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## Assessment of algebra at GCSE: do you really get what you test?

Geoff Wake<sup>2</sup>, Lawrence Wo<sup>2</sup>, Pat Drake<sup>3</sup>, Andy Noyes<sup>1</sup>

<sup>1</sup>University of Nottingham, Nottingham, United Kingdom, <sup>2</sup>University of Manchester, Manchester, United Kingdom, <sup>3</sup>University of Sussex, Brighton, United Kingdom

### Background

In seeking to understand potentially different mathematics pathways for 14-19 year-olds the Evaluating Mathematics Pathways (EMP) project has developed and used a comprehensive framework to capture the nature and texture of the qualifications that might be considered as the stepping-stones of emergent pathways. This has quantified and confirmed what is well known: that there is a gap in the algebraic knowledge, skills and understanding required for success at GCSE and what might be considered adequate preparation for the study of GCE AS mathematics. The project's scrutiny work suggests that GCSE students have possibly too few opportunities to demonstrate facility with algebraic skills and due to highly structured assessment items the skills they develop may not be suitable preparation for progression to AS level.

Research suggests that students starting AS mathematics with a grade C or B at GCSE are likely to either not complete the course or fail to gain a pass grade (Williams et al, 2008) and it seems likely that students' (lack of) facility with algebra is a major factor.

### Research Questions

This paper will discuss how algebra is assessed at GCSE together with analysis of student performance in relation to this. The study seeks to understand what might be considered the typical algebraic knowledge, skills and understanding of students who attain grades C and A at GCSE, effectively asking the question, "Do you get what you test?"

### Methods

Understanding the nature of assessment across the pathways qualifications has been gained using a framework that identifies major domains in relation to mathematical tasks / assessment that ultimately define mathematical activity: structure, content, process skills, task type and use of resources (Wake et al, 2008). The analysis is at several levels including individual items, papers and qualifications, as well as across qualifications. It suggests that the disjunction between the prominence given to, and the nature of, algebra in the two qualifications is particularly pertinent to issues of progression from GCSE to AS. Our most recent work, therefore, has focused on student performance in algebra in relation to potential/expected outcomes. We have analysed the examination scripts of 100 students who successfully obtained a grade A and a further 100 students who obtained a grade C on the pilot GCSEs in 2009.

### Frame

Our theoretical frame draws on previous work in two areas.

(i) Since the introduction of the mathematics National Curriculum there has been much concern about how to ensure that teachers encompass a broad range of teaching approaches, in particular emphasising the development of process skills. Currently formal assessments are attempting to support teachers in providing a broader range of learning experiences in relation to this and to better understand how assessment might support (or not) such intentions we use an evaluation framework that builds on the balanced assessment work conducted by the Shell Centre, University of Nottingham.

(ii) The literature relating to the development of school algebra is prolific, with many studies focusing on the cognitive development of students when engaging with this important domain of mathematics. Underpinning this work is the development of an understanding of how algebra is framed in school mathematics. In a recent review of current understanding of algebraic reasoning in relation to learning mathematics Nunes and colleagues (2009) suggest six categories in relation to algebraic activity in school. For manageability our analytical framework collapses these to three (generalizing pattern, working with expressions/equations, functions and graphs) as well as identifying the degree of algebraic representation required (not led to use algebra, led to use algebra, explicit and structured) and the expected level of response (low, medium, high). Having used this to determine what is being assessed in algebra items each individual student's response level is then coded allowing a picture to be developed of outcomes in relation to expectations at GCSE grades C and A.

## **Research findings**

Much time, effort and resource is being, and has been, directed to the development of qualifications in mathematics. This study suggests that this development might be more effective if greater use were made of evidence about how curriculum specification, assessment and teaching & learning interact. Our findings will be particularly pertinent in the case of algebra but may also provide a model for further work that might inform future curriculum specification and assessment development.

Initial findings lead us to conclude that students:

- obtain disproportionately fewer of their marks from algebra items
- often take a numerical approach when the use of algebra is expected
- are most secure when answering highly structured questions where they are directed to demonstrate manipulative skills
- are not well prepared to use algebraic thinking to solve problems.

In conclusion the paper will provide a critique of how assessment design is related to student outcomes and a commentary of how this is aligned (or not) with curriculum specification.

## **References**

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