# Coverage of topics during a mathematics pedagogy module for undergraduate pre-service primary teachers

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Recently, research on teacher preparation has begun examining the opportunities to learn that pre-service teachers have of the different forms of knowledge thought to be necessary for effective teaching. This paper reports on one component of a wider study of undergraduate pre-service specialist primary mathematics teacher preparation: the pre-service teachers' opportunities to learn about the primary school mathematics curriculum during a final-year undergraduate module on mathematics pedagogy (MPM). Using data from observations of the complete teaching of this module at two university colleges in Saudi Arabia, the findings indicate that while the pre-service teachers had some opportunity to learn about teaching aspects of the primary school geometry curriculum, they had little or no opportunity to learn about teaching topics related to the algebra taught in the upper primary school years. The main reason for this discrepancy was that while the MPM contained some sessions on primary school geometry, there were no sessions explicitly related to primary school algebra even though the current version of the relevant primary school curriculum now includes some algebra for Grades 5 and 6 (pupils aged 10-12).

**Keywords: opportunity to learn, school mathematics curriculum, geometry, algebra, pre-service primary mathematics teacher education**

## Introduction

For some time, research on teacher education in general, and on initial teacher education in particular, has focused on the forms of knowledge that teachers need in order to teach most effectively (see, for example, Rowland and Ruthven 2011). Such forms of knowledge have commonly been categorised into 'subject matter knowledge' and 'pedagogical content knowledge' (see, for example Petrou and Goulding 2011). Here, 'subject matter knowledge' (SMK) is, in general, taken to refer to the key facts, theories, models and concepts of mathematics, together with the processes by which such theories and models are generated and established as valid. Pedagogical content knowledge (PCK), in contrast to SMK, encompasses the representations, examples and applications of mathematics that mathematics teachers use in order to make mathematics comprehensible to students, together with the strategies that such teachers use in order to overcome students' difficulties in learning mathematics. PCK also includes knowledge of the school curriculum.

Researchers have, more recently, begun examining the opportunities to learn (OTL) that pre-service teachers have of these different forms of knowledge (see, for example, Chapter 7 of Tatto et al. 2012). One major reason for this focus on OTL is that pre-service mathematics teachers can experience difficulties in teaching primary school mathematics even though they have completed relevant university-based

training; this being an example of what is generally referred to as the 'theory-practice gap' (for more on this 'gap' see, for example Brouwer and Korthagen 2005).

Programmes for preparing primary mathematics teachers are diverse, globally. In some countries, for example the UK and Germany, primary teachers are prepared as generalists to teach all primary school subjects (though in the UK the training of some specialist primary mathematics teachers is beginning in 2013). In contrast, in some countries such as Thailand, Malaysia and Saudi Arabia, primary teachers are prepared as specialists to teach mainly mathematics. Even so, there is a lack of studies concerned with university-based teacher preparation curricula, with Stuart and Tatto (2000, 493) commenting that "much less has been written on the professional curriculum for teacher preparation". This study is addressing this issue by analysing the OTL aspects of the primary school curriculum during a Mathematics Pedagogy Module (MPM) taken by undergraduate specialist primary pre-service mathematics teachers in the first semester of their fourth year of study, immediately prior to spending a semester in school.

## Research into the design of mathematics teacher education programmes

A major study that is providing a global perspective on the design of initial teacher preparation programmes is the *Teacher Education and Development Study in Mathematics* (TEDS-M) being undertaken by Tatto and colleagues (see Tatto et al. 2008; 2012). TEDS-M is aiming to build a comprehensive picture of primary and secondary mathematics teacher education around the world. The TEDS-M study has three components: the first is examining teacher education policy, schooling, and social contexts at the national level, the second is studying primary and lower secondary mathematics teacher education routes, institutions, programmes, standards, and expectations for teacher learning, while the third is determining the knowledge of mathematics and related teaching of future primary and lower secondary school mathematics teachers.

In analysing the characteristics of mathematics teacher preparation across the 17 countries participating in TEDS-M, Tatto et al. (2012) report a diversity of practice in terms of institutional arrangements and regulatory systems. For example, Tatto et al. (2012) show that initial teacher preparation programmes that focus on preparing teachers to teach in lower and upper-secondary schools provide more opportunities to learn mathematics in depth comparing to the programmes that prepare teachers to teach at the primary level. This is likely to be because the overwhelming majority of secondary school mathematics teaches are specialists, while this is not the case for primary teachers of mathematics. In terms of opportunity to learn about the relevant school mathematics curriculum, the TEDS-M results show that for future primary mathematics teacher there is a high degree of variability across countries and programme groups. Greater OTL was found in preparation programmes for specialist primary mathematics teachers and for programmes preparing teachers to teach the higher grade levels (see Tatto et al. 2012, 181).

## Theoretical framework: opportunity to learn (OTL)

The TEDS-M study (see Tatto et al. 2008; Tatto et al. 2012) uses the concept of opportunity to learn (OTL) in order to investigate pre-service teachers' pedagogical content knowledge of mathematics subject topics (such as number, geometry, algebra, and data). The term OTL was first coined by Husen (1967):

> "students have had the opportunity to study a particular topic or learn how to solve a particular type of problem presented by the test …if they have not had such an opportunity, they might in some cases transfer learning from related topics to produce a solution but certainly their chance of responding correctly to the test item would be reduced". (Husen 1967, 162-163)

Carroll (1963, 727) is perhaps best known for taking up the term OTL as "time allowed for learning" For this study, the notion of OTL in the TEDS-M (2008) framework was used to examine the extent to which the content of the MPM provided opportunity for the pre-service primary mathematics teachers to learn about the primary school mathematics curriculum.

## Methodology

The purpose of the study was to analyse the extent to which pre-service primary mathematics teachers had opportunity to learn how to teach geometry and algebra as specified in the relevant primary school mathematics curriculum. The study was implemented in Saudi Arabia and focused on the mathematics pedagogy module MPM that was taught during the second semester of the academic year 2011-2012 at two university colleges.

Data was collected by observing university mathematics education lecturers teaching the MPM at each of the two university colleges. To document each taught session, an observation sheet was used. This observation sheet divided each session into 12 parts, each lasting for ten minutes (1-10 minutes; 11-20 minutes, 21-30 minutes and so on). The role of the researcher-as-observer was to determine what type of mathematical content was taught by the mathematics education university lecturers every 10 minutes in each session of the MPM. The type of mathematical content was based on the TEDS-M framework (Tatto et al. 2008).

The following categories were used:

*Very heavy emphasis*: if the lecturer focuses on topics related to the concepts: Geometry, Algebra for 75%≤100% of the session time (= 91 ≤ 120 minutes)

*Heavy emphasis*: if the lecturer focuses on topics related to the concepts: Geometry, Algebra for 50% < 75% of the session time to the concepts (= 61 ≤ 90 minutes)

*Average emphasis*: if the lecturer focuses on topics related to the concepts: Geometry, Algebra for 25 % < 50% of the session time to the concepts (= (31≤ 60minutes)

*Little emphasis*: if the lecturer devotes less than of 25% of the sessions time to the concepts (= ≤ 30 minutes)

As the study was conducted in Saudi Arabia, it is germane to know that the primary mathematics school curriculum in Saudi Arabia is specified across six grades. In each grade the curriculum emphasises different topics across the four mathematical subject areas of Numbers, Algebra, Geometry, and Data. Table 1 shows a comparison of the 2002 primary mathematics curriculum for Grades 1 to 6, compared with the curriculum in 2012.

| Grade | primary mathematical school topics 2002 | primary mathematical school topics 2012 |
|---|---|---|
| 1 (pupils aged 6-7 Years) | Comparison and classification, numbers up to 5, location and style, numbers up to 10, numbers up to 20, combine. Additions methods, subtraction, fractions. | Comparison and classification, numbers up to 5, location and style, numbers up to 10, numbers up to 20, combine. Additions methods, subtraction, *measurement, geometric shapes* and fractions, *money and time*. |

| | | |
|---|---|---|
| 2 | Numbers up to 100 patterns, combining methods, methods of subtraction, data representation and reading, collecting two-digit numbers, fractions, numbers until 1000, geometric shapes, measurement: length, area, measurement: collection of 3-digit numbers, subtraction of 3-digit numbers | Numbers up to 100 patterns, combining methods, methods of subtraction, data representation and reading, collecting two-digit numbers, fractions, numbers until 1000, geometric shapes, measurement: length, area, measurement: *Capacity and weight*, collection of 3-digit numbers, subtraction of 3-digit numbers |
| 3 | Addition, subtraction, multiplication 1, multiplication 2. Division 1, division 2, measurement, geometric shapes, display and interpretation of data, fractures | Addition, subtraction, multiplication 1, multiplication 2. Division 1, division 2, measurement, geometric shapes, display and interpretation of data, fractures |
| 4 | Addition and subtraction organize and display data and interpretation, patterns and algebra, multiplication in the number of number one, multiplication in a two-digit number. Divide by the number of number one; identify geometric shapes and its description. Measurement, fractions usual, and decimal. | Addition and subtraction organize and display data and interpretation, patterns and algebra, multiplication in the number of number one, multiplication in a two-digit number. Divide by the number of number one; identify geometric shapes and its description, measurement, fractions and decimals. |
| 5 | Addition, subtraction, multiplication, division. Normal for instance, 2/3, 4/5. Representation and representation of data, denominators and complications, collect and put fractions, geometric shapes, measurement: perimeter, area and volume. | Addition, subtraction, multiplication, division, *use of algebraic expressions for example (3+x)-1=? x=2, functions and equations such as 2x=6*, fractions such as 2/3, 4/5. Representation of data, denominators and complications. Geometric shapes, measurement such as perimeter, area and volume. |
| 6 (pupils aged 11-12 Years) | Operations on decimals, fractions normal and decimal fractions, measurement: length, capacity and mass. Normal fractions, ratio and proportion, percentages and probabilities, Geometric , polygons, measurement: perimeter, area and volume, | *Topics in algebra: functions and numerical patterns such as 2, 4, 8, or 15, 10, 5, 0. Statistics and graphical representations,* operations on decimals, fractions and decimals, measurement such as length, capacity and mass. Ratio and proportion, percentages and probabilities, Geometry: polygons, measurement: perimeter, area and volume, |

Table 1: the KSA primary mathematical school topics 2002/2012
Source: Obecan Education: 2002-2012 [changes by 2012 shown in italics]

As can be seen from Table 1, the main change in the primary mathematics curriculum in 2012, compared with 2002, is the introduction of algebra topics for pupils in Grades 5 and 6 (pupils aged 10-12).

## Analysis and result

Table 2 shows, for each session of the MPM, the percentage of time devoted to, and the degree of emphasis on, the two school mathematics subject areas of primary geometry and algebra.

From Table 2, it can be seen that the pre-service primary mathematics teachers had average (or below) opportunity to learn concepts related to geometric topics. In contrast, in terms of OTL about algebra topics, there was no coverage at all.

| | Sessions of the Mathematics Pedagogy Module | sessions | degree of emphasis on school geometry topics | | | | | degree of emphasis on school algebra topics | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | * VHE (1) | * HE (2) | * AE (3) | * LE (4) | % | * VHE (1) | * HE (2) | * AE (3) | * LE (4) | % |
| 1 | Classification concept | x(1) | -- | -- | -- | 0 | 0 | -- | -- | -- | 26 | 21.6 |
| | | y(1) | -- | -- | -- | 24 | 20 | -- | -- | -- | 24 | 20 |
| 2 | Counting concept | x(2) | -- | -- | -- | 0 | 0 | -- | -- | -- | 18 | 15 |
| | | y(2) | -- | -- | -- | 14 | 11.6 | -- | -- | -- | 10 | 8.3 |
| 3 | The four operations (+, - , ×, ÷) | x(3) | -- | -- | -- | 0 | 0 | -- | -- | -- | 22 | 18.3 |
| | | y(3) | -- | -- | -- | 0 | 0 | -- | -- | -- | 8 | 6.6 |
| 4 | Fractions and operations on them | x(4) | -- | -- | -- | 0 | 0 | -- | -- | -- | 4 | 3.3 |
| | | y(4) | -- | -- | -- | 0 | 0 | -- | -- | -- | 6 | 5 |
| 5 | Geometry concept, e.g. a straight line, angles | x(5) | -- | -- | 40 | -- | 33.3 | -- | -- | -- | 8 | 6.6 |
| | | y(5) | -- | -- | 56 | -- | 46.6 | -- | -- | -- | 0 | 0 |
| 6 | Geometric shapes and their properties | x(6) | -- | -- | 48 | -- | 40 | -- | -- | -- | 0 | 0 |
| | | y(6) | -- | -- | 54 | -- | 45 | -- | -- | -- | 6 | 5 |
| 7 | Geometric models, e.g. cylinder, cube | x(7) | -- | -- | 58 | -- | 48.3 | -- | -- | -- | 12 | 10 |
| | | y(7) | -- | -- | 38 | -- | 331.6 | -- | -- | -- | 10 | 8.3 |
| 8 | Measurement units | x(8) | -- | -- | 50 | -- | 441.3 | -- | -- | -- | 8 | 6.6 |
| | | y(8) | -- | -- | 40 | -- | 33.3 | -- | -- | -- | 0 | 0 |
| 9 | Applications of quantitative and qualitative analyses of the problems | x(9) | -- | -- | -- | -- | 0 | -- | -- | -- | 14 | 11.6 |
| | | y(9) | -- | -- | -- | 8 | 6.6 | -- | -- | -- | 10 | 8.3 |

* (1) VHE Very heavy emphasis (2) HE heavy emphasis (3) AE Average emphasis (4) LE little emphasis

Table 2: emphasis on school mathematics topics during sessions at university colleges *x* and *y*

## Discussion

Overall, the data indicate that while the pre-service teachers received average opportunity to learn topics related to teaching the primary school geometry curriculum, they had little or no opportunity to learn topics related to teaching primary school algebra. A key reason for this discrepancy is that while there are some sessions of the MPM related to primary school geometry, there are no sessions related to primary school algebra. Even though the mathematics school curriculum in Saudi Arabia has changed over the period 2002 to 2012, and now includes some algebra topics for pupils in Grades 5 and 6, the MPM has not changed for more than 10 years (according to the directory of undergraduate courses 2002-2012 at each of the university colleges).

## Conclusion

This study showed that there was average emphasis on some topics in school geometry during the MPM. However, there was little or no emphasis on school

algebra. This confirms how there is variation of opportunity to learn in some topics related to both subject areas of geometry and algebra.

What remains unclear is how to decide how much to emphasise topics such as school geometry and algebra in a teacher preparation programme for pre-service primary mathematics teachers. The implications of this are that more research is needed on how much, and in what way, topics related to geometry, algebra or other mathematical areas should be included in pre-service mathematics teachers curriculum to match topics in primary mathematics school curriculum.

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