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Signalling the value of studying Level 3 mathematics to those considering quantitative subjects at university

Report to the Royal Society and Advisory Committee on Mathematics Education

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1 Executive summary

The 2017 Smith Review articulated the desire to increase the number of students pursuing higher education (HE) courses with a quantitative element – within and beyond STEM – who have studied mathematics post-16. This was in addition to a more general aspiration that as many young people as possible should study at least some mathematics post-16, as there is evidence for earnings- and career-related benefits of greater mathematical skills for individuals, as well as wider productivity impacts.[1]

That recommendation was highlighted in the Government's 2017 Industrial Strategy and also its response to the Smith Review.[2] The Department for Education stated its intention to work with bodies like the Royal Society and the British Academy to encourage universities and employers to signal the value of post-16 mathematics qualifications, for entry to degree courses with a quantitative element and for a wide range of occupations. On behalf of the Advisory Committee for Mathematics Education (ACME), the Royal Society commissioned CRAC to undertake research to investigate how UK universities are currently signalling to young people the importance of quantitative skills, and whether and how this could be enhanced and made more effective in future.

The research comprised two phases of intelligence-gathering, both involving a combination of desk research and dialogues with a range of informants and stakeholders, including staff in a range of HE roles and in schools and colleges. The first established the channels currently used (or available for) signalling, which we identified as: (1) direct to students or parents; (2) via schools; and (3) via third parties. More detailed research in the second phase included intensive analysis of information provision by universities in three regions (East of England, the North East and the South West), focused on biological sciences, business and management, and psychology (selected as three examples of subjects with a quantitative study element).

The main objective was to investigate signalling activity by universities to young people specifically in relation to the value of studying mathematics post-16 (which could inform their choices about subjects and qualifications they study post-16). We deliberately focused less on universities' entry requirements for A-level Mathematics (or equivalent) and more on signals about other Level 3 mathematics qualifications for subjects where quantitative skills would be useful. In practice this meant signalling to those who might elect to study some mathematics at Level 3 rather than those who were going to study Mathematics A-level itself. This led to a strong interest in Core Maths, a qualification suite positioned to help students develop skills that will be useful at university or in employment, for which there is considerable scope to increase participation.

The main findings of this new research are summarised as the following:

[1] *Report of Professor Sir Adrian Smith's review of post-16 mathematics,* Department for Education, 2017

[2] Department for Education letter responding to Smith Review: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/631009/Letter_responding_to_Smith_review.pdf

Direct signalling

- Most universities currently attempt little engagement directly with mainstream pre-16 students or their parents/carers, so there are few opportunities for them to signal directly the value of studying mathematics post-16 to those who may subsequently apply to study courses with a quantitative element.
- We identified a small number of examples of good information provision or events by universities which aim to support post-16 choices, targeted directly to pre-16 students or via schools. The Russell Group's former *Informed Choices* publications signalled mathematics as a facilitating subject (but did not single out the value of Level 3 mathematics study other than A-level mathematics) but has been replaced by a website that is less prescriptive.
- In contrast, universities focus considerable effort on engaging and providing information to students who are post-16 (i.e. once they become prospective HE applicants). Although that audience has already chosen post-16 subjects, this information is also accessed by some pre-16 students (and their parents) so signals within it will inform some pre-16 students' decisions and, especially, guidance provided by those working in schools.
- Few universities have an overt requirement for mathematics qualifications at Level 3 for entry to their courses in subjects such as biological sciences, geography, psychology and business, which may contain a significant quantitative element in the study programme.
- Many universities have shown some support for Core Maths as a post-16 programme but very few mention it in their admissions requirements, which is where signalling would have the biggest impact on uptake of these qualifications.
- Only one university to date has announced that it will (in future) privilege Level 3 mathematics qualifications in its entry requirements (in parallel with the way achievement of an Extended Project Qualification (EPQ) may reduce a typical offer by one or more A-level grades).
- Many universities' course and admissions information published for prospective applicants to subjects such as biological sciences, psychology or business does not signal strongly the development of quantitative skills in these programmes, nor that there isvalue of prospective students undertaking Level 3 study of mathematics. Such signals, where present, are not consistently presented nor, in some cases, are they present in the best places.
- Universities also appear to attempt little engagement with parents/carers of mainstream pre-16 students.
- Although the intended scope of this project was direct signalling, other channels exist through which some signals are currently being sent and where there are opportunities for future signalling to take place.

Signalling via schools

- The backdrop in schools is that while A-level Mathematics participation itself has recently been rising, changes to A-level study have led to a marked reduction in the total number of students who take AS-level mathematics, reducing the total number of students studying mathematics at Level 3.

- The Core Maths suite of qualifications and programmes of study are ideally positioned to offer students who are not pursuing A-level mathematics itself the chance to study mathematics at Level 3 which would be valuable for future university courses. However, it is not universally available in schools and colleges, for a range of practical reasons including teaching capability and resourcing constraints (despite the existence of the mathematics premium).
- The value of Core Maths is not consistently promoted by all parties; this is not helped where universities refer to it as an alternative qualification in the absence of GCSE mathematics attainment, rather than a means to study mathematics at a higher level that will aid study of an HE programme.
- On the other hand, AMSP provides very good messaging for teachers about the value of Core Maths as an enabling qualification for those seeking to study a range of subjects at university, that could be amplified.
- Careers information, advice and guidance in schools is known to be patchy although guidance on post-16 study options will be a core element of most schools' provision. There are rare examples where universities directly assist in support for post-16 choice-making, through attendance at post-16 providers' open evenings, for example.
- There is strong current encouragement for schools to assess the quality of their careers provision using the Gatsby Benchmarks; Benchmark 7 is an overt requirement for interaction with HE and FE providers. Universities could utilise that opportunity to engage in schools' support for post-16 choices and within that activity signal to pre-16 students the value of studying mathematics at Level 3.
- Widening participation activities are extending from an original focus on raising aspirations to access HE towards a broader 'student lifecycle' approach which includes entry to HE, successful progression and graduate outcomes. Supporting students to make well-informed subject choices, so that they are well prepared to thrive in their chosen subject at university, clearly falls within this remit. Signalling the value of different post-16 subjects for successful progression in HE could be embedded more strongly in this agenda.
- Universities do engage with pre-16 students under the auspices of widening participation and other outreach activity, both directly and through collaborative activity. However, there is little *sustained* engagement with pre-16 students (which may be needed to change mindsets). Some activities, such as undergraduates mentoring teenagers with the intention of raising attainment or aspirations may not be reliable as a channel for potential signalling as the mentors are presumably untrained in this respect.
- There is evidence for a range of university and collaborative events in schools which specifically support post-16 choice-making by widening participation students (and some other students), which could be leveraged as opportunities for signalling.
- There is a wide array of enrichment activities taking place in schools – STEM inspiration, gifted and talented extension, enterprise education, employer engagement etc – in which universities are engaged, that currently may contain some signals about the value of mathematics but are likely not to be optimal. In some cases, university staff coordinate and deliver these activities, offering a clear channel for potential signalling to be developed.

Signalling via third parties (other influencers)

- AMSP has developed model messaging about the value of mathematics study, including Core Maths, for teachers, which could be augmented for use by a range of third parties which provide information to school-age students and parents/carers.
- There is a growing and extensive range of providers of information about progression to university (and other post-18 pathways), containing information and guidance that ranges from the very good to some which is unhelpful. Many carry no information about choice of subjects for post-16 study despite the importance of those choices when it comes to university applications and requirements.
- Some of the enrichment activities in schools (for example, for STEM inspiration) are undertaken by third parties such as professional bodies or subject associations and could be used to signal the value of post-16 mathematics study. Some of these involve a university collaboration but not all – the former would be easier to influence but the latter might also be receptive to embedding signals which are seen to enhance student participation and success.
- Employer engagement in schools is most common where it involves Year 10 and 11 students, so could be considered as another signalling channel to influence post-16 choices, where appropriate.

Recommendations

- Universities should articulate more clearly and consistently the needs for quantitative or numerical skills within relevant course information pages and the benefit of developing these skills for subsequent careers and employment.
- Universities should state clearly how they value Level 3 mathematics qualifications as preparation for these courses, including introducing entry requirements that overtly recognise them (including A-levels and Core Maths or others) and alternative offers that take these into account in a similar way that many treat the EPQ.
- Universities should be more consistent in their presentation of these messages, across course-level descriptive information and central admissions-focused information, especially how they are valuing Level 3 mathematics qualifications.
- To help universities implement these recommendations, ACME should:
    - Commend the University of Bath for its introduction of alternative offers for those with a Core Maths qualification for 2020 entry to a range of subjects and encourage other universities to follow suit;
    - Develop a range of clear content and messaging around the value of Level 3 mathematics qualifications (including Core Maths for those not studying A-level mathematics itself) which can be used by universities and to adjust existing resources such as *Informed Choices* and UCAS Progress This should build upon the current messaging by AMSP and amplify it;
    - Help universities to gain better understanding of the Core Maths qualifications, their provision and participation in them, by developing and sharing intelligence drawn from current research at the University of Leeds and already existing within AMSP.

- Universities should provide more and improved better advice to pre-16 students about subject choices, directly and to parents/carers or others who influence post-16 study choices, through improved information for prospective students hosted on their websites and linkage to third-party sources of good information.
- Universities should make more use of third-party information providers, especially UCAS but also other HE choice websites such as Unistats and career support tools, to reinforce these signals.
- Universities should seek to engage more with schools to support students' choices for post-16 study, which will help schools to satisfy Gatsby Benchmark 7, embedding signals about the value of mathematics study into that support
- Universities should look to embed such signalling within opportunities that already exist, i.e. within the enrichment and widening participation outreach activities that they already support and/or are delivered or coordinated by HE staff, and in accompanying resources.
- Universities should consider training or development of their staff who are involved in these activities, so that they are able to take opportunities to embed appropriate messages and signals in these activities and accompanying resources.
- In order to implement these recommendations, ACME could:
    - Develop a range of messages and signals to be embedded within the training and professional development of mathematics and other relevant subject teachers, and those in advisory roles, in schools and colleges, including leveraging collaborative opportunities such as Advancing Access;
    - Consider whether there are opportunities to develop and provide similar signals that could be embedded into other enrichment or extension activity taking place in schools, such as employer engagement or STEM inspiration, delivered by third parties;
    - Consider whether there are additional opportunities to embed messages through channels such as undergraduates' or postgraduates' mentoring of disadvantaged prospective applicants within widening participation projects.
- To maximise the reach and potential impact of these signals, ACME should develop an over-arching campaign of sustained messaging through the multiple channels identified in this study, which will require some coordination and resources. In support of such a campaign, we suggest:
    - An initial focus on influencing of collaborative opportunities where there is greatest power of messaging, such as the *Informed Choices* and Advancing Access initiatives, through UCAS and other activities by university groups;
    - Investigation of the impact of some specific signalling initiatives so that this can be relayed to universities or others when seeking their help to influence student choices;
    - Provision of examples of good practice in terms of channels that can be used for signals and how they can be influenced practically;

- Undertake research specifically on how schools might best wish to be supported by universities in their support for post-16 choice-making by pre-16 students and their parents;
- Undertake or encourage research into the effect of participation in Core Maths on attainment within post-16 and undergraduate study, to reinforce the value of selecting these programmes or qualifications.

2 Background

There is a strong case for increasing the mathematical and quantitative skills of young people, not only as future entrants to the labour market, to satisfy the demands of an increasingly technological economy, but more generally to make sound decisions in life and to engage in society. It has been argued that a level of numerical skills is a necessary element of citizenship, to understand public debate and potentially challenge arguments which are based on quantitative evidence.[3] Individuals' interactions with the modern world around them are increasingly digital, and mathematical and quantitative skills form part of the foundation for understanding how this digital world works and citizens interact with it and with each other. Without such understanding, individuals risk being excluded from active citizenship or reduced to passive consumers of services, as they are unable to think critically about their interactions with the digital world.

In education and learning, mathematics is an important enabling component in a wide range of disciplines, whether the learner is pursuing, broadly, a science-based or humanities-based path. In addition to its more widely understood role underpinning study of the sciences, mathematics has become intrinsic to social sciences and some applied subjects like business as well as to some aspects of the creative arts. A 2014 project for the Higher Education Academy looked at undergraduate study in business/management, chemistry, computing, economics, geography, sociology and psychology, concluding that all needed mathematics or statistics to some extent.[4] The proportion entering these disciplines with an A- or AS-level in mathematics had increased but reached a limit and many students had done little or no mathematics for at least two years. It felt that many students arrived at university with unrealistic expectations of the mathematical and statistical demands of their subjects. While many universities provided valuable support in these areas, students lacked confidence in them and too few made use of that support.

Although recent research suggests that the mathematical backgrounds of entrants do not necessarily affect degree outcomes directly in subjects such as biology or chemistry,[5] they do affect the content that universities need to provide on such courses and additional support.[6] Having to provide additional courses to enhance mathematical skills may restrict the content that can be offered due to time and resource constraints. Studies in both STEM subjects and in other disciplines have led to calls for significant quantitative skills to be a central component of school-level education in order that content of degree courses is not diluted.[7] Research also suggests that, practically, mathematics A-level has the greatest impact in facilitating entry to high-tariff universities across all university subjects.[8]

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[3] *State of the Nation: a review of evidence on the supply and demand of quantitative skills*, British Academy, 2015

[4] *Mathematical transitions: a report on the mathematical and statistical needs of students undertaking undergraduate studies in various disciplines*, Higher Education Academy, 2014

[5] Adkins, M. & Noyes, A. (2017) Do advanced mathematics skills predict success in biology and chemistry degrees? *International Journal of Science & Mathematical Education*, 16, 487–502

[6] Hodgen, J., Adkins, M. & Tomei, A. (2018) The mathematical backgrounds of undergraduates from England. *Teaching Mathematics and its Applications: An International Journal of the IMA*, hry017, https://doi.org/10.1093/teamat/hry017

[7] *Count Us In: Quantitative Skills for a New Generation*, British Academy, 2015

[8] *The relationship between A-level subject choice and league table score of university attended: the 'facilitating', the 'less suitable' and the counter-intuitive*, Centre for Longitudinal Studies, 2017

Within the sphere of employment, people in most sectors and occupations are required to use analytical reasoning, to make at least rudimentary calculations and, increasingly, to create, use and interpret data. For an individual to participate effectively in these types of work activity, they require an extent of mathematical achievement beyond basic numeracy.[9]

Within the labour market, quantitative skills are required in a wide range of occupations across the spectrum of industrial sectors. This is most readily understood in relation to STEM occupations, including engineering, technology and design, many of which require strong quantitative skills. However, measurement and data analysis are central to the performance of many types of organisations and can be critical – for example, managing public health or enforcing safety – so quantitative and data skills are key to management and business roles, across the sectors. The Royal Society's 'Dynamics of data science' project has been exploring the accelerating exchange and use of data in the commercial and everyday world, concluding that realisation of the benefits of data and digital technologies requires a skilled workforce everywhere from government departments to technology start-ups. Crucially, it identifies mathematics as one of the underpinning elements of the development of foundational data skills that should be developed during education for people to become skilled developers, users or citizens.[10]

The UK Government's Industrial Strategy in 2017 laid out with some clarity that improvements to the UK's productivity, the growth of which has lagged many other industrialised nations, require investments in both skills development and other kinds of infrastructure to foster productivity growth. The second of the 10 pillars it identifies is to develop skills by ensuring that everyone has the basic competencies needed in a modern economy, which include STEM, digital and numerical skills.[11]

Higher quantitative skills have been correlated with greater earnings for individuals as well as better overall productivity. Adults with at least basic numeracy skills earn higher wages and are more likely to be in employment than those who have failed to master or evidence these skills, while basic numeracy skills underpin achievement of higher qualifications which in turn support employment, upskilling and development. The OECD reports that in England, the links between better skills, higher wages and lower unemployment are particularly strong.[12] Sir Adrian Smith's review has summarised a whole range of more specific evidence for the earnings- and career-related benefits of greater mathematical skills for individuals, as well as the potential wider productivity impacts.[13]

Yet, as Smith argues, England is unusual in not requiring study of mathematics beyond age 16. An international comparison of participation in post-16 mathematics in 24 OECD countries showed that students in England, Wales and Northern Ireland had the lowest levels of participation in the 24 countries surveyed, at fewer than one in five students. In contrast, more than half studied mathematics post-16 in 18 of those 24 countries and in eight of them there

[9] *Mathematical needs: mathematics in the workplace and in higher education*, Advisory Committee on Mathematics Education, 2011
[10] Dynamics of data science, https://royalsociety.org/topics-policy/projects/dynamics-of-data-science/
[11] *Industrial strategy: Building a Britain fit for the future*, Department for Business, Energy & Industrial Strategy, 2017
[12] *Building skills for all: a review of England*, OECD, 2016
[13] *Report of Professor Sir Adrian Smith's review of post-16 mathematics,* Department for Education, 2017

was near universal take-up (reflecting the fact that mathematics is a compulsory subject post-16 in those countries, unlike in the UK).[14]

The proportion of young people in England taking A-level mathematics rose markedly between 2010 and 2018, although at the time of writing evidence is emerging that the number dipped in 2019. Prior to 2019, most of them will also have taken AS-level mathematics. However, 2019 is the first year of the new linear A-levels in mathematics, following the decoupling of the A-level from the AS-level, so many schools have not entered students for AS-level examinations in year 12 en route to A-level. Linear A-levels were introduced in many other subjects from 2017/18, which may also have impacted on numbers taking AS-level mathematics. Overall, most other students (i.e. those not studying mathematics A-level) who have achieved A*-C in GCSE mathematics at age 16 do not study it at post-16 level.

At university, despite STEM degrees becoming more popular and increasingly favoured by employers, over 40% of English students in STEM subjects (other than mathematics itself) in higher education (HE) do not have a mathematics qualification beyond GCSE. This is higher still outside the STEM disciplines.

Recent analysis shows that while degree courses with high mathematical demand do tend to recruit students with strong mathematical backgrounds, as few as 24% of undergraduates in England in subjects with medium-level mathematical demand had a mathematics qualification higher than GCSE and this was only 12% in subjects with low mathematical demand. Roughly 10% of all recent UK undergraduates do not have a C grade at GCSE mathematics, which is commonly assumed to be the minimum requirement for entry to university.[15]

To improve this situation in England, in addition to efforts to increase the number of students who study mathematics itself at university, a more general increase in the proportion of young people (who attend university or not) with some study of mathematics post-16 is highly desirable. Evidence from countries with high participation rates in mathematics suggests that the biggest incentive for students to continue with mathematics beyond GCSE is recognition that it will help them progress to HE and employment.[16] Recognising the role universities could play to encourage and incentivise prospective students – not only in STEM subjects, but also in the social sciences and more widely – the Smith Review included as its Recommendation 4:

> *"The Department for Education should work with UK learned societies to encourage universities to better signal and recognise the value of level 3 mathematics qualifications for entry to undergraduate courses with a significant quantitative element."*

The intention is to increase the number of students who in future will pursue courses in higher education (HE) with a quantitative element – within and beyond STEM – that have studied mathematics post-16, in addition to supporting the more general aspiration that as many young people as possible should study at least some mathematics post-16.

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[14] *Is the UK an outlier? An international comparison of upper secondary mathematics education*, Nuffield Foundation, 2010

[15] Hodgen, J., Adkins, M. & Tomei, A. (2018) The mathematical backgrounds of undergraduates from England. *Teaching Mathematics and its Applications*: *An International Journal of the IMA*

[16] *Mathematics after 16: the state of play, challenges and ways ahead*, Nuffield Foundation, 2014

This recommendation was picked up in the Government's 2017 Industrial Strategy and also its response directly to the Smith Review.[17] The Department for Education stated its intention to undertake work with bodies like the Royal Society and the British Academy which have already been active in encouraging universities and employers to signal the value of post-16 mathematics qualifications, for entry to degree courses with a quantitative element and for a wide range of jobs.

On behalf of the Advisory Committee for Mathematics Education, the Royal Society commissioned CRAC to undertake research to understand how UK universities are currently signalling to young people the importance of quantitative skills, and whether and how it could be enhanced and made more effective in future.

[17] Department for Education letter responding to Smith Review: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/631009/Letter_responding_to_Smith_review.pdf

3 Research aims and approaches

3.1 Aims and research questions

The two high-level aims of the research were:

1. To identify and understand **whether and how universities are signalling to young people**, who are prospective students, **the importance of developing quantitative skills**, particularly through the study of mathematics post-16; and
2. To investigate and make recommendations as to **how such signalling might be enhanced** in its reach and effectiveness in future.

In order to achieve these aims, a number of key research questions were identified, which included:

- **What** signals are universities currently sending (or intending to send) and to whom – potentially including both directly to young people and indirectly through their parents, peers, teachers and advisers or others?
- Within such signalling, **what content or messaging** is being sent – are the benefits of quantitative skills and/or post-16 mathematics study contextualised specifically for HE study or more broadly?
- **How** are universities attempting to undertake this signalling activity (i.e. through what channels) and **when**?
- Are there **variations** in these issues between different types of university and/or different disciplinary contexts?
- How could such signalling by universities in future be **enhanced or augmented** (including what else could they do)?
- Are there **examples of good practice** that could be shared?

3.2 Research approach

The broad approach to the study agreed with the Royal Society was for a combination of desk research and some primary investigations. It was also agreed to take a deliberately iterative approach, with an initial phase of intelligence-gathering that would steer the extent and form of deeper research in the second phase. It was intended from the outset that the first phase of work would determine the extent to which field-based primary research would be either fruitful or necessary to develop the understanding we sought.

Both phases of the research comprised a combination of desk research to explore existing information and knowledge, dialogues with a range of education professionals and stakeholders and a limited amount of 'fieldwork' in schools, colleges and universities. Informants, with whom we conducted interviews, included university admissions leaders and staff, university outreach and widening participation staff, university subject specialists, school and college teachers and careers/HE advisory professionals, representatives of certain third parties and other stakeholders.

In practice, the intelligence gained in the first phase of research revealed very consistent views about the nature and extent of universities' activities, including the channels that were being

used, which led us to believe that primary research fieldwork on a widespread basis would not be fruitful. We also agreed at that mid-point of the research to impose a sampling approach to our investigation of universities' information about mathematics in relation to their undergraduate courses. With the agreement of the Royal Society, we focused that investigation upon three disciplines:

- Biological sciences;
- Psychology;
- Business and management.

These were selected as three disciplines outside the physical sciences where mathematical skills are known to be of value in undergraduate study and also which attract a reasonably wide range of students. They are also three of the most popular subjects considered by prospective undergraduate students.[18] Business studies and management studies (if combined) were the most popular subject in terms of first-year, first-degree enrolments by UK students in 2017/18, followed by nursing and psychology.[19]

At the Royal Society's suggestion, to reduce the potential extent of university course information to a manageable sample for assessment, we focused on institutions in three geographical areas of England: East of England, the North East and the South West. This geographical sampling approach was only applied to this aspect of the research, whereas the remainder of intelligence-gathering was applied across England.

The research was undertaken between October 2018 and February 2019, with emerging findings shared with the Advisory Committee on Mathematics Education at its February 2019 meeting. This is the final report on the project.

3.3 Project focus and scope

The primary focus of this study (as described in the invitation to tender) was to investigate signalling activity by universities directly to young people and their parents. The content of the signalling of interest was in relation to the value of studying mathematics post-16, presumably with the practical intention of informing choices made by young people about the subjects and qualifications they pursue after GCSE. The target audience for such signals was therefore young people in Key Stage 4, especially Years 10 and 11 when such options are typically considered and, in most cases, decisions made.[20] At that age, parents and carers exert strong influences upon young people. Outreach staff regard them as being better channels for information than students themselves as they may retain it for longer and re-use it with their children at a later stage. Therefore parents/carers were also a key target audience. It is also important to remember that this particular stage of decision-making is made within the context of compulsory school-based education and that schools wish to be and are strongly engaged in it, not least because there are direct consequences educationally and financially for the school of those decisions.

[18] *Evaluation of Unistats: Early experiences of users*, HEFCE, 2012
[19] HESA: What do HE students study? https://www.hesa.ac.uk/data-and-analysis/students/what-study
[20] These students are referred to as 'pre-16' for brevity in this report, as they have not yet entered post-16 education

As expected to some extent in an intelligence-gathering study of this nature, its focus and scope evolved as the study progressed. At the outset, as described, the intention had been only to investigate signalling activity by universities directly to young people and their parents, not via their schools (or other channels). However, it became clear relatively quickly that this would give very limited insights, so the scope was widened to include a broader range of channels, as will be seen in this report. We also quickly realised that the extents of direct signalling activity of varying types were such that investigation at university level would not be a fruitful use of time within the project, other than in relation to course-related information provision.

Another issue of scope that was considered was the type of post-16 mathematical study. We deliberately did not focus on how universities articulated their entry *requirements* for A-level (or equivalent) mathematics but looked for signals about all Level 3 mathematics qualifications for subjects where quantitative skills would be useful. While there are clear policy aspirations to increase the number of students who obtain A-level mathematics qualifications, this project focused principally upon study of mathematics subjects at Level 3 by those who were *not* studying for a mathematics A-level or equivalent qualification. That focus was essentially on signalling which encourages some Level 3 mathematics study amongst the three quarters of those with A*-C in GCSE mathematics who do not pursue A-level (or equivalent), rather than trying to increase the proportion who do study it at A-level (or equivalent), for which there are many existing initiatives. Within the school/college context, this led to quite a significant focus on Core Maths (see section 4.1), which is arguably where there is greatest scope to increase participation.

4 Contextual issues and signalling channels available

4.1 Contextual issues

In the first phase of intelligence-gathering, a variety of issues emerged that could potentially or practically influence signalling activity by universities about the value of post-16 mathematics study and/or its implications for young people, parents and also, importantly, for schools.

For the HE provider (i.e. university), there is currently some tension in its offerings to prospective students. Following the 2012 change to the student fee regime and resulting direct relationship between fee income and the number of students, and removal of the cap on student numbers for 2015/16, there is a direct incentive for universities to maximise the number of undergraduate students they admit (subject to capacity constraints). At the same time, the shift of investment to the student has led culturally to a change towards commodification of undergraduate HE and a 'student as customer' approach, to varying extents in different universities and subjects. Universities may also have some concerns about 'maths anxiety' amongst students.[21] Together, these factors have led universities to want strategically to offer as much flexibility and choice to prospective students as possible, including being as flexible as possible in terms of eligibility for courses. While this may not have led directly to decreases in entry requirements, it has led to a culture where universities wish to accommodate prospective students and accept a wider range of study backgrounds than they might have in the past.[22] Tension arises because, for a number of subjects, a requirement for mathematics A-level, for example, may reduce the attractiveness of that course to prospective students and the number of applications and enrolments, and hence reduce income and sustainability of that provision. Chemistry is a good case in point, where it has been established that some students perform better academically once on the course if they have studied A-level or equivalent mathematics,[23] but universities have tended not to impose prior A-level study as an entry requirement in order to avoid numbers dropping, leading to increasing needs for teaching of what some term 'remedial maths' to chemistry students.

This was encapsulated by one of our informants who suggested that university admissions messages were essentially:

> *"We want you to have mathematics A-level, but we don't want to put you off from applying [if you don't]"*

The key issue for this project is that many universities, with the exception of the most competitive, are strategically seeking to be increasingly flexible in their entry requirements and widen the range of students that can apply to their undergraduate courses. Logically, therefore, some may be reluctant to introduce messaging that recommends that prospective applicants study mathematics post-16, if they believe this will reduce the attractiveness of their course, or to force students down the route of undertaking a foundation course first.

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[21] Higher Education Academy: https://www.heacademy.ac.uk/system/files/downloads/5.6_what_is_maths_anxiety_handout.pdf

[22] *Growth and choice in university admissions*, Universities UK, 2018

[23] *Skills in mathematics and statistics in chemistry and tackling transition*. Higher Education Academy, 2014

It should be noted that some universities with very competitive entry have consistently recognised the value of prior mathematics study, signalled through entry requirements for A-level mathematics or equivalent for many of their courses. Later in this report we consider the issue of any potential requirement for other forms of post-16 mathematics study. However, we are aware that some universities are considering other forms of testing of mathematics for entry to subjects where there is some mathematical demand.[24]

Concern to offer flexibility in entry requirements to maximise enrolments has almost certainly also been exacerbated in recent years due to the existence of a distinct 'demographic dip' in the teenage population of the UK, which has heightened competition between universities to maintain enrolment numbers and income. It should be noted that this population dip will reverse in coming years, and there will be a much-increased population of UK teenagers, but in recent years the demographic dip is likely to have impacted on universities' admissions strategies (and has likely also contributed to the sharp rise in unconditional offers recently).

More practically for prospective students and those advising them, the changing backdrop in universities has led to admissions processes in many universities that focus on the grades that students attain in their three main A-level subjects (or equivalent), rather than on their total UCAS tariff (which is calculated from all their post-16 qualifications). UCAS suggests that only around a third of university courses have a tariff entry requirement.[25] This could indicate relatively low importance being placed on other subjects or qualifications that a student has studied. It should be said that this does not apply to highly competitive courses and/or universities, where there is much more attention to factors other than achievement in three A-level subjects, nor within the domain of widening participation where contextual factors are deliberately included. However, in the mainstream, some universities may have become relatively mechanistic in their admissions and selection processes, which again will mitigate against prospective students thinking about the value of what else they might study, beyond their primary three A-levels (or equivalent core qualification mix).

Finally, it is acknowledged that much of the widening of participation in UK HE (in terms of a greater range of socio-economic backgrounds of students) has been driven by those with BTEC qualifications rather than A-levels. While studying BTEC qualifications does not obviate the study of mathematics at Level 3, it has been argued that university staff have less knowledge about mathematical learning in the context of BTEC study and less confidence in it as preparation for HE courses. This could complicate the messages about 'additional' mathematical study that universities feel able to develop and signal. Some also argue that current education providers' performance measures may encourage providers to divert weaker students into BTEC provision which has a higher coursework element and where they are likely to perform more highly than if they undertook linear A-level study. This may mean that they are not offered the chance to do A-levels and could impact both on the subjects available and how they will engage in any mathematics education.

Away from HE, there have been other trends and developments which may well influence participation in post-16 mathematics qualifications and the extent to which there is support for them, particularly where they are 'additional' to primary A-level or equivalent qualifications. One such trend is that there has been some success in terms of a total rise in the number and

[24] This is separate from the requirement for STEP or other tests by several universities for entry to mathematics degree courses

[25] UCAS: https://www.ucas.com/advisers/guides-and-resources/information-new-ucas-tariff-advisers

proportion of students studying mathematics A-levels, probably related to some extent to promotion of STEM subjects and choices, and this could deflect from the impact of other messaging about the value of studying mathematics post-16.

Interest in the value of 'additional' subjects studied, other than the three A-levels that comprise the main entry requirement for most university courses, is also likely to have been influenced by the recent change to AS-levels in England including their decoupling from A-levels. While the AS-level still exists and can be taken as a separate qualification at the end of Year 12, it no longer counts towards the overall A-level grade. This change may well act as a disincentive for selection of AS-levels, particularly in subjects seen as 'hard', in addition to students' three main A-levels or other core qualification/s. There was a 49% decrease in the number of AS Mathematics entries in 2018 compared with 2017 (and 52% across all subjects), which has been attributed to the decoupling from A-level as well as post-16 funding changes.[26] Many schools are no longer offering AS-levels or encouraging students to take them, focusing their staff resources on other priorities. This could partly be because the new linear A-levels are perceived as harder than the courses they replace, so schools are recommending that students study just their three main subjects and not four (of which mathematics to AS-level in year 12 could previously have been one). The introduction of new AS-levels in mathematics is very recent, with the first results in 2018. At the same time, previous A-levels in Quantitative methods and Use of mathematics, positioned as additional numerical subjects although not studied by large numbers, were abandoned from 2017 onwards, as was Statistics. These factors are all likely to mitigate against the number of post-16 students who study a Level 3 qualification in mathematics in addition to their three main A-level (or equivalent) subjects.

In contrast, the development and introduction of Core Maths in 2014 should have had a positive impact, as it was specifically designed to widen participation in post-16 mathematical learning and support the development of mathematical skills needed for progression to HE or employment. Core Maths is the generic title for a range of specific mathematics qualifications at Level 3 (currently seven offered by a range of examination boards) comprising two years of study, which focus on the application and context of mathematics, and are aimed at those who are not studying AS- or A-level mathematics. This should provide a good specific opportunity whose value universities could signal, although the lack of a single qualification with the title of Core Maths makes this more complicated and relies upon a level of understanding of the curricula and examination opportunities within schools. Fewer than 7000 students sat Core Maths examinations in 2018 and it is acknowledged that it is by no means yet universally available within post-16 provision, leading to the following recommendation within the Smith Review:

> *"The Department for Education and Ofqual should consider how the core maths brand could be strengthened with the aim of improving awareness and take-up of the qualification."*

More generally, there are pressures in the school environment which may have hindered either increased participation in subjects such as Core Maths, or how positively messages land about encouraging more students to do so. The current shortage of mathematics and other STEM

[26] *Level 3 maths update 2018-19*, Advanced Mathematics Support Programme, https://amsp.org.uk/uploads/files/31af5cbc1808fc387a1d8131958a4d2b.pdf

teachers is well rehearsed, and there is evidence to suggest that schools deploy their more experienced mathematics teachers to teach year groups where the external stakes are highest, including GCSE (and resits for it) and A-level, rather than, for example, Core Maths.[27] These pressures may limit schools' or colleges' capacity to support a greater number of students seeking to study mathematics post-16, beyond their main A-level provision, either due to physical shortage of the number of teachers or their expertise and ability to develop additional teaching required. Such practical restrictions on capacity could limit their enthusiasm to inspire or support greater demand from students, in response to potential university signals or other drivers. The Department for Education has made a premium available to schools if 'additional' students take mathematics qualifications, but this may not be sufficient to drive the increases needed in teaching capacity. At a time when school and sixth-form funding is at critical levels, the culture within them may be to focus on core provision as opposed to teaching and/or qualifications that are seen only as additional and/or having incremental benefits, or to streamline provision to be more cost-effective.

There is also weakness in careers provision in many schools in England following the removal of discrete funding for school-age careers support in 2012. While the current statutory guidance for schools about what they should strive to provide to students reflects current understanding of good practice, the acute lack of resources in schools to deliver it means that provision remains patchy and in many cases delivery is by unqualified staff.[28] The extent of investment in careers provision including support for HE choices and for post-16 subject choices is largely down to the individual school and its commitment to support these areas, in the absence of designated careers funding. This must have some impact on both the extent of support offered to students about their post-16 choices and the expertise of those providing that advice; it is likely in that context that any signals from universities may simply not be heard by many education professionals in advisory roles, and/or they will have less bandwidth (i.e. time and resources) to recognise the implications of those signals and act upon them. In turn, this may influence and limit the guidance that is given to students about their post-16 choices.

4.2 Signalling channels

The potential high-level channels we identified that are open to universities for signalling purposes are shown in Figure 4.1. The original focus of this project was to be on 'Direct' signalling, i.e. information sent directly to pre-16 students[29] or via their parents or families. We quickly realised that this would provide too limited a view of the actual signalling taking place, or opportunities for it, and so also included within the project scope at least some of the signalling taking place via schools during teaching, IAG (information, advice and guidance) that relates to progression and careers, and also during enrichment activities. In addition, we identified a range of third-party actors which included certain information providers supporting student choice-making and a wide range of providers of both STEM and (WP) widening participation activities. In practice, many of the physical activities undertaken by these third parties are in collaboration with schools (and in some cases also with university involvement).

[27] *How do shortages of maths teachers affect the within-school allocation of maths teachers to pupils?* Nuffield Foundation, 2018

[28] *Careers guidance in schools, colleges and universities (England),* House of Commons Library, 2018

[29] For brevity, 'pre-16' is used to refer to students who have not yet entered post-16 education (even though some such students may literally be aged 16)

The structure of much of the rest of this report utilises this categorisation of signalling or communication channels; more detail about more specific activities within each of the channels is given in the following chapters.

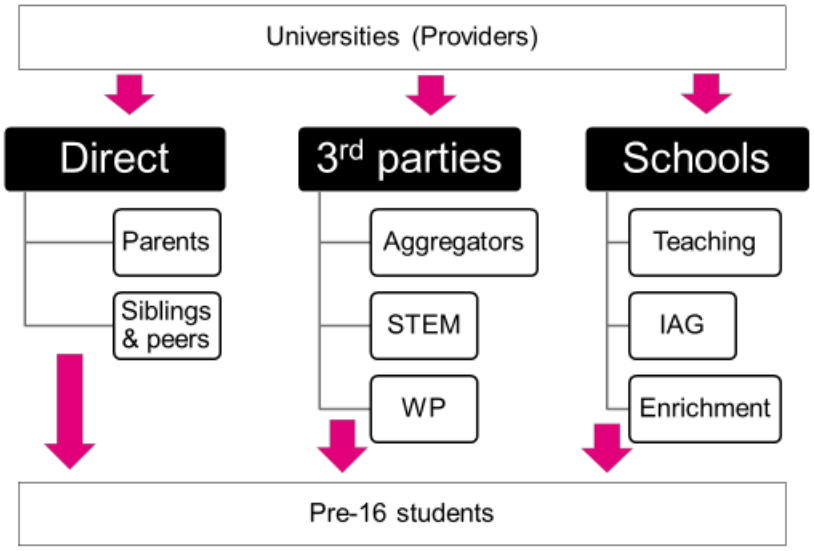


Figure 4.1 Schematic representation of channels available to universities for signalling to pre-16 students

5 Direct signalling

5.1 Signalling directly to pre-16 students

The ultimate purpose of the signalling investigated in this study is to increase the proportion of UK undergraduate students participating on courses with a quantitative element who have studied mathematics at Level 3. Practically, this means increasing the proportion of young people who study mathematics at this level during their post-16 education. Self-evidently, signals aimed to influence the subjects that young people study at that educational stage need to reach those students before they have chosen their post-16 subjects, i.e. when they are still 'pre-16' students, most likely in Key Stage 4 of secondary school.

The primary audience for this signalling is students who are yet to select or finalise the subjects that they will study in their post-16 education. Reaching them directly, rather than via their school, could be advantageous as their school may not be entirely impartial in the guidance it provides. The transition to post-16 education often involves a change of provider so the student's current pre-16 institution itself has an interest in the student's choices for post-16 study. Although the school has a responsibility to support the student's progression, practically it may wish to retain as many students as possible in its own post-16 provision, if offered, for financial reasons, which may influence the post-16 choices available to the student.

All the informants we consulted during the project agreed that the extent of engagement of universities directly with pre-16 students is very limited, at least for 'mainstream' students.[30] There may be other direct engagement with certain types of student under the auspices of widening participation activity, and some through other outreach and/or enrichment activities including support for increased interest in STEM subjects and careers. Those potential channels are considered within Chapter 6 on schools, as the activities are mostly school-mediated or in collaboration with schools. However, in terms of direct signalling, there was consensus that, overall, universities seek very little engagement with mainstream pre-16 students directly. This is in stark contrast with the position for post-16 students who are the prime target for their undergraduate recruitment campaigns and communications as prospective applicants. Understandably, universities will consider that although pre-16 students are also prospective students, they are not the primary target for engagement as they have not yet reached the stage when most are making decisions about applying for undergraduate courses.

That said, we did find evidence that some universities are undertaking a limited range of activities designed to send signals to influence post-16 study choices. Probably the best-known example has been the '*Informed Choices'* publication (issued by the Russell Group on behalf of its members, so arguably by a third party, since 2011). This publication has aimed to provide advice to students to help them to make well-informed post-16 choices, with a focus on entry to more competitive universities such as the Russell Group member institutions. It is possible that the Russell Group initiated this publication because it recognised that its universities were not individually signalling sufficient messages about post-16 study choices. The most recent (fifth) edition was published in 2017.

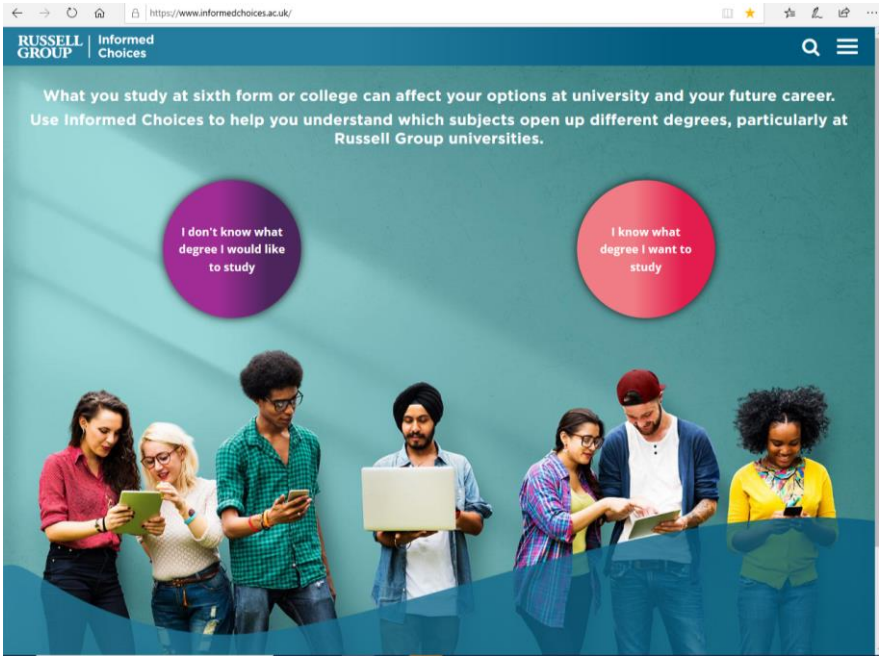
[30] By mainstream we intend to mean students that are not specifically targeted through particular initiatives such as widening participation, gifted and talented etc.

'Informed choices' introduced the concept of a range of specified 'facilitating subjects' (including mathematics) which were deemed to be the most common amongst entry requirements and which prepare students in the best way to cope with study at these institutions.[31] It also contained specific guidance on the value of Core Maths:

> *"Russell Group universities value mathematics skills for many different degree courses and many have GCSE or equivalent requirements. Mathematical and statistical problem solving, data analysis and interpretation skills can be useful for a wide variety of undergraduate degrees, and a Core Maths qualification may help you to improve and maintain these skills, especially if you are not taking AS or A-level Maths/ Further Maths."*

However, in May 2019 the Russell Group relaunched its guidance (and replaced the printed guide) with a new website[32] that still aims to support Year 10 and 11 students in relation to subject choices but principally through exploration. It invites the user to select a possible degree subject and then highlights A-level subjects that are most commonly required for entry (and also allows them to test what HE subjects are open to them given an existing A-level combination. It specifically removes the concept of facilitating subjects:

> *"It is no longer necessary to publish such a list. Here you can explore the various degrees and subject areas you're interested in – as many as you like – to build up a more personalised picture of the subject combinations which suit your talents and ambitions"*



Part of the rationale for this change appears to be reaction to the observation that some people have suggested that facilitating subjects are the only subjects pupils should consider to get into a Russell Group university. The website does reference mathematics where it is required

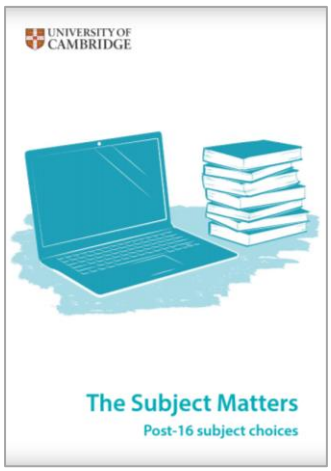
[31] *Informed choices: a guide to making decisions about post-16 education*, Russell Group,2017
[32] www.informedchoices.ac.uk

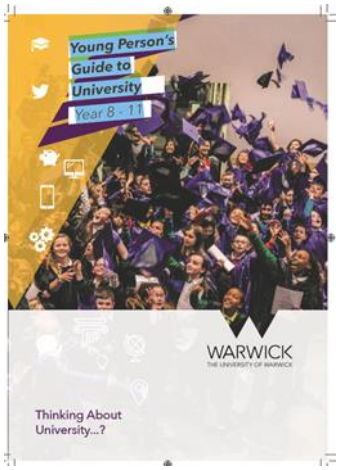
or is one of a range of possible essential subjects. Its description of Core Maths has shifted slightly to emphasise its value as an alternative qualification, rather than its utility in developing skills that will be useful during an HE course (as quoted above in the printed guide) although it does also offer a link to the AMSP website for further information. We did also find evidence for certain other activities by individual universities which specifically seek to engage pre-16 students to support and influence their decision-making about post-16 study. It should be noted that none of these was specifically designed to signal the particular messages in which we are interested in this project, but those messages could be embedded to some extent within the activity. They are also potential channels through which such signals could be embedded in future (even if they are not currently).

The University of Cambridge has since 2009/10 run an event called *The Subject Matters* which is targeted at Year 11 students and their parents. This promotes the concept of undergraduate study and Cambridge in particular, but also focuses on how to make educated choices about post-16 subjects with a potential Cambridge application in mind. Up to 10 sessions were held in 2018, with a total audience of over 2100 people, some of whom travelled long distances to attend.

> *"… experienced Admissions Tutors give key advice about making informed A-Level (or equivalent) subject choices so students put themselves in the best position for their studies after sixth form"*

We attended one of these events and can testify that mathematics did receive some special attention, in the form of recommendations and explanations of its value for those thinking about a degree in the arts, humanities or social sciences, with a case study on linguistics (and the need for quantitative skills within that subject). Although the attention to mathematics is less evident in the accompanying leaflet published,[33] which focuses more on useful combinations of A-level subjects, it is listed as one of the most valuable 'core' subjects for those seeking to study arts or social sciences and recommended as a subject for those seeking to study sciences (but described as a requirement only for physical sciences).





[33] *The Subject Matters*, University of Cambridge, 2018: https://www.undergraduate.study.cam.ac.uk/events/subjectmatters

Some universities provide generic advice about selection of post-16 qualifications within the information and support they provide to prospective students, which can be under the auspices of outreach, schools liaison or widening participation. The University of Warwick's *Young Person's Guide to University* is an example,[34] which contains a limited amount of content specifically about mathematics as a requirement for certain subject areas:

> *"Maths, Economics, Engineering, Physics, Computer Science - All these courses require Mathematics (Maths is also recommended for Business Studies)"*

Aside from that recommendation for business studies, mathematics is not cited as especially valuable for any other courses (such as psychology), other than being included in the list of facilitating subjects which Warwick consider of potential value to keep options open.

Study of the websites of the 19 universities in our sample found that specific guidance on the choice of post-16 subjects was largely absent, with the exception of Cambridge (as above) and Plymouth whose online section[35] promotes the value of facilitating subjects and links to guidance on the Which? University website for more detail (see section 7.2). At the time of writing, some (but not all) of the Russell Group universities in our sample made some reference to the *Informed choices* publications. Interestingly, within its guidance to prospective applicants (which is otherwise firmly targeted to those choosing between universities), the University of East Anglia signals strong support for the extended project qualification (EPQ).[36] Although it is embedded within content for post-16 students, this is the type of signalling that could support students to consider studying a post-16 mathematics qualification (albeit in this case it is highlighting the value of the EPQ).

Where generic guidance is provided about subject choice, it does tend to confirm that decisions made by students in Year 11 will have significant impact on the options available to them at university. Typically, universities suggest that students approach their subject choices from two angles. Those who have a specific career in mind can work backwards, starting with the desired occupation and identifying the degree/s that will lead to this and then the post-16 subjects that are required for that degree. Thus, a student who ultimately seeks a professional role in engineering will most likely need a related degree programme, entry to which will usually require mathematics at A-level. This signals that the particular A-level will need to be selected as one of a student's post-16 options.

The second approach is for those who are unsure about their future career direction, which is probably the majority (and for whom the new Informed choices website is also designed to cater). For them, universities' guidance tends to encourage students to select the subjects that they most enjoy, as this will contribute to them obtaining higher grades which, in turn, will maximise their options when they leave compulsory education aged 18. Clearly, this type of advice offers no signals to the particular value of mathematics post-16 study (except for those who have already identified their expected career direction).

A more sophisticated approach has been adopted by a consortium of universities and colleges in southwestern England. The consortium seeks to increase the progression of adults and young people to higher level study through providing online, impartial information and support

[34] *Thinking about university? Young person's guide to university years 8-11*, University of Warwick: https://warwick.ac.uk/study/outreach/p2332_thinking_about_young_persons_guide_a5_final_print.pdf
[35] University of Plymouth: https://www.plymouth.ac.uk/study/choosing-school-subjects
[36] Advice to future students: https://www.uea.ac.uk/study/undergraduate/advice/

about all progression routes. Its Careerpilot website is designed for 13-19 year olds and helps them by highlighting the different progression pathways available towards potential career directions or occupations.[37] This will support those with at least some idea of a potential career direction, in terms of subject choices post-16 that will enable such progression. It also offers them the chance to identify skills that will be valuable in HE study. The service is provided through a subscription model and so is likely to be accessed within a school setting, so arguably is not 'direct' in terms of an information channel to post-16 students.

5.2 Signalling via parents and siblings/peers

Universities routinely provide information for parents of prospective applicants, but this is focused firmly on support for decision-making about application to the university and is mostly not aimed at parents of pre-16 students. One exception is Teesside University, which provides a 'Leaving school' guide for parents on its website which is about transitions at age 16.[38] It also encourages parents to register to receive further information and guidance which is tailored to their child's school year, and a further guide 'Thinking about higher education.' The first of these will be particularly valuable to parents of first-generation HE entrants. These guides are an element of the information provided by Teesside about HE study there and the courses it offers, designed to augment the information provided to prospective applicants; this type of information is described in the next section (5.3)..

We found very limited evidence of strategies to engage parents of pre-16 students, other than that they were overtly included in the targeting of some information provision for pre-16 students described in the previous section. For example, parents are invited to accompany their children to Cambridge's *The Subject Matters* events. Our experience was that the audience for one of these events was roughly evenly split between children and adults (who were presumably parents/carers) with evidence of attendance by family groups and a few teachers who had brought small groups of students.

There was also evidence of a desire by universities to engage parents through some of the school-mediated channels they use (described in Chapter 6) including, especially, information evenings supporting university applications and, much more rarely, supporting post-16 choices. Parents are also targeted to some extent in universities' widening participation outreach work, most of which (again) is in connection with schools.

Our inference is that few universities are seeking to engage or support parents/carers of pre-16 students, as is the case for mainstream pre-16 students themselves.

The next section focuses on universities' provision of information and support about going to university, their courses and admissions, chiefly as online information but also through open days. Both are targeted at prospective applicants who are ready to apply, i.e. at a later stage than pre-16 students, and their parents (and not overtly at pre-16 students). However, it seems inevitable that some particularly keen pre-16 students will come across this information. There will also be some permeation of messages to pre-16 students if their parents are accessing this information in relation to older siblings, and we have evidence that family groups including younger siblings commonly attend university open days.

[37] Careerpilot: https://www.careerpilot.org.uk/information/your-choices-at-16
[38] Leaving school: https://www.tees.ac.uk/sections/parents/leaving_school.cfm

Parents who do engage with this type of information when supporting a post-16 child may internalise some of the messaging and replay it to their children of pre-16 age when they, in turn, are considering post-16 study choices. Equally, there could be some indirect permeation of signals to pre-16 students where their peers or friends have attended an open day with an older sibling or been party to family discussions about university choices. Recent studies have confirmed that peers can be important in relation to the way that young people consider post-compulsory education.[39]

5.3 Course information and marketing

It is hard to categorise exactly where these activities should reside in our schematic, as they are aimed squarely at prospective students and their parents but the prospective students that universities have in their sights are those actively considering or making applications to HE. Almost certainly that means they will be participating in post-16 education (or have completed it), not the pre-16 students on which we are focusing. However, the activities described here are vast in extent and in a variety of cases include messaging about prior study. Even if they are only rarely used directly by pre-16 students, they constitute such a prominent source of information that they merit examination in terms of the messaging they contain about the value of subjects that are studied post-16. In addition, some of the advice that does exist for pre-16 students directs them to these course pages to find out what different universities or courses require.

The activities considered here are essentially marketing used by universities to promote their opportunities for undergraduate study, aimed directly at prospective students and their parents. The key elements are information provided about specific courses and application to them (chiefly online via their websites), more generic information about HE admissions (also online) and presentations/information at their open days. Some of their other marketing activities and information provision are considered in other sections of this report, being indirect and in collaboration with either schools or other third parties.

Our focus of attention was on information provided about courses with a quantitative element, and specifically what was said about requirements for prior qualifications (i.e. their entry requirements) and any other messaging about the need for and value of mathematical skills (including in subsequent employment). In order to reduce the sheer volume of information about the vast array of courses that could be investigated through web research, the sampling approach described in Chapter 3 was taken – essentially focusing on the three subject areas of psychology, business and management, and biological sciences, and universities in three geographical regions of England. This led to detailed examination of course information for over 50 courses provided by 19 universities. It was augmented by discussions with a range of admissions staff, through which we were able to draw in some broader perspectives.

The mathematics-related signalling we identified on universities' course information pages could be classified as one of the following types:

- Information highlighting and describing the quantitative content of the degree programme and/or the skills developed by studying the course;

[39] *The causal effect of secondary school peers on educational aspirations*, Centre for Vocational Education Research, 2018

- Entry requirements including any comments about prior study and other qualifications.

5.3.1 Course content and skills

Overall, there was a greater emphasis on information in the first of these categories. Around half of the sampled universities' pages on business and management (11 of 19 courses) and psychology (9/19) indicated that there was quantitative course content and/or some need for quantitative skills within the high-level description of the course. Some of these overtly highlighted that the skills developed would be of longer-term use:

> *"Prepare for a career getting the best out of people with a degree in business management. You will learn how to combine an interest in people with an interest in numbers, becoming expert in both business strategy and human behaviour"*
>
> Business Management, University of East Anglia

> *"The knowledge and skills of applying a variety of quantitative analytical tools to support business decision making"*
>
> Module overview, Business Management, Northumbria University

> *"Combining a scientific approach, with the ability to think creatively, it's a subject that builds strong practical skills that are essential for success in the workplace. Psychology graduates now work in every area of society, using their numeracy, IT literacy, communication and problem-solving capabilities to add value in their professions"*
>
> Psychology, University of the West of England

> *"You will be introduced to the theory behind statistical analysis, looking at the best ways to describe your data and be trained in a variety of statistical tests that can be used to analyse and draw conclusions about human thought and behaviour"*
>
> Psychology, Anglia Ruskin University

This was much rarer for biological sciences (3/15). Descriptive information at module level typically did contain this information, although the descriptiveness of the module titles varied considerably. One university in the sample flagged that there would be foundational study including in mathematics:

> *"Our flagship Biological Sciences degree allows you to study a wide range of science subjects in the first year without prematurely committing yourself to any particular specialisation. You'll also be given a grounding in other core sciences such as mathematics, statistics and chemistry"*
>
> Biological Sciences, University of East Anglia

> *"As biological research is becoming more and more quantitative in approach, you will also receive training in statistical analysis, practical computing and bioinformatics through a combination of lectures and workshops"*
>
> Biology, University of Exeter

> *"To introduce and practise the development of hypotheses, appropriate experimental design, robust data manipulation and analysis, appropriate statistical testing and interpretation."*
>
> Module description, Biology, Newcastle University

Our analysis suggested that no strong correlation between the prominence or strength of mentions of quantitative skills or content and the entry tariff of the university, or its broad acceptance rates, for the psychology and business courses at least. Although the sample was not large enough for robust quantitative analysis, the evidence possibly suggested that overall the weakest signalling was for biological sciences where, perhaps ironically, candidates are the most likely (amongst these three subject areas) to have A-level mathematics.

The language used to signal quantitative or mathematical skill development or content varied significantly with the subject field. For business and management, such signals within descriptive text tended to be a very few words such as finance or economics content, and only rarely used the term 'quantitative'. However, for these courses, there were frequent messages from lower tariff institutions in particular that numeracy skills gained in the course would enhance graduate employability.

In contrast, psychology course descriptions much more commonly used terms including numeracy, quantitative or analytical skills, and also statistical procedures, frequently in the context of research that would be studied during the course. In the biological sciences, while there were few mentions in high-level course descriptions, at the more granular level of module descriptions there were commonly mentions of data and analysis skills and, in certain cases, specifically of numerical or quantitative methods or approaches in biology. Interestingly, employability-related outcomes cited for these subject areas rarely mentioned development of numeracy during the course.

Across the sample, our inference was that the signalling of the value of prior mathematics study through course descriptive content was not especially strong, and was somewhat inconsistent, not least in terms of different language being used. Nor was it necessarily consistent within a single university.

5.3.2 Entry requirements

Overall, we found that the extent of signalling of the value of post-16 mathematics study was even weaker within information relating to entry requirements. Mathematics A-level was not a stated requirement for any of the courses in our sample, and the absence of a mathematics A-level was cited as a clear disadvantage only for study of biology at Cambridge (where its absence restricts course options and requires additional pre-course study). Where mathematics (or other numerical subjects) featured within a list of 'preferred' or 'relevant' A-levels subjects, that list was in most cases of 10 or more subjects (demonstrating the flexible approach being taken by many universities). Only a minority of universities (mostly very high tariff) listed a much narrower list of preferred subjects, and this was mostly in relation to psychology (which is currently quite highly competitive for entry).

The most common mathematics entry requirement within the sample was a GCSE pass at grade C or 4, while most of the high-tariff universities specified or 'strongly preferred' a higher grade in GCSE mathematics for some or all of the sampled subjects.

Across the sample, we inferred that the strength of signals about the value of post-16 mathematics study being sent through the channel of entry requirements was very weak.

We paid particular attention to the way in which universities made any reference to Core Maths, given its positioning to develop mathematical skills relevant for HE study for those not pursuing mathematics A-level(s). None of the universities in the sample stated that they

routinely made alternative offers to those with such a Level 3 qualification for entry to 2019 courses, as has become common for the Extended Project Qualification (EPQ). Our inference is that the take-up of Core Maths has suffered from this lack of formal endorsement through inclusion in entry requirements (unlike the EPQ) to date.

Since our analysis, the University of Bath has been the first to announce introduction of systematic reduced entry offers for those with a Level 3 mathematics qualification, for entry in 2020. Extracts from its announcement included:

> *"[Bath] recognises that quantitative and analytical skills are invaluable to a range of degree courses, and that extra experience beyond the essential requirements of the course can be beneficial to students' future studies"*
>
> *"there will be greater recognition of level 3 maths qualifications through the use of alternative offers. If typical A-level offer is AAA, the alternative offer would be AAB"*

In relation to Core Maths specifically:

> *"all degrees that do not require A-level Mathematics (including Business, Biosciences, Chemistry, Psychology and Social Sciences) will include alternative offers based on achieving a grade B in a Core Maths qualification (etc) in addition to three other subjects"*

We anticipate that this type of endorsement of the value of Core Maths is one of the ways in which universities can signal the value of post-16 study of mathematics at Level 3. It seems likely that other competitive universities will follow suit, in future, although they will need to take into account that Core Maths is not universally available in schools and colleges and currently not widely studied.

We did not find any other examples of such strong endorsement within our sample. Newcastle's website stated that it may make dual offers to take account of a Core Maths qualification, although this was information on a central admissions page about curriculum reforms, not within the main section on qualifications within its entry requirements content on course pages.

Several high-tariff universities did refer to Core Maths within their information about alternative qualifications, i.e. information that would only be reached by clicking through to that section and not on course pages. However, these were mostly in the context of Core Maths being an alternative qualification for those who did not have the required GCSE grade. For example, Exeter "*may consider*" a pass in Core Maths in lieu of its requirement for a GCSE grade A in mathematics, while Bristol and Newcastle both listed how such a qualification could augment weak performance at GCSE.

Information about Durham's Business & Management course, unusually, stated:

> *"We particularly welcome the introduction of the Core Mathematics qualification and we will accept a Core Maths qualification (Grade B minimum) in lieu of our GCSE Mathematics requirement"*

While such endorsements have some merit in terms of signalling the value of Core Maths in particular, they fall short of what we might hope for in terms of signals about its specific value when studying these sorts of HE courses, or indeed for subsequent careers.

Analysis of entry requirements suggested that these did, unsurprisingly, correlate with the tariff of the university. Outside the high-tariff institutions in the sample, searches for terms relating to Core Maths revealed very little, and some universities did not include Core Maths within the qualifications they listed in their tariff tables or qualifications glossary.

On the basis of this desk research, we chose not to study the content available or the signalling taking place during university open days, although these are an important mechanism by which universities promote their courses to prospective students and parents. The research team had attended a total of over 10 such open days for personal reasons, including for potential study of psychology, and so were familiar with the nature of information presented. Our experience is that open days largely reinforce the information provided on universities' websites, including course information pages, although they additionally offer the opportunity for prospective students to ask university staff questions about admissions and qualifications. It was not possible to investigate that aspect of information provision within the project.

5.4 Other engagement

In the next chapter we consider the extent to which widening participation activities by universities are being used, or could be, for signalling about post-16 subject choices. While most of those activities are in collaboration with schools, there is a limited amount of outreach work that targets young people that does not involve schools, such as taster days hosted by specific university departments. However, there is no reason to think that any messaging within these activities would be substantially different from the school-mediated activities, which are treated in the next chapter.

6 Signalling via schools and colleges

6.1 Curriculum teaching

The development and introduction of Core Maths in 2014 is directly relevant to this project as it was specifically designed to widen participation in post-16 mathematical learning and support the development of mathematical skills that are needed for progression to HE or employment. The way in which schools provide Core Maths, in particular, and promote participation in it to their students should be a key element of the signalling considered here, although that will only be partially influenced by universities. It should be remembered that fewer than 7000 students sat Core Maths examinations in 2018 and it is by no means universally available within post-16 provision.

We undertook a limited amount of field research through attendance at a range of schools' open evenings about post-16 study. Our observations align well with what is emerging from the Nuffield Foundation-funded project 'The early take-up of Core Mathematics: successes and challenges' by Matt Homer and Rachel Mathieson at the University of Leeds, although they focus entirely on the post-16 environment and do not have direct knowledge of how 11-16 schools promote it. They indicated that in sixth-forms and FE colleges, students are encouraged (and in a few cases compelled) to do Core Maths alongside a programme of vocational study, such as psychology, biology or geography A-level, a BTEC in a science or technology subject, or a diploma in science. Our own investigations confirmed that some sixth-form providers are encouraging those studying subjects including psychology, especially, biology and (in a few cases) business or economics to study Core Maths in parallel. In this context it is promoted principally as a direct support for the post-16 studies:

"Doing core maths will help you get better grades in your A-level"

However, it may also be sold as *"looking good on your university application"* and providing additional UCAS tariff points, and this is likely to increase significantly once more universities make more overt reference to its value within entrance requirements and alternative offers. In our experiences, schools are unlikely to promote it on the basis that it will help once at university.

There is evidence that Core Maths is delivered in some schools as enrichment rather than a main curriculum subject, and it can be timetabled in a range of different ways in one or both of years 12 and 13. Homer and Mathieson reported to us that some of the most successful examples of participation have been where it is offered under an enrichment programme. In contrast, the lack of recognition of Core Maths as part of entrance requirements had led to some students dropping out of the course where it was offered alongside, for example, a science diploma, as many in reality selected or studied it not for its own sake or for educational value but directly to improve their potential university applications.

More generally, pressures in the school environment are likely to be hindering desired increases in provision and participation in subjects such as Core Maths and, in turn, how positively the schools are giving messages about participation. As described in section 4.1, current shortages of STEM teachers and strategic requirements for schools to focus on GCSE, GCSE re-sits and A-levels are likely to reduce any attention to Core Maths. Such pressures may limit schools' or colleges' capacity to support increases in the number of students studying mathematics post-16, beyond their main A-level provision, either due to physical shortage of the number of teachers or their expertise and ability to develop the additional teaching

required. The Department for Education's premium available to schools if 'additional' students are recruited to take mathematics qualifications should help but may not be sufficient to drive the increases needed in teaching capacity to deliver Core Maths at any scale.

The Advanced Mathematics Support Programme (AMSP, see section 7.1) is actively promoting provision of Core Maths to schools and teachers. This includes a presentation that teachers can use to promote Core Maths at, for example, open evenings about post-16 study, and was in the process of developing a range of promotional materials for 11-16 teachers on how to advise students. Part of its strategy is to support teachers of other subjects not only to promote this qualification but also to enhance development of quantitative skills during their teaching.[40] Training or professional development of teachers was not considered to be within the primary scope of our project, but we can report that AMSP believes that there is a problem in teachers in some 11-16 schools not being confident about giving advice on Level 3 subject choices. AMSP also reported that there is strong demand from teachers for its pre-16 events.

It should also be noted that many of AMSP's coordinators are based in universities and so are working to influence how their own university engages with Core Maths or other Level 3 study options, in addition to their enrichment work in schools and delivery of training/CPD to teachers.

6.2 IAG and progression support

Within the chapter on contextual issues, we have highlighted that the provision of careers information, advice and guidance (IAG) is weak in many schools in England. Schools are responsible for providing this support and the Statutory Guidance on this states that all young people in secondary school must get a programme of advice and guidance that is stable, structured and delivered by individuals with the right skills and experience.[41] It sets out that secondary education providers should use the Gatsby Benchmarks to develop and improve their careers provision. The Benchmarks are not themselves a statutory framework but, by adopting them, the intention is that schools can feel confident that they are fulfilling their legal duties.[42] Benchmark 7 is entitled "Encounters with further and higher education" which has the aim that all students should understand the full range of learning opportunities available to them, including academic and vocational routes. By age 16, every pupil should have had a meaningful encounter with a post-16 learning provider, to witness the full range of possible pathways, and by age 18 all pupils considering HE should have had at least two visits to universities.

While the Statutory Guidance about what schools should strive to provide to students reflects current understanding of good practice, the lack of resources in schools to deliver it means that provision remains patchy and, in many cases, much of its delivery is by unqualified staff. Investment in careers provision, which includes support for post-16 subject choices and, subsequently, decisions about HE entry or other pathways, is down to the individual school and its commitment to support these areas, in the absence of designated careers funding.

[40] For example, 'Improving quantitative skills at A level' course for non-maths teachers: https://amsp.org.uk/events/details/5339
[41] *Careers guidance and access for education and training providers Statutory guidance for governing bodies, school leaders and school staff*, Department for Education, 2018
[42] *Good Career Guidance*, Gatsby Charitable Foundation, 2014

This has an impact on both the extent of support offered to students about their post-16 choices and the expertise of those providing that advice.

As part of the intelligence-gathering work in this project, we consulted a variety of careers professionals working in the school environment. They reinforced the view that provision of support for post-16 choices is varied. The consensus was that most high-performing schools (including those in the independent sector) had strong provision which included effective and well-informed support and advice about post-16 choices, which was partly informed by their focus on HE entry post-18. On the other hand, guidance to mainstream students in many other schools was somewhat limited, partly driven by schools' relationships with local post-16 providers, and was not thought to be influenced significantly by engagement with HE providers.

As a result, it was considered by our informants that any signals from universities about the value of studying mathematics post-16 may simply not be heard by education professionals in advisory roles. In many cases they may not have the time or resources to seek out the signals or recognise their implications, and/or act upon them. In turn, this will almost certainly limit the nature of the guidance they give to students about their post-16 choices.

That said, the existence of Benchmark 7, which specifically highlights engagement with providers including HE institutions, offers an opportunity which could be leveraged for potential signalling activity by universities into schools which could, in turn, become embedded as part of the guidance given to students about their decisions for post-16 study.

Typically, a key element of support that a school will provide for its students and their parents/carers is an open evening, typically for those in Year 11,[43] although this will partly depend on whether it offers post-16 provision itself. Other post-16 providers (sixth-form colleges, FE colleges, schools with 11-18 provision) will also offer open evenings promoting their provision, to which Year 11 students and parents/carers will be invited. Providers are also increasingly offering open days for Year 10 students, where they can attend taster lessons in new subjects. Open evenings tend to comprise a combination of some generic presentations, a chance to question admissions staff and the opportunity to visit subject classrooms and engage with subject teachers (and current students). It is in the latter part that messaging may be found about good subject combinations and, in the relevant cases, the need for quantitative skills in the post-16 study programme and potential value of undertaking Core Maths, for example (if offered). This information – and advice – provided by subject teachers should be a prime target for universities' signalling activities, and emphasises the importance of engagement with teachers or subject leaders in a variety of disciplines, rather than relying on engagement solely with those who teach mathematics.

Good practice that we came across in such events that we sampled included posters (although they tended to be in mathematics classrooms, which is not necessarily the ideal place) and subject-based information sheets that incorporated AMSP-type messages about the value of Level 3 mathematics study to assist in the post-16 programme but also as preparation for university. One particularly interesting example of HE engagement we heard about was where the two local universities had a physical presence at a key sixth-form provider's promotional open evening in Newcastle in order to provide advice.

[43] There are increasing examples of these taking place in the summer of Year 10

6.3 Widening participation

Early intelligence-gathering work within the project suggested that much of the engagement of universities with pre-16 students takes place under the auspices of widening participation (WP) activity. To understand the range of this work better, we used a variety of approaches including dialogues with HE staff and others involved in delivering WP programmes and a review of the Access & Participation Plans of the 19 universities in our sample.

Universities have been undertaking outreach work to young people from less advantaged backgrounds for many years, which until recently was mostly intended to raise aspirations for entry to HE, i.e. widening access. This work has been targeted at school-age students in Key Stages 3 and 4 (years 7-11) as well as post-16.

More recently, widening participation strategies have been broadened so that there is support for targeted students across the entire student lifecycle. Some have referred to this shift as "*not just getting in but getting on*" which reflects that the intention is not only to widen access but also to support students from less-advantaged backgrounds while they are at university, to maximise retention and completion of courses so that there is successful graduation and positive graduate outcomes. This shift in strategy heightens the need to provide a somewhat wider range of support when they are prospective students, so that they not only apply to university but make well-informed decisions about what and where to study to give them the best chance to thrive once at university and to secure good outcomes.

We identified a range of activities that were either positioned to support choice-making by disadvantaged pre-16 students or were specifically related to mathematics. Some were activities by individual universities while others were through the National Collaborative Outreach Programme (NCOP) or other partnerships, including with third sector agencies. The NCOP constitutes 29 partnerships of universities, colleges and other local partners to deliver outreach activity in particular regions. Its primary aims are to reduce the gap in HE participation between the most and least represented groups and also to support young people to make well-informed decisions about their future education.[44] NCOP activities were reported in 2017/18 to have worked with 1,500 schools and colleges, and over 100,000 young people, so are substantial (although not all this activity will have been with pre-16 students, and not all to support decision-making).

Future Me is the main programme of the North East Collaborative Outreach Programme for year 9-11 students delivered by ambassadors and backed up with mentoring by current HE students.[45] As part of the programme there is a workshop on post-16 choices. We had no evidence to suggest that the value of mathematics qualifications or study at Level 3 was a focus, but the existence of programmes such as this offers universities an opportunity to signal such messages – and begs the question of the extent to which the ambassadors and mentors are aware of the desired signals to be transmitted. There is also provision of online tutoring in mathematics specifically alongside the aspiration-raising and mentoring, because attainment is of concern in this region. There is also a focus on provision of CPD to those teaching at Level 3 in FE colleges where attainment has been limited.

[44] Office for Students: https://www.officeforstudents.org.uk/advice-and-guidance/promoting-equal-opportunities/national-collaborative-outreach-programme-ncop/how-ncop-works/
[45] NE Collaborative Outreach Programme: https://futureme.ac.uk/

The University of York runs two year 11 conferences annually within its Shine programme specifically to support post-16 choice-making for less-advantaged students, which up to 100 students attend, as well as further similar events including a collaborative event with York St John.[46] Its Excellence Hub, in collaboration with Sheffield and Leeds, runs subject-specific events for individual schools which emphasise pathways into HE subjects and the post-16 subjects that support these, such as mathematics for HE courses in chemistry or computing.[47] Support for year 10 and 11 students is focused on keeping options open and the value of facilitating subjects, with regular reference made to Which? University guidance. These events are designed for students who have been identified as being high achieving by their school/college. Priority is given to students who also meet widening participation criteria but their footprint may be somewhat wider in terms of student background.

Examples in our South West region include Bath, Bristol and Exeter universities which have collaborated with IntoUniversity to set up learning centres in Bristol and a number of other locations.[48] At these centres, academic support sessions are run most days after school where teenage students can receive help with their homework. IntoUniversity specifically states that these sessions also provide:

> *"advice and guidance on GCSE, A-Level and university choices. We also run specific workshops on career choices and skills"*

Exeter runs a number of specialist mathematics interventions to raise attainment, as well as the Exeter Scholars Programme within which there is a student conference for year 11 students and parents specifically to help prepare for the transition to college or sixth form.

Plymouth runs a taster day within the university for year 10 students from Devon and Cornwall, in conjunction with AMSP, targeted at top set students with the intention of maintaining their interest by giving them an insight into what mathematics is like post-16 and post-18. It is positioned to appeal not only to those who might seek to study mathematics itself at university, but a wider range of subjects, and is one of a range of enrichment activities within the university's Mathematics Enrichment Programme.[49] The university also reports in its Access & Participation Agreement that it undertakes partnership work with several specialist colleges and academies designed to provide students with clear career pathways through secondary school to tertiary education.

These are but a small selection of the WP activities from our sampled universities that we identified either had a distinct mathematics theme and/or a focus on support for those making decisions about post-16 study. Detailed investigation of the content provided within these activities, whether through student conference-type delivery or individual mentoring and support, was beyond the scope of this project. However, together they constitute a substantial proportion of the engagement that universities have directly with pre-16 students and should be regarded as a channel that universities could consider using more strategically to signal messages about the study of mathematics post-16 or other issues around subject choices.

[46] University of York: https://www.york.ac.uk/schools-and-colleges/pre-16/shine/
[47] Excellence Hub: https://www.york.ac.uk/excellencehub/
[48] Into University: https://intouniversity.org/content/information-parents-guardians
[49] University of Plymouth: https://www.fose1.plymouth.ac.uk/mathematics_education/MEP/events.html

6.4 Other outreach and enrichment

We found it impossible to make hard and fast channel categorisations of the various activities that universities undertake in terms of outreach to and engagement with young people. In practice, some of the direct outreach activities described in Chapter 5 include some involvement of schools, even if only at the point of initial engagement with students. Equally, there is evidence that some widening participation activities are open to students who are not identified as disadvantaged, where capacity is available.

Within this categorisation of "other" outreach and enrichment-type activity in schools by universities (that is not overtly labelled for or targeted at widening participation students), there is a very wide range of activity. Some of it relates directly to raising aspirations and support for progression to HE, undertaken by universities' schools liaison officers and outreach teams who may respond to schools which request support. There is also substantial effort focused on support for improving attainment in specific subjects and/or to support other policy agendas. While a few of these activities may support particular subject choices by pre-16 students, many are not targeted for that purpose but may offer opportunities to embed elements of desirable signalling that could reinforce more direct messaging through other channels. Significant extension resources exist for mathematics, such as NRICH and Underground Mathematics, but these tend not to include many specific signals about the value of mathematics to future study of other subjects. Providing signals through a range of different channels could contribute to a more sustained communications pattern which may have greater effect than focusing on only a few channels.

In the last section, we highlighted subject-specific events for Year 10 or 11 students delivered by York and its partner institutions which aim to support attainment in those subjects and increase engagement by WP students with the subjects, presumably in the hope that they will select them post-16. These were reported to include mainstream students where there was spare capacity although they were designed primarily as widening participation events. Equally, Plymouth's mathematics taster days (with AMSP) are attended by high-performing students in the mainstream as well as those with backgrounds that would support widening participation objectives, while Wolverhampton runs days with AMSP which are targeted primarily at girls in Years 10 or 11 who are potential Core Maths or A-level Mathematics students but who may not be considering these subjects because of a lack of interest or confidence.[50]

Universities play a significant role in some enrichment activities hosted or facilitated by schools, whether this is under the auspices of widening participation or to support other policy objectives. These include enrichment activities within the STEM inspiration agenda or initiatives supporting other policy objectives (for example, Gifted & Talented provision, enterprise education, employer engagement, financial literacy or modern foreign languages). Part of universities' involvement is that it is their staff who, under external contracts, provide and deliver many of the activities on behalf of the third-party agencies that drive many of these initiatives. While third-party channels are considered in the next chapter (where there is not university involvement), university staff frequently act in coordination or delivery roles, or universities may physically host the team delivering the initiative. For example, around half of AMSP's coordinators are university-based staff and some of its taster days referred to above are hosted in a university. The same applies to enrichment offers from the myriad STEM

[50] Celebrating women in maths: https://amsp.org.uk/events/details/5540

inspiration initiatives, many led by professional bodies or third-party agencies, such as STEM Learning and the National Science Learning Network, the newly-developing National Centre for Computing Education, or specific initiatives such as Science and Plants for Schools. Equally, a good number of STEM Ambassadors are university staff, while some doctoral researchers in universities deliver enrichment activity through The Brilliant Club.[51] Practically, where universities are involved in the design, coordination or delivery of enrichment activity for these initiatives, there is a ready opportunity to embed signals or messages of the type we are discussing within the resources that are provided.

Recent years have seen a strong rise in policy emphasis on the engagement of employers with schools, to support both enterprise and career learning, spearheaded by the Careers & Enterprise Company (CEC). As a result, over 2000 English secondary schools now have a volunteer Enterprise Adviser and access to one of 125 professional Enterprise Coordinators located in a Local Enterprise Partnership (LEP), to broker engagement between the school and businesses. The CEC also routes government funding to expand employer engagement and target it into areas where there is historically low engagement. Facilitating encounters with employers is one of the 8 Gatsby Benchmarks of effective careers support (n addition to encounters with FE and HE), recommended in the Statutory Guidance on careers provision by schools to young people.[52] It is reported that just under 40% of 3000 secondary schools and colleges in a CEC sample had fostered at least one employer encounter for each school year in 2017/18, involving some 540,000 students in total. This was most common for students in Years 10 and 11, for each of which over 70% of year groups had at least one meaningful encounter.[53]

While the form of this employer engagement can vary, it can include a person from business visiting the school to talk about opportunities in their sector and their own career pathway, or group visits to local business (where similar presentations will occur). The content of these presentations by business people, some of whom could be STEM Ambassadors, should to some extent be influenced by the Enterprise Adviser for the school, so that it is tailored to the audience and school setting. In many cases the target audience will be students in Key Stage 4. This suggests that some appropriate signalling of the value of studying subjects such as mathematics post-16 could be embedded in these talks, but this may be reliant on the Enterprise Advisers supporting the schools encouraging it (and potentially providing the right message). Other potential channels through which such business people who act as speakers could be reached, and "trained" in this way, also include a number of agencies that coordinate this type of activity, including STEM Ambassadors, Speakers for Schools[54] and Inspiring the Future.[55]

The number and extent of enrichment activities undertaken by schools is vast and analysis of the messaging currently embedded within them is well beyond the scope of this project. However, it could be feasible to investigate those which aim to influence subject choices post-16 (i.e. in subject areas with a quantitative element, such as biology or psychology). Embedding potential key signalling messages within the content provided as part of

[51] The Brilliant Club: https://thebrilliantclub.org/
[52] *Careers guidance and access for education and training providers Statutory guidance for governing bodies, school leaders and school staff*, Department for Education, 2018
[53] *Careers and enterprise provision in England's secondary schools and colleges: State of the Nation 2018*, Careers & Enterprise Company, 2018
[54] Speakers for Schools: https://www.speakers4schools.org/
[55] Inspiring the Future: https://www.inspiringthefuture.org/

enrichment, or additional information resources to which participants are directed, could usefully add to the overall signalling ‘campaign.’

7 Signalling via third parties

7.1 Mathematics support

Although its inclusion within our 'third parties' category might be debated, brief attention must be paid to the work of the Advanced Mathematics Support Programme (AMSP). This government-funded initiative aims to increase participation in Core Maths, AS- and A-level Mathematics and Further Mathematics. Its principal work is to improve the teaching of all these Level 3 mathematics qualifications in state-funded schools and colleges in England.

Perhaps unsurprisingly, we found the content on AMSP's website about Core Maths was the clearest exposition of its purpose and potential value for university study. As previously stated, its content for teachers contains a presentation with which they can promote Core Maths including some of the potential benefits for young people if they study it. There is also significant content for universities, as part of AMSP's liaison role to encourage universities' departments, in turn, to promote the range of Level 3 mathematics qualifications. Amongst the content for teachers is the following, which we considered to be exemplary messaging:[56]

> *"Studying Core Maths helps students develop their quantitative and problem-solving skills. This is valuable preparation for the quantitative skills they will need for many degree courses, particularly subjects such as psychology, business-related courses, sports and social sciences, and natural science courses that do not require AS/A Mathematics"*

7.2 HE Information providers

There is an increasing array of information provision from third parties about HE opportunities and supporting choices and admissions and the Department for Education is encouraging further innovation in this area. The main UCAS website (to which AMSP links) does not give guidance on the selection of post-16 qualifications, as its target audience is students who are already in the post-16 stage already. Amongst its guidance, it has subject guides for a range of areas: however, the guides for psychology, business and management and biological sciences currently make no reference to demand for numerical skills or the value of post-16 mathematics (other than for psychology where it states that one STEM A-level would be preferred which could be mathematics).[57]

UCAS Progress, however, is designed as support for Key Stage 4 students who are making choices about post-16 study (although positioned within the Further Education section of the UCAS website). Core Maths is not mentioned (or for that matter AS levels) in its glossary of post-16 qualification types or its guidance on how to select the right type of qualification.[58] This takes a similar approach to some universities' guidance, i.e. either from a pre-identified ideal job and working backwards or suggesting choice of a "*subject that keeps options open*" for those who are undecided. However, there is no related content specifically about different subjects that could serve that purpose, and nor is there any signalling of the potential value of mathematics in its '*Tips on choosing A-level subjects*' within its content about A-levels. Given

[56] https://amsp.org.uk/universities/core-maths
[57] https://www.ucas.com/ucas/subject-guide-list; accessed March 2019
[58] Which qualifications are right for me? UCAS: https://www.ucas.com/further-education/post-16-qualifications/post-16-qualifications-you-can-take

the very high profile of UCAS and its information, these would seem to be opportunities to insert some signalling of the value of Level 3 mathematics study.

In contrast, there is more extensive and more nuanced content on the Which? University website, including guidance written by one of England's best-known careers advisers about A-level choices. This highlights the value of facilitating subjects, drawing upon the *Informed Choices* guides (originally written by the same careers adviser) but also offers more specific guidance on A-level choices for a range of university subject areas, in terms of entry requirements and also A-level subjects that are "useful" for that subject at university, while some subject pages highlight the mathematics skills that will be developed on the course.[59] Mathematics is identified as being a useful prior qualification for psychology, geography and business, while for biological sciences it is either useful or a potential requirement:

> *"Everywhere there are good jobs in the UK economy, you'll find psychology graduates - and it's hardly surprising as the course helps you gain a mix of good people skills and excellent number and data handling skills. A psychology degree ticks most employers' boxes — but we'd suggest you don't drop your maths modules"*[60]

> *"On the human and social geography side, there is a shortage of social science graduates with really good maths skills, and graduates from these disciplines who have them are in demand from modern industry. An ability to combine good data handling skills with good communication and social skills will really help start your career, and that's something a geography degree with a good stats component can really bring to the jobs market"*[61]

A few of the other HE choice websites (and a range of other more generic career information websites for young people) offer some advice on choosing subjects for post-16 study, in the context of their value for potential HE study, including The Student Room, Careers4u, The Good Schools Guide and icould. Some of these refer to the value of facilitating subjects but – based on the range we surveyed for this research – most do not, and fewer still identify the value of mathematics (other than for subjects with an obvious high mathematics demand and/or entry requirements for A-level mathematics). TargetCareers points out that many degree apprenticeships and sponsored degrees are in STEM disciplines, so if students want to pursue those routes it is well worth considering mathematics subjects post-16.[62]

> "What subjects should I take if I want to do a degree apprenticeship, higher apprenticeship or similar?
>
> *If you don't want to go to university, maths and sciences are good at keeping options open but by no means essential. Quite a lot of opportunities such as degree apprenticeships, higher apprenticeships and sponsored degrees are in technical areas such as IT and engineering, for which science and maths subjects are often required.*

[59] Which? University: https://university.which.co.uk/advice/a-level-choices/what-a-levels-do-you-need-for-the-degree-you-want-to-study
[60] https://university.which.co.uk/subjects/psychology
[61] https://university.which.co.uk/subjects/geography
[62] TargetCareers: https://targetcareers.co.uk/careers-advice/a-level-choices/315491-what-a-level-subjects-should-i-take

> *However, there are also a good number of schemes in other areas, such as finance and business, that often don't require specific subjects"*

On the other hand, some messaging about the value of studying mathematics post-16 is not helpful, including this example (from elsewhere in TargetCareers guidance):

> *"Getting good grades depends on both ability and motivation. If you love a subject or you know you need it for your dream career, your passion should help you along even if it's not your strongest area. But beware picking subjects that really aren't your best unless there's a very good reason for it.*
>
> *For example, perhaps you're working flat out to succeed in GCSE maths and just scraped a B in your mock exams, while you got As and A*s in other subjects with less effort. In that case you'd want to think very carefully about whether there was a good reason to pick it [maths] for A level or equivalent, even though it's on the list of facilitating subjects and your parents might think it's a good idea"*

Several high-profile sites including Unistats, which is pitched as the "official" site for comparing information about HE courses and entry, appear to offer no guidance on choosing A-level subjects. To varying extents, all these third-party information sites and sources offer an opportunity to embed potential messaging about the value of mathematics study at Level 3, although most focus quite specifically upon A-level subject choices.

7.3 Other third parties

In Chapter 6 we identified a range of extra-curricular activity in schools, or hosted by schools, that could potentially carry signals to pre-16s that will support decision-making about post-16 study choices. Within all three of the broad themes of widening participation, enrichment and employer engagement, there are third party organisations which seek to engage with young people outside school. Theoretically at least, there could be some opportunities within these for signalling to take place which will impact on choices made in education.

We are aware of some engagement of actors which are neither schools or universities directly with young people (i.e. not through schools), of the following types:

- STEM inspiration activities by professional bodies, employers and third sector agencies (e.g. British Science Association, the Big Bang Fair, science centres);
- Aspiration-raising activities, within the widening participation agenda, by a range of third sector agents (e.g. English Football League, Prince's Trust, Sutton Trust Scholars);
- Employer activities focused on teenagers (e.g. Network Rail charity partnerships, Rolls-Royce Industrial Cadets Scheme).

Investigation of these specific activities has not been attempted within this study. However, it seems logical to assume that any messages embedded within these activities about the value of different subjects post-16 will be relatively general. Nonetheless, in theory they represent another channel that could be used for signalling.

8 Key findings, emerging issues and recommendations

8.1 Summary of key findings

8.1.1 Direct signalling

- Most universities currently attempt little engagement directly with mainstream pre-16 students or their parents/carers, so there are few opportunities for them to signal directly the value of studying mathematics post-16 to those who may subsequently apply to study courses with a quantitative element.
- We identified a small number of examples of good information provision or events by universities which aim to support post-16 choices, targeted directly to pre-16 students or via schools. The Russell Group's former *Informed Choices* publications signalled mathematics as a facilitating subject (but did not single out the value of Level 3 mathematics study other than A-level mathematics) but has been replaced by a website that is less prescriptive.
- In contrast, universities focus considerable effort on engaging and providing information to students who are post-16 (i.e. once they become prospective HE applicants). Although that audience has already chosen post-16 subjects, this information is also accessed by some pre-16 students (and their parents) so signals within it will inform some pre-16 students' decisions and, especially, guidance provided by those working in schools.
- Few universities have an overt requirement for mathematics qualifications at Level 3 for entry to their courses in subjects such as biological sciences, geography, psychology and business, which may contain a significant quantitative element in the study programme.
- Many universities have shown some support for Core Maths as a post-16 programme but very few mention it in their admissions requirements, which is where signalling would have the biggest impact on uptake of these qualifications.
- Only one university to date has announced that it will (in future) privilege Level 3 mathematics qualifications in its entry requirements (in parallel with the way achievement of an Extended Project Qualification (EPQ) may reduce a typical offer by one or more A-level grades).
- Many universities' course and admissions information published for prospective applicants to subjects such as biological sciences, psychology or business does not signal strongly the development of quantitative skills in these programmes, nor that there isvalue of prospective students undertaking Level 3 study of mathematics. Such signals, where present, are not consistently presented nor, in some cases, are they present in the best places.
- Universities also appear to attempt little engagement with parents/carers of mainstream pre-16 students.
- Although the intended scope of this project was direct signalling, other channels exist through which some signals are currently being sent and where there are opportunities for future signalling to take place.

8.1.2 Signalling via schools

- The backdrop in schools is that while A-level Mathematics participation itself has recently been rising, changes to A-level study have led to a marked reduction in the total number of students who take AS-level mathematics, reducing the total number of students studying mathematics at Level 3.
- The Core Maths suite of qualifications and programmes of study are ideally positioned to offer students who are not pursuing A-level mathematics itself the chance to study mathematics at Level 3 which would be valuable for future university courses. However, it is not universally available in schools and colleges, for a range of practical reasons including teaching capability and resourcing constraints (despite the existence of the mathematics premium).
- The value of Core Maths is not consistently promoted by all parties; this is not helped where universities refer to it as an alternative qualification in the absence of GCSE mathematics attainment, rather than a means to study mathematics at a higher level that will aid study of an HE programme.
- On the other hand, AMSP provides very good messaging for teachers about the value of Core Maths as an enabling qualification for those seeking to study a range of subjects at university, that could be amplified.
- Careers information, advice and guidance in schools is known to be patchy although guidance on post-16 study options will be a core element of most schools' provision. There are rare examples where universities directly assist in support for post-16 choice-making, through attendance at post-16 providers' open evenings, for example.
- There is strong current encouragement for schools to assess the quality of their careers provision using the Gatsby Benchmarks; Benchmark 7 is an overt requirement for interaction with HE and FE providers. Universities could utilise that opportunity to engage in schools' support for post-16 choices and within that activity signal to pre-16 students the value of studying mathematics at Level 3.
- Widening participation activities are extending from an original focus on raising aspirations to access HE towards a broader 'student lifecycle' approach which includes entry to HE, successful progression and graduate outcomes. Supporting students to make well-informed subject choices, so that they are well prepared to thrive in their chosen subject at university, clearly falls within this remit. Signalling the value of different post-16 subjects for successful progression in HE could be embedded more strongly in this agenda.
- Universities do engage with pre-16 students under the auspices of widening participation and other outreach activity, both directly and through collaborative activity. However, there is little *sustained* engagement with pre-16 students (which may be needed to change mindsets). Some activities, such as undergraduates mentoring teenagers with the intention of raising attainment or aspirations may not be reliable as a channel for potential signalling as the mentors are presumably untrained in this respect.
- There is evidence for a range of university and collaborative events in schools which specifically support post-16 choice-making by widening participation students (and some other students), which could be leveraged as opportunities for signalling.

- There is a wide array of enrichment activities taking place in schools – STEM inspiration, gifted and talented extension, enterprise education, employer engagement etc – in which universities are engaged, that currently may contain some signals about the value of mathematics but are likely not to be optimal. In some cases, university staff coordinate and deliver these activities, offering a clear channel for potential signalling to be developed.

8.1.3 Signalling via third parties (other influencers)

- AMSP has developed model messaging about the value of mathematics study, including Core Maths, for teachers, which could be augmented for use by a range of third parties which provide information to school-age students and parents/carers.
- There is a growing and extensive range of providers of information about progression to university (and other post-18 pathways), containing information and guidance that ranges from the very good to some which is unhelpful. Many carry no information about choice of subjects for post-16 study despite the importance of those choices when it comes to university applications and requirements.
- Some of the enrichment activities in schools (for example, for STEM inspiration) are undertaken by third parties such as professional bodies or subject associations and could be used to signal the value of post-16 mathematics study. Some of these involve a university collaboration but not all – the former would be easier to influence but the latter might also be receptive to embedding signals which are seen to enhance student participation and success.
- Employer engagement in schools is most common where it involves Year 10 and 11 students, so could be considered as another signalling channel to influence post-16 choices, where appropriate.

8.2 Emerging issues and discussion

8.2.1 HE market dynamics

The current dynamics of the HE undergraduate market undoubtedly exert influence on the way universities consider their entry requirements. Currently, few of the courses on which we have focused (those outside the physical sciences but which have a potentially significant quantitative element, such as psychology, biological sciences or business) require applicants to have a mathematics qualification at more than grade 4, 5, or 6 at GCSE. The focus of attention during selection is strongly on attainment in three A-levels (or equivalent qualifications) rather than students' additional or supplementary qualifications or assets, except during selection for entry to highly competitive courses or universities.

The current 'demographic dip' in the population of UK teenagers as prospective students is a further disincentive to impose additional requirements and/or narrow the field from which they can select. Universities need to fill their places and are likely to be as flexible as possible in terms of the qualifications profile of the students they admit. However, in coming years the demographic dip will reverse and there will be strong increase in the population of UK teenagers – so the market dynamics may shift. In future, universities could have to become more discerning about their entry requirements and pay more attention to the qualifications profile of their applicants and incoming students. In such a context, the need for prior study of

mathematics at Level 3 could become more commonplace for entry to a range of subjects with a quantitative element, but universities will also need to understand their target market better, including why students may not choose mathematics (i.e. whether that is due to mathematics anxiety, liking other subjects more or other reasons). That better understanding will inform how they refine any messages about entry requirements or skills needs within course descriptions.

In the current market, other than in the most competitive universities and/or for the most competitive courses, most universities' course descriptions and information tend not to linger on the mathematical content of the programme or the need for applicants to have quantitative skills or Level 3 mathematics qualifications, nor that this could enhance ultimate employability. There seems little consistency or connection between universities' more general endorsement of the value of studying a subject like Core Maths post-16 and their specific course-level entry requirements or information. Presumably, in the current context, universities might respond differently if there was strong evidence that, for example, mathematics A-level is a good predictor of attainment in quantitative degrees, or Core Maths for subjects with a quantitative element, and/or better employment outcomes for graduates. However, the proportions of graduates who obtain 1st or 2:1 class degrees, and successfully enter employment after graduation, are already very high, so it seems unlikely that in practice such potential improvements would narrow or toughen entry requirements.

8.2.2 Core Maths provision

Many of our informants suggested that universities are not signalling Core Maths as a valuable or necessary requirement for entry to courses such as psychology or biological sciences because these qualifications are not universally available. The total number of students obtaining the Core Maths qualification in 2017/18 was very modest and we saw direct evidence in our research of differences in post-16 provision in this respect. The range of mathematics programmes or qualifications varies strongly across post-16 providers and, it is suggested, with levels of socio-economic advantage. Students in less advantaged neighbourhoods attending their local college are likely not to be offered Core Maths, whereas it may be routinely recommended and offered in high-performing schools or sixth-form colleges in affluent neighbourhoods where university entry is the expectation. Equally, it is important that weaker students are not wrongly advised to take Core Maths instead of A-level or a full BTEC diploma, as it does not provide the same weight for university entry.

The loss of provision of standalone AS-level qualifications is likely to have contributed to this variation in provision. Previously, AS Mathematics may have been seen as an attractive 'additional' Year 12 subject, providing additional UCAS tariff points to students and relatively easily delivered by those trained to teach A-level Mathematics. In contrast, the current low levels of participation in Core Maths, which in turn are affected by the fact that universities do not require it, mean that it is not a priority for many post-16 providers and they may not enable their teachers to be trained up to deliver it. With limited teaching capacity, providers will focus their resources (and best teachers) on A-level classes; the premium available to schools for additional participation in Level 3 mathematics qualifications may not be sufficient to overcome the current lack of critical mass in participation in Core Maths. This can only be made worse if reports of high levels of non-completion (once students realise that Core Maths does not 'count' for university entry) are confirmed more widely.

Clearer signalling by universities of the value of Core Maths, especially, in developing quantitative skills useful during university and beneficial in subsequent employment is one of the key drivers that could increase its momentum and increase its provision.

8.2.3 Training of teachers and advisers

Signalling to teachers and advisers was not intended to be within the scope of this project, nor the professional development or training of teachers. However, the range of teaching programmes that schools provide and the advice and guidance they provide to support progression are both influenced by the training or professional development undertaken by these workforces in schools. The increasing acceptance of the concept that support for careers and progression should be embedded within curriculum teaching (rather than seen as pastoral or additional support), means that subject teachers are an increasingly important source of advice.[63] It is therefore important that subject teachers – of mathematics and other disciplines – and HE/careers advisers are able to advise on the value of different post-16 subject choices in relation to potential university entry. This means they need themselves to understand what is available and to keep up-to-date about universities' requirements for and signals about prior study. There is also the benefit of a multiplier effect – upskilling a teacher or adviser potentially reaches many students, whereas signals sent directly only reach students individually.

Universities are active in trying to influence the information, advice and guidance provided to students in schools and colleges about HE entry. That activity includes a wide range of 'teacher/HE adviser conferences' and other events offered free to school staff by individual universities or partnerships of local universities. There are also collaborative initiatives such as Advancing Access, which specifically aims to enhance the advice given to those considering application to Russell Group universities (including guidance on post-16 choices).[64]

Equally, universities are engaged in the significant professional development of teachers of mathematics and other subjects. In order to broaden the offer of Core Maths, and to promote its value to those considering studying a subject like psychology post-16, those who teach psychology need to understand what universities are expressing in their requirements and thinking about when selecting students, and more of those who teach mathematics need to be trained to deliver Core Maths in particular. Within this professional development activity, it will be imperative to embed elements of signalling about the potential value of Level 3 mathematics qualifications.

8.3 Recommendations

- Universities should articulate more clearly and consistently the needs for quantitative or numerical skills within relevant course information pages and the benefit of developing these skills for subsequent careers and employment.
- Universities should state clearly how they value Level 3 mathematics qualifications as preparation for these courses, including introducing entry requirements that overtly

[63] Gatsby Benchmark 4 is specifically dedicated to embedding careers learning within the curriculum
[64] Advancing access: https://www.advancingaccess.ac.uk/

recognise them (including A-levels and Core Maths or others) and alternative offers that take these into account in a similar way that many treat the EPQ.

- Universities should be more consistent in their presentation of these messages, across course-level descriptive information and central admissions-focused information, especially how they are valuing Level 3 mathematics qualifications.
- To help universities implement these recommendations, ACME should:
    - Commend the University of Bath for its introduction of alternative offers for those with a Core Maths qualification for 2020 entry to a range of subjects and encourage other universities to follow suit;
    - Develop a range of clear content and messaging around the value of Level 3 mathematics qualifications (including Core Maths for those not studying A-level mathematics itself) which can be used by universities and to adjust existing resources such as *Informed Choices* and UCAS Progress This should build upon the current messaging by AMSP and amplify it;
    - Help universities to gain better understanding of the Core Maths qualifications, their provision and participation in them, by developing and sharing intelligence drawn from current research at the University of Leeds and already existing within AMSP.
- Universities should provide more and improved better advice to pre-16 students about subject choices, directly and to parents/carers or others who influence post-16 study choices, through improved information for prospective students hosted on their websites and linkage to third-party sources of good information.
- Universities should make more use of third-party information providers, especially UCAS but also other HE choice websites such as Unistats and career support tools, to reinforce these signals.
- Universities should seek to engage more with schools to support students' choices for post-16 study, which will help schools to satisfy Gatsby Benchmark 7, embedding signals about the value of mathematics study into that support
- Universities should look to embed such signalling within opportunities that already exist, i.e. within the enrichment and widening participation outreach activities that they already support and/or are delivered or coordinated by HE staff, and in accompanying resources.
- Universities should consider training or development of their staff who are involved in these activities, so that they are able to take opportunities to embed appropriate messages and signals in these activities and accompanying resources.
- In order to implement these recommendations, ACME could:
    - Develop a range of messages and signals to be embedded within the training and professional development of mathematics and other relevant subject teachers, and those in advisory roles, in schools and colleges, including leveraging collaborative opportunities such as Advancing Access;
    - Consider whether there are opportunities to develop and provide similar signals that could be embedded into other enrichment or extension activity taking place in

schools, such as employer engagement or STEM inspiration, delivered by third parties;

- Consider whether there are additional opportunities to embed messages through channels such as undergraduates' or postgraduates' mentoring of disadvantaged prospective applicants within widening participation projects.

- To maximise the reach and potential impact of these signals, ACME should develop an over-arching campaign of sustained messaging through the multiple channels identified in this study, which will require some coordination and resources. In support of such a campaign, we suggest:
  - An initial focus on influencing of collaborative opportunities where there is greatest power of messaging, such as the *Informed Choices* and Advancing Access initiatives, through UCAS and other activities by university groups;
  - Investigation of the impact of some specific signalling initiatives so that this can be relayed to universities or others when seeking their help to influence student choices;
  - Provision of examples of good practice in terms of channels that can be used for signals and how they can be influenced practically;
  - Undertake research specifically on how schools might best wish to be supported by universities in their support for post-16 choice-making by pre-16 students and their parents;
  - Undertake or encourage research into the effect of participation in Core Maths on attainment within post-16 and undergraduate study, to reinforce the value of selecting these programmes or qualifications.