The TIMSS 1999 Video Study and its Relevance to Australian Mathematics Education Research, Innovation, Networking, and Opportunities

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Results from the mathematics portion of the Third International Mathematics and Science Study (TIMSS) 1999 Video Study, comparing videotaped Year 8 mathematics lessons from seven countries, were released in March 2003. This paper presents selected findings from that study, with a focus on those results that might be of particular interest to Australian educators. In addition, the paper considers ways in which the results and products from this study can make a lasting contribution to the field of mathematics education. Three areas are described: the *innovation* associated with the study's "video survey" research methodology; the *networking* possibilities for mathematics educators and researchers internationally; and, the *opportunity* provided to educators and researchers around the world to "visit" classrooms from each of the Video Study countries.[1]

Mathematics Education Research: Findings of the TIMSS 1999 Video Study

The TIMSS 1999 Video Study was a follow-up and expansion of the TIMSS 1995 Video Study of mathematics teaching. Larger and more ambitious than the first, the 1999 study investigated Year 8 science as well as mathematics, and expanded the number of countries from three to seven, including more countries 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[2], Japan, the Netherlands, Switzerland, and the United States. The TIMSS 1995 and 1999 average mathematics scores for these countries are displayed in Table 1.

On the TIMSS 1995 mathematics assessment, Year 8 students as a group in Japan and Hong Kong SAR were among the highest achieving, while Year 8 students in the United States scored, on average, significantly lower than their peers in the other six countries.

Due to both the novel "video survey" methodology, in which national, random samples of teachers were videotaped teaching a Year 8 mathematics lesson in their regular classrooms, and the differences in teaching among the countries, the release of the TIMSS 1995 Video Study garnered much attention from those interested in teaching and learning. Three countries participated in the 1995 study—Germany, Japan, and the United States—and the results suggested that each country had a distinct cultural pattern of teaching mathematics (Stigler et al., 1999; Stigler & Hiebert, 1999).

In many ways, the TIMSS 1999 Video Study began where the 1995 study ended. The broad purpose of the 1999 study was to investigate and describe the teaching practices in Year 8 mathematics in a variety of countries. The research objectives were:

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1 Sections of this paper are drawn from the reports, Teaching Mathematics in Seven Countries: Results From the TIMSS 1999 Video Study (Hiebert et al. 2003) and Teaching Mathematics in Australia: Results From the TIMSS 1999 Video Study (Hollingsworth et al. forthcoming)

2 For convenience, Hong Kong SAR is referred to as a country. Hong Kong is a Special Administrative Region (SAR) of the People's Republic of China.

- To develop objective, observational measures of classroom instruction to serve as appropriate quantitative indicators of teaching practices in each country;
- To compare teaching practices among countries and identify similar or different lesson features across countries; and
- To describe patterns of teaching practices within each country.

A final objective, building on the interest generated by the TIMSS 1995 Video Study, concerned the effective use of the information from this study:

To develop methods for communicating the results of the study, through written reports and video cases, for both research and professional development purposes.

Table 1

TIMSS 1999 Video Study Participating Countries and Their Average Score on TIMSS 1995 and TIMSS 1999 Mathematics Assessments

Country[3]	1995	1999
	Average score	Average score
Australia[a] (AU)	519	525
Czech Republic (CZ)	546	520
Hong Kong SAR (HK)	569	582
Japan (JP)	581	579
Netherlands[a] (NL)	529	540
Switzerland (SW)	534	—
United States (US)	492	502

Nation did not meet international sampling and/or other guidelines in 1995—Data not available.
TIMSS 1995: AU>US; HK, JP>AU, NL, SW, US; JP>CZ; CZ, SW>AU, US; NL>US
TIMSS 1999: AU, NL>US; HK, JP> AU, CZ, NL, US

The mathematics component of the study included 638 Year 8 mathematics lessons collected from all seven participating countries (including Year 8 mathematics lessons collected in Japan as part of the earlier study[4]). 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. Table 2 displays the sample size for each country.

3 Rescaled TIMSS 1995 mathematics scores are reported in Table 1. Switzerland did not participate in the TIMSS 1999 assessment. Source: Gonzales, P., Calsyn, C., Jocelyn, L., Mak, K., Kastberg, D., Arafeh, S., Williams, T., and Tsen, W. (2000). *Pursuing Excellence: Comparisons of International Eighth-Grade Mathematics and Science Achievement from a U.S. Perspective, 1995 and 1999* (NCES 2001– 028). USA Department of Education. Washington, DC: National Center for Education Statistics.

4 The Japanese mathematics lessons collected for the TIMSS 1995 Video Study were re-examined following the revised and expanded coding scheme developed for the 1999 study.

Table 2
Sample Size for Each Country in the TIMSS 1999 Video Study

Country	Number of mathematics lessons filmed
Australia	87
Czech Republic	100
Hong Kong SAR	100
Japan	50
Netherlands	78
Switzerland	140
United States	83

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[5]. Each code used had an inter-coder reliability of at least 85%.

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. (forthcoming).

A Selection of Key Findings

The videotaped lessons in the TIMSS 1999 Video Study presented a wealth of opportunities for examining Year 8 mathematics teaching practices. The coding and analysis of the study data was broad in scope. Forty-five codes were developed, applied and analysed by the international code development team, and 19 additional codes were developed and applied by several specialist teams of coders. A selection of key findings that might provoke interest and discussion among Australian educators is presented in this section. These findings are drawn from the reports *Teaching Mathematics in Seven Countries: Results From the TIMSS 1999 Video Study* (Hiebert et al., 2003), and *Teaching Mathematics In Australia: Results From the TIMSS 1999 Video Study* (Hollingsworth et al., forthcoming), which also contain details about many other results.

A broad conclusion that can be drawn from the TIMSS 1999 Video Study is that there is no single method of teaching Year 8 mathematics adopted by countries with high levels of achievement on TIMSS. Although all the countries that participated in the study shared some general features of Year 8 mathematics teaching, each country combined and emphasized instructional features in various ways, sometimes differently from one, two, or even all of the other countries.

The following sections highlight and discuss some key findings in two main areas: pedagogical features of the lessons, and the nature of the content. Analyses in which Australian lessons appear both similar to and different from other countries are included.

Pedagogical features of the lessons. At one level, it appears that educators in the seven countries made similar pedagogical choices. They used many of the same basic

5 All of the Australian lessons were coded by native English speakers.

ingredients. For example, virtually all Year 8 lessons contained mathematical problems, and most of the instructional time was devoted to solving them. Some problems were worked on and discussed by the whole class and some were assigned as a set for students to work on in pairs or small groups. Across all lessons, teachers devoted some time to reviewing old content, introducing new content, and practising new content. In all countries teachers spoke more words than students. Nearly all lessons incorporated either a textbook or worksheet, and computers were used in relatively few lessons across countries.

A closer look reveals, however, that there were detectable differences among countries in the relative emphasis they placed on various pedagogical elements. Some of the key findings related to pedagogical elements in Australian lessons following.

Selected features of Australian lessons that were similar to those from all countries.

- Australian Year 8 teachers and students, like those in every country, spent a high percentage of lesson time engaged in mathematical work (Australia, 95%; range for all countries, 95-98%). That is, little time was spent on non-mathematical work.
- Mathematics in Australian Year 8 classes, and classes in all other countries, was taught predominantly through solving problems (Australia, 81% of lesson time; range for all countries, 80-91% of lesson time).
- Australian Year 8 teachers, like those in every country, spoke more words per lesson than students (a ratio of 9:1; all countries at least 8:1).
- In Australia, and in all other countries, a textbook or worksheet was used in over 90% of lessons (Australia 91%).

Selected features of Australian lessons that differed from some or all other countries

- Australian Year 8 students spent more time per lesson, on average, working on sets of concurrent problems than on independent or answered-only problems[6] (concurrent problems, 54%; independent problems, 26%; answered-only problems, 0%). Students in Australia, the Netherlands and Switzerland devoted a greater percentage of lesson time to concurrent problems than the other four countries. Conversely, students in the Czech Republic, Hong Kong SAR, Japan, and the United States spent more time on average than students in the other countries working on independent problems.
- Australian students spent, on average, 36% of lesson time reviewing previously introduced content, 30% of lesson time introducing new content, and 26% of lesson time practising new content. Students in the Czech Republic spent significantly more time (58% of lesson time) reviewing previously introduced content than students in Australia and students in all other countries except the United States. More lesson time in Japan was spent introducing new content (60% of lesson time) relative to Australia and all the other countries.
- Relatively even amounts of time were devoted to public work and private work in Australian lessons (public work, 52% of lesson time; private work, 48% of lesson time). Year 8 lessons in Hong Kong SAR spent a greater percentage of lesson time in public interaction (75%) than Australia and all other countries, except the United

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6 Independent problems were single problems worked on for a clearly definable period of time, solved publicly—as a whole class—or containing a private work phase. Concurrent problems were assigned as a set to be worked on privately; some were eventually discussed, however time spent on any one concurrent problem was not able to be determined because of their assignment as a group. Answered-only problems had already been completed prior to the lesson; answers only were shared and there was no time when the problems were discussed or worked on.

States. In the Netherlands, a greater percentage of lesson time (55%) was spent in private interaction compared to lesson time in the other countries, except Australia. When looking at how lesson time was divided among these interaction categories in each country, a greater percentage of lesson time was spent in public interaction than in private interaction, except in the case of the Netherlands and Australia. In the case of Australia, there was no detectable difference between the two.

- Homework was assigned in 62% of Australian Year 8 lessons (range of other countries, 36% of lessons in Japan—78% of lessons in the Czech Republic). Across the countries, except Japan, homework was assigned in at least 57% of the lessons. Japanese Year 8 mathematics teachers assigned homework less often than teachers in Australia and all the other countries except the United States.

Some of the findings of particular interest relate to the time spent on mathematical problems. Given that problems constituted the majority of lesson time, in what ways was the time spent on problems in Australian lessons similar or different to the time spent on problems in the other countries?

It was possible to examine independent mathematics problems in detail because the exact time spent working on each problem could be calculated. This allowed an analysis of the average time spent per independent problem as well as further exploration of the nature of the work that occurred during this time. How much time did Australian students spend per independent problem?

In Australian Year 8 mathematics lessons, on average, 3 minutes was spent working on each independent mathematics problem. This amount of time is significantly less than Japan but comparable with all of the other countries (which averaged between 2 and 5 minutes per problem). In Japan, on average, 15 minutes was spent on each problem.

Another way to examine the time spent on problems is to ask what percentage of problems was worked through relatively quickly. Because a mathematics problem was defined to include simple, even routine, exercises, it could be the case that some problems, even a substantial percentage of problems, were worked through quickly. One would not necessarily expect these kinds of problems to provide the same learning opportunities as those that required more time to complete (National Research Council, 2001).

Problems that were worked on for less than 45 seconds were distinguished from those that engaged students for longer periods of time (more than 45 seconds). The length of 45 seconds represented the consensus judgment of the mathematics code development team regarding a criterion that might separate many of the more routine exercises in the sample of Year 8 lessons from those that involved more extensive work[7].

In Australia and all of the other countries, the majority of problems per lesson for which time could be reliably determined extended beyond 45 seconds (Australia, 55% of problems). Almost all of the problems in Japan met this threshold criterion (98%), a higher percentage than any other country. As stated earlier, on average, Japan also had the least number of independent problems worked on in each lesson and the longest time spent on each independent problem. Australia had a significantly lower percentage of problems per lesson that lasted at least 45 seconds than Hong Kong SAR, Japan, the Netherlands, and Switzerland (Hong Kong SAR 78% per lesson; the Netherlands, 74% per lesson).

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7 Included in this analysis were all problems except for answered-only problems and concurrent problems for which no solution was presented publicly. For the concurrent problems in which a solution was publicly presented, the amount of time spent publicly discussing the problem could be computed (and determined to be greater or less than 45 seconds).

By itself, time spent on problems says relatively little about the learning experiences of students. But like other indicators examined in the TIMSS 1999 Video Study, it provides a kind of parameter that can enable and constrain students' opportunities. It might be difficult, for example, for students to solve a challenging problem, to examine the details of mathematical relationships that are revealed in the problem, or to discuss with the teacher and peers the reasons that solution methods work as they do if the problem is completed quickly (National Research Council 2001). The average short duration and quick working through of many problems in the filmed Australian lessons suggests that teachers may not yet be following the intention of *A National Statement on Mathematics for Australian Schools* (Australian Education Council, 1991), which advocates that students should be encouraged to persist with tasks for increasing periods of time and to work by themselves on problems from beginning to end.

Nature of the content. Students' opportunity to learn mathematics is shaped, in part, by the nature of the content presented. The TIMSS 1999 Video Study provided an opportunity to examine the content of lessons in considerable detail. Moving beyond the intended curricula contained in syllabi and textbooks, the filmed lessons reveal the implemented curricula. The focus then becomes the mathematical content that students actually encountered in their Year 8 mathematics lessons. Among the key findings related to the nature of the content in Australian lessons are the following:

- No problems in Australian lessons involved formal or informal proof. In fact, proofs were rarely found in any country except Japan (Australia, 0% per lesson; range of other countries, 0% of problems per lesson in the Netherlands and the United States—26% of problems per lesson in Japan).
- Most Australian problems (76%) were repetitions of previous problems (meaning that they required essentially the same operations to solve as an earlier problem in the lesson); although this was the highest of any country, Australia was statistically greater only than Japan on this variable (Japan, 40% of problems; range of other countries, 65% of problems in the Netherlands—73% of problems in Switzerland).
- Most Australian problems (77%) were of low procedural complexity (meaning that they required fewer than five small steps and contained no sub-problems); although this was the highest percentage of any country, Australia was statistically greater only than Japan on this variable (17%).

All of the problems worked on and discussed publicly during Australian lessons were categorized according to whether they emphasized using procedures, stating concepts, or making connections. Each problem was coded twice; first based on the way the problem was presented, and then based on the way it was publicly discussed. The problem as stated represents the potential for students to engage in particular mathematical processes, and the problem as solved represents what actually transpired in the lesson. The majority of problem statements in Australian lessons suggested an emphasis on using procedures, and 15% suggested that connections would be made. However, during public discussions of mathematics problems, only 2% involved making connections between mathematical ideas, procedures, or concepts. In other words, rarely did connections become the topic of public discussions—even when problems themselves suggested the opportunity.

From these data, it would seem that Australian lessons focus largely on procedures, and place little emphasis on concepts and reasoning. However, as noted in the pedagogical elements highlights, public work accounted for only slightly more than half of the lesson time in these classrooms. What happened during private work time? Each assignment given to students to work on privately was marked as involving repeating procedures or involving something more than repeating procedures, such as developing solution procedures that were new to them or modifying solution procedures they already had learned. Approximately one-quarter (24%) of the private work time per Australian lesson, on average, was devoted to assignments in which students were asked to do more than repeating procedures. Overall, during 13% of the lesson time, on average, Australian students were engaged in mathematics that went beyond basic, known procedures. As seen in Table 3, this was a relatively high percentage among the participating countries. From these findings one might hypothesise that Australian teachers use public work time to provide the tools necessary for more conceptual work done privately.

Table 3
Average Percentage of Lesson Time During Which Students Worked Privately on an Assignment That Involved More Than Repeating Procedures

Country	Per cent of lesson time
Australia	13
Czech Republic	3
Hong Kong SAR	4
Japan	23
Netherlands	9
Switzerland	13
United States	4

AU, SW>CZ, HK, US; JP>CZ, HK, NL, SW, US.

Innovation, Networking, and Opportunity

Innovation: Expanding Mathematics Education Research Horizons Through Video Surveys

Traditionally, attempts to measure classroom teaching on a large scale have used teacher questionnaires. Questionnaires are economical, simple to administer to large numbers of respondents, and usually can be transformed easily into data files that are ready for statistical analysis. However, using questionnaires to study classroom practices is problematic because it can be difficult for teachers to remember classroom events and interactions that happen quickly, perhaps even outside of their conscious awareness. Moreover, different questions can be interpreted differently by individual teachers (Stigler et al., 1999).

Direct observation of classrooms overcomes some of the limitations of questionnaires but important limitations remain. Significant training problems arise when used across large samples, especially across cultures. A great deal of effort is required to assure that different observers are recording behavior in comparable ways. In addition, and like questionnaires, the features of teaching being investigated must be decided ahead of time. Although new categories might occur to observers during the study, the earlier lessons cannot be re-observed.

Video offers a promising alternative for studying teaching (Stigler et al., 2000). Although videotaping classroom lessons brings its own challenges, the method has significant advantages over other means of recording data for investigating teaching.

- Video enables detailed examination of complex activities from different points of view. Video preserves classroom activity so it can be slowed down and viewed multiple times, by many people with different kinds of expertise, making possible detailed descriptions of many classroom lessons.
- Collecting a random national sample provides information about students' experiences across a range of conditions, rather than the exceptional experiences. The ability to generalise nationally can elevate policy discussions beyond the anecdotal.

The TIMSS 1999 Video Study is the largest video survey of its kind to date. Through conducting the study, much was learnt about the logistical and academic challenges and constraints associated with the methodology (see the *TIMSS 1999 Video Study Technical Report*, Jacobs et al. forthcoming). Much was also learnt about the effectiveness of the video survey research process. For example, video images can be too powerful; although memorable, they can be misleading and unrepresentative. Fortunately, video surveys provide a way to resolve the tension between anecdotes (visual images) and statistics (Jacobs, Kawanaka, & Stigler, 1999; Stigler et al., 2000). Discoveries made through qualitative analysis of a few videos can be validated by statistical analysis of the whole set. While watching a video, for example, researchers might notice an interesting technique used by an Australian teacher. If they had only one video, they would not know what to make of this observation: Do Australian teachers use the technique on a regular basis, more than teachers in other countries, or did they just happen to notice one powerful example in the Australian data? Because the TIMSS 1999 Video Study collected a large sample of lessons, researchers could turn their observations into hypotheses that could be validated against the database. In a complementary process, the research team might, after coding and analysing the quantitative video data, discover a statistical relationship in the data. By returning to the actual videos, they could find concrete images to attach to their discovery, giving a means for further analysis and exploration, as well as a set of powerful images that can be used to communicate the statistical discovery. Through this process, the statistic can be brought to life.

Another way in which the TIMSS 1999 Video Study contributes to the video survey research process is through the development of specialist software tools for the coding and analysis of video data, and for presenting video cases. A software program, *vPrism*, was created for the first TIMSS Video Study and improved for the TIMSS 1999 Video Study (Knoll & Stigler, 1999). It enables the efficient coding and retrieval of time-coded video segments. A new interactive web-based software platform for examining video cases has also been developed. That platform is being used as the environment housing video clips illustrating the TIMSS 1999 Video Study coding scheme, and the collection of public release lessons that are part of the study. More information regarding these innovations is presented later in this paper.

Networking: Establishing an International TIMSS Video Study Community

As mentioned earlier, one of the objectives of the TIMSS 1999 Video Study was to develop methods for communicating the results of the study. Associated with that objective is the hope that the study will stimulate discussions of mathematics teaching among educators locally and internationally.

To facilitate such discussions, the research company responsible for conducting the study, LessonLab Inc., has been developing an on-line web-based TIMSS Video Studies learning community. The vision for this community is to: (a) provide a place for educators and researchers to share information related to events and publications associated with the TIMSS Video Studies; (b) join in discussion forums on topics of interest related to the Video Studies and video survey research; and (c) network with one another. At the time of writing this paper, the learning community is under development. General information regarding the TIMSS Video Studies and information about how to become a member of the TIMSS Video Studies learning community can be found at www.lessonlab.com.

Opportunity: A Rich, Reusable Resource for Research and Learning

In addition to the video clips that accompany the TIMSS 1999 Video Study international report (available at www.nces.ed.gov/timss), entire Year 8 mathematics lessons for public release were collected as part of the study. Twenty-eight lessons, four from each of the participating countries are now available on CD-ROMS (for ordering information visit www.lessonlab.com). The lessons include:

- video-linked text tracks in English and native languages;
- artifacts of the lesson (including customised lesson graphs, textbook and worksheet pages, and overhead transparency notes);
- video-linked commentary by the teacher, by educators within the respective countries, and by research members of the international code development team.

The goal is to provide researchers and educators around the world with samples of the kind of lessons that were analysed as part of the TIMSS 1999 Video Study and to stimulate local and international discussions of mathematics teaching. It is anticipated that the lessons will be a rich and reusable resource providing opportunities for teacher professional development and further research.

Conclusion

The Third International Mathematics and Science Study (TIMSS) 1999 Video Study has much to contribute to mathematics education researchers and educators in Australia and throughout the world. An Australian report titled, *Teaching Mathematics in Australia: Results From the TIMSS 1999 Video Study* is due to be released through the Australian Council of Education Research in July 2003 (Hollingsworth, forthcoming). This report will provide further opportunity for researchers and educators to become familiar with the results of the study from an Australian perspective.

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