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RESEARCH BRIEF

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TEDS-M: Teacher Education and Development Study in Mathematics

An International Comparative Study of Mathematics Pre-service Education

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THIS INTERNATIONAL COMPARATIVE STUDY examined the training of future primary and lower secondary Mathematics teachers in 17 countries and assessed their Mathematics Content Knowledge (MCK) and Mathematics Pedagogical Content Knowledge (MPCK) and beliefs about mathematics teaching. Altogether 380 primary student teachers, 393 secondary student teachers, and 77 educators at the National Institute of Education (NIE) participated in this study on November 2007 and May/June 2008. Singapore and Chinese Taipei had the highest requirements for Mathematics before entry into teacher education. NIE student teachers ranked among the top countries in their MCK and MPCK, but were relatively weak in certain topics compared to some other countries. They considered NIE programmes to be effective in preparing them to teach Mathematics, but certain learning experiences could be strengthened. Most of them held commendable reasons for becoming teachers. About 20% of first-career student teachers indicated that they may not consider teaching as their lifetime career.

INTRODUCTION

The training of qualified teachers is a major concern in many countries. The Teacher Education and Development Study in Mathematics (TEDS-M) was the first international study on the training of future Mathematics teachers, undertaken under the aegis of the International Association for the Evaluation of Educational Achievement (IEA). The study covered 17 countries, about 500

KEY IMPLICATIONS

- *Policy.* Singapore should continue to recruit student teachers with strong mathematics background. NIE courses can further strengthen their knowledge of school mathematics to address the relatively weak performance in some topics found in this study.
- *Teacher training.* NIE teacher educators and student teachers generally held similar beliefs about mathematics teaching, but there were some differences in perceptions of opportunities to learn about pedagogy, which need to be looked into.
- *Research.* Secondary analyses of the Singapore and international data can help to identify factors that account for the performance of future teachers in MCK and MPCK and their beliefs, thus contributing to new knowledge in this research area.

teacher education institutions, 770 pre-service teacher education programmes, 14,000 primary and 8,000 secondary future teachers who were trained to teach Mathematics, and 5,000 mathematicians, mathematics educators, and general educators. Singapore participated in this study in order to compare NIE programmes and performance of NIE student teachers in MCK and MPCK against international benchmarks. By participating in this study, NIE teacher educators also contributed to the creation of knowledge about pre-service teacher education. Findings from the copious amount of data collected in this study can suggest national policies for Mathematics teacher education and revision of NIE programmes and courses in order to produce a sufficient number of competent Mathematics teachers for Singapore schools.

RESEARCH DESIGN

TEDS-M was a survey study using specially designed questionnaires to collect the data. The methodology of the study was developed by an international team comprising the National Research Co-ordinators (NRCs) of the participating countries, Michigan State University, Australian Council for Educational Research, Statistics Canada, and IEA Data Processing and Research Centre.

The theoretical framework (Tatto, Schwille, Senk, Ingvarson, Peck, & Rowley, 2008) describes the relationships among the key variables in three components. Component 1 is about national contexts and policies for teacher education. NRCs provided country reports to explain these contexts and policies.

Component 2 covers the nature of Mathematics teacher education programmes. Co-ordinators of the institutes that were sampled in each country answered the Institution Questionnaire and educators answered the Educator Questionnaire on their beliefs about pedagogy and activities offered by their courses to the future teachers. Information about the school Mathematics curricula (content standards) and Mathematics teacher education courses were also collected and analysed.

Component 3 examines the outcomes of teacher education in terms of the performance of future teachers in MCK and MPCK and their beliefs and perceptions of opportunities to learn (OTL) about mathematics and pedagogy. The MCK items covered four knowledge domains (Number, Data, Algebra, and Geometry) and three cognitive domains (Knowing, Applying, and Reasoning), set at two grade levels above what the future teachers were expected to teach. The MPCK items measured three types of mathematics knowledge for teaching: mathematical curricular knowledge; knowledge of planning for mathematics teaching and learning (pre-active); and enacting mathematics for teaching and learning (interactive). Within 1 hour of supervised administration, primary future teachers answered about 22 items and secondary future teachers about 30 items in different booklets. Their responses were coded locally using the TEDS-M scoring guide. The MCK and MPCK scores were generated using Item Response Theory, which gave an international mean of 500 and standard deviation of 100.

The beliefs and OTL sections comprised 53 Likert-type items covering a wide range of constructs, some of which are reported below. In addition to these components, eight countries, including Singapore, also took part in a national option to test future teachers about their knowledge of general pedagogy.

Since NIE is the sole teacher education institute in Singapore, it provided a census sample to represent Singapore. All student teachers who had taken the Mathematics Curriculum Studies (CS) courses and were at the end of their training (after the final practicum) during the study period (2007–2008) were invited to participate on a voluntary basis. Altogether 380 primary and 393 secondary student teachers took the TEDS-M tests and questionnaires, and the response rates (90% and 91%) satisfied IEA requirements. These student teachers were from the DipEd (July 2006 cohort), PGDE(P) (July 2007 cohort), BA(Ed) and BSc(Ed) (July 2004 cohort), PGDE(LS) and PGDE(S) (January 2007 and July 2007 cohorts) programmes. In addition, 77 NIE mathematicians, mathematics educators, and teacher educators who taught at least one course to these student teachers responded to the Educator Questionnaire at the end of 2007.

KEY FINDINGS

The international report was published in 2012 (Tatto et al., 2012). Some findings are highlighted below.

Component 1: National Contexts and Policies for Teacher Education

Teacher education policies varied widely across the 17 TEDS-M countries, and it is not possible to draw definitive implications about the effects of these policies on the performance of future teachers.

Policies in several countries, including Singapore, have changed since the country reports were submitted in 2008. Singapore and Chinese Taipei had the most co-ordinated quality assurance systems for teacher education, and countries with strong quality assurance arrangements tend to score high on the TEDS-M tests. In Singapore and 10 other countries, graduation from teacher education institutes led automatically to official entry to the teaching profession without further tests set by external agencies.

Component 2: Nature of Mathematics Teacher Education Programmes

Primary Mathematics teacher education programmes were classified along a generalist–specialist continuum into four categories: lower primary generalist up to Grade 4; primary generalist up to Grade 6; primary/lower secondary generalist up to Grade 10; and primary Mathematics specialist up to Grade 6. Secondary Mathematics teacher education programmes covered either lower secondary up to Grade 10 or upper secondary up to Grade 12. Singapore and Chinese Taipei had the highest requirements for Mathematics before entry into teacher education. However, secondary future teachers in countries like Chinese Taipei and Russia were prepared to teach only one subject, whereas NIE secondary future teachers were prepared to teach one major and one minor subject.

Component 3: Performance of Student Teachers in MCK and MPCK and Their Beliefs and Perceptions of Opportunities to Learn

NIE student teachers ranked among the top countries in MCK and MPCK within the respective programme groups (see Table 1). Among the primary student teachers, those who were trained to teach only two subjects (Option A of DipEd and PGDE(P)) performed better than those trained to teach three subjects (Option C). In all programmes except the BSc(Ed), males did better than females.

NIE student teachers scored well in some topics but not so well in others. Some examples are given below.

Table 1. Ranking and score of NIE student teachers (international mean = 500).

	Primary generalist	Primary Math specialist	Lower secondary	Upper secondary
N	263	117	142	251
MCK	2 (586)	2 (600)	1 (544)	2 (587)
MPCK	2 (588)	1 (604)	2 (539)	4 (562)

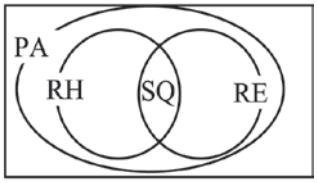

Figure 1. Venn diagram.

Primary MPCK: Consider this scenario: A pupil notices that when he enters 0.2 × 6 into a calculator, his answer is smaller than 6; and when he enters 6 ÷ 0.2, he gets a number greater than 6. He is puzzled by this and asks his teacher for a new calculator. Student teachers were asked to identify the misconceptions underpinning this scenario. About 68% of NIE student teachers could identify at least one misconception, much higher than the international average of 42%.

Secondary MCK: For an item about different types of numbers, 66% knew that the result of dividing 22 by 7 is *never* an irrational number, whereas 31% thought it is *always* an irrational number, probably not realizing that 22/7 is only an approximation for π. About 69% knew that the solution to the equation $3x = 6$ in the plane is a line, but 27% thought it was a point, thinking that the solution is $x = 2$, which gives a single value. Both responses suggest weak conceptual understanding of some basic Mathematics.

Secondary MPCK: In proving the quadratic formula, only 37% knew that the proof requires the knowledge to complete the square of a trinomial; this result was much worse than the international success rate of 55%. Two major reasons could account for this poor result. First, the term *trinomial* is rarely used in Singapore textbooks. Second, some secondary school teachers do not teach this formula using "complete the square"; those student teachers who had not encountered this proof during their school days may not have another opportunity to learn it in their post-secondary Mathematics lessons.

NIE student teachers generally agreed that they wanted to become teachers because they liked to work with young people and wished to influence the next generation. These were commendable reasons indeed. About 80% of the first-career student teachers and 90% of the mid-career student teachers considered teaching as their possible lifetime career. However, 20% of the first-career student teachers thought that they would probably resign after serving the bond or until they found another career. Ways could be found to help them become more committed to remain in the teaching profession.

NIE student teachers and educators generally endorsed the conceptual orientations of mathematics learning more strongly than the procedural orientations. For example, 78% of the educators believed that Mathematics should be learned through student activity, compared to 72% of the primary and 66% of the secondary student teachers. Student teachers who held conceptual orientations tended to have higher MCK and MPCK scores compared to those with procedural or fixed ability beliefs.

On a scale of 0 to 1, coverage of Mathematics education pedagogy in NIE programmes ranged from 0.68 to 0.72, similar to the international mean. However, the coverage of general pedagogy in the range from 0.57 to 0.65 was low compared to Russia, Switzerland, and United States. NIE student teachers were also below the international mean on opportunities to learn about teaching diverse students, and they rated "rarely experiences" to: read about research on mathematics and mathematics education; write mathematical proofs; develop research projects to test teaching strategies for pupils of diverse abilities. A significant difference between the perceptions of student teachers and educators was that the educators felt that they had provided fairly frequent opportunities for the student teachers to engage in interactive learning experiences, such as to ask questions, participate in class discussion, work in groups, and make presentations to the class. However, with the exception of group work, the student teachers rated the other three interactive experiences lower than the educators. Nevertheless, about 90% of NIE student teachers rated their programmes as effective or very effective in preparing them to teach Mathematics.

IMPLICATIONS

For Policy

Compared to many countries in the study, Singapore has recruited trainees with strong Mathematics background, and they performed well in the MCK and MPCK tests. However, some of them were still relatively weak in certain MCK topics compared to some other countries, and recruiting trainees with poorer Mathematics background would weaken the effectiveness of the training. Thus, Singapore should continue to recruit student teachers with strong Mathematics background. NIE courses can further strengthen their knowledge of school Mathematics to address this issue.

For Teacher Training

NIE teacher educators and student teachers generally held similar beliefs about mathematics teaching, but there were some differences in perceptions of opportunities to learn about pedagogy, which need to be looked into.

For Research

The international TEDS-M database can be utilized to test various hypotheses about Mathematics teacher education. Secondary analyses of the Singapore and international data can help to identify factors that account for the performance of future teachers in MCK and MPCK and their beliefs, thus contributing to new knowledge in this research area.

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