Teaching and learning for 'moving goal-posts': Reformed A Levels in mathematics

Ben Redmond[1], Jennie Golding[2], Grace Grima[1]

[1]*Pearson,* [2] *UCL Institute of Education*

Reformed English pre-university mathematics 'A levels' feature enhanced content and renewed focus on mathematical reasoning and problem solving. Related assessments, at scale from 2019, had negligible piloting, and preparation time for resources and teaching was pressured, with teachers/assessors typically having little experience of teaching/assessing for the renewed foci. We used an institutional ethnographic lens to study the first 3 years' enactment from the leading awarding organisation, and impact on students' learning, affect and pathways. We followed students and teachers in a fairly representative sample of 46 classes, drawing on termly data collection. Initial 'specimen assessments' were largely considered valid and accessible; however, we evidence insecurity due to perceptions of 'moving goal posts'. Early final assessments were perceived as significantly more demanding than predecessor comparators and of limited reliability for many students. We analyse contribution to knowledge around introduction of curriculum aspirations at this level and discuss ways to address identified challenges.

Keywords: A Level Mathematics; curriculum reform; problem solving; proof; large dataset

Introduction: the policy context

This paper discusses the introduction of ambitious new curriculum aspirations for the reformed A Levels in mathematics, the core calculus-based pre-university mathematics courses in England, and explores challenges and opportunities identified around their assessment. Our data suggest that the development of new assessment practices which are aligned to intended teaching and learning is key to successful curriculum reform. However, we also argue that, consistent with Drijvers (2019), changing approaches to teaching, learning and assessment require time and ongoing support for students, teachers and assessors.

Mathematics and Further Mathematics A Levels were part of a wider reform of A Level qualifications. Those for mathematics were developed largely top-down from Higher Education input (ALCAB, 2014), and were generally well-received by the subject community. The new specifications were seen as focusing in on mathematically important processes rather than superficial facts and procedures, although many teachers reported themselves apprehensive about related teaching (Golding and Smith, 2016). The content shows significant continuity with previous specifications, though, consistent with changes in the new 'GCSE' examination at 16, there is significantly more emphasis on genuine mathematical problem solving, on proof, and on mathematical modelling. Edexcel Pearson, the dominant assessment provider, is unique in assessing all statistics and mechanics content in the third of three papers, the other two being entirely focused on pure mathematics. As part of the wider changes, most A Levels, including A Levels in mathematics, became entirely

terminally assessed. At the same time the reformed mathematics curriculum included an increased focus on mathematical problem solving and reasoning, with students expected to be able to:

> Recognise the underlying mathematical structure in a situation and simplify and abstract appropriately to enable problems to be solved. *(DFE, 2016)*

A new feature within the statistics strand is that all students are expected to engage with technology to become familiar with and analyse a large data set, and to be examined on their grasp of that as part of timed written papers. Students should:

> Become familiar with one or more specific large data set(s) in advance of the final assessment (these data must be real and sufficiently rich to enable the concepts and skills of data presentation and interpretation in the specification to be explored);
>
> Interpret real data in summary or graphical form;
>
> Use data to investigate questions arising in real contexts. *(DFE, 2014)*

In the Edexcel Pearson specification, the large data set that students are asked to engage with is focused on Met Office weather data (~184 records of each of 11 variables for each of 8 locations in each year) (Pearson, 2017).

These changes, together with enhanced demand for problem solving and proof, offer opportunities for students to engage more deeply with mathematics. However, they also create new challenges, with teachers and assessors having to adapt their practices to fit the renewed foci. Due to the timeline of development, resources and assessments related to this qualification had negligible piloting and preparation time for resource development and teaching was pressured. In this context, research which explores the implementation and assessment of the reformed Mathematics A Level becomes particularly important, both to support well-informed development, to better meet student and teacher needs and to understand how the qualification is being implemented and assessed.

This paper draws on the findings from the first and second years of a three-year study (2017-2020), by Pearson in collaboration with UCL. The study sets out to analyse the implementation and efficacy of the reformed Mathematics/Further Mathematics A Levels and Pearson's associated free/paid for resources. The aims are to understand

1) motivations for centres adopting Edexcel Mathematics A-Levels and students' motivations for enrolling
2) how the free/paid-for support materials, including appropriate technology, are used, including in preparation for summative assessments
3) perceptions of their effectiveness in meeting cognitive and affective needs of teachers and students, including students' progression from GCSE and into further work/study
4) how the above develop as the qualifications bed down in order, where possible, to address any issues and improve support available.

Methodology

As indicated in Table 1 which outlines data collection for the second year, each yearly cycle comprises three phases, collecting largely primary data from 12 centres using mathematics A-levels. Each year included similar activities, at a similar scale, involving two groups of A Level Mathematics students in each centre, some of them also studying A Level Further Mathematics.

Table 1: Data collection in year 2

Phase 1: Autumn 2018	- 33 Heads of Maths and maths teachers complete survey (completed via telephone in year 1, to establish relationships) - 24 study class sets of Mathematics grades at age 16 (and in year 2, 22 other class sets of attainment data)
Phase 2: Spring 2019 (centre visits)	- 22 lessons observed - 22 teachers interviewed after lessons - 22 student focus groups following observed lessons - 161 students complete survey
Phase 3: Summer 2019	- Survey completed by teachers (18 responses achieved) - Survey completed by students (168 responses achieved) - Collect end of year progression assessment data

The sample of centres for this study was drawn from a range of Pearson centres willing to participate. This restricts the extent to which outcomes are generalisable, however, Pearson has a very dominant share of the market for A Level. Participating centres featured reasonable variation in other aspects known to affect teaching and learning, although previously low-attaining centres were somewhat under-represented. In each centre we collected data from the Head of Mathematics or person responsible for A Level Mathematics, and in the first year, on two Year 12 (age 16-17) classes and their teachers. In year 2 we expanded this to follow through those students into Year 13, and to included two Year 12 classes from the new cohort and their teachers. We recruited two further centres to address the prior performance skew, and made further progress on that in year 3, following through 46 classes in all. All interviews were recorded and transcribed; all qualitative data was then iteratively analysed by research question and then using an open grounded approach (Charmaz, 2006) to expose grounded sub-themes. In parallel, documentary analysis of specification and assessment materials and of school 'schemes of work' and other local documents were analysed in an attempt to understand enactment with an 'institutional ethnography' lens (Smith, 2005).

Findings

It was evident from comments made by both students and teachers that the increased requirement for problem solving and reasoning has created challenges for most students. Teachers were supportive, in principle, of this element of the reformed curriculum but were also having to adapt their pedagogical approaches:

> I personally like it as a mathematician: it is nice to combine skills and do more problem solving and modelling. Students are definitely not prepared for [problem solving and reasoning]. *Centre 5, Autumn 2018 Teacher Survey.*

The introduction of the large dataset, while in principle valued by almost all teachers, has also put additional pressure on students and teachers:

> [Students are] not enjoying the LDS though, and it's quite a struggle to get them to play around with it, and explore different things … I understand the … point of it because it's real life data; however, they're not really seeing it. *Centre 3, Autumn 2018 Teacher Survey.*

There was concern from some teachers that while more able students may benefit from the more aspirational A Level, lower performing students may be impacted negatively by the changes:

> Low attaining pupils, particularly the lowest, will potentially feel overwhelmed and may struggle to manage demands, therefore further support would be required. *Centre 9, Summer 2018 Teacher Survey.*

> I would say some of the class are a match to it. Some, however, seem to be really struggling with style of questions, and getting their head around modelling. Perhaps with the old spec they would have been ok. *Centre 5, Autumn 2018 Teacher Survey.*

Given that the Mathematics A Level is a high-stakes, terminally assessed qualification, this additional pressure was a clear source of anxiety for students participating in this study. However, while teachers and students were respectively working to adapt their teaching and learning relating to aspirational elements of the reformed curriculum, they also reported uncertainty relating to assessment. This was particularly the case for questions related to problem solving and reasoning as well as the large dataset.

> I think since the A level has changed, there is this feeling amongst teachers in terms of the unexpected. Like, what are we going to expect in the exams, what are the key differences that are going to occur? That translates to the students, and I think there's a bit of nervousness amongst them. That's completely natural because it's changed. *Centre 9, Teacher 1, Post Observation Interview 2019;*

> We still don't really know what kind of questions will come up, and how it might be different types of questions. *Centre 10, Year 13 Student Group, Spring 2019.*

Lack of available sample assessment material (SAMS), connected with limited preparation time for resource development, was cited as key to uncertainty:

> They are not as prepared. Naturally, as they don't have tons of past papers to work through. Centre 1, *Summer 2019 Teacher Survey*;

> [I would appreciate] more specimen papers for the new specification. I think there's only a few out but it would help to have another set of papers. *Centre 2, Year 12 Students Focus Group Spring 2019.*

Teachers and students also reported a perceived mismatch between publisher textbook questions/SAMs and the live papers. This added an additional layer of uncertainty and meant that some students felt underprepared for the demand of the 2019 live papers. Some teachers' comments implicitly suggested that they felt that they had been teaching for assessment objectives that had shifted over time:

> They found questions very difficult, many of the good students were very disappointed as any of the practice questions they were solving as practice did not match the questions in the exam. *Centre 9, Autumn 2019 Teacher Survey;*

> Pupils…feel that questions don't always reflect the questions seen in assessments which they feel are more difficult. *Centre 8, Autumn 2019 Teacher Survey.*

This was compounded by the complexity and style of some problem-solving style questions which teachers felt did not give lower-attaining students the opportunity to demonstrate what they were able to do mathematically:

> There was a lack of easy entry questions for the less able. Although many of our students attained good grades, I'm concerned that they had a very negative experience of the exam. *Centre 1, Autumn 2019 Teacher Survey;*

> Students are having problems to change from …just a few steps to get to answer to…full methods in multiple stage calculation to obtain full marks. *Centre 8, Autumn 2019 Teacher Survey;*

Questions related to the large data set were also a source of anxiety with students and teachers uncertain as to the demand and style of these questions:

> We knew that this was going to be something they were going to be examined on but I don't think we had a lot of clarity as teachers as to what depth they need to know. *Centre 2, Teacher 2, Post Observation 2019 Interview;*
>
> It's still very unknown how much we need to know from the large data set which is kind of confusing. *Centre 10, Year 13 Student Focus Group Spring 2019.*

This uncertainty was seen as putting considerable pressure on students, with potential to impact their enjoyment of and engagement with mathematics as well as potentially impacting uptake to A level Mathematics in the future:

> The students do actually know a lot but they are not getting to show this which is damaging to confidence and hard for us as teachers. *Centre 3, Summer 2019 Teacher Survey;*
>
> I feel the level of challenge is going to have a knock-on impact on numbers in future years … One pupil said (grade 9, target A*) that if she knew the examinations would be like that she would not have considered maths A Level. *Centre 9, Summer 2019 Teacher Survey.*

In this context it is important to track not just the enactment and assessment of the reformed A Level, but also its impact on students and their relationship with the subject. This will be a key focus for the final year of this three-year study.

Discussion

The data from this study clearly illustrate that the introduction of these new curriculum aspirations is demanding that teachers and students adopt new approaches to teaching and learning. In the high-stakes environment of A Level Mathematics the pressure to adapt to these new requirements is putting increasing pressure on students. In this context, uncertainty around assessment is likely to increase anxiety for students who are already struggling. While this uncertainty is an inevitable consequence of curriculum reform and is likely to reduce over time, our evidence suggests this uncertainty persists into at least the third cycle. It is also worth noting that the sample slight skew suggests that challenges reported by teachers and students might typically be even more pronounced elsewhere.

In our data uncertainty arose from four main areas:

- Significant, unpiloted changes in content and emphasis of mathematics
- Common inexperience in teaching or assessing for such changes
- Lack of sample assessment materials, linked to short development timelines
- Perceived mismatch between live examinations and questions in materials

Changes in content and style of the question are largely due to the more aspirational intentions of the qualification, with problem solving questions requiring students understand complex problems and to draw from different areas of mathematics in their answers. Teachers suggested that lower-attaining students struggled to gain straightforward marks where they were obscured within larger questions; further, teachers themselves were typically not experienced in teaching for such aspirations. The introduction of the large dataset also generated significant uncertainty, in relation to the style of the questions as well as the extent to which students would need to be familiar with the dataset. A number of participating centres chose not to cover this element of the course or only to engage with it superficially, as they felt that the time and resources required to engage with it did not reflect the marks available; this trend increased over time.

Challenges were compounded by a shortage of available assessment materials, and this was a key source of anxiety for students. Teachers too relied on the availability of sample assessment material to inform both the content taught and pedagogical practices adopted, yet awarding organisations were constrained by lack of time and opportunity to pilot.

The perceived mismatch between live examinations and sample assessment material, as well as with questions in the textbook, also added to the sense of uncertainty among students and teachers. Teachers suggested a discontinuity in the depth and demand of questions, with questions in the live paper requiring a deeper engagement with mathematics compared to those students had encountered previously. Data from surveys completed by students and teachers in summer 2019 suggested that students felt deeply demoralised by their performance on the live exams. Pearson has prioritised these issues, conducting an external comparison with 2019 A level Mathematics exams and the textbook to ensure suitable coverage. A new 'Content Exemplification' document was also released to support teachers in knowing what to teach and new mocks have been made available.

It is evident from our data that there have been avoidable challenges because of the short timescale in which these new A Levels were introduced, exacerbated by lack of piloting of new content and approaches. Consequently, there is still substantial progress to be made before the A Level Mathematics enactments are widely and fully aligned with aspirations. Both teachers and assessors needed more time and support to ensure the range of students can demonstrate their mathematical learning while also engaging at a deeper level with complex problems. It is urgent that these issues are resolved as they have the potential to impact not just current students' ongoing relationships with mathematics, but also future levels of participation in mathematics A levels.

Acknowledgement:

This paper draws on research funded by Pearson UK.

References

ALCAB. (2014). *Report of the ALCAB panel on mathematics and further mathematics.* Retrieved from https://alevelcontent.files.wordpress.com/2014/07/alcab-report-on-mathematics-and-further-mathematics

Department for Education. (2016). *Mathematics AS and A level content.* Retrieved from https://www.gov.uk/government/publications/gce-as-and-a-level-mathematics

Drijvers, P. (2019) Assessing mathematical thinking as part of curriculum reform in the Netherlands, *Educational Studies in Mathematics 102*, 435-456

Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis.* Thousand Oaks, California: Sage.

Golding, J. & Smith, C. A. (2016). *Beginner mathematics teachers learning to teach and assess advanced problem solving.* London: FMSP.

Pearson. (2017). *A level mathematics specification.* Retrieved from pearson.com/en/qualifications/edexcel-a-levels/mathematics2017.htm

Smith, D. E. (2005). *Institutional ethnography: A sociology for people.* Walnut Creek, CA: AltaMira Press.