# What impact could A-level reform have on new STEMM and social science undergraduates and university departments?

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# Abstract

Reforms to A-level Maths and Further Maths in England and Wales after September 2017 will see changes to both their structure and their content. Over 4,000 current Science, Technology, Engineering, Mathematics, Medicine (STEMM) and Social Science undergraduates with these qualifications reported that the A-levels were useful in preparing them for the mathematical demands of their degree, with the pre-2017 opportunity to specialise in certain areas of applied maths a useful feature of the qualifications. 430 maths undergraduates reported that some admissions tests and extension papers taken by some prospective maths undergraduates proved useful in challenging them, and potentially preparing them for the demands of university maths. Due to the planned reforms, there is the potential for such tests and papers to be used on a wider scale to help more universities select the best candidates, as they will likely have less information available to them to make selection decisions. Furthermore, it is anticipated that fewer students will take Further Maths, which could have an impact on the mathematical preparedness of students of certain degrees.

# 1. Introduction

A-level Maths and A-level Further Maths in England and Wales are being redeveloped for first teaching in 2017. The reforms will entail significant changes to both the structure and content of these qualifications.

The primary purpose of A-levels is to prepare students for university study; however, not all students who take A-levels go onto university and instead go into employment. Universities use students’ AS-level results in conjunction with other information (e.g. predicted A-level grades, admissions test result, references) when making decisions regarding offering conditional places.

A-level Maths and Further Maths prepare students for a wide-range of university subjects, not just Maths. Hence, the redevelopment of these qualifications thus also has implications for the readiness of future undergraduates in the sciences and social science.

A-level Maths was the most popular A-level subject in 2016, and the uptake of Further Maths has been increasing over recent years (see Figure 1).

*Figure 1 – Number of Further Maths AS- and A-levels awarded 2004-2016*Source: Joint Council for Qualifications (2016)

Many A-level Further Maths candidates first study the subject as an AS-level, unsure as to whether they would wish to study it for the full two years. Some find that they enjoy the subject and are successful, and end up taking the full A-level.

## 1.1 Pre-2017 A-level Maths and Further Maths

AS-level results counted towards 50% of the overall A-level result. After taking AS-level examinations, students could continue to stop studying the subject and be awarded the AS-level, or continue studying for another year to earn an A-level after sitting further examinations.

Pre-September 2017, there were five different ‘strands’ of units available to study as part of AS- and A-level Maths and Further Maths:

1. Core Pure: 4 units
2. Mechanics: up to 5 sequential units, depending on the awarding body
3. Statistics: 4 sequential units
4. Decision Maths: 2 sequential units
5. Further Pure Maths: 4 units

Some units are compulsory, others optional:

* AS-level Maths: C1, C2 + one applied unit
(i.e. M1, S1 or D1)
* A-level Maths: C1, C2, C3, C4 + 2 applied units
(i.e. M1+M2, S1+S2, D1+D2, M1+D1, M1+S1, S1+D1)
* AS-level Further Maths: FP1 + any 2 units not already studied in A-level Maths
* A-level Further Maths: FP1 + another FP unit + 4 units not already studied in A-level Maths

Hence, there are six possible routes through A-level Maths, and many more through A-level Further Maths.

Each unit is assessed individually by means of a single 90 minute examination.

## 1.2 Post-2017 A-level Maths and Further Maths

AS- and A-levels will be ‘decoupled’. That is, students’ results in AS-level examinations will no longer count towards the final A-level grade. However, students will be able to take the AS-level examinations if they wish to.

Instead of the optionality within the applied maths component, A-level Maths will have compulsory mechanics and statistics components. Decision Maths units will no longer be available as part of A-level Maths. This means that A-level Maths students will no longer be able to specialise in any of those three areas by studying two units of the same strand. A-level Further Maths will no longer follow the existing four-strand system of optionality, and instead the different awarding bodies may introduce innovative new options.

## 1.3 Admissions tests

In addition to requiring students to achieve certain A-level grades, an increasing number of universities now require students to pass admissions tests or what I shall term ‘extension papers’. The three most common are:

1. **The Mathematics Admissions Test (MAT)**, required by the University of Oxford and Imperial College London for shortlisting for interviews. The MAT is based on AS-level Maths material only.
2. **The Advanced Extension Award (AEA)** was introduced in 2002 in order to help universities distinguish between the highest-performing candidates. It is based on A-level Maths content. No universities make the AEA compulsory; however, they might make reduce A-level grade requirements to students who perform well.
3. **Sixth Term Examination Papers (STEPs)**, which the University of Cambridge requires applicants to pass at certain levels in order to gain a place. Other universities will make reduced A-level grade requirements of students who perform well on STEPs. There are three papers – STEPs I, II and III – and students usually take two, depending on the university and whether they have taken A-level Further Maths.

Each of these extension papers assess different types of mathematics skills, with the STEP found to be most aligned with undergraduate mathematics assessment (Darlington, 2015).

In 2016, Cambridge Assessment Admissions Testing introduced a new maths admissions test – the **Test of Mathematics for University Admissions (TMUA)** – which aimed to assess a range of skills according to the Mathematics Assessment Task Hierarchy (Smith et al., 1996). This test is based on AS-level Maths material, as well as mathematical logic. It is not compulsory to take the TMUA; however good performance in the TMUA could result in reduced A-level grade requirements for candidates.

# 2. The study

The work outlined in this paper has already been published in various forms. The overarching project, The Mathematics Needs of Higher Education, and the articles which have stemmed from it are outlined in Darlington and Bowyer (2016).

## 2.1 Rationale

In 2014/15, a study was undertaken which aimed to guide OCR’s redevelopment of Further Maths units. We sought to explore the role of the current maths A-levels in preparing students for the mathematical demands of university study, and whether particular areas of maths were considered to be useful for students of certain subjects. This information would also be helpful to clarify the needs of prospective students of different STEMM and social science subjects, and to see whether the current A-levels provided students with the preparation which they believed they required to be successful in the transition to university study.

## 2.2 Research questions

The research questions relevant to this paper we sought to answer were:

1. Which optional units in A-level Maths and/or Further Maths do undergraduates find useful as preparation for their degree?
2. Do students who took A-level Maths and/or Further Maths believe the qualification(s) to be useful preparation for their degree?
3. Are there any areas in which A-level Maths and/or Further Maths could be improved to suit the needs of future undergraduates?
4. Do students believe extension papers useful preparation for maths degrees?

## 2.2 Method

An online questionnaire was devised to survey students who were in at least their second year of a mathematically demanding degree. Students who had taken AS- or A-level Maths and/or Further Maths were contacted via their universities and asked to take part in the questionnaire which asked questions regarding:

* Students’ backgrounds: Gender, university, degree, year, attainment, entry requirements
* A-levels: Year taken, grades, optional units
* Students’ perceptions of the usefulness of AS- or A-level Maths and/or Further Maths and any extension papers

All UK university departments of relevant disciplines were contacted via email, meaning that a wide range of university types are included in the sample. Over 4,000 responses were collected. However, it should be noted that for many degree subjects, it is not ‘the norm’ for most students to have taken A-level Maths (e.g. Geography, Psychology, Architecture) and as such the responses to the questionnaire are not representative of the whole student cohort of some subjects. A-level Maths is always required of students of Maths, Engineering and Physics.

# 3. Findings

## 3.1 Which optional units in A-level Maths and/or Further Maths do undergraduates find useful as preparation for their degree?

The answer to this question varied according to students’ degrees. Specifically, the following optional units were found to be particularly beneficial for the following degree subjects:

* **Statistics**: Business and Finance, Bioscience, Economics, Geography, Medicine, Psychology
* **Mechanics**: Architecture, Engineering, Physics
* **Decision Maths**: Computer Science
* **Further Pure Maths**: Chemistry, Maths

This suggests that the specialisation afforded by the pre-2017 A-levels was beneficial for students of certain subjects. Additionally, the option of studying Decision Maths was useful for prospective Computer Science undergraduates.

## 3.2 Do students who took A-level Maths and/or Further Maths believe the qualifications to be useful preparation for their degree?

For students of all subject areas, the majority described AS- or A-level Maths as useful preparation for their degree (see Figure 2).

*Figure 2 – Participants’ (by degree subject) perceptions of AS- or A-level Maths as preparation for the mathematical demands of their degree*

Whilst students of the most mathematically-demanding degrees, as well as those which higher-ranking universities usually make A-level Maths an entry requirement, overwhelmingly reported that Further Maths had been useful preparation for their degree, the converse was true for students of other subjects (see Figure 3).

Students who found Statistics units to be the most beneficial preparation for their degree were usually least likely to describe Further Maths as good preparation for their degree.

*Figure 3 – Participants’ perceptions (by degree subject) of AS- or A-level Further Maths as preparation for the mathematical demands of their degree*

## 3.3 Are there any areas in which A-level Maths and/or Further Maths could be improved to suit the needs of future undergraduates?

The most commonly-suggested changes for each subject area were as follows:

* **Architecture** – Practical applications of maths, problem solving
* **Business and Finance** – Accountancy, econometrics, opportunities to use statistical software
* **Bioscience** – Statistics in scientific contexts, opportunities to use statistical software
* **Chemistry** – Complex differentiation
* **Computer Science** – Number bases, logic
* **Economics** – Game theory, linear programming, in-depth calculus
* **Engineering** – Advanced calculus
* **Geography** – Opportunities to use statistical software
* **Maths** – Proof/analysis, advanced calculus, number theory, set theory
* **Physics** – Advanced calculus
* **Psychology** – Opportunities to use statistical software, particularly in terms of ANOVA and MANOVA

Many students also made comments regarding the difficulty of the examinations. In particular, students of more mathematically-demanding degree subjects tended to express a belief that the examinations should have been more demanding.

## 3.4 Do students believe extension papers useful preparation for maths degrees?

430 undergraduate mathematicians had taken at least one of the MAT, AEA and STEP. Participants’ views regarding the usefulness of those papers as preparation for their degree varied by extension paper (see Figure 4).

*Figure 4 – Participants’ perceptions of extension papers as preparation for undergraduate maths*

Those who described the MAT as bad preparation often reported that this was because it assessed logical thinking and puzzles, rather than the type of maths studied at undergraduate level. Others commented that the MAT was more demanding than A-levels, and as such proved useful to prepare them for the challenge of university maths.

Many participants described the AEA as being too similar to A-level assessment, rather than requiring deeper understanding or more advanced problem-solving skills than necessary at A-level.

Most participants reported that STEPs gave a more accurate expectation of university maths, with questions emphasising the importance of proof and formal maths. Many claimed that the question styles were similar to undergraduate maths questions, and helped develop their problem-solving ability and synoptic understanding of different areas of maths. However, a number of participants described STEPs as too difficult and stress-inducing, with others commenting that support was easier to come by for students at higher-performing schools.

# 4. Discussion

Maths educators and educational researchers expect that the reforms to A-level Maths and Further Maths will more than likely reduce the uptake of Further Maths. The research here indicate that this could be very damaging for prospective students of a large range of university subjects as Further Maths is viewed so positively by undergraduates who took it before embarking on mathematically demanding degree courses.

This comes at a time when universities are struggling to to select the best students, despite the introduction of the A\* aiming to differentiate between the highest-performing students. AS-level results are generally viewed by universities as being the most useful predictor of final A-level results; however, the decoupling of the AS- and A-level means that many schools are changing their AS- and A-level provisions (UCAS, 2017). This means a decrease in the number of students taking three A-levels plus an additional AS-level, and an increase in the number of students taking three A-levels only is likely. Furthermore, funding pressures mean schools may choose not to enter students for AS-level examinations just so that they have additional information for their university applications, making admissions processes more challenging for university admissions tutors.

Whilst an increasing number of university maths departments are requiring/encouraging applicants to take Further Maths, school policies and student confidence in enjoying and succeeding in Further Maths could see fewer students taking the qualification post-2017. Hence, it could become more common for universities to use extension papers, as the information that they can gain from GCSE results and predicted A-level results – which are more often wrong than right (Wyness, 2016) – will likely be insufficient to select students. Fortunately, it appears that students believe extension papers are beneficial preparation for undergraduate study; however, their accessibility must be taken into account, in terms of the provision of support from schools, and whether those currently available are appropriate for use at all universities, and not just the most selective.

It remains to be seen whether the TMUA can act as a more accessible admissions test, and provide students with preparation for the challenge of university maths, and universities with more information from which to select the best students for their courses. Universities should also consider whether they might have a role in promoting the study of Further Maths to prospective applicants if the A-level is to survive this reform programme.

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