The Importance of Teaching Styles and Curriculum in Mathematics: Analysis of TIMSS 2011

Nadir Zanini and Tom Benton

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ARD Research Division
Cambridge Assessment
1 Regent Street
Cambridge
CB2 1GG

Zanini.N@cambridgeassessment.org.uk

www.cambridgeassessment.org.uk

Background and motivation

In these times of rapid change fuelled by technological advances the demand for improved mathematical knowledge is growing at global level. Mathematical skills such as problem solving and inference are not only increasingly becoming part of university access requirements, but are also predominantly required in the labour market. The importance of mathematics for individual progression, as well for the economy and the society at large, has been recognised by policy makers in many countries. In the UK, for instance, the National Curriculum has been revised in order to stimulate a deeper knowledge of the fundamentals of mathematics and a broader learning of mathematics reasoning (Oates, 2010; DfE, 2013).

Nevertheless, the debate about which teaching methods and resources used in classrooms may be most effective in improving mathematics achievement is still open. Furthermore, there is no definitive answer to the question regarding which aspects of the mathematics curriculum should be emphasised. International benchmarking surveys, such as TIMSS and PISA, have depicted East Asian students outperforming their Western counterparts (Mullis et al., 2012; OECD, 2013) and this led policy makers and educational practitioners in the UK and the US to emulate high-profile jurisdictions such as Singapore. Although an important role in determining mathematics performance has been attributed to the curriculum and textbooks adopted in these countries, other societal and cultural factors of the country (e.g. geographical and economic conditions, aspects of the education system) can have stronger influence on students' mathematics achievement (Andrews, 2012; Usiskin, 2012).

In this study, the link between mathematics achievement, curriculum, teaching methods and resources used in the classrooms is investigated at an international level, allowing for country-specific factors potentially affecting educational achievement. More specifically, the aim of this research was twofold: on the one hand to investigate the prevalence of different teaching styles (also referred to as teaching methods or instructional practices) and topics taught within different countries with respect to their mathematics achievement; on the other hand, to study in more detail the relationship between features of the mathematics curriculum and achievement in mathematics focussing on the UK. This research made use of data from the 2011 TIMSS survey, the latest available.

It should be noted that, although international benchmarking surveys have generated a wealth of research investigating what contextual factors might be important in raising achievement (for a broad review see Hanushek and Woessmann, 2011), much less of this research has been focussed on how aspects of a mathematics curriculum are associated with mathematics achievement at international level. More specifically, with respect to the UK – where the government identified the reform of the curriculum as the key to a new and more effective school system (DfE, 2010), this relationship has been rarely analysed in any detail.

This study is not aimed at suggesting that the particular teaching methods and specific topics taught that are most frequently used within high performing jurisdictions should be adopted more frequently elsewhere. However, the results of this analysis can be used by policy-makers and educational practitioners to reflect upon mathematics teaching styles and curriculum and their role on a more effective mathematics education at secondary level aimed at preparing students for their future lives and careers.

Methodology

In this study data from TIMSS 2011 is exploited, as a rich set of information regarding aspects of the curriculum, resources used by teachers in the classroom and teaching styles, along with measures of achievement in mathematics are provided. Analysis in this research was restricted to grade 8 students. Data from a total of 42 countries participating in TIMSS 2011 were included within the analysis.

Grouping of countries with similar patterns of answers was performed using latent class analysis. Data was analysed at teacher level and groupings were produced at country level. Separate latent class analyses were undertaken to produce groupings of countries in terms of some aspects of *what* is taught in different countries and *how* it is taught.

Our analyses examine mathematics achievement within different countries measured by TIMSS 2011 and PISA 2012[ii] results. Whilst the former provides a measurement of pupils' achievement in relation to the kind of mathematics curriculum that is generally taught internationally (Wu, 2009), the latter is focussed on pupils ability to apply maths more broadly beyond the specific topics they have been taught (OECD, 2013).

In order to control for the impact of other background variables, information was drawn from the school and student questionnaires collected as part of TIMSS 2011. By aggregating student-level linear regressions to country level, this data was then condensed into a single measure for each country capturing the likely influence of the background variables upon achievement. This aggregated background measure was augmented with additional data on the per capita Gross Domestic Product (GDP) of countries in 2011. In this way it was possible to analyse the relationship between the groupings of countries in terms of what and how they teach and mathematics achievement whilst taking account for the aggregated background measure and GDP per capita using meta-regression (Benton, 2014). This method allows us to account for the fact that the achievement of each country is measured with error.

For the analysis within England, a linear regression approach to model pupils' mathematics performance was employed. By doing this it was possible to estimate the association between topics, teaching methods and achievement as measured by TIMSS once the other factors are accounted for.

Summary of the results

The country-level analysis highlighted that countries were grouped differently by teaching styles than by curriculum. More specifically, grouping by teaching styles identified 5 groups of countries. This segmentation matched with geographical descriptions of the countries, suggesting that, within countries with a similar geography, teachers tended to share the same methods of teaching. Conversely, countries within the same groupings by topics taught did not share a common geographical description. This is an indication that mathematics curriculum may be less influenced than teaching styles by countries' cultural characteristics. Furthermore, the results of the meta-regression analysis suggested that teaching styles can be more connected than curriculum to the mathematics performance, even when socio-economic factors are accounted for. In particular, our findings indicate that some specific teaching methods may be more beneficial in terms of PISA rather than TIMSS results and vice versa.

The regression analysis within England suggested that students' mathematics performance in TIMSS could have been boosted by specific teaching methods, resources and topics taught. As an example, after accounting for background factors, students who have been taught problem solving mostly before grade 8 outperform their peers who have not been taught problem solving mostly before grade 8 by around 20 points. The 10% of students in grade 8 who have not yet been taught simple linear equations and inequalities were outperformed by more than 40 points by those who have been taught this topic. As for teaching styles and resources, findings suggested smaller, though significant, advantages for the 30% of students whose teachers made use of textbooks as a basis for instruction. Similarly, frequently asking students to work on problems for which there is no immediately obvious method was associated with a gain in TIMSS performance of 11 points.

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[i] This is the conference submission. For the full article see Zanini and Benton (2015).

[ii] Data on achievement in PISA 2012 was available for 29 of the 42 countries with relevant data for TIMSS 2011.