talented group of students (S25).

Some expressed as sense of relief, that as they'd settled down they'd found the community fairly 'normal' in its range of interests; there were also comments about the range of other activities available (although these met with variable appreciation!):

One of my worries was that it could have been too concentrated maths, and it very much wasn't: …there were all sorts of other things going on, many different activities, and I appreciated that. …some conversations would be about maths, some would be about whatever else, it was fairly normal and possibly more normal than I was expecting…because I'd been working on my own for maths before then because I was the only one in my class doing what I was doing, I wasn't really used to it. It took me some time to get used to people talking about maths. It was kind of good, it didn't always work, but overall, good (Kim);
The very first term there was quite a lot going on it was a really big jump from secondary school. Going for language lessons in the evenings just made me tired, I think most of us eventually just stopped going. The Wednesday 'cultural' visits to certain places in London were a good idea but I think the art gallery stuff bored most people. These eventually stopped anyway (S10);

I had a lot of fun. Because it was such an odd environment it felt staged at first but then I settled into the new reality. I thought that the trips so early on in the year, although they sound fun and like they mix people, I felt quite separated and like I didn't get to know people very well during them. At the time I thought the social skills days at the very beginning were a joke but I can still remember good conversations I had during them so they can stay (S19).

Some commented on how the composition of the community supported ambition – but also to the limitations of that:

There was a sense of exclusivity. Built ambition and provided the space to focus on the subject, but at the cost of extra-curricular activities that are accessible in non-specialist sixth form colleges such as drama productions, political societies, sports borough leagues (S5).

And for early cohorts, there were of course practical routines to developed and established, though these students recognised the one-off nature of such challenges:

If I had to think of something that could be done better I would probably say just the logistics of having so many people in such a small space for lunch and such, although this was improved as time went on and the school adjusted to having so many students for the first time (S16).

Common in responses, though, was an appreciation of the support offered by teachers – and of the pervasive challenge:

On the whole there was a very supportive atmosphere and also a large effort to make sure we did as well as possible. At the time it felt stressful but in retrospect it set me up well by guaranteeing me grades. Although there was definitely a concern for student wellbeing, you could feel that the staff were stressed for us to perform well (S11);

I found it exciting for the most part, I made one of my closest friends in my first term at Kings, a friend who is at university with me now. I found the transition a little hard from GCSE to A-level but the standard of teaching I experienced (shout out to Mr Watkins) was beyond anything I'd experienced at state school. I believe the standard of teaching at Kings is one of the things that make the school (so far) so successful (S13);

Was amazing just how much support we received from teachers. I honestly think, if it wasn't for them, I wouldn't be where I am now academically. I think the best thing was the constant assessment, throughout the year, making sure people who fell behind got (compulsory!!) extra support that they needed. It wasn't seen as shameful or embarrassing to be behind, instead it was a very encouraging atmosphere. It didn't seem like there was any focus on competition, but instead on collaboration which made for a very productive environment. The school's focus on improving its own internal systems and a methodical approach of doing so also motivated me to improve myself. Cons: I think the class system with A1-B2 and certain classes taking extra modules and others not, wasn't the most productive. It was better when in Year 13 those who wanted to take FP3/S3 could do so regardless of their class. I think it wasn't a necessary separation and wasn't as fitting given the whole collaboration atmosphere I mentioned above (S19);

It was very different and the style of learning, encouraging you to think about learning to understand concepts not just memorise them (S7);

New style of teaching was great, maybe a workshop at the beginning showing us to throw our preconceptions out (S9);

What had the biggest impact on me was how different KCLMS was from any other school I had been to (and I have been to quite a few), mainly due to the way we were taught as it seemed that the objective was not to teach us how to achieve the highest mark in an exam, but how to think mathematically (S16);

I personally found it difficult to keep up with the content at first as it felt like a new style of teaching from what I was used to, and we had some very young teachers that were not as experienced at explaining things. There was also a lot of emphasis on learning outside of the curriculum which is good, but at times it felt like this took priority over the A Level syllabus. For someone like me who didn't work outside of the classroom I would have found it more beneficial to learn the A Level stuff in more depth with more examples (S10);

I think at first I really struggled with maths, and it was really nice because there was a lot of support. It wasn't like, if you don't understand something then just leave it. As soon as you don't understand something, they are on to it straight away, and they are there to help you…. I even thought it would be a bit more relaxed because when you are older and go to college, it's not as school-like. It was nice to have it very structured and you know what to do, you get told what to do and stuff. If you struggle they have

homework clubs, all things like that. They are just basically on top of it if there's something you don't understand. At first I was really nervous about it, I didn't really like it…. Because I'd never met people like that who were there before. They were all incredibly intelligent. I just felt like I didn't fit in, that I wasn't doing very well…. It wasn't that I was jealous or very competitive, I just didn't feel I was really good enough to be there. I gave it a few months, and I made such good friends and I started to enjoy the maths a bit more, which was good (Grace).

The evidence is that for most of these students, the early stages of the transition were daunting in terms of social and academic adjustment – but that the school put in place very deliberate, and largely effective, routes to addressing that. There was both appreciation of, and challenge from, approaches to teaching and learning that were usually new to students, demanding of them, but perceived in the medium-term to be effective, and some suggestion that such changes could productively be addressed rather more overtly, explicitly recognising the novelty, and challenge, for students.

4.2.2 The concentrated mathematical community

We asked the students about the pros and cons of being in such a concentrated mathematical community over their two years at the school - one that in many ways was more concentrated than that found in many university departments at an undergraduate level, and certainly than in e.g. cross-disciplinary Oxbridge colleges. Again, it's important to remember that these graduates largely had no other post-16 experience with which to compare their time at KCLMS; nevertheless, this was obviously an important issue for them, with almost all participants responding at some length, and with a range of perspectives. Additionally, many offered a balanced view on the nature and impact of the community.

For a minority the pitch of aspirations and of their peers' academic functioning remained intimidating, whereas for others that was a source of affirmation of identity and they came to feel full participants in the wider mathematics community. For some it was humbling, and for others a spur to higher aspirations themselves. There was a pervasive sense of the valuing of mathematical thinking, though also some concern about the marginalisation of full development in other disciplines or of the resultant narrowness of academic interest. For some students, too, there was an acknowledgement that their lens has matured since leaving KCLMS, so that their reactions at the time, while important, perhaps needs moderating with longer-term perceptions:

Met a lot of different people who you wouldn't even expect to be so passionate about maths, learned far more in depth for every single topic than any other school I've been to, the passion shown by the teachers and the students made lessons so productive and enriching. On the flip side, it was always very difficult to integrate other subjects into the curriculum (S2);

I just looked at all the other people who'd applied at open day and met them, and I did feel that I was going to be at the bottom of their barrel before going there. I think I'd prepared myself. There were a few people there who had not done that and I think they struggled to begin with, to not be at the top of their respective classes…ours was definitely the most fun set, that was the silver lining (Fabio).

It was great, it helped me build a strong work ethic and in an environment where you were given as much attention as any other student was refreshing. The teachers helped you whenever you were struggling and they were always there if you needed help with anything even if they didn't teach your

class. Whilst I was there I remember hating it, the extra sessions to help you if you failed a weekly class test, but looking back the experience was so so good and I would recommend it to anyone (S3);

I got very good grades. Made friends that have a lot in common. However I definitely missed out on knowing a variety of people (S4);

I enjoyed the work, but not the environment. It made me want to apply for a less academic university (S22);

Always people to ask and discuss problems with, lots to inspire you. You develop awareness of mathematical thinking rather than mathematics just as an applied subject. Cons: can feel suffocated if you lose confidence in your abilities in maths (S5);

Pros: It was both humbling and encouraging to be surrounded by people better than me at maths and physics, conversation topics were almost always interesting. Cons: Despite the first pro, it was quite easy to feel inadequate at times (this might just be a function of age/experience however, since such feelings no longer exist) (S6);

Pros - It allowed me to work with others who had a similar ability in maths, hence it added a slight element of motivation as it allowed you to be slightly competitive, whilst also creating several opportunities to work in teams to tackle problems. Cons - The interaction with other students outside KCLMS was very limited (S8);

Pros: Although I found it difficult at the time, it made university easier because they don't spoon-feed you the course content like they do in secondary school, and you have to put more work in by yourself from fewer resources. I also found that the maths modules in my first and second year at uni were easy since the MEI course included a module on differential equations and the further maths covered a load of stuff as well. Helped to understand the level of ability that is expected to go to a top university, most people at Kings were really smart so it helped with what to expect for competition when applying for places. Everyone studied the same subjects so it was easy to find help if you wanted it.
Cons: Socially boring. Not enough diversity (seemed like more or less everyone was the same in terms of interests) (S10);

To be honest, for the most part it was quite intimidating. To go from being top set in every subject at school to then being in a crowd of people smarter or as smart as you is a transition that I think could be hard on a lot of new students. I found being immersed in maths constantly, at times rather intense (and a bit annoying haha), but looking back, it really helped me longer term learn a lot about myself and how I view the subject (S13);

Pros: Strong support community, could always share conversations around topics and methods and exchange ideas with a likeminded group of peers. I found although similar in interests, there was still a strong diversity of individuals that shirked the idea of a stereotypical mathematician and made me proud of my appreciation of mathematics. Many of the students, including myself, had most certainly struggled to find likeminded peers prior to joining KCLMS (S14);

I believe that going to King's has given me a completely different view of the mathematical community. While before I perceived it as something really closed off and far away from me, being exposed to so many amazing, intelligent people at King's completely changed my mind on that and made me feel part of it (S16);

It was easy to compare yourself to others and judge yourself based on how good your grades were. It is was nice to feel very comfortable somewhere but at the same time I think it's better to get to know people from a variety of communities and be out of your comfort zone so you can discover what you like (S17);

It taught me to seek help from my peers sometimes instead of teachers. I also felt like I really got to understand what I was studying instead of just learning it for the exam. When I came to uni I realised, this isn't at all a universal experience during A Levels. On the other hand, I do wish I had taken slightly different A Levels and had done an Arts subject instead of Physics (S19);

I loved it. I thought, before going there, that everyone would be the same, and I think that could have been the case if the school had picked it to be like that and I was very happy that although everybody had an interest for maths, they were also whole people who had lives (and some of them interesting) outside of the school. I don't know what it's like to study maths at a normal college but it was great that there was nowhere to hide your love for maths, which meant that everybody encouraged everyone else to carry out their love for it too. The only negative thing I can think about is the competitive nature that can arise from such concentrated specialism in one subject, I think that got to some people (S20);

It made maths more interesting and made me want to explore stuff more as there were other people who would explore things as well. It was a hard adjustment to make going from being one of the best at maths to being much closer to the middle of the pack, but after that adjustment it made me better as I was constantly challenged (S26);

A big impact. It encouraged my learning and my interest, and I felt very comfortable talking to everyone and the teachers about maths and physics about any problems we had. It helped getting into Oxbridge (Bill);

It made me want to do really well at physics and apply to places like Oxford as well, which I don't think I would have even thought of if I'd stayed at my old school. And also just sitting there and talking about it without feeling you are boring people or they don't care what you're talking about. Everyone is genuinely interested if you say you've watched at video on YouTube on maths or something like that. Lots of people there didn't feel like they were superior…they were so nice and really helpful too. Like if you were stuck on a question in your homework, you wouldn't feel embarrassed to ask someone, because they liked explaining it and it was a really nice exchange (Grace);

People did talk about physics and were interested in physics, but not nearly as much as maths. Physics A level wasn't very interesting at all to begin with. I think the first year most of the people didn't want to do physics, so there was not so much of physics people getting together. For example they had these recreational maths clubs and stuff like that, but there was not really anything like that for people doing physics. I think that would have been quite nice, because a lot of people did end up doing physics or engineering. It would have been nice to have had a bit of a buzz around physics as well (Grace);

That was the best thing about it. The fact that you could make jokes about maths and people would laugh, that was unprecedented. I loved that, the atmosphere. And also I think the fact that I definitely wasn't the best person in my class any more was really good because it made me push myself more. Because you knew it was possible to be better than you were and it wasn't possible to coast. It was really

good. I'm quite a competitive person so having that external impetus to work was extremely useful (Michael);

When you are home educated …I attended various tutor groups so I interacted with people in small tutorial settings and my parents often organised get togethers and events to museums, landmarks, that sort of stuff. So it wasn't that I was sort of starved of people to discuss maths with. But,..if I had to choose between the home education socialising with the maths at KCLMS, I would choose KCLMS because you have more people, you're with them every day, you're in classrooms with them working together, you have the homework you have to complete together, you're developing your understanding alongside each other and you're all funnelled in the same direction, without it seeming like a race. It's like building a tower (Noreen);

Before I came to the sixth form, I didn't really have an idea of the community behind maths and I came to see that throughout my time at King's. That it's obviously much more than just a subject you do at school and there's a community behind it, so many things going on (Dan);

Note in particular the references to the building up of peer support and other references that demonstrate foundations for longer-term approaches to learning. Although most reports were on balance very positive, and others positive at least in the longer-term, there were still occasional reservations about the restricted nature of the main focus:

Most of my fellow students were very different from me. I felt most of the students were stereotypical maths students, and they flourished more in this kind of environment than I did. I felt a bit out of sorts, the attention was totally on academics - even extra-curricular activities were all based in mathematics. I wish there had been more emphasis on keeping us as individuals rather than all becoming these mathematical robots (S23).

…and related curriculum:

Allied to these comments were those focused on the range of the curriculum available, and also on the quality of provision in subjects other than mathematics – for these students, computer science, physics, and economics:

I would have liked to have done Art but I knew that was not an option coming into it, so I was OK with that…but you wonder how restricted this makes (KCLMS) in terms of breadth of applicants….. (Bill);

It's restrictive, but you know that when you opt into it – and it gives you all something in common (Grace);

I think it's a very good thing, because everyone in the school has very close interests and passion …in the first term they pushed the extended curriculum quite hard…but then it sort of tailed off….I did finish the project and that was another example of developing the investigation skills you need for university. Also sports was something they encouraged. And languages… I went to all the classes but I still stopped it in a heartbeat when I had the option…, I think for the most part they developed the school very well. I think

they figured out what was working and what wasn't working, and filtered out the extraneous bits and pieces that weren't too helpful. They figured out what it was important to focus on (Noreen);

I felt so motivated when I went there, really you are surrounded by people all working on similar things, and if you have problems you can go and talk to someone who's doing the same thing, and it's a lot more easier to push yourself because everyone else is doing it as well…. The physics, I found it sometimes it was good, sometimes it wasn't. In the first year I didn't do very well, I got a C, but in the second year I got an A. I think it's just because physics as a subject is quite intimidating, it's like a whole step up, whereas maths is furthering your knowledge. Physics was very much like you go from doing a tiny bit of physics, 1% of what you do, to now being a whole load. I found it a lot easier in the second year when I got to grips with it. But I don't know if that was about the teaching, maybe a little bit, but maybe the effort that I put in as well (Otis);

A few friends I know were having some struggles, wanting to go off maybe into a completely different direction like arts and things. So in that sense, I guess they didn't really have that much of a choice, or consider what kind of choices they might have if they wanted to go off in that sort of direction (Dan);

..so I chose economics, and my teacher was really amazing, so good, and that's when. Importance of other courses, particularly in subjects not yet encountered: All my life, my family, my friends, would say I'm really good at science…so I never looked at anything else. And when I started economics, I just knew that was what I wanted to do…when I started going into it, I really loved maths so much and every lesson was so interesting. We had the extended project, those lessons were quite interesting because it was such a dramatic change. So for me it wasn't so claustrophobic because I was doing economics which was not mathsy much at all. We'd have double economics and go in and talk about the world, whatever was happening, and what that meant, and that was a distraction….. I would have liked, I know not everyone likes economics, but more economics space like enrichment or visiting the uni economics department (Carly).

In general, it's clear that most felt the restricted A Level curriculum was fine for them choosing to go into that, although it might deter some other students who would make god use of the mathematics provision – but they recognised that a small school can't offer everything. However, there were also consistent messages about the importance of sustained high quality provision in whatever other subjects were offered, and of supplementary provision that was inclusive of the range of pathways related to those.

4.2.3 Relationships with mathematics

We asked students how their relationship with mathematics had changed over their time at KCLMS. A significant majority talked about positive changes, to come to appreciate mathematics as a collaborative, connected, creative discipline and for many, a life-changing force. They attributed much of this to the inspiration and approach of teachers – and to the richness of the mathematics community. A few, though, felt they had experienced over-aspiration that had sometimes sapped motivation. There were also reservations about the scale of teacherly support at KCLMS sometimes impacting on the transition to university, with an implication that perhaps a slightly re-balancing of responsibility towards the student might have supported more effective transition*:*

I grew to appreciate mathematics as more of a collaborative effort, as a result of being able to have so many discussions about it with my peers. Prior to sixth form it was very much something I did on my own in my room (S1);

Gradually had a much more in depth understanding and developed a whole new way of thinking and collaborating (S2);

Deepened profoundly mostly through exposure to many new areas which provided an overview through which connections and meaning could be independently perceived (S5);

During my time at KCLMS maths became more than just a list of algorithms to perform. I grew to really appreciate mathematical proof and the notion of a statement being invariably true for eternity, and in studying the derivations of the tools we used I understood maths to be a creative as well as logical endeavour (S6);

I actually enjoyed it less and stopped trying because it was made too intense and too important. A lot of stuff that was higher than A level didn't make sense at the time and was poorly explained by people that were really smart but bad at teaching, this was demotivating. That said, eventually things started to make sense and now I can learn pretty much any maths with relative ease (maths that I see on my course anyway). I liked the MEI course I think it covered the most important bits of maths to prep for a maths-based degree, and wasn't as easy as the other A Level options (S10);

I became better at understanding the logic behind maths, instead of just being able to solve problems correctly without much thought (S12);

It was up and down, at times I loved it and felt really smart and cool for knowing 'hard' Maths and at other times I literally wanted to leave because I couldn't imagine myself ever doing this past A-level. Clearly, nearly being a Maths and Physics graduate, the love outweighed the hate (due to stubbornness or passion we will never know). One thing can be said about the school though, if you have a passion for Maths and want to be around it 24/7, then Kings really is the place (S13);

I think this is quite personal to me, as others didn't seem to have experienced this, but I started relying really heavily on teacher's expertise and support. In KCLMS there was always reassurance that if you didn't understand something, you could get help and someone would explain it to you and make sure you get it. There was no chance to get left behind;
When I experienced uni-style teaching for the first time, I was really unprepared. No one was there to make sure I was understanding the content so I spent the first year or so developing independent learning skills which students from other schools seemed to have already (S19);

I was quite apathetic towards maths as a subject before going to KCLMS, I only did it because people kept telling me I was good at it and I couldn't think of a reason to do anything else. Over my time at Kings I really developed a genuine love and appreciation for it though. By the end of my studies I felt really competent not just as a maths student but a learner in general which is also really nice. Learning so much about one thing is great, and being encouraged to learn about the history, not just the modern applications of it, helped me see the process and existence of maths in a different way. A lot of people who don't study maths don't get what about it anyone can like and I always take pleasure in explaining my feelings about it to them and why it's so important to me (S20);

A big impact. It encouraged my learning and my interest, and I felt very comfortable talking to everyone and the teachers about maths and physics about any problems we had. It helped getting into Oxford…it became more difficult, it got harder and more challenging. For the first time I struggled with maths at maths school, and the pace was a lot faster. I think I realised that I didn't like some areas of maths, like statistics, a few of those (Bill);

At first I didn't like anything that was any way abstract at all, complex numbers etc., I really hated it. But when you started using it more, seeing all the different approaches, I enjoyed that much more, and even things like statistics, they started off on probability trees and Venn diagrams which was not much fun, but when you do it more, and there were classes and lectures you could go to, I definitely started to enjoy it more. I thought I'd like mechanics and the physics side, which I still do, but the actual pure maths I do like a lot more (Grace);

I think that every lesson or every week, in every topic, it was more like a journey. So we'd get introduced to a bit of a taster of the topic and then we'd have to do exercises and things that would make us discover the topic ourselves instead of just being shown it or having that explained to us. It was more like we were encouraged to discover and find the topic ourselves through exercises and things (Dan);

I think, it had to do with both the curriculum and the teaching. I think teachers treat you with more respect when you are doing A level, I think that the complexity of the curriculum allows you to just be more mature with it, and I really liked that and I felt that I wasn't just doing processes, I felt like I was thinking and working things out, and being a bit creative which I had never felt before with maths. I had never felt I enjoyed it, it made me feel smart. I think that was both to do with the curriculum and the teaching. I felt more respected by the work that I was doing (Fabio);

We lived and breathed maths, I think it was since then, because it was yesterday I was trying to think how it impacted me and I tried to think about how I was before. You know maths was just a lesson you went to a few times a week but, since, maths has become my whole life. It's changed the way I think and approach things, and the way that I view the world and the way I interact with the world and I don't know, just being surrounded by that community the whole time, you know you're all mathematicians, you have that in common but you're all different, well it's just changed me (Lizzie).

4.2.4 Teacher expertise

We wanted to know what students thought about the impact on them of the particular teacher expertise available, including that of the unusually specialist core and visiting mathematics teachers. Inevitably, for some this provoked comparisons with the perceived mathematics expertise available to them pre-16 – but again, that might have been the case had they stayed in standard state provision. There was considerable appreciation of the level of mathematics knowledge possessed by the core teaching staff, but also a recognition that effective teaching, even of well-disposed and capable students, takes more than knowledge of the target discipline. There were also mixed accounts of some teaching, particularly beyond mathematics – and those other subjects are important to all students for progression, but centrally important for some:

They can answer every question! Any question you can think of, they will be able to answer it and further your knowledge. Again, every teacher is so, so passionate about what they teach it's extremely easy to

pay attention. The cons are that they're so focussed on maths that extra sessions at lunch and after school and any free time always had to be focused on it - there was no real rest or break and it can be tough on mental health (S2);

The teachers I had were perfect, they had the right level of passion for the subject and expressed that clearly, which made sitting in classes enjoyable and fun to participate in them (S7);

The teachers were really hit and miss, they were either excellent or really bad at explaining things. Mr Watkins was the best one by far he's probably the reason I got an A in maths. The other teachers were not as good at explaining things, and physics seemed really abstract and off focus. The resources for the course were really bad as well so there wasn't much to learn from.*
Pros:- Teachers made us figure things out and teach from first principles- very important in understanding what the maths is actually doing, but often poorly executed or explained to the point where it made it more complicated than it should be, and actually made it harder to learn how to apply it. The teachers cared about the subject and wanted us to do well, they could always see where the mistake was and knew how to solve any problem. Cons:- Just because the teachers have good degrees from top universities and are very intelligent doesn't mean they will necessarily be good at teaching. I think the better teachers are the more experienced ones that are good at breaking down a problem and making it simple to conceptualise, then backing it up with lots of examples. Not all of them could do that. I once had a maths teacher that had a mediocre degree and wasn't necessarily the most intelligent person but he was so good at explaining what he knew to us, probably because it didn't initially make sense to him either (S10);

Learning how to learn, not just how to answer questions (S12);

Massive. I was lucky enough to have the same teacher for core, and tutor, for the entire 2 years at kings. Honestly, Mr Watkins was one of the best teachers I've ever had and I genuinely think how well I did in my core modules (C3,C4,FP1,FP2 etc) was down to not only his expertise in the subject but the patience and compassion he displayed in delivering the material. The same can be said about Mr Robson, who I think is probably one of the smartest people I've come across haha. The standard of teaching across the Maths department exceeded my expectations, and there is little negatives I can say about that. I think the Physics department really lacked, especially in first year, with only one physics teacher running a really obscure physics syllabus (S13);

I found the best taught classes naturally engaging, I always appreciated that classes stemmed from an idea that was explored rather than introducing theorems without any prior context. Some university lecturers would do well to observe the same mantra. The statistics classes in particular run my Mr Abramson inspired a passion for the subject that would lead me to pursue an undergraduate degree in the subject (S14);

I honestly have nothing but gratitude and praise for all my teachers during my time at KCLMS. From my economics teacher Ms Saundry who made me fall in love with the subject and was always there for me during stressful times, through my mechanics teachers who had so much patience with me even though I complained non-stop about how much I hated that subject, to my core teacher who taught me to have confidence in myself. Every single one of them shaped me a little bit and helped me grow so much in only two years (S16);

The quality of teaching that I received in maths and physics was excellent. Maths and physics teachers always endeavoured to explain principles thoroughly and followed the 'Socratic teaching' style excellently. This made these subjects much easier and more meaningful (S18);

Unfortunately, teacher expertise in economics was not good enough. One economics teacher (Mr. Lewenstein) did an excellent job, supporting teaching with real-world examples and often being available for assistance. However, the other (N - the main econ. teacher) did a terrible job. She missed a large number of scheduled lessons with no explanation and little-to-no warning, she almost never attended 'catch-up' classes, she was never available outside of lessons. She spent most of each lesson talking about herself and not the subject matter. If students didn't understand, she would tend to say "that's just how it is" rather than giving any sort of explanation (S18);

I think I received some of the best teaching available at KCLMS and I hope to emulate a lot of it as I continue my career in education. I did well in my exams thanks to the teachers but I also have a better idea of who I want to be as a teacher because of them. Obviously not everything was great about them (I don't appreciate unnecessary strictness) but I learned a lot about teaching and being a teacher watching them (S20);

The teachers were great, they understood the material they were teaching and went as far as to anticipate some of the questions we may have. I also enjoyed the attitude to teaching the material: it was quite open-ended and we were almost re-discovering things instead of reading them out of a book (S21);

Specialist maths teachers were good because they always held high standards and pushed us to do well. Many questions could be asked extending the curriculum and completely unrelated and they would answer the questions really well (S26);

I was mainly taught by Mr Robson and he was fresh out of uni basically, and he still had our mindset of maths, I don't think he'd taught anyone apart from our age, and he was very close to our age so he still understood what sixth form was like, what the maths was like, how it needs to be taught. He was able because you are taught things at a lower level than at university, he knew like the extension of all the maths we were learning…Yes and he taught us extension bits on the side which was really good….I didn't get that at high school so much (Bill);

Some reservations also: The selection of a few of the teachers because we had some PhD students from King's to teach us some maths who at the same time were doing teacher training, and I don't think it was the right time for me because they weren't the best at teaching stuff. They were too specialised in their own field and that made it quite difficult (Bill);

Computer Studies (only to AS): We ended up with a CS teacher called …it was obvious that he didn't know what he was trying to teach, he had taught a course in another language at GCSE and he didn't understand basic fundamentals. And then the other teacher they hired after that, …, I don't remember his first name, also had a bit of a strange attitude to the fact that he had to teach slightly arsey 16 and 17 year olds.. He was not cut out to be a teacher. Then we had one of the PhD teaching mentors that they drafted from King's College London who was really really good, Mr Chu, he was quite good but physically with all the work, he was probably thinking about post-docs as he had just finished his PhD meant it would have been unfeasible for him to teach two years of curriculum (Ettie);

It's very easy to teach maths as if it was just a set of tools, and I think they tried very hard not to do that so, for example, even if you can't really find a derivative at that point, trying to work with it and not just saying this is a tool to find the gradient of a curve… Of course I was only in the second class in the first year and then I was in the top class in year 13 and I guess a lot of people found they didn't really care about finding the proof and it's probably hard to convince people who just see themselves as using the tools. I'm not entirely sure (Ettie);

I think they made all the difference. If you are in a lesson and the teacher doesn't care about what they are doing, or they don't enjoy it, it's very difficult for you then to enjoy it. If you have a question and they are just like 'that's not part of the syllabus', then it's just a waste of time because you could learn the course from a textbook at home if you wanted to, but at King's they were just really happy to talk about their subject… I didn't talk to the teachers at high school, to be honest, and that was their attitude as well. Just get through the course, do the syllabus, basically just do what's expected (Grace);

What struck me was when were in secondary school we were learning about sine and cosine and I asked my teacher what these functions really were, because I thought they were some sort of weird stitched together polynomial curves, and the teacher basically had no idea. Which strikes me now as rather odd as they had a maths degree and surely they would know, but they could not answer me (Michael);

The fact that I got passionate about computer science while these teachers were going in and out is a testament to how much I enjoyed the subject. I did really enjoy the curriculum in the second year, and one feature that was really amazing, I can't remember her name again but Mr Abramson brought her in to help us with our projects, …he correctly identified … the project was something we had to get started on. So he hired…some sort of project specialist. To say that she knew what she was doing is a massive understatement. She told us specifically 'You need to get this bit done her, this bit done here. Here are examples, here's what you need to do. Your idea sucks, think of a new one. Here's how to get a new one.' She was amazingly capable and she helped me develop my project which was a tool that allowed maths teachers to randomly create maths questions, with homework sheets. The project had its own pitfalls but she was an incredible teacher who really challenged my passion into the software development side of things (Noreen);

For the core maths, the maths and further maths, that was just so perfect for me, I just loved it and I understood it and it was a good set up. You get a problem and you get the topic explained to you and you go through the problem and you do loads of problems yourself, and I think that was so good. Because of the small class sizes it was really like hands-on, everyone knew what they were doing. In comparison with my old school, I was lucky because I had a good teacher for my two years of GCSEs, but before that my teachers had to control a class of people who didn't want to be doing maths and didn't understand it, which is very difficult when you're trying to explain it, because they didn't want to understand it (Otis);

It was quite shocking to me how different it was to any other school I'd been to. The methods, the people, the environment, you can talk to anyone, and everyone will have something to talk about. The teaching was so different. I hate just 'read the textbook and you'll pass the exams', but at King's it was really different. With the maths, you get to learn it so well, you do well in the exam. That was what was really different about it. And also because it was so small, I'd never been in a small school. It was crazy with all the teachers having so much energy, and everyone in the class getting all the help they needed…

I also never had really young teachers, and I think the fact that she was so eloquent and commanding…. The way she explained it, I have never had anything like that. … I think it was a mixture, I think definitely the teacher but also that it was a revelation to me (Carly);

There's a difference between people who are that involved with maths and that excited about it. That kind of excitement kind of wears off on you. Osmosis. And especially asking the more in-depth questions where in a normal school you'd be like 'Oh don't worry about that, come back in five years' or whatever, in the maths school they would know, and they had the knowledge and the importance to share that with you (Lizzie);

It was brilliant. I couldn't fault them at all….they were helpful. Look it's a maths school so it's always intimidating asking questions, so at times I guess I was forced to be more independent, but still I couldn't really fault them for that. It was great, I got the support I needed, and the material they taught was engaging enough, it wasn't too difficult to be not engaging, but they were willing to slow down if needed. I guess physics was the only subject that I struggled with because firstly I wasn't very interested in it, and also I don't think I was as engaged in the material as with, say, statistics or further maths (Amandeep).

For the vast majority of these students then, the available subject knowledge and the pedagogical approaches adopted were perceived to have been very fruitful, especially in mathematics, often in contrast to their previous experiences. This was tempered by some comments, especially in relation to inexperienced teachers or university lecturers, about teacher knowledge of the subject by itself being insufficient for effective teaching.

4.2.5 Choice of university pathway

We asked students to describe any experiences or incidents that were especially influential in their choice of university pathway. Of course, we only accessed students who had progressed to either Oxford or Bristol, and that obviously skewed the responses, although the vast majority of KCLMS graduates have gone on to Oxbridge or other Russell Group universities. The general view was that although high aspirations were well supported, including through appropriate visits and visitors, and made much more conceivable through that support, teachers were also realistic; teachers were also not backward in challenging student plans when they considered those plans unhelpful, or students ill-fitted. Individual teachers sometimes played a key role in the choices made. As always, though, provision was not 100% effective for all students:

A visit to Oxford during year 12 really sold me on applying here (S1);

We were encouraged to aim for the top but that's about it (S2);

It made me want to challenge myself and do something difficult (S3);

The fact that I got a chance to study computing definitely affected my choice of choosing a maths and CS as a degree. Without it I would have most definitely studied straight maths. I also luckily had an opportunity to research at the centre for longitudinal studies after year 12 over the summer. That was definitely influential too (S4);

The lectures we had from outside professors opened my mind to ways mathematics was used and thus how I could go on and use it (S9);

In all honesty I should have put more thought into my choice of university, although I don't regret my choice. I knew I didn't want to apply for Oxbridge as I didn't feel my personality type would fit, but there seemed to be quite a focus on these applications. I think more support regarding university choices for students who aren't applying to Oxbridge would be useful, because I landed up just picking 5 good universities that I read were good for my subjects and weren't too far from home. Luckily I made a good choice (S13);

Undoubtedly my economics teacher, Ms Saundry, who as I said was the reason I fell in love with Economics and also the person who consoled me when I didn't get into my first choice university and basically forced me to visit Bristol because she knew that I would fall in love with it. In addition to this, I would say that the politics club that the school allowed me and one of my friends to run in year 13 helped me cultivate my passion for politics which kind of pushed me towards choosing to do a joint honours degree (S16);

At a parents evening in Y12, Mr Abramson questioned why I was choosing to apply for physics at university and recommended I do maths instead. We had a really productive discussion and I realised that that was the right decision.
I was glad that I was challenged and not just encouraged to do what I had first chosen (S19);

I knew I wanted to study maths but didn't know where to start looking so when I was talking to my tutor about it, she mentioned she thought I would like Bristol and Bristol is where I ended up. It was a combination of me not having to make my mind up myself and the fact that I thought she knew me well enough to make a good suggestion and not just be saying things. We did have a trip once to a Cambridge college and there weren't any people there that weren't white so that confirmed that I didn't want to go there (S20);

The huge academic focus and pressure put me off applying for a really academic university like Oxbridge. I wanted to attend somewhere I could have fun outside of my learning (S22);

Yes, I think they wanted everyone to try and get into Oxbridge, or had expectations that everyone wanted to and could. Training very early. (Would you have had those aspirations if you had stayed at school?) No I don't think so. I think my mum would have encouraged me but I think it would seem very alien and impossible: because all the teachers at maths school went to Cambridge and so it was very achievable as all the people had gone through it. Made it a bit more attainable (Bill);

I kind of decided I didn't want to go to Cambridge so that left Oxford as a possible to look at, and I'd been here for maths things before and like them. I like the way you can see their course materials on line and look at things in advance. I'd done that when I was in year 13 and interested in what maths would be like at university, and wanted to look at the lecture notes for, say, linear algebra or whatever, to see what it was like, and I liked the way it was available for anyone…. In the first year I had a lot of classes and tutorials because that's how they do it at (my college), classes and tutorials. So I don't know how different they are, I haven't been to other universities so I don't know how the teaching structure is in other places. I guess it is somewhat….. the collegiate structure has been a bit of a factor, it has been helpful knowing people and not an overwhelming number of people that you might never know. And in

some ways it is not unhelpful but it makes it more difficult to know people at your college unless you have a reason to (Kim);

She (the economics teacher) sort of forced me come and see Bristol. I think though that in general all my teachers were supportive of anything that we wanted to do. I think some friction came with people who wanted to apply to Oxbridge and they were like, you could but your grade won't get you in. It's obviously a fair enough thing to say but when you really want to go there. It wasn't an issue for me because I didn't want to go there. But there were people I know, …really wanted to do it and the school was like realistic really. With me it was more like 'Just be sure that is what you want to do. Look at everything.' (Carly);

I think I've come to respect maths much more, but they didn't really sway me towards studying maths full time…definitely no direct pressure from the staff or the school to go and do maths. (Amandeep).

Of course, it is not easy to completely envisage HE life from a school perspective, which probably makes teacherly (or other influential) support and wisdom fairly central to decisions which are perceived to be satisfactory in retrospect.

4.2.6 Additional university entrance papers

Implicit in some aspirational applications is the need for additional entrance papers, compulsory for entry to several mathematics courses in highly selective universities, as well as to the most competitive engineering, physics and some other courses. In recent years demand, or preference, for completion of such papers have proliferated with the advent of TMUA, but engagement with one or more of these is also recognised to support students in developing mathematical qualities that are valued in HE (e.g. Darlington and Bowyer, 2018). All of MAT, PAT, STEPs 1-3, AEA, TMUA assume a prior mastery of core related A-Level content, though sometimes, as in MAT, only the first year of that. We asked students if their preferred university course choices included a need for, or a choice of, such additional papers, and if so, to describe their experiences of working for those and the impact that had on their longer-term development. Of the 26 students responding to the survey, 5 said they had needed to do at least one extra paper, and another 5 took at least one anyway. Of interviewees, at last 9 of the 12 had taken extra papers – unsurprisingly, as Oxford, where 6 of the interviewees were undergraduates, demands an attempt at a MAT ('mathematics aptitude test') paper for mathematics-based courses, or PAT for physics. Sometimes students talked about the very real satisfaction gained from engagement with these papers, irrespective of a university requirement, but they also reflected on the limitations of their own study skills. Some problematized the effort needed as a distraction from core work needed to master A Level curricula, understandably choosing to prioritise the latter, but it is clear that for students well-placed in relation to A Levels the support for, and challenge available from these extra papers, was an effective supplement and worthwhile experience in its own right. Others, as above, suggested that perhaps supplementary such work in physics was at that time less well developed than in mathematics:

My university course didn't require STEP but I did enjoy practices with STEP papers (S7);

One of my university choices required me to sit the AEA paper. Since AEA was required for my second choice, my priorities were my A-level exams, hence my time spent working on AEA was very limited. However, the time that I did spend working on AEA was very useful, especially when working with the teachers as they helped identify different ways we could use to solve problems and these have been very applicable in some university modules (S8);

STEP/AEA for offers, MAT for application to Imperial. These papers are like the UKMT maths challenge (or the KCLMS entrance exam) but more difficult and extended. The school gave ample preparation to students - however, I performed poorly in these papers as I had done very little self-study. I would recommend that students taking these papers spend time to do several past papers in the lead-up to the exam, with emphasis on speed (S18);

I sat the PAT. The PAT sessions were helpful. They helped with the sort of thinking needed for those types of questions. If I were to make a suggestion: maybe integrate the preparation for the PAT with the Physics Olympiad. I believe that the BPO is a bit before the PAT so this could be used as a vaguely similar mock test. Plus it'll inflate the BPO participation a bit (S21);

STEP and AEA I didn't find had much impact on longer term development, I found it hard to thoroughly prepare for them on top of preparations for A Levels (S25);

It was stressful at the time and I struggled a bit with time management and sorting out both A-level and practice papers and sessions but overall it was well balanced between being structured time and free revision time to ask questions in. In the longer term it did help but more with thinking about exam technique and how to approach questions that you don't immediately know the answer to or necessarily how even to start without panicking (S26);

Well they gave us lots of training for the tests and interview practice which I don't think I would have got in other schools. So I think the first year we had weekly or fortnightly STEP prep so we were very prepared (Bill);

I did STEP 1 but that was an extra. In an ideal world I would have enjoyed doing the other ones but there is only so much time and I had my A levels as priority (Ettie);

Yes, they had a class once a week, for everyone so there was one for the STEP, one for the MAP, one for the PAT. It was a hour a week and they'd set you papers, and if you ever had a question every teacher would make time;

They gave as much support as they could because of course not everyone is taking the PAT so they can't give so much time, it's not fair (Grace);

I did MAT, STEP 1 at the end of year 12, STEP 2 and 3 at the end of year 13. Preparation for that was really useful. So they had MAT and STEP teaching sessions once a week with someone from King's and there was some problem solving stuff and sheets that we went through and some STEP preparation that was really useful. And the teacher was really useful with any questions that I'd done, or if I was stuck on a problem, we'd work it out together. Especially STEPs 2 and 3 there are tips and tricks that are part of mathematical knowledge that don't appear on A Level papers…. I really enjoyed those questions, at the time they were the most interesting questions that I'd had and I enjoyed it all (Kim);

I took the MAP, and basically all of them. With the MAP I did the Durham one. I did the extended award, I did all the STEPs…..I did some past papers, I didn't even know the Durham test was happening, I just turned up at school one day, and 'Why are you late? You have an exam!' For STEP I just did some past papers, and for MAP I did all the past papers, it was quite important, but beyond that, not too much. My primary focus, which in hindsight was not probably the best thing to do, was the Olympiads. I was really

keen on Olympiads. My Christmas holiday at Year 13, I'd spend the whole day literally just doing Olympiad questions. Perhaps it would have been better to learn some actual maths (Michael);

(And they gave you reasonable support for these papers?) Yes. At KCLMS they were very keen on the problem-solving side of maths. That was very important to them, every week they would have a problem solving session where they bring in a graduate mathematician who would help me through a sheet of problems where you apply what you have learnt in an interesting way (Noreen);

Everyone had to do some preparation for that, but when I knew that I wasn't going to apply for Oxford or Cambridge I didn't end up doing the tests (Dan).

4.2.7 Even better if …

It is evident that almost all participants were highly appreciative of their experience at KCLMS; nevertheless, we wanted to know what would have made it 'even better' in their eyes, so asked 'what would you choose to have changed about your two years at KCLMS? (please think 360° and include social, cultural, curricular…)', and this was interpreted variously as meaning a change in school structure or approach, in particular provision, or a change in a student's own response to the opportunities offered. Some of the answers given were both sobering and supportive of further development:

In truth, not much. I found the bombardment of feedback sheets extremely irritating while there, but I'm sure that, from a statistical standpoint, their use is a good idea (S1);

I wish we had been able to learn to look after ourselves more. The lessons had very few faults but overall people were struggling. I had friends struggling with jobs at the time, having issues with diet, lack of sleep was major issue…. Yes work is important but it's not so important that it should be detrimental to your health. If we had learned some mental, emotional and physical well-being, it would have set us up for uni better because workloads only get more intense (S2);

Maybe a bit more soft skills like reading, since going to KCLMS I've lost that touch when it comes to books and I find comprehension really difficult when before KCLMS I was top of the class for humanities subjects. I also think making sure you don't neglect students that aren't genius level at maths because a lot of us in the middle sets felt like forgotten about and although some of us could have gone to Oxbridge we were openly discouraged from applying and told that if we did apply the school would not write a good enough statement for us. So we all went to unis that were okay but at KCLMS we all had the potential to go to better unis if we felt like we were listened to individually instead of feeling like another statistic to the school (S3);

I guess it would've helped to have a larger and better campus. Besides that nothing really. Oh wait it would have been really helpful to have some career related talks (S4);

Relaxed a bit more. Continued weekly Wednesday cultural outings - we did this only for the first couple weeks which included a visit to the Courtauld Gallery collection, really enjoyed it (S5);

I should have honestly attempted to speak to everyone within the first few weeks, it's a shame there were many people I only just got to know at the end of year 13….I shouldn't have neglected physics as

much as I did; it was too tempting since the maths felt so much easier. I also should have gotten into the habit of studying properly; it probably would have gotten me an A in physics, would have enabled me to formally take further modules, and would have been great preparation for the very necessary studying I do now. Finally I think I should have gotten involved more with the extra curricular activities the school had going going on, at least trying the ones I had a vague interest in (S6);*

I think more guidance and support for a broader range of university choices. And encourage other options aside from university. More exposure to the clubs available; most of the time it wasn't clear what clubs were available (S7);

- *It's both a diverse community as well as very white, could have more multi-faith/multi-cultural discussion events to unite the year group and also make us grow.*
- *more individualised study leave plan/ plan from April*
- *talks on autism etc to make everyone aware and comfortable as are thing you encounter.*
- *curriculum maybe missed a trick not having as much as a philosophical angle sometimes as approaching everything mathematically can become sameish (S9);*

Improvements: - Better teaching of the A Level syllabus (especially physics)- focus on making it make sense and getting the grades before the extra stuff (not everyone is as eager to spend all of their spare time learning maths).- School trips abroad like other sixth forms do.- Industry visits, so that people can pick a degree based on what they want to go onto do in the future.- Respect individuality, having more options in terms of what extra activities the school gets involved with - Maths Challenge and Olympiad are not for everyone. - I have since come to realise the importance of computing, although computing was attempted at AS level it was taught badly and seemed really boring. My third year dissertation is on machine learning dimensionality reduction methods and I have had to learn some coding for it, it is actually really interesting so it would have been beneficial to realise that earlier on. The school could make it seem exciting through examples, rather than just telling people to go through code academy and a textbook. - Chemistry and economics would be good A level options to offer.- Better disciplinary process, the school didn't seem to know how to handle certain situations, but then we were the first cohort so that is to be expected to some extent.- Just in general make learning more interesting and less stressful, it is effort to get there for most students so give them a reason to want to go to school everyday, probably better for mental health. - The school seemed to have a lot of people with mental health problems or learning difficulties but didn't really know how to manage it. I think autism, dyslexia support could have been better. Not everyone learns the same way or handles day to day things as easily as everyone else (S10);

At times, I felt that the school was quite intrusive in our personal lives and how we spent our time outside of academics. I had a few instances where I felt a bit invaded in that respect, and that the school didn't have trust in my ability to get the work I needed done. Although intervention is required for some students, more trust in pupils, given we are all 17/18, would have made the experience more enjoyable. I can't say much socially, as I found my group of 3 friends and stuck with them throughout (all of whom are massive parts of my life still) and I don't regret not being more social at all. Everyone works differently, even in a maths school, and respecting this fact I think would have improved my experience at Kings. Overall though I had a laugh and got my work done, so not many complaints haha (S13);

It should be emphasised that most, if not all, students at the time will be using much of their time at KCLMS to make mistakes from which they will find themselves learning from in later life, which I have

certainly done. The limited cohort size made it easier to make friends and the environment was not hostile in any way, much less so than every other school I have attended. There was no choice at the time as to any alternative AS level, and given the opportunity at the time I would have enjoyed to have taken a language or studied economics at AS level with the school. I really enjoyed the extra-curricular activities and always looked forward to football on a Wednesday, as well as the trips to art galleries, science museums and talks to broaden my general knowledge and help me hone my own perspective. Above all, the people I met at KCLMS made and continue to make a huge impact on my life and I would not be the same person without them, and the layout of the school with its open pods and cafeteria helped to encourage students to interact which cannot be understated. At times one felt slightly inundated with the length of sheets and competitive with all peers doing all of the same subjects, which lead to me most probably overworking myself in competition rather than for a genuine passion for the subjects (S14);

I would have changed the administrative structure of the school. The Senior Leadership Team (SLT) has the role of ensuring the numerical performance and success of the school, and as a result it should NEVER be mixed with the teaching staff, whose only role MUST BE to ensure the success of the students. In KCLMS, as the school was such a small operation, every member of the SLT was also a teacher in some capacity. This meant that the SLT had to choose between working to make the school 'business' succeed or working to make the students succeed. I was disappointed (but not terribly surprised) to see that all of the SLT chose the school over the students. It is ethically unacceptable to risk jeopardising students' futures in order to improve the statistics of the school (S18);

I do wish I had done an Arts/Essay Subject A-Level but don't really see how that could have been possible as the maths focus is what makes KCLMS what it is. Socially and culturally I think the school was absolutely great (S19);

I appreciated the extracurricular activities but being told what I can and can't do on a study break at the age of 18 really pissed me off, I would change how strict they were on that sort of thing. I can't blame the teachers because I think they probably can't remember ever not having a work ethic but I really wish someone had taught me what I needed to know before I left about working. I don't know how helpful the EPQ has been for other people but I certainly didn't care for it. I also think some racial bias training is needed because I remember there being a few incidents where I thought people of colour were treated harshly compared to white students by members of staff and there was no way to complain about it (S20);

I wish the sport side of the curriculum had been a little better developed throughout my time at KCLMS. I admit the situation improved significantly for year 13 and also that because of the space limitations the school has a harder time finding the facilities required. VEX was definitely amazing, the hardware was not cheap and all the responsibilities to perform were in our hands. I don't think many schools would even dare to attempt this, let alone succeed. I felt that a significant issue on the social side arises from the distribution of the student body across a large area. I believe this very much limited the interaction between students outside school and played a large role in determining the social groups into which the student body ended up separating into (S21);

That we had to be in Monday- Friday, 9-4 + compulsory after school sessions. It was very high pressured, with a lot of work and huge emphasis on being the best academic you could be. I wish there had been

more social focus and activities, and also things that were optional. I enjoy maths, but I have no desire to spend all day every day doing it (S22);

I think if they had been able to offer some non-STEM subjects, maybe not as A levels. I think we had that to start, but it got dropped due to time constraints. It would have been nice to have….Maybe languages, arts..we had languages, free language lessons at King's, but nobody liked that because it was compulsory and as soon as it wasn't compulsory, everyone left. Six o'clock in the evening! I think our year was quite coddled, and I think a bit more freedom would have been appreciated and good because it was strict (Bill);

Re CS: you can treat complication as a mathematical thing and some people might be interested in that. You might be able to say like 'here is the mathematical formula and this is how we can apply mathematics to the problem', and there are lots of interesting problems that computer scientists don't solve by algorithms and you just use mathematics to extend certain ideas to other ideas (Ettie);

Maths is about straying from the straight and narrow, so it is a very good question as to how effectively you can teach maths in a classroom. I have to say there was a lot of time in lessons: so the work is there, you figure it out, you stretch yourself. I think they encouraged collaboration. I remember quite a lot of exercises where we are put you in pairs, race with other teams, those were very interesting. And not widespread in sixth forms (Ettie);

The main thing would be to be treated more as an adult rather than a school student.. In some respects it was nice to have this structure and be clear 'this is what you do', and if you're not doing well, go to the homework club and so on. But when it came to break time, we had to stay inside, just little things like that that made you feel like you weren't an adult … In terms of maths and physics, it would have been nice, not for me because I wanted to do physics, for other people to have the choice to do computing as a third subject, or economics as well…. I'd say OK, when you get there be prepared to work hard and just don't get put off at the beginning, because it's very difficult to feel comfortable at first because it's really high intensity. Everyone is very intelligent and it's easy to be put off, so just keep going and maybe after the first two terms you still don't like, it may be time to do a rethink (Grace);

*I think my biggest criticism of the school was, certainly when I was there, I felt very much that the main objective of the school was to take students who would have got As in maths and make absolutely sure that they got A*s. This is obviously very good for the students and very good for the school because they topped the league table for value added, but I did feel that those who were (a) towards the lower end were either terrorised into doing better or got kicked out, and those towards the high end were going to get A* so it really didn't matter that much. So of course the school gave us extension stuff to do but I think there could have been more of a focus on the extra things…. I would have liked more support with other maths stuff that I wanted to do, which is obviously hard because a school has limited resources and lots of students to look after…. For example, nobody ever told me how to break an Olympiad solution which would have been useful. There was a point in year 13 where I basically hunted down teachers and showed them my solutions and begged them to give feedback. And that was useful…. and maybe advice on how to read a maths book, which is not easy…. So things like that, things that contribute to your wider development as a mathematician beyond A levels and Step questions and the like. (Michael);*

The staff were maybe not well equipped enough to cope with students who came from a different background to them, and I think …there were a group of boys in that bottom set, not necessarily me but more the other boys in that set, that I think often had a harder time with the staff, not any fault of the students but more to do with the staff. I think that was a bit of an issue… having limited experience of people from different backgrounds and like a big umbrella term for, I don't know, antiracism, anti Islamophobia, a lot of things, a whole cascade of being not necessarily more tolerant but working more in solidarity with those young people (Fabio);

For me, there would have been gains from doing Computer Science to A Level, particularly the project element …. I think there's this atmosphere at King's since it's very competitive, what tends to happen is that only the guys at the very top are encouraged, I think at least, to apply to more prestigious universities like Oxford or Cambridge. King's is already competitive as it is, just the top five percent of those students are like encouraged to apply for Oxford. So support for a more inclusive approach to that, even if the chances are small, would make people feel they'd given it a go. (Amandeep).

Note the seriousness with which these graduates approached the task: these suggestions might not align with teacherly or governor perceptions, but they were offered in sincerity and with serious intent.

4.3: Student experiences/critical incidents since KCLMS

Key Findings

- For most, transition to university had been a socially and academically relatively smooth process, perhaps via a refreshing 'gap year'. In HE, small Oxford cross-discipline collegiate communities, and small-group tutorials, were particularly appreciated. All seemed content with the pathways followed to this point.
- HE contacts had increased participants' appreciation of the quality of the mathematical and learning experiences they had had at KCLMS, and the mathematical confidence endowed.
- The rigorous and problem-solving approaches privileged at KCLMS had supported participants well in transition to university mathematical expectations, though some thought the development of more independent study skills would have been useful.
- Inevitably, individuals' relationships with mathematics had changed, and often fluctuated, over their time at university, depending in part on their course. For those studying courses with high mathematical content, relationships with mathematics had often become highly fulfilling.

- Transition into HE
- Distinctive, valued KCLMS experiences
- Building on KCLMS in HE
- Relationships with mathematics

Into and through Higher Education 4.3

4.3.1 Transition from school to Higher Education (HE)

Moving beyond KCLMS, three sample students had taken 'gap years' but all others had moved direct to university. We asked about key transition experiences, and how those were perceived to have been influenced by graduates' experiences at KCLMS. Participants commonly commented on their observation of others experiencing the 'I'm suddenly not the best in my class' syndrome that most at KCLMS had experienced in their transition at 16. Similarly, some social and learning changes were often perceived to be less challenging than they might have been because of earlier transition. On the other hand, it was not uncommon for students to express some disappointment at the quality of teaching and social experience easily available to them at university, compared with their experiences at 16-18, with some commenting on the sudden lack of structure, though views on the impact of KCLMS's expectations of level of independent working, and restricted curriculum, were mixed. Similarly, for some students, their university course was perceived to be a nirvana, a 'promised land', with the small cross-cultural Oxford college communities appearing to be particularly valued, whereas for others there were aspects that were disappointing. These included areas such as richness of interactive mathematical community, overt teacherly commitment, and deep engagement with mathematical ideas, where for a few, experiences in High Education did not always live up to the quality of experience at KCLMS :

KCLMS made me assume that all lecturers and students would be as passionate and that everything would be explained at uni but that's not true at all. It's hard and it's tiring and it was painted as something amazing which simply doesn't agree with a lot of people. I have several friends, and I myself don't enjoy university but now we're all in debt and there's no choice but to see it through (S2);

KCLMS made math lectures at uni level a breeze (S3);

Had many critical personal experiences during a gap year proceeding KCLMS, the decision to do so influenced by some of the pressures experienced during KCLMS. Critical experiences during university enrolment such joining a community of like-minded, high achieving individuals were not unfamiliar because of KCLMS (S5);

Perhaps this is not so "crucial" but it was clear to see a large number of people were now also experiencing the "I'm suddenly not the best at maths" shock King's students know fondly. My own experience with this promoted a rather sympathetic response which probably helped a lot of people bounce back from it with the same drive to improve oneself that I developed (S6);

When I first started at KCLMS, I knew no-one else as I was the only person to attend from my secondary school, therefore I was forced to interact with people I usually wouldn't come across on a daily basis, allowing me to become a more confident and sociable person. This helped when going to university as again I went to university, only knowing one other person so I was forced into a similar situation and this time around I was more comfortable, since I'd experienced it before (S7);

I think the tutorial sessions (I can't remember what they were called, classes of 4/5 students where we went through STEP type questions) were a good introduction to HE. Other than this though I felt pretty unprepared for university learning as KCLMS sort of 'babied' us and spent a lot of time controlling how we work and study etc, which is the complete opposite to HE (S13).
KCLMS helped bridge the gap with their choice of exam board and offering of extra modules. OCR MEI was much closer to university standard and style mathematics than alternatives, and allowing me to choose additional statistics modules helped me feel at ease with the start of my undergraduate career, as I was already familiar with many of the concepts and most of them had been taught better at KCLMS than how they were being introduced at the time (S14);

Prepared to be much more independent and in control of my own time was helped a lot by the free periods and KCLMS (S15);

I think KCLMS has given me the confidence to be able to put my hand up in a lecture with 300 people and answer a question, without being afraid to be wrong which I definitely did not have before going to King's and I am pretty sure I would not have if I hadn't studied there (S16).
Transition was rough, tutorials/lectures at university were not as fun as learning in the KCLMS class room. University you can get away with not doing anything, attendance isn't tracked. Had to learn to push myself through (S17);

As I had witnessed, and been the target of, jeopardising action by the SLT, I learned that it is important to know and understand my rights what I can do if I am at risk of mistreatment by another party. I have applied this learning principally when finding accommodation for university, as I have come into conflict with the estate agent, landlord and utility suppliers (S18).
I felt like I really lacked independent learning skills. I was very used to being taught as opposed to seeking out information and learning it myself. In 1st year I almost dropped out because I thought that Maths was too hard and really not for me. Only now in 3rd year have I started to get to grips with the style of teaching (S19);

I had to retake some exams by myself after I graduated KCLMS to get into the university I wanted, this has been really critical. Since I was reteaching myself the modules I really learnt how to study and that I am capable of it, which I did not know then. I was spurred on to teach myself because I knew that Fermat had taught himself and I felt I only read about Fermat because of KCLMS (S20);

Felt the change of routine was really hard but KCLMS helped lessen this change by going further than the curriculum in lessons (S25);

Some people I think struggled not only from the big change of moving away but also from going from being the best or one of at their school to being amongst people who were as intelligent and as good academically as they are. That transition had already been gone through at King's so it made it a bit easier. KCLMS also was good at making you think and figure stuff out more for yourself and so not being given the answers straight away wasn't new but I think for some people it was more of a shock. Although because study and revision time near exams was so structured I found it quite difficult to know how to revise and set up my own revision schedule (S26);

(the curriculum at KCLMS) meant it was a more restricted background than some of the others at university. So a lot of people doing my course have done chemistry so they understand that better, and the lecturers will often say 'that's just A-Level Chemistry. But maths-wise, doing MEI, There was a whole module that they chose for us to do, which I don't think a lot of people do, was the differential equations module. It ended up being a very difficult lecture series and I had a lot of help with that from what I did at maths school. I would have failed that without (Bill);

*It's a bit of a culture shock to go back to a place where people do lots of different things rather than just maths….. And now it's a cross cultural community. I think it's a tremendous privilege….academically there was not much of a problem apart from the problems that anyone would have. For example, you get your first problem sheet and the tutor rips you apart because you didn't state every axiom step by step and you went 'I know how addition works'. Or you get ripped apart because you prove two sets are actually the same set by **** rather than by manipulating, rather than using double exclusion. I don't think that the school could have helped me with that because: can you imagine a world where people graduate from this sixth form knowing how to prove things and not spending any time on A levels, and all ending up failing (Ettie);*

I don't think Computer Science is a very useful A level at all. In fact I believe, I got told, I went to a Cambridge open day and the guy literally stood up and said 'We've been asked countless times by people taking four A Levels, what is more important, my computer science or physics. We always say physics or whatever the other subject is as long as it is relevant'. And I think teaching it the way the curriculum suggests is a massive waste of time and…doesn't build up the capacity you need…. Well, on the other hand they did not expect much and they tried to build people up. Teaching Python from the perspective of 'let's get people to understand what's going on rather than pass an exam on Python' would be good. Also when I started functional programming last year, one of the things that struck me was that the programming is a mathematical exercise and that could be emphasised. You can look at these from a lot of mathematical perspectives. You can look at them from an algorithmic perspective and say 'what's' going on here is that we are looking at one thing at a time here', or you can look at it from functional perspective and that ends up being an incredible mathsy sort of thing. I remember, you can end up proving category theorems to your programming problems and I thought that was really interesting (Ettie);

I was quite well prepared. It's hard to say because it's hard to compare. French education heavily emphasises analysis and they don't do a lot of calculus at all and other education systems copy this. A lot of people coming from France or Poland are like 'Oh this analysis, I did in sixth form. But I couldn't tell you how to calculate the integral of log x'. On the other hand, I didn't do a lot of analysis in school, but I found the early analysis courses stupidly easy. The A Level after a while becomes entirely about calculus (Ettie);

I think the transition was a lot easier because I went to King's….Because I'd been in an environment which was specialist and everyone was really good at what they were doing, and that's the type of environment that you get here… Yes, it was less of a shock coming here than going to King's. And it's really nice because you don't just get people who are good at maths, you get people who are good at classics, and you have all these other types of conversation, not only about maths….It's a really exciting community, a cross-discipline college….I really like it. And in terms of the workload, the workload at first

was a bit of a shock just in contrast to other people who really don't have much to do, and you have so much…. It was really nice to have people from King's here, my friend is doing physics in the year above me and I always had that support there. Every college has a college family, and that's really nice as you have your college brothers and sisters, and parents (Grace);

I remember it being quite stressful in some ways. I felt quite stressed about my work and whether it was good enough. I'm more confident about that now than I was at the beginning of the first year. Overall it was all right, the maths was difficult but not too difficult….Much less of your week is structured than it was at the school….. I don't think that's much of a problem. As I was saying, at (College N) we have classes and tutorials in the first year so quite a lot of your time is structured, and actually a bit of a problem with Oxford is that the first year courses are very intense and packed so the way it works is that in the first year you have five problem sheets a week for the entire year. In the third year, well this term I have had eight problem sheets over the whole term, maybe not even that. It's very different, and I'm not convinced it's the best way to do things. If you gave people a bit less in the first year they might not be quite so overwhelmed … Yes, and the problem sheets are not long but not short either in the first year. They are a reasonable chance of work and you have both of them a week and it's very overwhelming. I think our first problem sheet of the year was in the Tuesday of week 1. We had three lectures and had to hand in this problem sheet by 5pm on Tuesday having been to three or four lectures, and not having any time to do anything….It does not give you much time for mulling which is important in maths…… it didn't give us much time for reflection, it barely gave us enough time to go to the relevant lectures. The problem sheets weren't really meant to be done two days in, it didn't give us much time and set the year off badly really. You have to keep up and get used to it, which I didn't find helpful…. I go to lectures, I very much like lectures. I find reading quite difficult and hearing the lecturer saying it out loud helps me, even if it's one which is just reading the notes, it's better than me reading the notes myself. Generally they are not just reading the notes, they are clarifying important points and whatever. It just means I get a good set of notes. I like that, lectures are very useful. Some people don't, I understand that. If it made it more confusing it would be better not to go. But I like to go through all the material and learn it, it's helpful to me and gives me a structure to the day, say if I have to be somewhere at 12.30. (Kim);

Really good, I absolutely loved it. I was finally doing the kind of maths I wanted to be doing. It was exactly as I hoped it would be. This year is even better, it's even more exactly what I hoped it would be. The only difficulty I had, I went to Promise the summer beforehand so I arrived here with a warped perspective of how rigorous I was meant to make everything. At Promise the whole thing is to build up number theory and some abstract algebra really really rigorously from axioms, like every time you use community you have to cite it. I remember one of my analysis problem sheets, you had to sketch proof of reals and unreals, and I wrote 13 sides. From the axioms I proved that phase 3 expansions existed and were well defined and then used those expansions I had made to … but they were looking for decimal expansion this, like ones become one and sevens, whatever. Overall, I was really happy (Michael);

Everything I learned in maths school, from the mechanics and the core modules, like even the basic Python knowledge that I knew, every single bit I used in my course in the first year. (Otis)
this (engineering mathematics at Bristol) is a course where I actually felt was a natural progression from maths school, it was really so similar to my year 13 which was really crazy. The second year got harder, but it was really good, I felt so prepared for it (Otis);

(Is this (economics) course at Bristol working out how you anticipated?).. Yes. I didn't expect it to be as mathsy as it is. You go to other universities and it's not so much maths. I just did not anticipate so much maths. So it was in vain. All my friends say 'Do you see maths?'. Because they do economics and they see me doing this formula, and …I have to put extra in because it's hard to understand at the level we do it…. I get to choose units now as well so I'm very excited (Carly);

I had to retake a couple of exams… I chose not to give up the teaching scheme idea and go for Bristol again…but I don't think I ever learned how to teach myself until then, so that was good for me … The first year I found a bit boring but I think that was because I didn't give it the time it deserved, but now I am doing that bit more, well a lot more actually, and I'm enjoying it a lot more too. People have been telling me for years that the more effort you put in the more you understand it and the more you enjoy it, and it's true (Fabio).

It is clear there is a wide diversity of such transition experiences, varying not only across university and course, but by individual. There are few clear messages except that by the time of the interviews, so for the vast majority of participants, in the Spring of their second or third year at university, significant challenges and disappointments seemed a distant memory – and all had persisted. As a set of snapshots of 'this transition won't always be unproblematic', though, they have much to offer to younger students embarking on that phase.

4.3.2 Distinctive and valued KCLMS experiences

At the point of our data collection, students had spent some time mixing with HE peers from a variety of educational backgrounds: all of them were into the Spring term of at least their second year. We asked them to describe any features of their experiences at KCLMS that they valued but thought peers from some other backgrounds might have missed out on, and some responses were fairly graphic. Although most were appreciative, there were also a small number of reservations:

Pretty much everything. I was particularly struck by someone telling me that their further maths teacher literally did not understand the content of the A Level course, so clearly having teachers who are genuine experts is extremely valuable. A culture of love for mathematics was for me the most important thing at KCLMS, which is plainly available almost nowhere else (S1);

The solid foundation in maths and the understanding that you are not the biggest fish in the sea. We had that click in year 12 and it humbles you and makes you work harder but also stops you from feeling awful at uni (S2);

The work ethic and true passion for the things we study (S3);

Central London location; the feasible outings, visits from speakers, academics and networking opportunities that come with it (S5);

I learned rather quickly that a significant number of schools simply don't teach further maths, or if they do, not properly. I think the knowledge I gained from learning that material at KCLMS had been crucial to my course, and even in second year you can quite accurately tell the students who took it apart from the students who didn't (S6).

I value that way mathematics was taught and demonstrated. For example, doing workshops on Euclidean geometry wasn't entirely necessary for the A levels but it provides a different viewpoint in understanding real world applications (S7).

I actually think my peers had better experiences in regular sixth forms, but that's just my personal opinion (S10);

I think the main benefits of KCLMS come from the standard of education, rather than the community/cultural aspect of the school (S13);

Feeling part of a strong cohort with shared interests and appreciation of Mathematics and its applications. In a way, I felt like I had already experienced the relief and sense of community those entering university were at the time and hence felt less pressure to be a part of these social groups, and maintained strong ties with close friends from KCLMS (S14);

Time management and independence (S15);

I would say that for mostly everyone else that I met in first year it was really hard to adapt to the university teaching methods, where the lecture is more of an open discussion than a lesson and is not bound to a textbook. However I was already used to that because of the teaching methods at KCLMS and therefore my transition was much smoother than most people and it wasn't hard for me to gain that independence that you need at uni to be able to study without being told to (S16);

The depth of knowledge in our subject. Turned out many people learned purely to pass the exam and lacked the deep understanding that we had in KCLMS. This really helped apply this knowledge in a wider context and not just familiar problems (S19);

I would actually say there was a lack of 'normal people' at kings. Normal as in, did not have their entire world revolve around how good they were at maths or physics (S22);
Working in a group to solve problems especially in subjects like maths. Linked to this is the ability to explain the thought processes that have gone into solving a problem. Being able to clearly set out the maths behind thought processes makes trying to explain potential solutions for issues in group projects a lot easier (S26).

Experiencing hardship and having to work harder than others, as some may not be able to afford a tutor etc (S23);

I think it's more useful to ignore the comparison side of things. KCLMS prepared me for university: they encouraged that independent problem solving and investigation side of things. I think in a strange way that the computer science teaching forced us to develop and accelerate our projects with independent thinking. That was very helpful and that was the whole atmosphere of the school and the fact that they were all very eager to help you develop the skills that you need for STEP papers and maths and that sort of stuff, yes, that was very helpful (Noreen).

4.3.3 Building on KCLMS experiences in HE

In a linked question, we asked participants what of their mathematics or wider education at KCLMS they felt they'd particularly drawn on in HE, especially if their perception was that's not available to be drawn on for all their peers. Again, the vast majority were highly appreciative of the way in which KCLMS had supported their capacity to benefit from HE experiences:

I think the way I problem solve has been heavily influenced by the way we were taught (S2);

Ambition (S3);

I've particularly drawn on derivations of results most of my peers have only seen quoted, and the general Socratic style of teaching and learning heavily employed at KCLMS which compels me to learn further derivations on things quoted to us now. In particular the module we did at KCLMS on differentially equations has definitely kept me ahead of the curve in my related modules (S6);

Particularly looking a problem and branching out into different potential solutions. And it's okay to fail as long as you tried (S7);

I have definitely drawn a lot from the further mathematics modules such as FP2 for a mathematical methods course and S3 for an elementary statistical theory course (S8);

How to solve a problem and understand what is going on behind the mathematics conceptually. This can help make things make more sense than just remembering how to apply them. I seem to be able to learn things a lot quicker than my peers, which was the complete opposite when I was at Kings (S10);

I ask 'why' all the time- sometimes to my detriment as if the answer is not apparent, which at university it sometimes is not, it can be very hard to motivate myself! Nevertheless I need to understand the value add of ideas and appreciate their power in order to cultivate a passion for learning them myself. Problem solving sessions helped my logical thought process, I still use whiteboards to this day to map out my thoughts. Also, the support KCLMS gave me during revision helped me to become very strong during exam season and an edge over my HE counterparts. I also believe KCLMS helped me to create a very strong university application and focus on my employability early on in my HE career (S14);

I make sure I understand things conceptually instead of memorising and that's helped a lot (S17);

Depth of knowledge, especially in stats. Am studying a master's level stats and stochastic modelling course in France at the moment for Erasmus and still recalling how basic concepts were explained to me at school. It's given me the best possible foundation of knowledge (S19).
I LOVED mindfulness and have not stopped practising it. I think it should be an integral part of every establishment - school, church, workplace etc. (S20);

Mathematical intuition, especially seeing how parts of a problem come together without having to explicitly work it out (S21);

We were taught at University standard through Kings (S22);

Again, the ability to approach problems from different angles (S25);

The ability to think through a problem logically and try to apply stuff you already know to a situation you are not familiar with. Seeing maths as problems and challenges to solve rather than something you just have to learn by rote (S26);

The study pattern is different. In third year we have about 4 or 6 lectures, we have a full day of labs and we have half a day of project, well a full day of project for our third year project, plus tutorials. I think the tutorial system in first two years was very valuable, you have someone to go to if you are stuck and ask for help. I think I struggled with how broken up the contact hours were, because I was used to 9-4, five days a week, and then it was all your own time management and blocks of time between which I wasn't used to.I think at King's we had 4 study hours a week. Maybe a bit more but somewhere like that. And you had to stay in college for that…. you just turn up and then go home. I know that's different at other sixth forms. My sister goes in and comes home for a couple of hours, and organises her time herself which is more like universities are…. it took a while to get used to because there were five people I didn't know and I had to be open about what I didn't understand whereas in a classroom you can hide a bit more (Bill);

Where they analysed that they'd had a particularly privileged experience, but that this was common among university peers, students often went on to reflect on the wider implications of that:

I don't think I was that much different. I think most people I know have had a lot of help. They've either gone to a grammar school and been part of a group that have been coached for Oxbridge. There's a girl from Exeter Maths School like me. Or they've been to private school and had help getting in. Not too much difference. I think it's just the amount of maths I've done that's different…..The question remains for the university: is it that you cannot get in without a lot of help or is it that people don't feel confident to apply, don't think they've got a sporting chance. So you 've talked about teachers with personal knowledge of the system….That helped a lot, and I did several practice interviews. When it came to the actual interview, I knew what they'd ask and I'd already practised about half the questions they could possibly ask me (Bill);

I think having a strong mathematical base, because it's very easy in physics just to be able to do the problems and not really understand it. To do any problem you have to understand the maths behind it first and I think that's really useful, coming from the maths school….I think that for some (of my peers) it's more of a memory game: they will remember the equations, the whatever, they'll remember the facts but they don't really understand the maths (Grace);

Things that have been helpful, I don't know how it would be in different places, but compared to secondary school I cared more about my work and doing my work well. The fact that they put effort into making homework problem sheets, rather than just saying do the questions in the book or read this chapter, meant that wanted to put work into it also. The fact that they marked your work properly and gave real feedback made me feel that I owned my work more and that was definitely helpful here because that's how you feel about your problem sheets here. That made it easier….It's complicated.

Being around lots of maths people is less difficult if you are used to it. You still don't know what to expect, you don't know. I think I work more with people here than I did at King's (Kim);

I really like the tutorial system, I think that's great…I like the more flexible style of teaching where you can choose which classes or lectures are worthwhile…some of the lecturers are passionate, some are just doing it because they have to (Noreen);

Just the maths. Everyone struggles so much with anything that wasn't the A Level maths core curriculum, and I see things which, even though I didn't strictly study at King's, I can have an approach to it…..also just the way we were taught was to look at a question and see if you can solve it without knowing the method. We will eventually get to the method, but just look at it, how would you approach it? That's so useful now, I can sit down and look at it and I have at least a way of getting started….I would not even call (what we do) maths, to be honest, more like differential equations, there's a lot of fitting equations to a model, which is quite hard. It's mostly differential equations, I would say, but there's some of it that I wouldn't really call maths but you have to make sense of it. And there's methods in economics that are nothing like I have seen before (Cary);

King's had made me think for myself such a lot, and the style we were taught in, going into a lecture I wasn't scared and I didn't fall behind and I found, because of all the extra things I'd learnt at King's, the first year was not particularly challenging for me which was great. The change in style…So at Kings we weren't taught out of a textbook and obviously at university you aren't either, and I think that was huge. I remember in first year some of my friends were like, 'Why isn't there a text book I can follow for all these questions I'm being asked?'. And I'm 'That's just not how you're taught in the real world.' And I forget that I am one of the few people who experienced that (Lizzie).

Broadly speaking, students at Oxford were less aware of very distinctive background experiences than those at Bristol, with several suggesting that KCLMS offered very comparable experiences to many successful independent schools, in terms of mathematical and broader cognitive and, to a lesser extent, social preparation for mathematically demanding courses at university.

4.3.4 Development of the relationship with mathematics

KCLMS is, as it says, a mathematics-focused school. All participants were studying HE courses with a significant mathematical element, even if not primarily mathematical in nature. It was therefore important to probe how their relationship with the discipline developed over their time in HE. Again, responses were mixed, as well as changing over the time since A Levels, though for many it remained positive, although clearly matured, over their time at university. For some, this was related to their enhanced appreciation of mathematics as a tool and language for applications, and for others, a relationship enhanced by glimpses, and sometimes full philosophical and ontological engagement with new mathematical horizons. For others, their developing maturity as learners meant they were proactive in selecting from the available ways of working in HE, to make most sense of, in particular, the mathematics they could be learning:

There was a dip in my enthusiasm in first year, as the content was not as exciting or suited to me as I had hoped. However, the choice of modules available in second year has me doing topics I really love, and I'm now more enthusiastic than ever (S1);

I've had two basic modules which were half a level and half not explained so my maths has stagnated really. I am tutoring at GCSE level though so I'm learning to explain and teach maths through my perspective (S2);

Poorly, not really a fan of maths anymore. I think having too high of expectations of uni and being let down because it wasn't the same (S3);

To be very honest, the mathematics at high school level was very boring. It was very easy, but boring. So overall it hasn't been inspiring. But that's not KCLMS's problem. I still think they helped us in more ways than other school (S4);

In natural sciences, it's certainly applied. For me, mathematics is no longer something I explore itself, but use it as a skill set to represent, analyse or communicate physical concepts. A consequence of this would be, for example, disregarding the validity of a particular solution based on its inconsistency with observed physical phenomena despite its mathematical consistency. The limitations of mathematics as a language that we are still discovering/inventing is more apparent (S5);

I've now come to be somewhat puzzled by the unreasonable effectiveness of maths, it seems to have the power to do almost anything in the right hands. Real analysis might be one of the coolest things that is, and together with what I've read of abstract algebra, neural networks and topology, my understanding of what maths is has progressed yet another step further, as a way in which we can describe logical systems and the properties they manifest when we impose certain structures on them. Rigor is everything (S6);

My relationship with mathematics has become more advanced since I have been exposed to different aspects of mathematics such as real analysis (S8);

I prefer it now, and want to continue to develop it even when I leave university. I see many more practical applications of it and relevance in certain situations (S10);

I have struggled with seeing the point in it but now am very happy to do it. It has become much more interesting as it has become more difficult and I can see the applications of the skills you develop while engaging with it such as general problem solving and rational thinking (S11);

I feel like I can add value to real world problems now, which I find motivates me more than anything else with regards to mathematics, as I can use subjects such as linear regression and algorithms and merge these skills to analyse data and use it to draw narratives and powerful conclusions. Coursework has helped me to develop a close relationship with applied mathematics and feel confident I can add value to employers with my passion for mathematics (S14);

It's vital every day in my engineering work, however it is also very difficult at the level I have to do it (S15);

During first year, I found my more mathsy units really boring and not stimulating because it was a lot of the same methods repeated over and over again and often found myself being excited about helping my friends studying engineering or maths with their complex numbers and proofs (everyone thought I was crazy). However luckily this year so far I have been really loving the maths side of my course and often had discussions with my tutors on how to take it further, for example by proving certain formulae which we are just given and such. So all in all I would say that my curiosity is still there and I am now exploring new sides of maths, linked to economics, which I had not had the chance to see before (S16);

Declined, don't enjoy it as much as I used to (S17);

I have learnt that it does not matter why something works, as much as it matters that it DOES work (S18);

Absolutely hated first year and wanted to drop out/change course. Really thought that maths wasn't for me, that I wasn't clever enough/just couldn't do it. In second year, was given freedom to choose all modules so chose specifically what am good at and enjoyed it slightly more. At the moment, in 3rd year on a study abroad placement have had the opportunity to study maths in a very applied context which has helped me regain my passion for it (S19);

I feel a lot more seriously about it now, like a grown up, but other than that it's a pretty similar relationship to what I had before (S20);

I'm ready to be finished in education now, and get a job where mathematics can be more applied and less theoretical (S22);

Maths has become more interesting as I have begun to see more and more where what is learnt is applicable in the real world from harmonics and vibrations in structures to calculating the moments of inertia of various objects (S26);

A lot of the time (in my course) we don't go very far into the maths, we get these equations that someone has come up with and told that the maths has been worked out and we don't to worry about it….you..just sort of plug it in (Bill);

The thing is we really didn't talk about it (proof) that much. You don't need it for A Level. Frankly it's true that the analysis stuff I learned was in the first year of university. I think it was hard enough conceptualising, it's a culture shock when you come from thinking you can write functions in terms of x. I think one of the modules I took was Further 3 and it had multivariable calculus in and the teacher said that we are assuming that you have a turning point if these two derivatives are zero, in this direction and that direction, but in fact that's not true because you can think of a function like a knife point. It's hard to conceptualise because you come from the idea that all the functions that you work with are the ones you can write down; and what we are talking about here is something that applies to none of the functions that we can write down and functions to do with limiting processes that we didn't talk about either. We

really only talked about sequences…..But you have to start somewhere. And in terms of school maths functions that are not differentiable anywhere are still the exception, awkward cases.In spite of the fact that there are way more of them than any other function, I still think of them as being the exception, I do remember seeing something that amused me, that a while ago I read about an exam question for some European university in the 1900s, in fact pre-Weierstrass: Prove that any continuous function is differentiable almost anywhere, which is comical to say the least now (Ettie);

(So the sort of maths you were into was more the maths you met in UK challenges and STEP than by GCSE or A Level?) Definitely. In fact it was quite weird when I did probability in the first year coming across a problem and thinking I saw that on a STEP paper. It was proving that the expectation can be written for a continuous probably positive distribution as the integral of the probability. Which I thought was really cool, I did see that in STEP paper….In sixth form I quite liked probability because that was one of the topics at A level that has the most proof in, which is really weird when you think about it. I enjoyed that, especially the extension stuff, I didn't really enjoy the statistics at all. I can't really say, it's really hard. (So how you think of mathematics now, is that more aligned with the UK Olympiad-type thinking?) No. You realise that the Olympiad thing is kind of silly. They have a certain number of things and a whole lot of things that we already understand very much but they just made the questions arbitrarily difficult. Is that really maths? Surely maths is finding new things rather than things we already understand like Euclid geometry, like what if we make this incredibly hard? (Ettie);

I also found out that you can do arithmetic just using a compass and a straight edge and that made me happy. I didn't realise you could do arbitrary multiplication. I thought OK, yes I can think of some way where I get a line and a point and I can do four times this length but I did not realise you could have one length and another length, I'm going to construct the thing which is the product of their length (Ettie);

(You wouldn't have seen the elegance without doing the A level?) No. Electromagnetism, we did Maxwell's equations. That's really nice. There's a lot of maths topics as well. We did linear algebra last term, and that's a big course and that's good to have under your belt. We did calculus, and then next term we get to pick an option and everyone says the best one is one called functions of a complex variable (Grace);

Here I don't actually go to lectures, well I've been to three lectures so far, so really the only structure I have is tutorials which is fine. I do all the work… Lecture notes are all on line. I just find it more efficient to go through the lecture notes by myself at my own pace. If I go to the lecture, if I struggle with something, if I don't understand, next thing you know they are miles ahead. With the notes, I can digest everything at my own pace, which I think is just much more efficient…. I just enjoy it, the feeling of struggling with something, and then understanding it, is really satisfying. So for example, last term in linear algebra we did primary decomposition theorem. |When I first saw it I found it really strange, I didn't know what was going on, there were all these words and I could follow the symbols but I didn't really know what was going on. Now looking at it, it's really obvious, it has meaning. It's really easy now and that gives me a great feeling of progress (Michael);

From school to King's, massively. From maths as something that was core, something I was good at and something I was interested in, into something that was really a part of me and really something that I did every day and that I got enjoyment out of almost every day. And I think it just changed the way I think, and gave me more of a problem solving mind even more so. And then in the transition from King's

to university, obviously you live and breathe it less because the nature of university, but I think, because I'd had that experience, I'd seek to live and breathe it (Lizzie);

I guess I don't really appreciate the more theoretical maths side of computer science. Strangely enough coming from the King's maths school, I don't enjoy maths as much as I do coding for instance. But I appreciate it's part of the course and it will help me be more well-rounded as a computer scientist (Amandeep).

What we see, then, is a variable landscape of developing relationships with mathematics, sometimes in a continuum towards a deeply committed and enriching one brought to fulfilment for this point in time, in others appropriately edited and re-framed for different purposes, and yet others where the accounts offered are of a somewhat impoverished and disappointing development given the depth absorbed at KCLMS.

4.4: Student overview of KCLMS goals and of their future pathways

Key Findings

- Participants overwhelmingly thought KCLMS had, in their time, fulfilled its mission of enhancing equitable access to mathematically-rich HE courses. Some were sceptical of the potential for maintaining that once outstanding examination and HE entry results were established.
- In terms of retaining students on mathematical journeys, participants felt effective provision had supported an inclination to persist in mathematical engagement, but none reported feeling pressured to continue in pathways other than those to which they were at that stage best suited.
- At the stage of data collection, some clearly felt ready to move out of education while others were keen to progress into research. Beyond-university career aspirations were varied and often ambitious, but these young people all appeared confident, and well-prepared, for their planned pathway, with many effusive about the foundation given for that by KCLMS.

- Equity of access
- Retention on mathematical journeys
- Aspirations for the future

KCLMS goals and student pathways 4.4

4.4.1 Equity of access

KCLMS was founded with a particular focus on supporting equity of (social and economic) opportunity – in development of potential, access to HE and access to a range of employment and career routes. We therefore asked participants to reflect on their experiences at or with the school, and to suggest ways in which they thought that was supported – or not - by KCLMS.

While aware that their lens might be limited in this respect, students in general, with one or two exceptions, seemed to feel positive about the extent to which this aspiration had been achieved during their time at the school. They were clearly aware of a widespread 'tutoring' culture beyond the school, as well as the affordances of high quality independent education. Some, though, had reservations – about experiences in their own year group, the outlook for future year groups as KCLMS's reputation grows, and possibly negative impacts on university admissions:

Enrichment classes aimed that preparing for the MAT and STEP papers were very useful for giving everybody a chance to tackle these exams on the right footing (S1);

Money was never a problem. If you couldn't afford something they could help you (S3);

Cultural and ethnic diversity was apparent in the group (S5):

I think every teacher was driven to ensure students performed as well as they knew they could. The school also supported a range of post sixth form opportunities, educating us on the pros and cons of university and the viable alternative forms of higher education, an example that comes to mind is the Google interviews (S6):

I didn't feel like I wasn't meant to be there because of my background, but felt supported academically and socially and the help was available as long as you asked (S7):

This did not really impact me, my alternative to KCLMS was offers from 4 local grammar schools and I grew up in a suburban middle class area. I don't think I would have been disadvantaged had I not gone to KCLMS. I already had access to good education, parental financial support for university and extracurricular, and I had work experience from knowing people in industry. I do however, think most of the students at KCLMS were 'disadvantaged' in national terms (during my time there) and it is a really good thing what they are doing to make it more equal for people that haven't been born with an advantage in life, but want to work for it (S10);

KCLMS was one of the most diverse places for mathematics I have ever seen. There were also events for Women in STEM which I think helped but mainly intake was handled very well (S11);

Coming from a private school that my family could no longer afford, I feel like KCLMS offered a standard of education and culture that one could scarcely find in any other educational institution in the country without great expenditure. There was a strong and representative demographic in terms of ethnicity and

especially gender, and I believe one of KCLMS' absolute strongest qualities was the support it offered to students regardless of background or privilege (S14);

The wide variety of backgrounds which I got to interact with, which I really enjoyed and was mainly unlike my previous experience (S15);

Unlike any other school I had been to, I don't think I have ever heard anyone comment on or even notice if someone came from a different social or economic background to them. I believe this is because, unlike any other schools, all students at King's have something in common (maths) which meant everyone always had something to talk about with everyone else (S16);

The people that studied there were a lot more diverse than I was expecting to find and that can only be a good thing. I have participated in the physics+ programme as an ambassador and I think that that is wonderful, I wish there were more places doing that (S20);

KCLMS certainly have me a better start to university than I could've got at my old school (S23);

I believe the travel bursaries were very helpful for those who lived quite far from the school (S21);

I didn't attend an academic secondary school but was still given the option to attend Kings. However, the cost of travelling into London everything was expensive and no financial help was given to me on that front (S22);

I think it was done very well. We went to a lot of universities and did personal tours. I think we had a tour of the maths institute here, we had a tour of a college at Cambridge, and that was very good. I think my year was very diverse in like background. It felt like that. And in ability as well. Everyone liked maths but at different levels, and I think that was good….I think as time has gone by, it has become more competitive to get in…We saw that from the second year. We saw them come in with more maths than us (Bill);

I'm cynical here. I don't think, If the point is to allow people who went to comprehensive schools to study maths at say Oxford, I have a feeling that will undo itself as time goes on. For the first two years you will find most people from state schools because realistically when the question is: would you rather go to (N college), which, despite its good performance, can have questionable things, and this brand new place that just does maths, you will say 'Yes'. But if you have the money to send your child to say Eton and they say I want to go here, you might think there is no track record. But now there is a track record, I'm guessing you will end up with this cause being undermined because they will say 'well actually this place is better than some independent private sixth form and no fees'. It's not giving a place to someone from a state school background, it's just transferring someone from an expensive fee paying school (Ettie);

I think a lot of the people in my year were at schools that didn't perform great in A levels or didn't have further maths and things like that. So in that sense, it did, but I think in the younger years, the ones below me, you can see a lot more clearly that they are doing that because they must have had a much larger volume of applicants (Grace);

I am pretty convinced that Oxford at least was biased against students from the maths school on application. The reason I think that is because we had loads of students apply to Oxford, and I think only nine got in. It struck me that in my evaluation the nine who got in were actually the nine best mathematicians who applied….I was impressed that in one one and a half hour test and two interviews they have managed to select extremely accurately what the hierarchy is like in the school. But on getting here, I think there were actually several people at King's who didn't get an offer who were still significantly above average for Oxford. So I think that because we come from this incredibly elite maths school, there is a bias against us which I think is unfair… So for example …the head of undergraduate maths, told me, jokingly, that my school was basically like a private school, which is indicative that the perception is that the people from there are not normal state school kids and they are already at an advantage over other people which I don't think is fair because Oxford is also a selective institution. It's just that they have been selected a little bit earlier (Michael);

I come from a very low income household, I was home educated all my life so I didn't go to a good secondary school, and I only had five GCSEs, I did two years at KCLMS and I went to Oxford…. my personal experience is that it is helping people who are passionate about these subjects to learn more about them. It was also university focused I think, because they really helped people complete their applications, interviews and entrance tests in a way that some other sixth forms may not be able to do…it never really entered my mind that 'oh I'm going to get rejected because I don't have enough GCSEs'. KCLMS really made me feel I had a strong enough understanding of the subject (Noreen);

*Everyone was so diverse, everyone was from different places across the whole of London. Everyone had different things, and I think a lot of people, the reason they moved school was because they needed something more. If they'd been happy at the school, they would not have left. A lot of people were determined enough to move to a better school, everyone has their off days but every single person really tried… I got my A*s in maths and physics, but I also got six Bs or something. … They did a good job. of selecting people who would actually not have done so well where they were, and I think that's a very hard thing to measure though (Otis);*

Speaking for my close friends that come from a range of very different backgrounds, all of them have gone to places like Bristol, all of them, UCL, Oxford, and I know for a fact that they come from varying backgrounds, countries (Carly);

The only thing we really had in common was the maths, we were from all walks of life which is a huge benefit, and obviously you can be friends with people quite easily. But at the same time I don't think there was any kind of … For example last week I went to a multi-faith talk because I thought it would be really interesting, about how faith comes into your university life, and I thought something like that would be good for King's because you do have people from all these different walks of life and try to understand each other. London is diverse but at the end of the day a lot of people ….go to schools which are dominated by their own community, whatever that is. And as King's is so mixed that is something that could be, I think it would make us more of a close community (Lizzie).

4.4.2 Retention on mathematical journeys

Another aim for KCLMS is to retain young people on their 'mathematical journey' as long as is consistent with that person's interests. Participants were asked to comment on aspects of their KCLMS experiences which they thought have supported – or undermined - that aim. Again, students were overwhelmingly, but not uniformly, positive about the attainment of such aspirations. Within that, though, they were explicit about support for students to pursue other, related, pathways as and when their interest and strengths supported that:

> *Problem solving sessions (while they were available) and enrichment classes, as well as the general wider approach to learning have all helped (S1);*
>
> *Supported, teachers listen to you and they'll do anything to help you on your mathematical journey (S3);*
>
> *The choice of topics taught was broad and there was also a focus on fundamental parts of mathematics that feature prominently in related STEM subjects, such as differential equations. This provides a good overview and permits intellectual freedom (S5);*
>
> *I think sometimes it did feel as if there was only an interest in mathematics which was good for the majority of students who went into mathematical subjects but sometimes it would have been nice to have someone to show how the 'mathematical journey' may not just be specific to mathematics degree (S7);*
>
> *The problem solving classes supported this aim as we got the opportunity to apply maths in different way, i.e. not to answer exam style questions. Activities like mathsaganza supported that aim as again, it was a rare and different way of doing maths in teams (S8);*
>
> *I found it overbearing and some of the poor teaching made me hate going to school to just be confused all day, when watching videos explained it so much clearer. That said I now enjoy maths again so it hasn't done any long term damage (S10);*
>
> *Being around lots of other people who enjoyed Maths made it easy to continue enjoying without feeling self conscious about it (S12);*
>
> *At times the pervasive mathematics in all classes could feel intimidating and that there was a lack of variety, i.e. all branches of mathematics had to be explored by all students regardless of specific interests, which at times could hinder motivation for learning. Providing some options to specialise helped myself and others to feel like we were shaping our own 'mathematical journey' rather having it mapped out for us, and hence natural talents and interests could thrive more organically rather than being required as a formality, which was occasionally the case (S14);*
>
> *I think that being in such a focused environment may have made it hard on some people who might have realised that they aren't that interest in maths after all to recognise that. However, I have seen the school support a few people who were struggling with the workload, or maybe just changed their minds,*

by allowing them to drop a subject at first or facilitating their transition to somewhere else if they decided that maths was not indeed their path (S16);

KCLMS you ended up with a network of very high achieving friends. People doing internships, knowing what they want to do after university, etc. I think this motivated me to figure out what I want and stopped me from dropping out of university when I was struggling (S17);

Ultimately the SLT makes these decisions based on what would benefit the school - any suggestion that the person's interests are considered is empty rhetoric. The SLT completely and totally undermines any aim to retain students by its jeopardising behaviour. Unfortunately, very few students are aware of the dangerous nature of the SLT's behaviour (S18);

I definitely feel my mathematical knowledge essentially grew from KCLMS, it was planted a seed and it is still growing to this day (S23);

I had always planning on carrying through with maths to university (although KCLMS also allowed me to explore the possibility of studying engineering) (S25);

The lessons were fun, extra curricular exploration was encouraged and supported. Just being around people who enjoyed maths and problem solving meant that I learnt a lot of stuff (S26);

I don't want to make disparaging remarks but maths teachers in secondary school (pre-KCLMS) weren't very inspiring. I think very few young mathematicians want to be teachers and that is understandable, it's not a very well paid profession and it's a bit downtrodden by society, media and so on (Ettie);

I think they succeed in that because they promote that maths is enjoyment rather than just a tool to get a great career. They want you to do the work experience stuff just so you have the choices, but I don't know, ….they weren't trying to persuade us to. And we had all these lecturers come in from King's College and talk to us, so that makes you want to do what they're doing rather than people from a bank or somewhere coming in. I think it might have been nice to have a bit more of that just so you can see more of the research that you can do in maths (Grace);

At the end of AS the default choice was always to send the student on to do A level in the subject they did better in, and I performed worse in computing than physics. But I specifically asked to do computing because I really loved computing and I wasn't happy with how I had performed in the AS. …So I asked if I could do computing and they said I could. That was really helpful, because I think if I hadn't taken the A level, even with all this clunky teaching, I would have probably applied for maths I think because I wouldn't have had the computer science experience (Noreen);

I don't think there would have been pressure (to continue in a maths-related theme). I only know one friend who was considering doing something else, and I remember that they were having lots of conversations with the teacher in our first year at sixth form about what they could do, so I think they got that kind of support, advice. They ended up doing an engineering subject anyway. I didn't see a lot of examples though…. (What would you say now to a year 11 who had seen the school, knew they wanted to do A level maths, not sure what else. Worth going for?) Yes, 100%. If I knew someone who wanted to

do A level maths, I would definitely recommend King's Maths School. I'd tell them to probably try to venture out on their own, try to find things in the field they enjoy, do things for fun, because then they will appreciate it more (Dan).

4.4.3 Aspirations for the future

The sample students were at a variety of stages in their careers, with some about to graduate, some in the penultimate year at university, and some taking four-year course, at any earlier stage than that in relation to final graduation. They were asked about their aspirations for the future, including any that related to mathematics, and what aspects of their KCLMS experiences they felt particularly supported those aspirations. At least 3 wanted to continue to complete a doctorate in mathematics, but other aspirations varied widely:

I have an interest in completing a doctorate in mathematics and I think being challenged and encouraged by the school to do mathematics has partially led me there (S11);

I want to get chartered in the future, my mathematical skills are coming in handy on placement especially (S2);

Earth sciences degree and further geophysical research. A strong prior HE maths/physics background at KCML would me confidence to approach, contribute to or scrutinise any form of quantitative research that has geophysical / earth science relevance despite not having a degree in maths or physics (S5);

Others' aspirations were wide and varied, and often ambitious:

All my long term aspirations really boil down to solving big problems, I dream especially of answering questions concerning quantum gravity and the Standard Model for particle physics, but have also developed interests in biology, aerospace engineering and artificial intelligence. More short term goals include wanting to earn a strong first in my degree and going on to do an impactful PhD in mathematical/theoretical physics. Naturally my future will be highly mathematical, and I think my KCLMS experiences have given me and approach to learning (the Socratic method) and failure (the growth mindset) that will facilitate success (S6);

Honestly, my experiences in KCLMS and HE have provided me with so many opportunities to choose from (S7);

I plan to pursue a career in finance, either consulting or asset management. Aspects of my KCLMS experiences which supported these plans include being exposed to this career paths through speakers coming in. On top of that, the school was incredibly helpful and supportive through the university choices and UCAS process and that was fundamental as it got me into LSE, and therefore led to helping me to choose the line of work I'd like to be in (S8);

I will soon graduate with a BEng in Mechanical engineering. I have decided not to stay on and complete the MEng as I am going to work in financial services instead of engineering. I will be starting a graduate

scheme in rotational advisory in August this year with a big accountancy/audit/consulting firm. That said I still have a strong interest in mathematics and will bring it into my work where I can, I chose this job over others as I felt that it was the most open in terms of what I can learn and innovation in the industry is rapidly progressing. I think there is a lot of opportunity for the people that have a strong maths background in financial services as they bring an extra skill to the table that most other grads they will be working with won't have. Kings supported this in that they were interested in all applications of mathematics and understood that some people will not go onto be mathematicians. We had frequent talks from visitors from a range of backgrounds (S10);

I've accepted a graduate job offer at SSE to work in the utilities and telecommunications business. In the future I'd like to work specifically in renewables. This aspiration was only developed when I started university, but KCLMS gave me the tools I needed to get there (S13).
I hope to add value in my role as a Senior Analyst for Trading Services at the Bank of New York Mellon by using my quantitative skillset to make powerful inferences from data and help decision making. KCLMS helped me to feel employable and focus on what I want from my future. I will not be satisfied with my career if it does not involve some daily quantitative work and I have a thirst for learning that will not stop with the end of HE, in part thanks to KCLMS cultivating an inquisitive mindset (S14);

It may sound cheesy (like probably every other answer I have given so far) but before KCLMS I never really though I would go on to have a big impact on the world. However, the confidence that my teachers instilled in me, combined with being surrounded by such smart and ambitious peers, has completely changed that and now I know that I can do whatever I set my mind to. I would say since the end of year 12 my aspiration has been to work for the United Nations or for a group such as Michelle Obama's Global Girls Alliance, to tackle all the big global issues one by one, starting with helping girls and women all around the world to have equal opportunities (S16);

Aspiration for the future, is probably to focus on happiness above all else instead of academic, career achievements. That said I'm excited to have got onto a grad scheme for a technology company and hope to learn more, build more skills and succeed in this environment. KCLMS through their career talks, showed me what's out there (S17);

My aspirations are to get a job as an actuary. I do not feel that KCLMS supported this aspiration particularly (S18);

Planning to get an internship in data science/data analytics/stats. KCLMS has given me best foundations to make that possible (S19);

I either want to be a part of the global revolution or start a school of my own. Maybe both. Seeing that how a school forms and some of what it takes has helped me consider all the things I need to do to get there (S20);

KCLMS encouraged competitions, which I believe was helpful in setting up a positive impression of taking part in competitions in general. This is something I'd like to do more of (S21);

My aspirations are to find a job that I actually enjoy doing, and not that I feel i have to live up to others expectations. Probably in energy markets (S22);

To explore careers related to mathematics. I was always encouraged to step outside my comfort zone and to ask lots of questions; these are very important points to keep in mind for my future career (S24);

I have an internship with a well-known bank which I hope I'll enjoy and are able to pursue in future. Kings allowed me to believe that I am good enough to have these dreams (S25);

I still don't know what I want to do but the problem-solving sessions, rec maths, and the approach to problem solving, logical thinking and challenges I'm sure will help wherever I end up (S26);

*I'm interested in teaching, and that is something that last summer I had a teaching internship at a *** in Surrey. That was something I enjoyed, but I'm very aware of the fact that it's much easier to go from industry into teaching than to go from teaching into industry. So I think if I went into teaching it would be via industry. I'd prefer to get industry experience before I commit to teaching. And also teaching is a very hard industry in this day and age, teachers have to work incredibly hard, don't get paid very well. I think that something like 50% of first-time teachers quit in less than two years…. a sad thing because if I could make as much and work as comfortably as I could in an industry position as I would in teaching, I would take teaching in a heartbeat. But I think the average income for an Oxford computer science graduate is £40,000 in six months, and I met teachers on the internship who weren't making that much after two decades. So it's hard to justify the decision when you look at like that (Noreen).*

The picture, then, is of a highly (including mathematically) enabled group of young people, confident and keen to 'make a difference' in their chosen field. As a note of caution, we did not of course access any of the very small number of KCLMS graduates from these two years who had not successfully progressed to, or continued to this point in, Higher Education.

5. Discussion and conclusion

As indicated in chapters 2 and 3, the sample used means that interpretation of the data in general terms needs careful consideration, although that data offers a range of responses, viewpoints and suggestions. We were only accessing those who successfully made it to this stage: for example, Bill referred to one of his peers who had been rusticated, and we do not know about the views of those who did not respond to the invitation. One aspect of our analysis was an attempt to isolate views distinctive among our sample to those who were undergraduates at either Oxford or at Bristol. Clearly, cross-disciplinary college communities, and widespread use of small-group tutorials, are distinctive to Oxford among our interview sample, and those were both deeply appreciated. In general, Oxford interviewees commented rather less on disjunctures between KCLMS and undergraduate approaches to the academic enterprise, than Bristol undergraduates did. That would not be surprising, given the academic background of most KCLMS teachers, but it is a small sample. It is striking, across the range of participants, how content all were the pathways then being followed, even if also reporting some 'hiccoughs' along the way. That might not be true of alumni who did not respond, of course! For the sample undergraduates, though, we have evidenced:

Pre-KCLMS

- Mixed level of contact with school pre-enrolment or admission.
- School or KCL outreach activities key motivators for about half, with other enrichment opportunities also key motivators in building awareness of, and commitment to, mathematics as more than routine GCSE.
- Application to KCLMS often linked with critical enrichment, from whatever source – or else via an influential teacher or parent.
- 'Switching on' to mathematics appears usually to have stemmed from enrichment, and especially, mathematically challenging additional experience, though 'being unusually good at' more standard school provision was also instrumental for some.

That 'switching on' (and 'staying switched on') is of course critical if young people are to choose to follow mathematically-rich pathways post-16, into Higher Education and beyond. There is no reason why that should not be provided as part of a deep and challenging teaching of GCSE, but even within a 'top set' of a typical comprehensive school, that does require highly skilled and knowledgeable teaching. As evidenced in Borovik, young people with an unusual aptitude for mathematics also benefit from a peer group with similar mathematics developmental needs, and by definition, that is not available in ordinary schools; there is some evidence that for some of our sample, that encounter with a like-minded 'community' made as much impact as the content of the enrichment or outreach activity engaged in.

In-KCLMS:

- Early days were daunting for most, but students appreciated induction provision.
- Most found the concentrated mathematical community surprisingly 'normal' and affirming, though for a small minority it remained unhelpfully niche/aspirational. The restricted nature of the curriculum was acknowledged as a challenge for targeting entry more widely. 'Other' subject support was important and was perceived perhaps to have been less effective than for mathematics.
- Most had developed deeper, more rigorous and satisfying relationships with mathematics through KCLMS core provision, akin to but different from the satisfaction gained from enrichment opportunities.
- Teacher and visiting expertise was highly appreciated, while respondents also talked about the pedagogic limitations of some inexperienced teachers, including academics unused to communicating with school-age learners.

- Students largely felt they had been well-supported in finding appropriate aspirations/university pathways, although some still regretted limited encouragement to apply to Oxbridge. Those who had taken, or studied for, additional university entrance papers had enjoyed the experience but students were clear they needed to prioritise optimum performance in A Levels.

The experience of being part of a like-minded and affirming mathematically-focused community was clearly profound for most participants – and their often-transformed relationship with mathematics both consonant with school aspirations, and for many, in contrast to their experiences pre-16. There are two caveats here: one is developmental and curriculum-related, in that at age 16 these young people embarked on a programme of study significantly different from that experienced pre-16. The other is in relation to the knowledge and approach of the teachers: KCLMS has been able to attract unusually mathematically well-qualified teachers, especially of mathematics, as well as to offer postgraduate and university academic input, but as students themselves point out, 'mathematically knowledgeable' does not always equate with 'effective teaching'.

Other students moving into A Level study also often report a similar step-change in identity and relationship with mathematics, and some other state institutions are also able to offer mathematically-knowledgeable and committed teaching. Students in those schools or colleges, unless having exceptional mathematical needs, probably have less to gain from KCLMS than did some of those contributing here. Some among our sample pointed to contrast between KCLMS enrichment or outreach experience, and their school experience to date, but there would be less incentive to apply for students who already enjoyed a high degree of enrichment and challenge in their school. Similar comments pertain to the breadth of curriculum available at KCLMS: the schools des not set out to cater, for example, for those who are committed to studying an Arts or Humanities subject alongside mathematics, so such students were not involved in the study.

Post-KCLMS:

- For most, transition to university had been a socially and academically relatively smooth process, perhaps via a refreshing 'gap year'. In HE, small Oxford cross-discipline collegiate communities, and small-group tutorials, were particularly appreciated. All seemed content with the pathways followed to this point.
- HE contacts had increased participants' appreciation of the quality of the mathematical and learning experiences they had had at KCLMS, and the mathematical confidence endowed.
- The rigorous and problem-solving approaches privileged at KCLMS had supported participants well in transition to university mathematical expectations, as had the work ethic and community inter-dependence, though some thought the development of more independent study skills would have been useful.
- Although not directly alluded to, it was apparent from much of what was said that KCLMS had, probably with one exception, supported development of a robust and well-founded mathematical (or mathematics-user) identity and confidence that had been helpful in adjusting to university.
- Inevitably, individuals' relationships with mathematics had changed, and often fluctuated, over their time at university, depending in part on their course. For those studying courses with high mathematical content, those relationships had often matured into something highly fulfilling.

'The Big Picture':

- Participants overwhelmingly thought KCLMS had, in their time, fulfilled its mission of enhancing equitable access to mathematically-rich HE courses. Some were sceptical of the potential for maintaining that once outstanding examination and HE entry results were established.

- In terms of retaining students on mathematical journeys, participants felt effective provision had supported an inclination to persist in mathematical engagement, but none reported feeling pressured to continue in pathways other than those best suited to them as individuals.
- At the stage of data collection, some clearly felt ready to move out of education while others were keen to progress into research. Beyond-university career aspirations were varied and often ambitious, but these young people all appeared confident, and well-prepared, for their planned pathway.

In line with other evidence about successful transition to mathematics-intensive courses at university, and retention in those, this study suggests that the robust and challenging approaches taken to mathematics and related A Levels at KCLMS, a supportive, committed and focused student and teacher community, and expectations of problem-solving, of rigour in thinking and of hard work, were at this stage felt to be bearing fruit. These issues will be further developed and discussed in relation to the existing literature, in a publication for academic consumption.

Appendix 1: Research tools

KCLMS alumni googlesurvey

Pathways to success in mathematics: what can mathematics specialist schools offer?

We are very grateful to you for completing this survey, which sets out to probe your perceptions of the impacts, and particularly distinctive impacts, your experiences at KCLMS have had on your pathways and development. KCLMS is a pretty special place, but because it sets out to make different provision – and has a distinctive group of students – we have very limited knowledge of what works best for those students. In this study we are attempting, with the support of UCL, to begin to find out. This survey is therefore in four sections, relating to your experiences and incidents that have been critical for you pre-, at, and post- KCLMS, and your overview and plans for the future. We think it will take you no longer than 15 minutes to complete. At the end you will be able to add your preferred email details if you would like to see a summary of the findings – or if you'd be happy in the future to share your experiences with current or potential KCLMS students.

Please complete: I am happy for you to quote or analyse what I say in this survey, without identifying me, for purposes of reports, academic and scientific papers, presentations and other publications. Y/N

I understand you might keep the data securely for up to ten years for such purposes. Y/N

Your name (optional):

Your year of graduation from KCLMS: 2016/17

Your university and course:

Section 1: Your experiences/critical incidents pre-KCLMS

1. *Did you participate in any KCL or KCLMS enrichment or outreach activities before you applied to KCLMS? Y/N If so, what activity, when, and what impact did it have on you?*
2. *When and why did you decide to apply for KCLMS?*
3. *Applying for KCLMS is a pretty definite step to take. Before you applied, what experiences would you say 'switched you on' to mathematics?*

Section 2: Your experiences/critical incidents at KCLMS

1. *How would you describe your first term experiences at KCLMS? What had a particular impact, and what could have been done better?*
2. *Over your time at KCLMS, what was the impact on you of the concentrated mathematical community (pros and cons)?*
3. *How did your relationship with mathematics develop over your two years at KCLMS?*
4. *What was the impact on you of the particular teacher expertise available, including that of the very specialist mathematics teachers? (pros and cons)*
5. *Please describe any particular experiences or incidents that were especially influential in your choice of university pathway.*
6. *If your preferred university course choices included a need for, or a choice of, additional papers such as STEP, MAT, PAT, …. Please describe your experiences of working for those and the impact that had on your longer-term development (pros and cons!)*
7. *Looking back, what would you choose to have changed about your two years at KCLMS? (please think 360° and include social, cultural, curricular….)*

Section 3: Your experiences/critical incidents since KCLMS

1. *Please describe any critical experiences in your transition from school to Higher Education (HE) and how you think your response was influenced by your time at KCLMS.*
2. *You have now mixed with HE peers from a variety of educational backgrounds. Please describe any features of your experiences at KCLMS that you value but you think your peers from some other backgrounds might have missed out on.*
3. *What of your mathematics or wider education at KCLMS do you feel you've particularly drawn on in HE, especially if your perception is that's not available to be drawn on for all your peers?*
4. *For all students, not just mathematicians! How has your relationship with mathematics developed over your time in HE?*

Section 4: Nearly there! Your overview and thoughts about your preferred future pathways

1. *KCLMS was founded with a particular focus on supporting equity of (social and economic) opportunity – in development of potential, access to HE and access to a range of employment and career routes. Reflecting on your experiences at or with the school, please suggest ways in which you think that was supported by KCLMS.*
2. *Another aim for KCLMS is to retain young people on their 'mathematical journey' as long as is consistent with that person's interests. Please comment on aspects of your KCLMS experiences which you think have supported – or undermined - that aim.*
3. *Looking forward, what are your aspirations for the future (including any that relate to mathematics), and what aspects of your KCLMS experiences do you feel particularly supported those?*

Finally, would you be prepared to talk with current or potential KCLMS students about your pathways to date? Y/N

Would you like to be sent a summary of the findings of this study? Y/N

If you answer 'yes' to either of these questions, please include here your preferred email address:

Thank you so much for your time in completing this survey. If you have any queries about its use please email Dr Jennie Golding (j.golding@ucl.ac.uk)

KCLMS alumni interview outline schedule

First of all, thank you so much for fitting me in again. Just a reminder that the purpose of this research is to find out your retrospective view, including being frank about things that you wouldn't find easy to say to the school directly. I'll record this interview so I can concentrate on what you're saying, but everything you say will remain confidential and we shan't disclose your identity in any of our future reports. Thank you for your consent form. So the interview really focuses on 3 things: your experiences before you went to KCLMS, your experiences at the school, and what those look like and how they've impacted what has happened since then. Then finally, there's a bit about where you see yourself going from here.

It will take about 20 minutes. Any questions? (pause)

To recorder: Interview with Oxford/Bristol undergraduate in their 2nd/3rd year of studying ……on (date)

Your year of graduation from KCLMS: 2016/17

Section 1: Your experiences/critical incidents pre-KCLMS

1. *Did you participate in any KCL or KCLMS enrichment or outreach activities before you applied to KCLMS? If so, what activity, when, and what impact did it have on you?*

2. *When and why did you decide to apply for KCLMS?*
3. *Applying for KCLMS is a pretty definite step to take. Before you applied, what experiences would you say 'switched you on' to mathematics?*

Section 2: Your experiences/critical incidents at KCLMS

1. *So if you can remember, how would you describe your early experiences at KCLMS? What had a particular impact, and what could have been done better?*
2. *Over your time at KCLMS, what was the impact on you of the concentrated mathematical community (pros and cons)?*
3. *How did your relationship with mathematics develop over your two years at KCLMS?*
4. *What was the impact on you of the particular teacher expertise available, including that of the very specialist mathematics teachers? (pros and cons)*
5. *Please describe any particular experiences or incidents that were especially influential in your choice of university pathway.*
6. *Did you need any additional university entry papers such as STEP, MAT, PAT, …? If so, please describe your experiences of working for those and the impact that had on your longer-term development (pros and cons!)*
7. *Looking back, what would you choose to have changed about your two years at KCLMS? (please think 360° and include social, cultural, curricular….)*

Section 3: Your experiences/critical incidents since KCLMS

1. *Please describe any critical experiences in your transition from school to Higher Education (HE) and how you think your response was influenced by your time at KCLMS.*
2. *So can you give me an overview of your time in HE to date? Was it the right course for you? What of your whole HE experience have you enjoyed, what have you valued, what really hasn't worked for you?*
3. *You have now mixed with HE peers from a variety of educational backgrounds. Please describe any features of your experiences at KCLMS that you value but you think your peers from some other backgrounds might have missed out on.*
4. *What of your mathematics or wider education at KCLMS do you feel you've particularly drawn on in HE, especially if your perception is that's not available to be drawn on for all your peers?*
5. *For all students, not just mathematicians! How has your relationship with mathematics developed over your time in HE?*

Section 4: Nearly there! Your overview and thoughts about your preferred future pathways

1. *KCLMS was founded with a particular focus on supporting equity of (social and economic) opportunity – in development of potential, access to HE and access to a range of employment and career routes. Reflecting on your experiences at or with the school, please suggest ways in which you think that was supported by KCLMS. Any ways the equity agenda could have been pursued rather better?*
2. *Another aim for KCLMS is to retain young people on their 'mathematical journey' as long as is consistent with that person's interests. Please comment on aspects of your KCLMS experiences which you think have supported – or undermined - that aim.*
3. *Looking forward, what are your aspirations for the future (including any that relate to mathematics), and what aspects of your KCLMS experiences do you feel particularly supported those?*

Appendix 2: KCLMS key attainment and inspection data

Class of 2016

King's College London Mathematics School opened in September 2014 and our first cohort completed their A-levels this summer. We are delighted to share with you news of our first ever A-level results, and we hope

you agree that our students have achieved incredibly highly, and that they deserve the greatest of praise. Here are some of the highlights:

- An A-level average point score per entry of 272.9. This places King's Maths School as the top performing state school in the country[1].
- 94.5% of entries are A*/A/B. This places King's Maths School in the top three state schools in the country[2].
- 100% of students attained A*/A in A-level Mathematics, with 83% awarded an A*

The results in each and every subject have been outstanding, and here summary data is presented (with the national average figures given in brackets for comparison):

	Proportion attaining	
Subject	**A*/A/B**	**A*/A**
Maths	100% (65%)	100% (43%)
Further Maths	100% (78%)	77% (58%)
Physics	82% (54%)	57% (32%)
Computing	93% (37%)	57% (16%)

The AS results are just as fantastic, with 92% of all grades at A/B, and an incredible 40 students (63% of the year group) gaining at least three A grades. This year group had the opportunity to study Economics and attained well in this subject, helping the second cohort's AS results to represent an improvement on our AS results from a year ago.

Students have also significantly outperformed expectations based on prior GCSE performance: in both year groups, they have attained on average half a grade higher in each subject than their GCSE grades predict.

King's Maths School was set up to increase the number of well-trained mathematicians going on to study and work in subjects and careers involving a high degree of mathematics. We'll be able to confirm our progression data shortly, but we know already that it will be up there with the very best state schools, indeed, the very best schools, in the country. We may be small, but there are only five schools in the country who have more students studying Further Mathematics than us – so when it comes to mathematical futures, we really are making a significant difference. We would like to take this opportunity to thank all of our students, their parents and carers, their wonderful teachers and everyone at King's College London and elsewhere who have supported our development over the last few years. We think that these results show just how good an idea it is to have a school dedicated to mathematically inclined students.

[1] Data from 2015 entries was taken directly from the Gov.uk website: https://www.compare-school-performance.service.gov.uk/download-data

[2] Comparing data from 2015 entries as published by the Telegraph: http://www.telegraph.co.uk/education/leaguetables/11803533/A-level-results-2015-results-from-400-state-schools.html

Class of 2017

Our second cohort graduated in Summer 2017, and attained some stunning results.

59% of all entries are A* grades, 89% are A*/A, and 99% are A*/A/B. We believe these proportions to be the best of any state school in the country. Even more critically, we are adding huge value to our students: each

student is on average doing more than 1 whole grade better than their GCSE grades predict. We are confident this places us as one of the top few schools in terms of value added.

The results in each and every subject have once again been outstanding:

	A*	A*/A	A*/A/B
Mathematics	92%	98%	100%
Further Mathematics	58%	88%	100%
Physics	27%	77%	96%
Economics	33%	100%	100%
All results	59%	89%	99%

The AS results are just as fantastic, with 93% of all grades at A/B, and an incredible 80% of the year group gaining at least three A grades. These results are better even that last year's year 12 results.

Progression

Progression to university is exceptional:

- 23% of leavers have confirmed Oxbridge places
- 100% of university applicants have secured places at Russell Group or Sutton Trust 30 universities
- Over half those applicants are going on to study mathematics, with everyone else studying physics, engineering, computer science or economics.

Our heartfelt thanks go to the students first and foremost - they are so inspiring to teach. But we'd also like to thank teachers, all other staff who perform such vital functions, governors, parents and carers, and the many people at KCL and beyond who make King's Maths School the special and impactful place that it is.

The class of 2018

attained exceptional results that confirm King's Maths School as one of the highest performing schools in the country. The results are extremely similar to those attained by the class of 2017 - and these were ratified by the Department for Education performance tables as the best around.

Even more powerfully, the 2018 results demonstrate clearly that the school is serving its mission to widen participation in the mathematical sciences.

59% of all entries are A* grades, 89% are A*/A, and 97% are A*/A/B. In terms of value added, our students have attained more than a grade better on average, per entry, than was predicted by their GCSE results. This would place us in the top 0.5% of all schools in terms of value added, with no other selective school (except perhaps the Exeter Mathematics School!) coming close to that level.

A notable feature of this year's results is that female students outperformed their male peers, with 92% (compared to 85%) A* and A grades. They did this in every subject, including in Physics.

There are many inspiring individual stories that demonstrate King's Maths School's impact.

- Amongst the 37% of students who have no parental history of higher education is Serkan, who achieved A*A*A* and will go to Bristol to read Engineering Mathematics, and Levi, a young carer who is off to Newcastle to read Theoretical Physics.
- A third of the cohort is female, including Taiwo, who takes three A*s to Oxford for Engineering; Ife, with A*A*A and a place at MIT where she will study Mathematics and Computer Science; and Katherine and Siana, who achieved straight A*s as well as top grades in STEP to secure places at Cambridge for Mathematics and Computer Science respectively.
- 35% of graduating students are from challenging backgrounds, including a student who was a refugee to the UK, arriving in 2013 to escape persecution in his home country, who has gone on to achieve A*AA and will now read Aeronautical Engineering at a top university.

Here are the results in each subject:

	A*	A*/A	A*/A/B
Mathematics	93%	100%	100%
Further Mathematics	49%	92%	96%
Physics	35%	73%	95%
All subjects	59%	88%	97%

66 students in year 12 sat either an AS in Computer Science or Economics, with 88% of these students attaining the top grade.

Progression to university is exceptional, with 20% of applicants progressing to Oxbridge and nearly every single student having confirmed a place at a Russell Group or Sutton Trust 30 university.

The class of 2019

have attained astonishing results that once again place King's Maths School as one of the very top performing schools in the country.

- 100% of grades in A Level Mathematics were A or A* grades.
- Over 90% of entries across all subjects were graded A or A*.
- Over 25% of students in this cohort have secured places at Oxford or Cambridge Universities.

We are proud to see students from backgrounds currently under-represented in the mathematical sciences excel in their studies and progress to outstanding institutions. As shown on results day on BBC Breakfast, we have many inspiring female students who are passionate about the mathematical sciences. To highlight just a few:

- Sae, an incredibly deep and talented mathematician, attained A*A*A* alongside two distinctions in her STEP papers, guaranteeing her place to read Mathematics at St John's College, Cambridge.
- Maggie took A*A*A to secure a place on St Andrew's Mathematics and Physics course, whose competitiveness is evidenced by the fact that this is a King's Maths School first.
- Tabs, who aspires to be a mathematics teacher (at King's Maths School, of course) secured A*A*A, and is excited to go to Imperial to study Mathematics and Computer Science.

There are others, with different stories. Nahome and Abu are both black students who are going to Oxford, to read Physics and Mathematics & Computer Science respectively. Abu's parents are Somali refugees who did not have the privilege of tertiary education; Nahome will also be the first in his family to attend university.

King's Maths School has a phenomenal record of adding value to students through its inspiring learning culture. This year students have on average attained +0.85 grades higher in each subject than predicted by their GCSE performance.

Here are the results in each A Level subject:

	A*	**A*/A**	**A*/A/B**
Mathematics	90%	100%	100%
Further Mathematics	63%	89%	99%
Physics	27%	83%	91%
All subjects	60%	91%	97%

Congratulations also to the 68 students in year 12 who sat either an AS in Computer Science or Economics. 91% of these students attained the top grade.

Further education and skills inspection report

King's College London Mathematics School

16–19 academy

Inspection dates 25–27 April 2017

Overall effectiveness			**Outstanding**
Effectiveness of leadership and management	**Outstanding**	16 to 19 study programmes	**Outstanding**
Quality of teaching, learning and assessment	**Outstanding**		
Personal development, behaviour and welfare	**Outstanding**		
Outcomes for learners	**Outstanding**		

Overall effectiveness at previous inspection	Not previously inspected

Summary of key findings

This is an outstanding provider

- Governors and senior leaders have set a clear vision and secured a well-planned curriculum, which provides excellent learning opportunities for talented young mathematicians.
- The proportion of learners who complete their qualifications successfully is exceptionally high. Learners make outstanding progress when compared to the grades they achieved previously at GCSE level.
- Learners benefit from the excellent partnership with King's College London University. As a result, learners are prepared very well for entry into the most prestigious universities, with almost all learners gaining places, including to Oxford and Cambridge.
- Learners make excellent progress in their learning and become highly accomplished scholars. Their work is of the highest standard.
- Governors monitor the performance of learners assiduously and hold senior leaders to account, expecting them to take rapid action to make any required improvements.
- Teachers have the highest expectations for their learners to be successful and ensure that learning is fast paced and stimulating.
- Learners are highly accomplished; they develop strong mental resilience as a result of using their excellent mathematical skills to solve complex problems.
- Learners benefit from a very broad range of clubs and societies that extend their learning and knowledge of the world around them exceptionally well. Learners have a good understanding of how to contribute effectively to life in a cosmopolitan society.
- Teachers ensure that learners are well informed on current affairs. Learners debate topical subjects in a vigorous and persuasive manner and develop excellent skills of oracy.
- Learners' behaviour is exceptionally good. Their positive attitudes and collaborative teamwork both inside and outside lessons are outstanding.

Appendix 3: Bibliography

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