FROM RESEARCH TO PRACTICE: USING THE TIMSS VIDEO STUDY FINDINGS TO ENHANCE AUSTRALIAN MATHEMATICS TEACHING

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The findings of the Third International Mathematics and Science Study (TIMSS) 1999 Video Study have been reported at both international and national levels, however its impact on Australian mathematics teaching has yet to be realised. How can the results of the video study inform teachers' efforts towards excellence in mathematics teaching in Australia? This paper highlights some of the findings and recommendations in the national report, Teaching Mathematics in Australia: Results from the TIMSS 1999 Video Study, and anticipates ways that the products of the study might be used for improving teaching and teacher development.

Background: The TIMSS 1999 Video Study

Purpose

The broad purpose of the TIMSS 1999 Video Study was to investigate and describe Year 8 mathematics and science teaching practices in a variety of countries, including several with varying cultural traditions and with relatively high achievement on TIMSS assessments. Countries participating in the mathematics component of the TIMSS 1999 Video Study were Australia, the Czech Republic, Hong Kong SAR, Japan, the Netherlands, Switzerland, and the United States.

Method

The mathematics component of the study included 638 Year 8 mathematics lessons collected from all seven participating countries. In each country, the lessons were randomly selected to be representative of Year 8 mathematics lessons overall. In each case, a teacher was videotaped for one complete lesson, and in each country, videotapes were collected across the school year so as to try to capture the range of topics and activities that can take place throughout an entire school year. In each sampled school, no substitutions of teachers or class periods were allowed. The designated class was videotaped once, in its entirety, without regard to the particular mathematics topic being taught or type of activity taking place. The only exception was that teachers were not videotaped on days a test was scheduled for the entire class period.

A series of codes was developed for and applied to the TIMSS 1999 video data by a team of individuals that included bilingual representatives from each country as well as specialists in mathematics and mathematics education. An international team that included representatives from each country and a mathematics education specialist oversaw the mathematics code development process. This team worked closely with two advisory groups: a group of national research coordinators representing each of the countries in the study, and a steering committee consisting of five North American mathematics education researchers. More information about the methodology used in the study can be found in Jacobs et al. (2003).

Reports and other resources

Reports and other resources related to the mathematics component of the TIMSS 1999 Video Study that have been published include:

Teaching Mathematics in Seven Countries: Results from the TIMSS 1999 Video Study (Hiebert et al., 2003) – an international report that includes a CD-ROM of video segments illustrating the codes developed and discussed

Teaching Mathematics in Australia: Results from the TIMSS 1999 Video Study (Hollingsworth, Lokan & McCrae, 2003) – a national report providing an Australian perspective on the results, accompanied by a CD-ROM containing four Australian public release lessons and one lesson from each of three other countries

TIMSS 1999 Video Study Public Release Lessons – a collection of 28 public release lessons presented as a 4 CD-ROM set

Various journal articles and conference papers

A Core Finding

One of the core findings of the TIMSS 1999 Video Study is that there is no single method for teaching mathematics across countries; different methods of teaching can lead to high achievement. This means there are many choices to make in mathematics teaching. How can we position ourselves to make the best choices for our students in Australia? How can we get to know the range of teaching methods available to choose from, and when to choose one particular method over another?

It is acknowledged that Australian students have consistently performed well in studies of achievement, however "the results [of the TIMSSS 1995 assessments] demonstrated clearly the possibilities for improvement" (Stacey in Hollingsworth, Lokan & McCrae, 2003, p.119). Australian educators have recognised the value of the video study not only for research, but as an extremely rich resource for professional development and "for helping set future directions for improvement" (Stacey in Hollingsworth, Lokan & McCrae, 2003, p.119).

The following sections of this paper highlight the potential of the TIMSS 1999 Video Study as a rich resource for moving towards excellence in mathematics teaching through:

- illustrating the kinds of discussions that can be prompted by the video study
- anticipating ways that the products of the study can be used for improving teaching and for teacher development

What Kinds of Discussions can the Video Study Prompt?

In his paper titled, *Windows on others' Classrooms… Mirrors for Our Own*, Will Morony states that the major implication of the TIMSS 1999 Video Study national report "will be its capacity to prompt… questions, and to inform teachers' discussions of the questions and issues that arise" (Hollingsworth, Lokan & McCrae, 2003, p.115). He, and other Australian mathematics educators have noted that the video study reports, together with the 28 public release lesson videos, offer opportunities for teachers to:

reflect deeply on their own and others' practice

make comparisons that will inform them about themselves

become aware of new alternatives

What kinds of questions and discussions are prompted by the Study? To illustrate the possibilities, some of the findings related to the nature of mathematical 'problems', and a list of questions that might be prompted by each finding are presented below.

Setting the context – lesson time devoted to problems

In all of the countries, including Australia, most lessons focused almost entirely on mathematical work (at least 95 per cent of lesson time). The remaining time may have involved organizational tasks for the lesson, discussions not related to mathematics content, or official breaks between double-lessons. During mathematical work time students were either engaged in 'problem segments' or some other kind of mathematical 'non-problem segment' (such as a brief lecture by the teacher about a concept, an account of the historical background of a mathematical idea, a discussion relating mathematics to real-world situations, etc.). Working on mathematical problems constituted a majority of lesson time – at least 80 per cent – for all of the countries, and so a close-up look at the nature of these problems provides a useful lens for considering different approaches to teaching and learning mathematics.

How much time is spent on each problem?

Solving problems made up a large part of Year 8 students' mathematical work. What types of problems did students work on? Three kinds of problems were identified:

Independent problems – single problems worked on for a clearly definable period of time

Concurrent problems – presented as a set of problems to be worked on privately over a period of time

Answered-only problems – problems completed prior to the lesson, usually through homework or an earlier test, with only their answers shared during the lesson

It was important to distinguish these problem types, as each of these provide different experiences for students, and a teacher's selection of any of these determines, in part, the structure and organization of lessons. In addition, separating out the independent problems, for which it was possible to mark beginning and ending times, allowed further analyses of the nature of these problems. How much time did students spend per independent problem? Figure 1 displays the average time per independent problem per lesson.

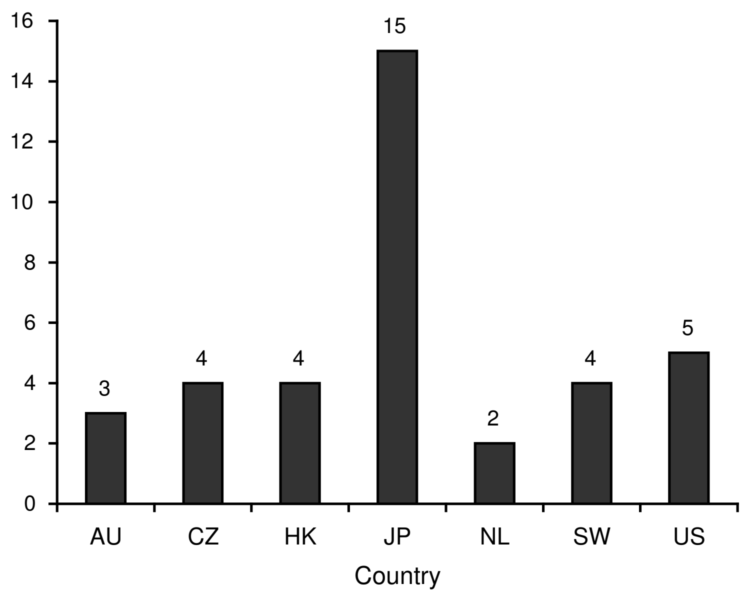

Figure 1. Average time per independent problem per lesson.

On average, more time (15 minutes) was spent working on each independent problem in Japan than in all the other countries (2-5 minutes). More time per problem could mean that the problems were more challenging, that the class spent more time discussing the problem, or simply that the teacher allowed more time for students to solve the problem.

SOME QUESTIONS PROMPTED BY THIS FINDING

Is the amount of time spent on independent problems in Australia adequate?
What kinds of problems do the Japanese work on that take so much longer than ours?
What methods do the Japanese use to explore problems in such depth?
Is it necessary to engage in problems requiring extended time if other high achieving countries don't appear to do so?
What can we learn about the problems presented in other high achieving countries, and the way they work on them?

What is the procedural complexity of problems presented?

The complexity of a problem depends on a number of factors, including the experience and capability of the student. One kind of complexity that can be defined independent of the student is procedural complexity – the number of steps it takes to solve a problem using a common solution method. How complex were the problems presented in the lessons? Every independent or concurrent problem worked on or assigned during each lesson was classified as low, moderate, or high procedural complexity according to these definitions:
Low complexity – problems requiring four or fewer decisions, with no sub-problems (e.g. solve $2x + 7 = 2$)
Moderate complexity – problems requiring more than four decisions, and possibly one sub-problem (e.g. solve for x and y: $2y = 3x – 4$; $2x + y = 5$)
High complexity – problems requiring more than four decisions and containing two or more sub-problems (e.g. graph the following inequalities and find the area of intersection: $y \leq x + 4$; $x \leq 2$; $y \geq -1$).
As shown in Figure 2, like all other countries except Japan, most of the problems presented in the Australian lessons were of low procedural complexity (77 %), and few were of high procedural complexity (8%).

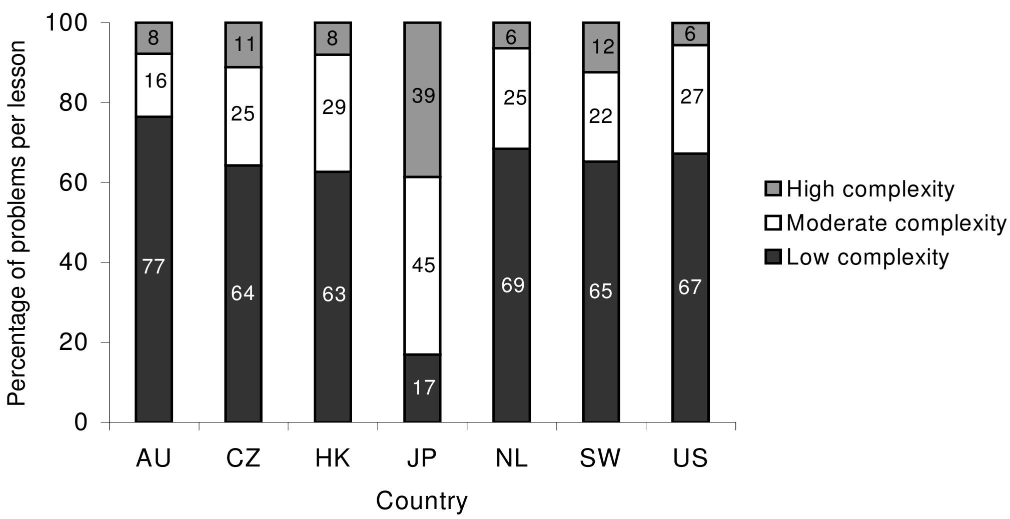

Figure 2. Average percentage of problems per lesson at each level of procedural complexity.

SOME QUESTIONS PROMPTED BY THIS FINDING:

What does this result suggest about our expectations of students?
How would very capable students feel in these Australian lessons?
How can we shift away from the current emphases on low procedural complexity problems?
What are the implications for Australian curriculum guidelines, textbooks, and other resources that we make use of?

How are problems related through the lesson?

Because mathematical problems were used as a vehicle for much of the content of the videotaped lessons, the mathematical coherence of a lesson depended, at least in part, on the way in which the problems within the lesson were related to each other. How were the problems in lessons related? The relationships among all the problems presented during the lessons were coded. Each problem, except the first problem in the lesson, was classified as having one (and only one) of these four kinds of relationships:
Repetition – the problem was the same, or mostly the same, as a preceding problem in the lesson
Mathematically related – the problem was related to a preceding problem in the lesson in a mathematically significant way (including: using the solution to a previous problem for solving this problem, extending a previous problem by requiring additional operations, etc.)
Thematically related – the problem was related to a preceding problem only by virtue of it being a problem of a similar topic or through a connection of a real-life scenario. If the problem was mathematically related as well, it was coded only as mathematically related
Unrelated – the problem was none of the above; it required a completely different set of operations to solve than previous problems and was not thematically related to any other problems in the lesson

Figure 3 displays how problems related to previous problems.

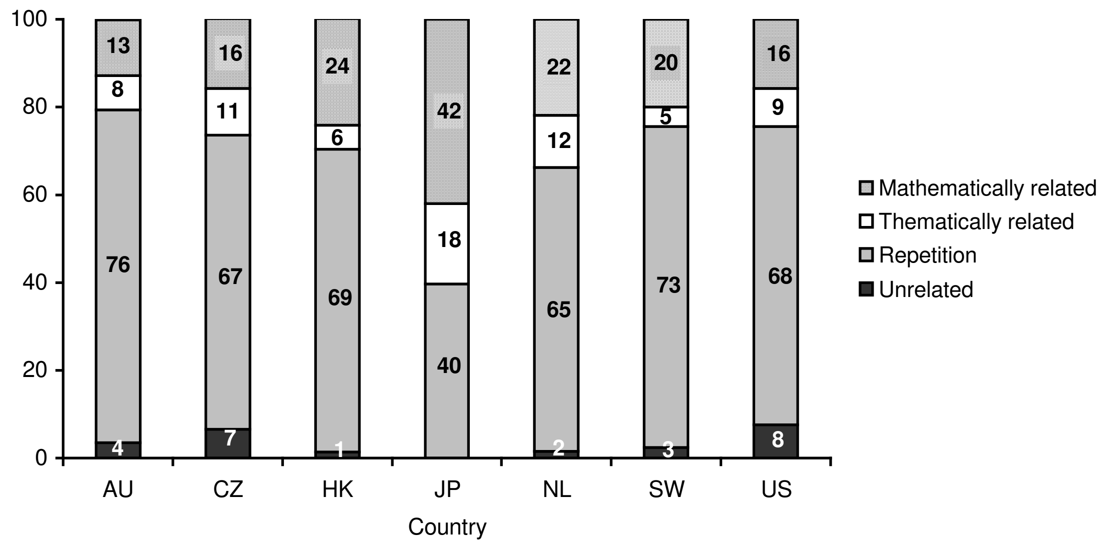

Figure 3. Average percentage of problems per lesson related to previous problems.

Overall, the results on mathematical relationships indicated that, in all the participating countries, most of the mathematics discussed and studied within the videotaped Year 8 lessons was related. For many lessons in most of the countries, including Australia, however, the relatedness seems to have been achieved, in large part, through repetition. Only in Japan were the majority of problems per lesson related mathematically in ways other than repetition.

SOME QUESTIONS PROMPTED BY THIS FINDING:

Are we conscious of the time spent on repetitions in Australian lessons?
Is the emphasis on repetition and practice desirable?
How might students feel in lessons where repetition dominates?
What can we learn about the mathematical relatedness of Japanese problems?

What kinds of problems are presented and how are they worked on?

Previous research has shown that problem statements can be examined for the nature of the mathematical work that is implied, and then compared with the mathematical work that actually is performed – and made explicit for the students – while the problems are being solved (Stein, Grover & Henningsen, 1996; Stein & Lane, 1996; Smith, 2000). What kind of mathematical processes were implied by the problems set, and how were those problems worked on? Three types of problem statements were identified and applied to all independent and concurrent problems for which a solution was reached publicly (public interaction was needed to examine the way in which the same problems were solved; Switzerland was not included in this analysis because English transcripts were not available for all lessons as some of the coding was done in Switzerland). The three problem types were:
Using procedures – suggesting the problem was typically solved by applying a procedure or set of procedures (e.g. solve for x in the equation $2x + 5 = 6 - x$)
Stating concepts – calling for the use of a mathematical convention or concept (e.g. draw an isosceles right triangle)
Making connections – implying the focus of the problem was on constructing relationships among mathematical ideas, facts, or procedures (e.g. graph the equations $y = 2x + 3$, $2y = x - 2$, and $y = -4x$, and examine the role played by the numbers in determining the position and slope of the associated lines)
Figure 4 displays the average percentage of problems per lesson of each problem statement type.

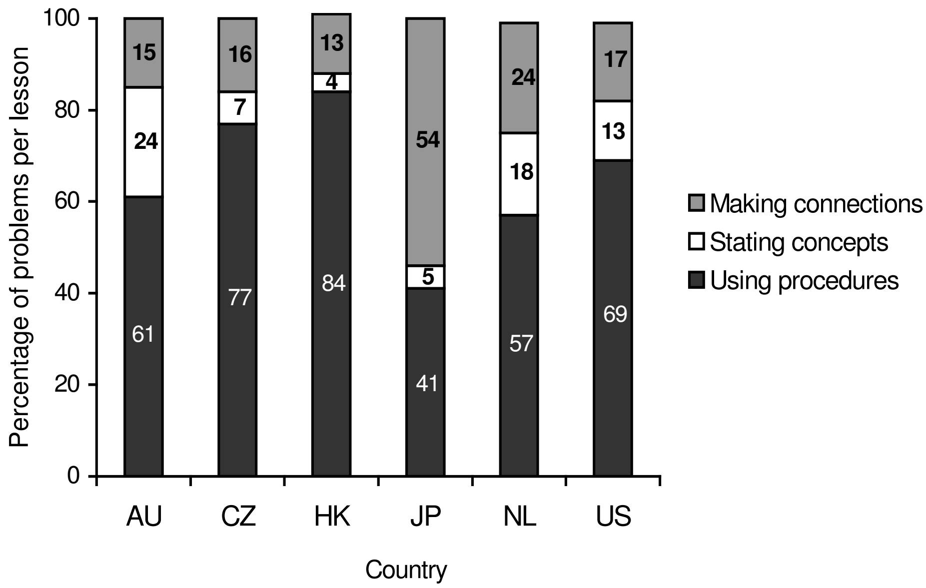

Figure 4. Average percentage of problems per lesson of each problem statement type.

An examination within each country of the relative emphases of the types of problems per lesson implied by the problem statements shows that in five of the six countries, including Australia, a greater percentage of problems per lesson were presented as using procedures than either making connections or stating concepts. The exception to this pattern was Japan, where there was no detectable difference in the percentage of problems per lesson that were presented as using procedures compared to those presented as making connections.

Each problem was also classified into exactly one of four categories based on the mathematical processes that were made explicit during the problem-solving phase. The categories for solving problems were the three types of processes defined for problem statements, plus an additional category – giving results only.

Giving results only – the public work consisted solely of stating an answer to the problem without any discussion of how or why it is attained

Using procedures – the problem was completed algorithmically, with the discussion focusing on steps and rules rather than the underlying concepts

Stating concepts – mathematical properties or definitions were identified while solving the problem, with no discussion about mathematical relationships or reasoning

Making connections – explicit references were made to the mathematical relationships and/or mathematical reasoning involved while solving the problem

Figure 5 focuses just on the problems that were categorised as 'Making connections' problem statements (for Australia, this was 15% of problems as shown in Figure 4), displaying the average percentage of those problems per lesson solved publicly by explicitly using processes of each type.

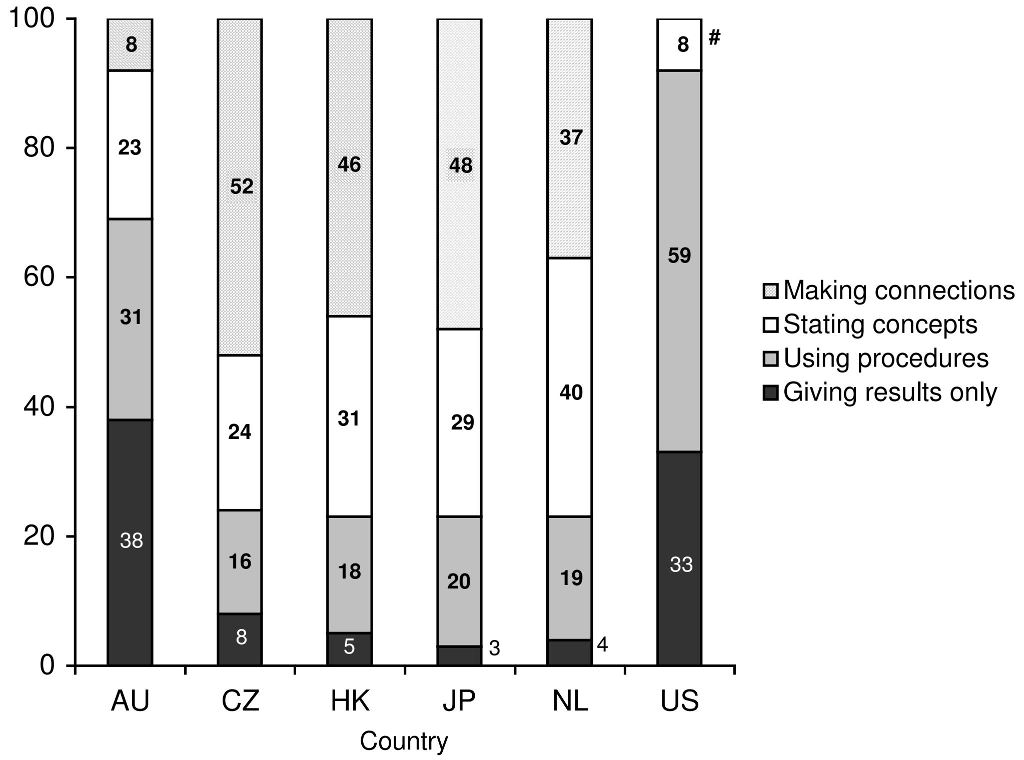

Figure 5. Average percentage of 'making connections' problems per lesson solved publicly by explicitly using processes of each type.

For problems solved publicly in Australian Year 8 mathematics lessons, it was found that, on average, the majority of both using procedures and stating concepts problems were in fact solved using the types of mathematical processes implied by the problem statements. However, as shown in Figure 5, in Australia only 8 per cent of making connections problems were in fact solved that way, a lower percentage than all other countries except for the United States. Thirty-eight per cent of making connections problems were solved by giving results only.

SOME QUESTIONS PROMPTED BY THESE FINDINGS:

Is the emphasis in Australia on assigning 'using procedures' problem statements appropriate for our students?
What can we interpret regarding the contrast in problem types assigned in Hong Kong SAR and Japan?
Can we decide whether 'using procedures' problems or 'making connections' problems are more important in promoting high achievement?
Do we have a clear image of what 'making connections' problem statements look like?
Are we conscious of the frequency with which 'making connections' problems are completed by 'giving results only'?
Are we satisfied having only 8 per cent of 'making connections' problems per lesson implemented as 'making connections'?
What can we do about the apparent absence of mathematical reasoning in Australian lessons?
Only a few of the findings related to the nature of mathematical problems have been highlighted here, and only a few questions that these findings might prompt have been suggested. Hopefully these examples make transparent the richness of the data collected and the strength of the video study reports as a basis for serious and rigorous discussion about mathematics teaching and learning. The final section of this paper describes ways that teachers might make use of the TIMSS 1999 Video Study resources to engage in such discussions and move towards excellence in mathematics teaching.

How can the Video Study Resources be Used by Australian Teachers to Move Towards Excellence in Mathematics Teaching?

Elsewhere the author with other members of the TIMSS 1999 Video Study research team has suggested:

The subtleties of implementation require teachers to focus not on *whether* particular features characterize a lesson but on the *processes* by which teaching and learning proceed in the classroom… In teaching, it is the details of implementation that seem to matter far more than the broad-stroke characteristics of teaching... Many different techniques of teaching… can be effective if they are implemented appropriately and in the right time and place. (Hiebert et al, in review).

How can teachers in Australia begin to identify, understand, and appreciate these subtleties and details of implementation? And, how can they engage in a serious and rigorous examination of them so that their response is informed and appropriately contextualised?
Many researchers have acknowledged the need to place teachers at the centre of efforts for improving teaching (see for example, Clarke, 1994; Cohen, 1990). However, as Hiebert & Stigler (2000) have noted, while the rhetoric has prevailed for many years, opportunities for teachers to learn in the immediate context of their own teaching have been few.

It is widely agreed that students learn best when taught in the context in which their knowledge is to be applied. But this principle has not been applied when teachers are the learners. Teachers perform their work in classrooms, but rarely does their training occur in classrooms. (Sarason, 1983 and Schaefer, 1967, cited in Hiebert & Stigler, 2000)

At least two promising approaches that provide opportunities for teachers to work on improving their teaching in their classrooms using the TIMSS 1999 Video Study resources to prompt discussion are currently being explored in Australia.

One approach involves a teacher professional learning program designed by ACER and AAMT. In that program, teachers use the TIMSS 1999 Video Study reports and public release materials as key resources when they design and undertake customised workplace learning projects based on the AAMT Standards for Excellence in Teaching Mathematics in Australian Schools. A detailed account of this approach can be found elsewhere in this publication (see, *Engaging with Excellence in Mathematics Teaching: Creating Excellence in the Learning Environment*).

Another approach involves the adaptation of the Japanese 'Lesson Study' model of teacher learning:

> … in the context of this new [TIMSS 1999 Video] study, we can see more clearly why the detailed analysis of lessons that forms the core of lesson study might be so important in efforts to improve teaching… programs for teachers must place the examination of teaching at the center… significant time must be devoted to examining classroom lessons and to learning how to do this with increasing skill. This includes analyzing the way in which different features can be implemented, how different implementations can influence students' learning in different ways, and why these effects might occur. (Hiebert et al., in review)

Lesson study is an ongoing professional learning experience involving small groups of teachers meeting regularly to engage in a collaborative process of lesson planning, implementation, evaluation and refinement. Key to their work is the hypothesising of anticipated student responses, the testing of those hypotheses, and the refinement of the lesson design. The groups typically meet once a week for several hours and focus on only a few lessons over the year with the aim of perfecting them. Once the lessons have been refined to a point of 'readiness' (where the group feels they can not perfect them any further – usually after several months or even years), they are shared with other teachers and other schools, complete with development and test information, and expected student responses to questions and problems. Skills gained through the detailed process of observation and analysis in lesson study transfer to teachers' work on other lessons. As Hiebert and Stigler (2000) suggest, "lesson study reverses the relationship prevalent in the U.S. [and Australia] between improving teaching and improving teachers. Working on improving teaching yields teacher development, rather than vice versa." (For further reading about lesson study see Stigler & Hiebert, 1999).

Some schools in Victoria are at the beginning stages of piloting local versions of this approach to improving teaching. These schools are using the TIMSS 1999 Video Study public release lessons together with findings in the study reports as a beginning point for their lesson study analyses and refinement, with the view to incorporating videotapes of their own teaching later in the process. While it is too early to determine the success of these pilots, early meetings with prospective teacher participants are being met with enthusiasm and optimism. It is hoped that through the lesson study process teachers in these schools will have the opportunity to:

examine the TIMSS lessons and their own lessons in detail
reflect on their own and others' practice
make comparisons that will inform them about themselves
become aware of new alternatives
engage in serious questions and discussions about mathematics teaching
develop their observational and analytical skills
improve their teaching
develop as teachers

If the lesson study process is as successful as expected, teachers will have the opportunity to use the TIMSS 1999 Video Study resources as springboards to move towards excellence in mathematics teaching, with improvements in teaching yielding improved student learning and teacher development.

Author Note

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