



**The purpose, role and impact of additional ‘extension’ papers for entry to mathematics courses at English universities: invitation to propose a small study**

**Background**

Since HEIs in England are autonomous bodies, there has been comparatively little scrutiny of admissions practices in relation to degrees in mathematics that require, or offer advantage to, students taking additional papers prior to university entrance, often alongside their A Level examinations. Credit should go to Ellie Darlington for pursuing this issue in 3 key papers (Darlington 2014, Darlington 2015, Darlington and Bowyer, 2018), the second of which exposes the different mathematical demands of 3 such examinations, namely MAT, AEA and STEP papers<sup>1,2</sup>. To this suite has comparatively recently been added the Cambridge Assessment TMUA examination.

Darlington (2018) argues that there was significant evidence of a ‘gap’ between the mathematical preparation offered by participation in A Levels in mathematics, although with new, more mathematically demanding A Levels for first mass examination Summer 2019, and designed to be more aligned with universities’ mathematical requirements (ALCAB, 2014), any current gap is barely yet evidenced. She also writes (p125) ‘Students of the mathematical sciences are more likely to achieve top grades at A-level than students in other subject areas, with 8.1% of them achieving three or more A grades at A-level (Vidal Rodeiro & Zanini, 2015), a figure much higher than in other degree subjects. Furthermore, the number of mathematics undergraduates has been steadily increasing over recent years, from 13,188 in 1996/7 to 30,340 in 2014/15 (Higher Education Statistics Agency, 1998, 2016). Consequently, there is a need for admissions tutors to find additional measures of differentiating between well-qualified candidates, given the A grade reflects a high degree of accuracy as well as mathematical competency’. This is undoubtedly true for the most competitive universities (say Cambridge and Warwick, who either require or prefer STEP papers, for Oxford and Imperial, usually requiring MAT papers, and perhaps a \*small\* number of others), although again, the new A Level assessments should be more aligned with what is typically valued in university mathematics or applications of mathematics. Of the focus additional papers, STEP papers 1, 2 and 3 are generally reckoned to be most, and increasingly, demanding, MAT next most, and AEA least so. STEP and AEA papers are typically taken in the term prior to university admission, and MAT and TMUA the previous Autumn, to inform admission offer processes. Early, informal, indications are that TMUA is somewhat less demanding than MAT, though somewhat different in nature.

A number of questions of interest to the mathematics and mathematics education communities then arise:

1. What are the benefits to students who succeed with these papers?
2. What are the benefits (or costs) to those who enter for them but do not succeed?
3. What is the range of students who would benefit from preparing for such papers, and what support would they require?
4. What are the disadvantages and costs for students who could benefit from preparing for such papers but are not supported to do so?
5. Is it beneficial for a wider range of A-level students to embed consideration of the questions in STEP, MAT AEA and TMUA in their regular classwork?
6. What are the transferable benefits of having engaged with such questions at different levels of intensity, for example the benefits for university progression?

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<sup>1</sup> The MAT challenges students by requiring them to solve unfamiliar problems which do not have an obvious method towards a solution. AEA Mathematics challenges students by requiring in-depth use of the content of A-level Mathematics in order to solve more complex versions of A-level Mathematics style questions. STEPs, on the other hand, combine the use of more advanced mathematics with some questions more familiar to A-level Mathematics students, as well as questions which require deeper mathematical thinking. In doing so, STEPs give students an insight into what undergraduate mathematics assessment (editor: at the target institutions) might be like. (Darlington and Bowyer, 2015, p.126).

<sup>2</sup> MAT- usually required by Oxford and Imperial, option for some other competitive HEIs

AEA - not typically required but might be recommended, by more competitive universities

STEP – required by Cambridge, sometimes by Imperial, option for slightly lower A Level grades at Warwick

TMUA – relatively new option sometimes resulting in lower entry grades, emerging use by Lancaster, Durham and others

JMC trustees have a particular interest in these issues since some of these questions bring with them obvious questions around equity of access to competitive universities to read mathematics, and of opportunity for young people to optimise their mathematical capabilities, both at school and in HE. There is of course also potentially longer-term impact of differential opportunity.

Darlington and Bowyer (2018) largely address question 1, and 6 in part, via a sample of 430 undergraduates, 361 of whom were studying mathematics and the rest for an honours degree in which mathematics was one component. All had taken (not just studied for) at least one of AEA, MAT and STEP papers, including 322 (75%) who had taken STEP. Their sample was therefore highly skewed: STEP papers are designed to be accessible to at most the top 5% of A-Level Mathematics candidates (University of Cambridge Faculty of Mathematics, 2015). Student responses confirmed Darlington's (2015) analysis of the nature of the mathematical demands of the different papers and its relation to the nature of undergraduate mathematics at the destination universities (largely Cambridge, sometimes Warwick, for STEP). Darlington and Bowyer conclude that 'Participants were positive about STEP, commending its similarity to undergraduate-style assessment and its challenging questions. However, their abstract also says 'The students' views suggested that those wishing to be well prepared for tertiary mathematics should take one of these papers, preferably STEP. However, whilst universities may not necessarily wish to require applicants to pass extension papers, it may be beneficial for universities to recommend students to take them, in order to improve their mathematical thinking and expectations of undergraduate mathematics study.'

These conclusions seem perhaps over-stated given the sample, and to ignore the fact that any of these papers requires a deep and confident grasp of the related mathematics (which for e.g. STEP papers 2 or 3, includes, or at least significantly benefits from, familiarity with much of a Further Mathematics AS and/or A Level specification, together with additional knowledge). Golding, Redmond and Grima (2019) suggest the vast majority of A Level candidates do not have that grasp even when they come to A Level examinations, and certainly not well in advance of those, when they would need to be preparing for additional papers. Indeed, Golding (2019) shows that even for mathematically very selective cohorts such as those at one of the national Mathematics Specialist Schools, preparation for such papers can be a distraction from acquiring robust grasp of A Levels in mathematics, for students who are not exceptionally advanced in their mathematical grasp.

Questions 2-5 therefore remain open, and aspects of answers to 1 and 6 are not clear.

**The Trustees of the Joint Mathematical Council invite proposals for small-scale research that would contribute to addressing these questions.** Up to £5000 is available to fund such work. A report of outcomes should be delivered to trustees by the end of May 2020. Proposals by a named individual, maybe on behalf of a group, should provide an outline budget. Applicants should outline the methodology to be adopted, their relevant experience to undertake such work, the ethics authority who will approve the study, and any dissemination planned. Details of a referee who has knowledge of the applicant's relevant work should also be provided, together with a brief cv. Proposals should be 500-1000 words in total, excluding cv.

Proposals should be submitted to the Secretary of the JMC, at [secretary@jmc.org.uk](mailto:secretary@jmc.org.uk), by 2359h on Friday 6 December 2019. Outcomes will be communicated to applicants by 13 December 2019.

#### References:

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