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Forces for Change in Mathematics Education: The Case of TIMSS

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Abstract
The results of the Third International Study in Mathematics and Science Education (TIMSS) were published in 1996/7. Since that time the participating countries have reacted in a variety of ways to the comparative performance of their students. This article investigates the diverse effects these reactions have had on mathematics curricula and teaching methodologies in a selection of these countries, within the context of a wider analysis of the motivations which determine change in education.

Introduction

What causes schools' mathematics curricula and teaching methodologies to change over time? To what extent do they change in a rational response to external objective considerations; to what extent subjectively in accordance with beliefs and social pressures? What does success mean in relation to change? Often enough, the effect of change (planned or otherwise) is to metamorphose antecedent success criteria to validate the change, at least in the short term. In the world of politics this is a commonly recognised practice; in education, less so. Fullan (1993) documents many such instances in education from the 1960s onwards. Reviewing the last 30 years, he concluded that "we have been fighting an uphill battle.... We need a different formulation to get at the heart of the problem, a different hill, so to speak. We need, in short, a new mindset about educational change."(p 3). For an analysis in a Scottish context, see Macnab (1999a).

In Fullan's words, the essence of the difficulty is that "we have an educational system that is fundamentally conservative. The way that teachers are trained, the way that schools are organised, the way the educational hierarchy operates, and the way that education is treated by political decision-makers results in a system that is more likely to retain the *status quo* than to change. When change is attempted under such circumstances it results in defensiveness, superficiality, or at best short-lived pockets of success." (Fullan, 1993, p. 3).

All those involved in promoting and implementing change do so from a sense of moral purpose to improve education. In a study of educational innovation in science mathematics and technology education in 13 countries (Black & Atkin, 1996), the authors conclude that "things are much more complicated than they seem.... Comparisons [between different countries] illustrate how the historical perspective and the cultural embedding—of educational thinking, of conceptions of change, and of the nature of the particular subjects involved—all have a profound effect on any process of change. [These comparisons] also illustrate the complexity of change. Fashionable opposites, such as top-down v. bottom-up, or teacher-active v. teacher-passive, are not helpful. In the real world action and change take place in more complex ways and at intermediate points along these bi-polar axes. There is another reason why change is complex. When it succeeds, it often does so for unforeseen causes. Those who think they control it sometimes find that unpredictable inner imperatives have passed control to others. Planned hierarchies of people collapse. Students may be better motivated but learn less. Teachers may be enthusiastic but students resistant, or vice-versa." (Black & Atkin, 1996, pp. 1-2).

Black and Atkin devote a chapter of their book to the question "What drives reform?" They comment that "every country that participated in our international study is dissatisfied with that education of its students in science, mathematics, or technology. Every country is trying to make changes.... Every country seems to be more or less unhappy with what it has today.... At any moment, however, each country will be preoccupied about different perceived ills.... Each country is fighting its own demons. But there is a paradox. All the most important pressures and influences that promote change in science, mathematics, and technology education in schools keep re-appearing as we move from one country to another. None appears only in a single country, and in that sense little is unique. Yet the countries are different and distinct, because each attributes a different weight to particular problems and to how they combine and interact. No country is ever exactly in phase with any other because each is a creature of its own unique history and evolution." (Black & Atkin, 1996, pp. 12-13).

In an earlier study, (Adams & Chen, 1981), the authors ask "Why then is the history of innovation such a doleful one? Why, according to the literature, is failure its companion so frequently? Why, given the burning enthusiasm of the advocates of reform, do teachers remain unimpressed, even glum, and administrators shudder?" (p. 1). In the final two paragraphs of their book they conclude a further set of questions commenting that, "the questions, it seems are endless.... [T]o finish the book on such a note of uncertainty is distressingly unimaginative." (p. 282). They do not, however, provide clear-cut answers to the questions with which they began.

The evidence from these studies and others is that the central imperative and dilemma underlying the change process in education is a sense of dissatisfaction with the status quo giving rise to the feeling that change is necessary, combined with confusion about its purpose, and uncertainty about the nature and value of its outcomes, with potential resulting disappointment and frustration for planners and teachers alike.

TIMSS and Change

The Third International Mathematics and Science Study (TIMSS), the largest international survey of attainment in mathematics and science ever attempted, took place in 1994/5 in over 40 countries, (Martin et al., 1996, 1997). Details of the underlying research questions and project design are contained in Robitaille, (1996a). For detailed technical reports see Martin and Kelly (1996, 1997). Two main groups of children were tested: Population 1, 8/9 years old, and Population 2, 13/14 years old. In addition, a third population, students in their "final year" of secondary school, was tested. A summary of the average scores of the various nations is presented in Table 1.

Table 1
TIMSS 1996/97 National Average Scores: Mathematics

	Pop. 1 (8/9 yrs)	**Pop. 2 (13/14 yrs)**	**Pop. 3 "Final Year"**
(AUSTRALIA)	546	530	522
(AUSTRIA)	559	539	518
BELGIUM-FLEMISH		565*	
(BELGIUM-FRENCH)	526		
(BULGARIA)	540		
CANADA	532	527	519
(COLOMBIA)	385		
CYPRUS	502	474	446
CZECH REPUBLIC	567	564	466
(DENMARK)		502	547
(FRANCE)		538	523
ENGLAND	513+*	506+*	
(GERMANY)		509+*	495
GREECE	492	464	
HONG KONG	587	588	
(HUNGARY)	548	537	483
ICELAND	474	487	534
IRAN, ISLAMIC REP.	429	428	
IRELAND	550	527	
(ISRAEL)	531	522+	
(ITALY)			476

JAPAN	597	605	
KOREA	611	607	
(KUWAIT)	400	392	
(LATVIA)	525	493*	
(LITHUANIA)		477+	469
(NETHERLANDS)	577	541	560
NEW ZEALAND	499	508	522
NORWAY	502	503	528
PORTUGAL	475	454	
(ROMANIA)	482		
(RUSSIAN FEDERATION)		535	471
SCOTLAND	520*	498	
SINGAPORE	625	643	
SLOVAK REPUBLIC		547	
(SLOVENIA)	552	541	512
(SOUTH AFRICA)		354	356
SPAIN		487	
SWEDEN		519	552
SWITZERLAND		545*	540
(THAILAND)	490	522	
UNITED STATES	545	500*	461

Mathematics International Average = 529 for Pop. 1
Mathematics International Average = 513 for Pop. 2
Mathematics General Knowledge International Average = 500 for Pop. 3

Nations not meeting international sampling or other guidelines are shown in parentheses.

Nations in which more than 10% of the population was excluded from testing are shown with a +. (In Latvia, only Latvian speaking students were tested, which represents less than 65% of the population.)

Nations in which a participation rate of 75% of the schools and students combined was achieved only after replacement for refusals were substituted are shown with a *.

Sources:

- Mullis, I.V.S. et al. (1997) Mathematics Achievement in the Primary School Years. Table 1.1. Boston College: Chestnut, MA.
- Beaton, A. et al. (1996) Mathematics achievement in the middle school years. Table 1.1. Boston College. Chesnut Hill, MA.
- Mullis, I.V.S. et al. (1997) Mathematics and Science Achievement in the Final Year of Secondary School. Table 2.1. Boston College: Chestnut, MA.

TIMSS caused or was partly responsible for the initiation of curricular change in mathematics and science education in a number of the participating countries—mostly, but not entirely, the poorer performing countries. What follows is a survey of what happened in 23 of these countries. Information was obtained from a questionnaire sent to TIMSS representatives in participating countries, from TIMSS country reports, and from official documents and related sources.

The 23 countries for which information was available were as follows:

Argentina	Belgium(Flemish)	Belgium(French)
Canada	Cyprus	Czech Republic
Denmark	England	France
Germany	Hong Kong	Iran
Ireland	Israel	Japan
New Zealand	Norway	Scotland
Singapore	Spain	Sweden
Switzerland	USA	

The range of possible effects of TIMSS was structured under the following headings:

- Nature of official response to TIMSS.
- Degree of publicity given to TIMSS.
- Changes to mathematics curricula as a result of TIMSS.
- Changes to teaching methodology in mathematics as a result of TIMSS.
- General comments on the effect of TIMSS.

Nature of Official Response to TIMSS

In 14 of the 23 countries there was a national response to TIMSS, namely:

Belgium(Flemish)	Cyprus	Denmark
England	France	Germany
Iran	Japan	New Zealand
Norway	Scotland	Singapore
Sweden	USA	

The nature of the response varied from country to country as shown below.

Type of Response	**Countries**
PUBLICATION OF AN OFFICIAL REPORT	Belgium(Flemish) Canada(*) Denmark France HongKong(*) Iran Japan New Zealand Norway(*)

	Scotland Singapore Spain Sweden USA * Issued by the national TIMSS team.
NATIONAL/REGIONAL CONFERENCES	Belgium(Flemish) England Iran Japan Scotland
FORMATION OF NATIONAL/REGIONAL POLICY GROUPS TO PROMOTE CHANGE	Cyprus England Germany Iran Norway Scotland USA
PLANNING IMPLEMENTATION OF POLICY INITIATIVES	Cyprus Germany
INITIATION OF DEVELOPMENTAL PROJECTS	Belgium(Flemish) Norway USA

Publicity Given to TIMSS

Type of publicity	**Countries**
WIDESPREAD THROUGH MEDIA	Belgium(French)(*) Cyprus England Germany Norway Scotland Sweden Singapore Switzerland USA * For Science only.
MINOR ITEM IN NEWS MEDIA	Hong Kong Iran Ireland Israel Czech Republic Japan Spain

WITHIN EDUCATIONAL COMMUNITY	Belgium(Flemish) Canada Denmark New Zealand
LIMITED TO THOSE IN SENIOR EDUCATIONAL POSITIONS	France
NO PUBLICITY OUTSIDE RESEARCH TEAM	Argentina

Changes to Mathematics Curricula and Teaching Methodology as a Result of TIMSS

England, Cyprus, Denmark, France, Japan, Norway, Scotland, and Sweden all indicated a variety of changes in curricular emphasis, while England, Denmark, France, Japan, and Scotland also indicated changes to teaching methodology, mainly in the direction of increasing active pupil participation in the learning process

Individual Country Effects

We now look at the effect of TIMSS, country by country. Essentially direct quotations from questionnaires or official documents are given in quotation marks.

- ARGENTINA
  Results not included in official TIMSS report. Little governmental interest in the outcomes.
- BELGIUM(FLEMISH)
  Only Population 2 (13/14 years old) tested. No curricular action taken due (a) to the relatively high position in the comparative tables, and (b) to a perception that there were variables affecting student achievement which TIMSS had not considered.
- BELGIUM(FRENCH)
  Only Population 2 tested, performing moderately well. Main emphasis on Science results, with little publicity given to mathematics.
- CANADA
  In Canada there is no Federal Ministry of Education. Educational decision-making rests with individual provinces. For details, see Robitaille (1997a). The Canada TIMSS team have published two detailed reports, (Robitaille, 1996b, 1997b). Individual Canadian provinces—for, example British Columbia and Ontario—have revised their mathematics curricula in the wake of the TIMSS survey.
- CYPRUS
  Cypriot students performed relatively poorly in both Populations. Mathematics curriculum is under scrutiny. Some topics to be deleted from the curriculum.
- CZECH REPUBLIC
  In both Populations 1 and 2 Czech performance was good. "The Czech ministry of Education used the results to argue against innovation. Critics of Czech mathematics education based their arguments for change on TIMSS background variables—attitude to the subject , for instance."

- DENMARK

  Only population 2 tested. "Ministry of Education has focused on gender differences. Greater emphasis to be given to participation of girls in mathematics and science. Comparisons are being made between TIMSS results and national tests."
- ENGLAND

  England performed relatively poorly in the TIMSS tests. Detailed results will be found in Keys et al. (1996,1997). The main reaction was the setting up of a Numeracy Task Force which produced two Reports—*Numeracy Matters* and *The Implementation of the National Numeracy Strategy*—(Reynolds, 1998a,b), in which, as the second title indicates, a national numeracy strategy for England is developed. The essence of the strategy is contained in the following set of practices recommended to Primary school teachers (Reynolds, 1998b, p. 16):
    - teaching all pupils a daily 45 to 60 mathematics lesson;
    - teaching mathematics to all pupils within a class at the same time, with a high proportion of lessons concentrating on the development of numeracy skills;
    - teaching mathematics to the whole class or to groups for a high proportion of the time, promoting participation from, and co-operation between, pupils;
    - including oral and mental work within each daily mathematics lesson;
    - providing regular mathematical activities and exercises that pupils can do at home.

  The complementary National Numeracy Project (NNP) with its detailed *Framework for Teaching Mathematics: Reception to Year 6* (Department for Education and Employment, 1999) emphasises the enhanced importance given to numeracy in the primary mathematics curriculum. A first evaluation of NNP is available from The National Foundation for Educational Research in England and Wales, (Minnis et al., 1999))
- FRANCE

  France participated in Population 2 only, performing moderately well somewhat ahead of England and Scotland. A national government report was published but there do not appear to be direct links between the TIMSS results and curricular change in mathematics.
- GERMANY

  Germany participated in Population 2 only, performing similarly overall to England and Scotland. "The Federal State Commission for Education Policy and Promotion of Research installed a group of experts to examine deficits in Science and Mathematics education and make suggestions for change. Their report was in published November 1997. As a consequence of this report an interstate five year program was installed with 15 of the 16 states (Laender) taking part. Under the co-ordination of the Institute for Science education (IPN) in Kiel, an intervention program was instigated in 180 schools to optimize science and mathematics instruction."
- HONG KONG

  Hong Kong students performed well. No government response. Minor item on news media. The Hong Kong TIMSS team have published two reports (TIMSS Hong Kong, 1996,1997).
- IRAN

  Iranian students performed comparatively very poorly in both Populations. "A group of educational experts has been formed to identify the reasons for students' low performance. During the last two years (i.e. 1997/8) many steps have been taken by the group and the national research co-ordinator in order to create positive attitudes to the outcomes of the project (for curricular change)and as a result tangible changes have been observed among educational policy makers as well as senior education experts. More emphasis to given to topics of proportion, data analysis, and measurement."

- IRELAND

  No direct publicity or government interest. Irish students performed somewhat better than those in England and Scotland but not markedly so.
- ISRAEL

  Israeli students overall performance was similar to that of England and Scotland. "Reports analysing national standing relative to other countries were published (in Hebrew) in the maths teachers journal for each of the TIMSS Populations. Very few take the results seriously. Many look for excuses and find ways to ignore TIMSS results."
- JAPAN

  Japanese students performed very well in both populations. "TIMSS revealed that Japanese children didn't like (mathematics). Therefore spontaneous activities were emphasised. In order to find time for this, topics were deleted from the curriculum. Greater emphasis was placed on childrens's' mathematical activities." A report of the Japan National Curriculum Council (1988) included the following recommendations:
    - "greater emphasis on practical and problem-solving activities, and on real-life contexts, in the process of acquisition of basic knowledge and skills in number, quantity, and geometrical figure;
    - "some reduction in curriculum content, in particular complicated computation and the use of complicated geometrical figures;
    - "use of repetitious learning as a help in mastering computation skills;
    - "establishing a new subject in upper secondary school incorporating mathematical history and statistical processing of daily events, this subject to be a required elective."
- NEW ZEALAND

  The performance of New Zealand students was very similar overall to England and Scotland. A full report is contained in Garden, (1996,1997) The New Zealand Government set up a Mathematics and Science Taskforce which reported in December 1997 (NZ Ministry of Education, 1997). Quoting from the initial Background Section of the report, "The Taskforce was established because of reported difficulties of classroom teachers (especially primary teachers) in implementing the new curricula for mathematics and science and in the light of the reported results of the Third International Mathematics and Science Study." In Section 2 of the report, entitled *Overriding Issues*, five concerns are identified and analysed. These are:
    1. "The need to raise expectations;
    2. "Under achievement amongst Maori and Pacific island students;
    3. "Professional skills and knowledge of teachers;
    4. "Material resources for teachers;
    5. "Professional development."

  In particular, the report places considerable stress on the availability of effective material resources, stating that its recommendations are made in a spirit of pragmatism and "are based on the realities if the current situation in schools, and not on idealistic notions of teachers' ability to invent rich activities by themselves and teach them with the pedagogical knowledge of an experienced researcher in (mathematics)education."

- NORWAY

  Norwegian children performed similarly to those in England and Scotland in Population 2, but rather less well in Population 1. The main effect of TIMSS has been an increased emphasis on mathematics in the training of primary teachers. "Statistics to be given lesser emphasis."

- SCOTLAND

  Scottish children performed disappointingly in both Populations 1 and 2 (Scottish Office Education and Industry Department, 1996, 1997a). The reasons for this are not fully understood and a variety of explanations have been put forward. For one analysis and overview see Macnab (1999). Scotland has also an internal standards survey—the Assessment of Achievement Project (AAP)—which has reported a continuing decline in standards of mathematics attainment since 1983, (Macnab et al., 1988; Robertson et al., 1993,1996; Scottish Office Education and Industry Department, 1998). The evidence of these reports has been largely ignored by the educational community for reasons explored in Macnab (1999a). However, publication of the TIMSS results has led to an official government report, *Improving Mathematics 5- 14* (Scottish Office Education and Industry Department 1997b), which put forward a series of recommendations for improving the situation, based at least partly on the perceptions of HM Inspectorate of Schools (Scotland) regarding characteristics of teaching in high performing TIMSS countries mainly in the Far East, and including:

  - Moving from mixed ability to some form of setting by ability;
  - Moving from individualised approaches to learning to more teacher-led whole class activity;
  - Reducing dependence on the calculator;
  - Increasing pupils facility in mental arithmetic.

  Roughly contemporaneously with the publication of the report three regional conferences were organised to which both teachers and education administrators were invited. The effects of the report and the conferences on the teaching and learning of mathematics in Scottish schools will be the subject of a separate article, (Macnab, 1999b). They are outlined briefly in the section on Discussion of Survey Outcomes.

- SINGAPORE

  Singapore students performed well in the TIMSS tests. A national report has been published on the TIMSS website: http://TIMSS.bc.edu. This report listed 7 possible reasons for this success.

  1. THE HOMOGENEITY AND COHERENCE OF THE EDUCATION SYSTEM.
  2. CHANGES TO THE CURRICULUM - placing greater emphasis on the development of mathematical concepts and the ability to apply them to solve mathematical problems.
  3. THE WORKING ETHOS OF TEACHERS.
  4. TRAINING AND PROFESSIONAL DEVELOPMENT.
  5. HOME ENVIRONMENT - the virtue of hard work and the need to strive for excellence is ingrained in students in Singapore from an early age.
  6. PEER INFLUENCE - while students in Singapore feel that doing well in schools is important, what is perhaps more important is that they also

perceive their friends to place a similar emphasis on academic achievement.
7. FOSTERING OF INTEREST IN MATHEMATICS AND SCIENCE - the climate of opinion in Singapore is conducive to the learning of mathematics and science.

- SPAIN

  Spain participated in Population 2 only. No official government response. "There is no tradition of evaluation in Spain and up to now there are no channels created by the administration to spread and give relevance and impact on possible consequences to the outcomes of evaluations in which we take part, no matter whether they are national or international evaluations." A report in Spanish has been published by INCE, the Instituto Nacional de Calidad y Evaluacion, in Madrid.
- SWEDEN

  Sweden participated in Population 2 only, performing slightly better than England and Scotland. National government reports have been published in Swedish . Curriculum change is underway but not because of TIMMS as such.
- SWITZERLAND

  Switzerland participated in Population 2 only, performing moderately well. No government report has been published and no program of curricular change initiated.
- USA

  The United States did not come out well from the test results, although at both age levels it was placed above the UK countries. A national curriculum development program, *Attaining Excellence,* has been prepared involving a set of video-taped lessons from classrooms in the US, Germany, and Japan, together with an action strategy for improving achievement in mathematics and science. Two books have been published—*A Splintered Vision* (ASV) (Schmidt et al., 1997b) and *Facing the Consequences*(FC) (Schmidt et al., 1998)—which analyse the US results in their international setting and discuss in detail their consequences for US mathematics education. These publications reveal considerable soul-searching regarding the causes of the poor performance of the US. Three of the main conclusions reached are that US schools mathematics curricula are:
    - Too fragmented and lack coherence;
    - Cover too many topics and lack depth;
    - Concentrate too much on skills and too little on problem-solving.

Discussion

The most obvious outcome of the study is the difference in the degree of attention individual responding countries gave to the TIMSS results and in their reactions to them, varying from the extensive documentation emerging from the USA, and to a lesser extent the UK and New Zealand, to the almost nil. reaction in Argentina. In a number of countries - France and Sweden, for example - curricular change in mathematics education is in progress but not directly because of TIMSS.

The case of Scotland is interesting. The main recommendations for change contained in *Improving Mathematics Education 5-14* concerned matters such as increased emphasis on whole-class teaching, inter-active teaching, and mental arithmetic, rather on the mathematics curriculum as a whole, its content and coherence. These recommendations were, moreover, agreed and accepted with virtually no dissent at the February 1998 Conferences (McKaig, 1998). There was not felt either by teachers or by the schools inspectorate - who in Scotland have a curriculum development role - to be any need to revise the 1992 curriculum document *National Guidelines: Mathematics 5-14*, which sets out official guidance on the mathematics curriculum and standards of attainment in the Primary and early Secondary years; indeed, the curriculum development emphasis from 1998 has been on Environmental Education.

This being so, it is a valid question to ask why the near unanimity on the way forward occurred. If teachers were indeed so persuaded of the rightness of the recommendations, why did they not implement them sooner? If not, why the sudden apparent enthusiasm to implement them now? It is still too early to judge in what measure implementation will actually take place, but an early survey (Macnab, 1999b) suggests that those at the conferences have moved to put at least some of the recommended changes into place and that school pupils perceive that change has occurred.

In England Wales, on the other hand, a much greater degree of prescription has been applied, with the publication of *The National Numeracy Strategy: Framework for Teaching Mathematics from Reception to Year 6*. This bulky loose-leaf format document, with a Foreword by the Secretary of State for Education and Employment in England and Wales, has been implemented in Session 1999/2000. It sets out not only macro aspects of teaching such as methodology and classroom organisation, but includes also a breakdown of lesson structure with time guides for the various elements. Detailed guidance on Oral Work, on Teaching Input and associated Pupil Activities, and on Lesson Conclusions is given. By far the greater part of the document, however, is devoted to a description of pupil learning outcomes relating to numerical work, of which the following example from Year 1 conveys the general character:

"Pupils should (be able to):

- Respond rapidly to oral questions phrased in a variety of ways such as:
  - 4 take away 2.
  - Take 2 from 7.
  - 7 subtract 3,.
  - Subtract 2 from 11,
  - 8 less than 9,.
  - What number must I take from 14 to leave 10?
  - What is the difference between 14 and 12?
  - How many more than 3 is 9?
  - How many less than 6 is 4?
  - 6 taken from a number leaves 3. What is the number?
  - Find pairs of numbers with a difference of 2.
  - I think of a number. I take away 3. My answer is 7. What is my number?
- Record simple mental subtractions in number sentence using + and - signs."

There are thus quite considerable differences between the two areas of the UK—England and Wales, and Scotland—in the degree of detailed guidance provided, and in the degree of consequential apparent leeway available., reflecting to some extent differing perceptions of the scale of the problem and so of the scale of reform required. Time alone will tell which of the two will be the more effective in implementation and in the effect on pupils' standards of attainment, although official figures (Summer 1999) have been published to show that standards in England and Wales are improving, in advance of the across-the board introduction of the Strategy. In Scotland we may have to wait for the results of the next round of the Assessment of Achievement Survey scheduled for Year 2000.

In the US different states have a freedom to devise their own mathematics curricula. California, for example, has prepared a set of mathematics standards (California, 1999) of which the Introduction says:

> These standards are based on the premise that all students are capable of learning rigorous mathematics and learning it well, and all are capable of learning more than is currently expected. Proficiency in mathematics is not an innate characteristic; it is achieved through persistence, effort and practice in the part of students and rigorous and effective instruction on the part of teachers.....The standards emphasise computational and procedural skills, conceptual understanding, and problem-solving. These three components of mathematical instruction and learning are not separate from each other; instead they are intertwined and mutually reinforcing.

We can see from these examples and from the generality of the survey evidence that a perception of the need for curricular reform in mathematics education is widespread, but that there is no overall consensus on the nature of the change required. I have argued elsewhere (Macnab, 1999c) that what may be missing in at least some of the poorer performing countries is the necessary will to ensure success in mathematics, by administrators, by teachers, by pupils and students, a will admirably expressed in the California Standards document quoted from above.

Surveys such as TIMSS perform a valuable service in that they give participating countries the opportunity in mathematics (and science) education to "see oorselves as ithers see us", to quote from Scotland's national poet Robert Burns. The survey reported here demonstrates that not all the countries made use of this opportunity; of those that did, not all were prepared to accept what was revealed; and that among those who did accept the verdict of TIMSS, there was not agreement as to the nature and depth of the changes required. Mathematics has a long history of being badly taught and worse understood. It would be pleasant that this time TIMSS will indeed make a difference.

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