ABSTRACT OF APPLIED PROJECT

Joyce O. Watson, M.A. in Mathematics Education

Graduate School

Morehead State University

1998

Abstract

This work is a proposal for communicating the results of the Third International Mathematics and Science Study to educators and other interested persons so that the findings can be used to promote an improvement in mathematics and science education locally. The work is a result of reading and researching the official documents as well as a bulk of the ensuing literature. The purpose of the work is to make the information more accessible to more people so that the results of this important study may have an impact on local education efforts. A pamphlet is included as an appendix.

Accepted by:

Thomas Diamantes, Chair

Deborah Grubb

Dale Duvall

A STUDY OF HOW THE RESULTS OF THE THIRD INTERNATIONAL MATHEMATICS AND SCIENCE STUDY MIGHT BE USED TO PROMOTE IMPROVEMENT IN MATHEMATICS AND SCIENCE LOCALLY

ABSTRACT OF APPLIED PROJECT

An applied project submitted in partial fulfillment
of the requirements for the degree of
Education Specialist at Morehead State University

by

Joyce O. Watson
Committee Chair: Dr. Thomas Diamantes
Professor of Instructional Leadership
Morehead, Kentucky
1998

A STUDY OF HOW THE RESULTS OF THE THIRD INTERNATIONAL MATHEMATICS AND SCIENCE STUDY MIGHT BE USED TO PROMOTE IMPROVEMENT IN MATHEMATICS AND SCIENCE LOCALLY

APPLIED PROJECT

An applied project submitted in partial fulfillment of
the requirements for the degree of
Education Specialist at Morehead State University

by

Joyce O. Watson
Committee Chair: Dr. Thomas Diamantes
Professor of Instructional Leadership
Morehead, Kentucky

1998

APPLIED PROJECT

Joyce O. Watson, M.A. in Mathematics Education

Graduate School

Morehead State University

1998

Accepted by the graduate faculty of the College of Education, Morehead State University, in partial fulfillment of the requirements for the Education Specialist Degree in Instructional Leadership

Thomas Diamond

Director of the Applied Project

Applied Project Committee: Thomas Diamond, Chair

Deborah Grubb

Dale Duvall

6-10-98

DATE

TABLE OF CONTENTS

Acknowledgment

The reports from The Third International Mathematics and Science Study, referenced as the Pursuing Excellence documents, are in-depth reports of the results of the TIMSS study. In no way does this work intend to minimize the findings nor to underestimate the significance of any finding. In fact, these are the most significant findings that the author has ever read in that there are very real implications for mathematics educators. Some, such as the few that I have chosen, are almost obvious. No doubt, additional implications will become more obvious upon further investigation. Neither is it the intent to misrepresent any finding through interpretation.

A written permission to use the information set forth in the documents is included as an appendix. A copy of this study will be sent to Dr. William Schmidt, Director of the United States TIMSS research.

I thank the Commissioner of Educational Statistics Pascal D. Forgione for the invitation that he extended to "anyone who is dedicated to enhancing the quality of our nation's mathematics and science education to make the fullest possible use of this rich resource". (Pursuing Excellence p.5)

Chapter One: Overview

When the U.S. National Research Center for Educational Statistics provided a fourteen page synopsis of the initial findings of the Third International Mathematics and Science Study (referred to as TIMSS) in December, 1996, the performance of the nation's eighth graders was described as "disappointing". The report was presented as a communiqué of the results of the three year research project which had been classified as embargoed from the end of the study until November 20, 1996.

Fortunately, better news accompanied the release of the United States fourth grade scores and their international ranking among the 26 countries tested for that grade level. The June, 1997 release provided a great deal of data which the media summarized as being "near the top" in science and above average in mathematics.

If American educators were celebrating that news, the celebration was abruptly halted with the third release of the study featuring the scores of students tested in twelfth grade.

"Dismal" was the response given by President Bill Clinton upon hearing the results of the study (Press release 1998, February 24).

"Unacceptable, but not unexpected," was the response by National Council of Teachers of Mathematics (NCTM) President Gail Burrill. (National Council of Teachers of Mathematics Press Release 1998, February 24 PR Newswire).

The release of the twelfth grade results elicited a greater response from the media than that of the other two grade levels. Perhaps that response was due to the fact that twelfth grade results for students in the United States showed a poor comparison to students of the other countries in both content areas. Apparently, the eighth grade scores were more acceptable and the fourth grade scores were received as good news. Additionally, twelfth grade students are ready to embark upon the world and these scores showed them less prepared to do so than their counterparts around the world.

The scores of students in grade twelve and their international rankings were embargoed until February 24, 1998. Before the end of that workday, representatives from major corporations such as Bayer and Lanacaine were responding with company press releases calling for an improvement on the part of United States education stakeholders. The President of the United States was calling for federal funding to target the improvement in mathematics education in America.

It is the purpose of this study to accomplish two goals. First, to compose a review of and to summarize a portion of the immense amount of information about TIMSS. (The sheer magnitude of the literature in astounding - 434,917 entries on the Internet to date.) The second goal of this project is to analyze the results in relation to the teaching and learning of mathematics within the Kentucky Reform Act. The end result of the second goal of this project is to prepare recommendations for Kentucky teachers, educational leaders, and policy makers.

It is not the purpose of this project to add to the overwhelming amount of literature already written. The numerous reports are excellently written and are produced by major research organizations. *Attaining Excellence: A TIMSS Resource Kit* is available for purchase from the Superintendent of Documents, United States Government Information. The resource kit is available for purchase by any interested educator. The three official reports published as Pursuing Excellence show the results of the study in a very sophisticated manner.(A sample of these documents is presented as appendix 2 . The complete documents are accessible by the internet addresses which are included in the bibliography.)

More importantly, these documents provide findings that can be explored concerning the connections among curriculum, assessment, methodologies, teacher practices, and learning environment.

However, these materials are not read universally by classroom teachers nor developers of local educational policies. While leaders in the mathematics education community may have access to these materials, the majority of classroom teachers do not. Television newscasts have given only brief descriptions that have communicated parts of the official press releases.

Perhaps a truer purpose of this project and the expected result is to provide communication concerning the results, and more importantly, how we can use these results for improvement in teaching and learning mathematics (and science) in local schools as well as throughout Kentucky.

Chapter Two: Research Description

The Third International Mathematics and Science Study (TIMSS) is lauded as the largest international comparison of education ever undertaken. The results of the study have been released in three installments over the last year and a half. Each installment has been greatly publicized. The scope of the study has no precedent in educational research according to Pascal D. Forgione, Commissioner at the National Center for Educational Statistics at the United States Department of Education in Washington, D.C. The National Center for Educational Statistics (NCES) serves the U.S. as the federal entity for collecting, analyzing, and reporting educational research data. Neal Lane, Director of the National Science Foundation, which collaborated with the other two centers to sponsor this $10 million study, states that the "Third International Mathematics and Science Study (TIMMS) was designed to enable educators and educational policy makers to compare the achievement of the U.S. students in mathematics and science with the achievement of students of the same age group and most comparable grade level."

In addition to the National Center for Educational Statistics, there were two other sites that served to collect, analyze, and report data. Boston College served as the sight for the coordination of the study. Albert Beaton oversaw the entire management of the study at the TIMSS International Study Center at Boston College. Each nation that participated collected the data in its own country and paid for the expenses incurred in that process. The cost of the international coordination was shared by the U.S. Department of Education, National Center for Educational Statistics, National Science Foundation. The sponsors of the huge study included the International Evaluation of Educational achievement (IEA). The overall coordination was originally provided by Boston College.

Dr. William Schmidt served as the coordinator for the U.S. portion of the research. Policy concerning the study was made by the U.S. National Coordinating Committee under his guidance. Dr. Schmidt's work was completed at Michigan State University which remains as the site of the U.S. TIMSS homepage. The U.S. data were actually collected by a private research company named Westat.

The four major sites for dissemination of the resulting information are currently the National Center for Educational Statistics,Washington, D.C.; TIMSS International Study Center at Boston College, Dr. Tjeerd Plomp, Chairman; Michigan State University; and the Eisenhower National Clearinghouse (ENC).

The study involved a half million students in forty-one countries. Students were actually enrolled in five grade levels but divided into three populations. Population 1 identified those students in adjacent grades that contained the most nine-year olds. In most countries, that was Grade 3 and Grade 4 as in the United States, although some countries had these students placed in grades 2 and 3. Population 2 identified the adjacent grades in each country in which most thirteen year olds were clustered. In the United States those grades were seven and eight. Population 3 identified students in the final year of secondary school whatever their ages. Students in most countries were tested in grade twelve. A few countries identified the grade level to vary between grades nine and fifteen. For the purpose of reporting results these three populations are referenced as results for fourth graders, eighth graders, and twelfth graders. Twenty-six countries were involved in testing in grade four, forty-one in grade eight, and twenty-one in grade twelve.

The assessment was administered to students in both private and public schools. The testing was held between 2-3 months before ending the 1995-1996 school year. Students with special needs were excused from the assessment.

The testing was translated to the primary language of regular instruction. In the U.S. the testing was done completely in English. Strict quality controls were observed to prevent some criticisms which have been made of earlier international studies. For example, general knowledge assessments were representative of all students at the end of secondary school, not just those who enrolled in a highly defined academic program. All of the factual information cited here is given in the official reports.

The credibility of the study may be considered sound due to the caliber of the researchers and the balance and oversight of the three principal groups provided one another. Evidence for quality assurance for the research is reported in Martin and Mullis's Third International Mathematics and Science Study: Quality Assurance in Data Collection (1996).

The results of the study were embargoed until press releases on November 20, 1996 for grade eight; June 10, 1997, for grade four; and February 24, 1998, for grade twelve.

The significance of the study extends beyond its scope and magnitude. The combination of methods of data collection allowed the researchers to gather valuable information that can be used if analyzed closely. The researchers used questionnaires to derive insights of how teachers were designing and implementing instruction. Commissioner Forgione declared in his formal statement in Pursuing Excellence A Study of U.S. Eighth-Grade Mathematics and Science Teaching , Learning, Curriculum, and Achievement in International Context (1996) that the innovative methods create a large information base. The methods of collecting information included questionnaires, in-depth analyses of textbook and curricula analyses, videotaping instruction, and case studies of educational policies. Forgione continued to say :" The result is a more complete and accurate portrait of how U.S. mathematics and science education differs from that of other nations, with extended comparisons to Germany and Japan" (p.3). Forgione refers to the total work as a benchmark for establishing what is meant by the commonly used term "world-class" education.

The other two principal documents used to report the results to the public are Pursuing Excellence : A Study of U.S. Fourth-Grade Mathematics Science Achievement in International Context (1997) and Pursuing Excellence: A Study of U.S. Twelfth-Grade Achievement in International Context (1998). The documents are described as the initial findings from the study and invite educators to make full use of all information compiled by the researchers to learn whatever can be learned from the data.

Chapter Three: Review of Literature

The official reporting documents for the TIMMS results are referred to as Pursuing Excellence : A Study of U.S. (Eighth Grade (1996) Fourth-Grade (1997) and Twelfth-Grade (1998) Mathematics and Science Teaching, Learning, Curriculum, and Achievement in International Context. Each of these three reports offers numerous important findings. The findings are not only about student achievement, but also about students' lives, teachers' professional lives, curriculum, and teaching pedagogy. Each document provides interesting details which describe similarities such as how much television is viewed by students in the TIMSS countries.

The Pursuing Excellence reports share a similar format. Each chapter is prefaced with a bulleted listing of key findings. The chapter provides the reader information that leads to an understanding of how those findings were substantiated. The written explanation embeds tables and figures to promote a greater understanding of the findings.

A caution is warranted not to oversimplify the findings or to lose sight of the fact the reform movements that have been put into place may not have had time to impact students who were tested in 1995. With this note of caution, the findings can be analyzed to look for significant ways to improve mathematics and science education in America.

Some of the key findings from the first release of data in Pursuing Excellence (1996) (Eighth- Grade) found that U.S. Eighth graders:

- score below the international average in mathematics.
- score not significantly different from eighth grade students in Germany and England.
- score about international average in algebra; fractions; and data representation and analysis; and probability; but compare less favorably in geometry and measurement.

Eighth graders:

- score above international average in environmental issues and life science but about average in chemistry and physics.
- study content that is not as challenging as the content studied in other countries.
- study many topics that are not focused nor connected to other mathematics topics.

The evidence derived from questionnaires suggests that teachers in the United States receive more overall college training, but not as much practical training. Teachers in the United States do not report having as much daily professional support as do teachers in other countries.

Pursuing Excellence (1997) reports key findings that U.S. fourth graders:

- score above average in both mathematics and science
- have an international standing that is stronger at fourth grade than it is at eighth grade in both mathematics and science.
- have no significant gender gap, although U.S. boys scored better than girls in specific science content areas.

A very significant finding is that fourth-grade students in the United States report liking both mathematics and science.

Pursuing Excellence Prepublication Copy (1998) offers many key findings of interest which are currently being taken as cause for alarm. Some of those findings state that U.S. twelfth graders:

- scores were below the international average and among the lowest international scores of the 21 TIMMS nations in both mathematics and science.
- scores were weaker in international comparisons than scores of U.S. eighth grader and fourth graders.
- scores reflect no significant gender gap in mathematics general knowledge.

- scores reflected a gender gap in science; however, the gap was the one of the smallest gender gaps reported among all of the TIMSS countries.
- achievement showed an international standing on the general knowledge component of TIMSS was stronger in science than in mathematics, just as the pattern had been noted in both grades four and eight.

Some additional findings about the achievement of students who were enrolled in higher course work in mathematics and science may be an even stronger cause for alarm. Students enrolled in pre-calculus, calculus, or AP calculus in the United States were given the same advanced mathematics assessment as that given to students enrolled in advanced mathematics classes in other nations. Performance of U.S. students in the areas of advanced mathematics and physics was among the lowest of the 16 countries which administered those assessments. In advanced mathematics 11 of the countries out-performed the U.S. and no country performed more poorly than the U.S. The results of the physics assessment showed that U.S. physics students scored at the bottom of international comparison. In both advance mathematics and physics, U.S. males out-performed females.

When U.S. Department Secretary of Education Richard W. Riley shared the news about twelfth graders during the official press release, the public was quick to react to the bad news. At 11:03 a.m. the same day, the National Council of Teachers of Mathematics produced a press release of its own with the title "U.S. Showing in Twelfth-Grade International Math Study Unacceptable, But Not Unexpected." National Council of Teachers of Mathematics and Secretary Riley urged in their respective press releases that school communities to provide a stronger curriculum aimed at providing a high-quality mathematics education for all students. National

Council of Teachers of Mathematics President Gail Burrill used the press release to underscore what Secretary Riley had said a week earlier at a Seattle conference.

" U.S. educators must quit arguing over whether to teach addition and subtraction or problem solving and teach both since both are necessary," stated Riley.

The N.C.T.M. is joined by the Mathematical Association of America, the American Mathematical Society, and the American Mathematical Association of Two-Year Colleges in advocating a solid mathematics education for every child ", said President Burrill.

United States President Bill Clinton declared before the end of the day that the results were "unacceptable". He further declared that he was requesting $ 60 million to be placed in the U.S. budget for FY99. He promotes earmarking money from the federal budget to implement a "Volunteer National Math Test" for eighth grade students.

This solidarity in purpose in the national leadership of mathematics education appears to be the result of the dismal showing of the nation's twelfth graders. Corporations were also quick to react. A company spokesperson from the Bayer Corporation provided a press release at 5:39 P.M. citing that science literacy is a critical factor for future economic success for the United States. That spokesman continued to say that within ten years science literacy would be a job requirement for corporate America. The next day a Lanacaine Company Press Release entitled, "New Math and Science Scores Show the Need to Interest Kids in Science" (1998), offered a contest for young students which required students to use science knowledge to participate.

The temptation to oversimplify student performance as "average", "below average", and "awful" certainly exists. However, the prudent action is to analyze the other findings of the study and what they can truly contribute to a deep, significant, steady improvement for achievement in the United States.

The TIMSS researchers report additional findings that they were able to derive through interviews, questionnaires and videotaping. Again the Pursuing Excellence documents report these thoroughly with a caution that more research is needed to determine the significance of the impact of various factors on achievement of U.S. students.

The TIMSS reports do not try to identify any single factors as why the performance of United States students resulted; however, the Pursuing Excellence documents report findings about teaching. For example, it is important that researchers who wish to compare achievement between twelfth graders in Germany and those in the U.S. understand that students attend different types of schools in Germany. The students may be enrolled in the *Gymnasium*, an academic high school, or a type of vocational school which provides an apprenticeship work experience.

Another finding shows the differences in the ages of students in the U.S. with the ages of students leaving secondary school in other countries. Most of the other nations had a much higher percentage of eighteen year old students. Some of the TIMSS countries have one-fourth to one-third of the classes composed of 20 year-olds. In the U.S. only two percent of the secondary students were 20 years of age.

It is the age difference that David Friedman uses as a point to negate the soundness of the TIMSS study in the March 22, 1998, article in the Lexington Herald-Leader. His story (which attributes the copyright to the Los Angeles Times) finds fault with the validity of the results of the TIMSS stating that U.S. students were among the youngest tested since they averaged 18.1 years of age, compared with 21.2 for students who were leaving secondary school in Iceland, 19.8 in Switzerland and 19.5 in Norway and Germany. He further states that the study was in error for testing students of different ages and that it was, "akin to pitting college sophomores against high school seniors."

This age difference is due to the situation that students were tested at the point where they were exiting secondary schooling. Mr. Friedman's points of information about students' ages are true. However, there is a point that policy makers can view as a factor for pondering. At what point should students be allowed to complete secondary schooling?

Mr. Friedman's article points out what he deems as fallacies in the study. He states that America's wealthy, socially advantaged students outperform students around the world, but poorer rural and urban students rank dead last. Although he does not cite evidence, his points are well taken and are commonly held opinions. (Consider how the National Science Foundation considers the Appalachia area as a geographical region that has been traditionally "under served" in mathematics and science.) He further states the obvious scenario that the nation is apparently embracing contradictory beliefs in trying to promote national standards and testing and at the same time promoting school choice and giving the power to choose curriculum to local school authorities.

Mr. Friedman's suggestion that the achievement of United States students is not really behind that of the students in the rest of the world is refuted greatly in a report published by the U.S. Department of Commerce Office of Technology Policy. The report entitled "America's New Deficit: The Shortage of Informational Technology Workers" bemoans the fact that even though the United States has previously led the world into the Information Age, evidence shows that the United States is currently having trouble keeping up with the demand for new workers. "A survey of mid- and large-size U.S. companies by the Information Technology Association of America (ITAA) concluded that there are about 190,000 unfilled information technology jobs in the United States today due to a shortage of qualified workers" (p. 3). This report explains that there is a sufficient number of technicians who are being trained; but there is a definite shortage in workers for jobs that require a strong background knowledge of mathematics and science.

In fact, the University of Minnesota is implementing a model curriculum designed to equip students to meet the needs of employers. The technology report continues to point out the necessity of the federal investments which focus on enhancing teacher skill and improving mathematics and science curricula.

Additionally, the Software Publishers Association has encouraged federal, state, and local governments to take the responsibility for producing a world-class work force. They advocate the "re-engineering of K-12 education". The article states that the process has begun. Many other companies have formed partnerships to improve mathematics and science education at the K-12 levels. Some companies have tried to do this through helping teachers sharpen their own skills. The Boeing Company, for example, now sponsors a Space Academy for Educators and a Discover Engineering Summer Science Camp where students take part in "hands-on" workshops in mathematics, engineering, and science taught by Boeing engineers.

David P. Baker's article in *Phi Delta Kappan* (December,1997) points out what he sees as strengths and weaknesses of the study in his article, "Surviving TIMSS, Or Everything You Blissfully Forgot About International Comparisons." He notes that it will be hard for anyone with a remote interest in American education to escape the TIMSS news in the upcoming year and U.S. educators could use the TIMSS data for "more thoughtful analysis of the strengths and weaknesses of American education from an international perspective."

Mr. Baker was actually in agreement with the Pursuing Excellence documents when he stated, "It is too early in the process of data analysis to provide strong evidence to suggest factors that may be related to performance." (1998, p.15)

Whether Mr. Baker agrees with the TIMSS results or not, educators can at least consider the differences in the way instruction is designed and implemented. Findings concerning classroom instruction were derived by interviewing teachers, using questionnaires and videotaping actual instruction. The collection of videotapes study sample for grade eight included 100 samples from German classrooms, 50 in Japan, and 81 in the United States. Analyses focused on both content and instructional practice. The findings were reported that in the United States, the lesson was primarily designed to offer an acquisition of knowledge and then an application. During the acquisition phase, the teacher demonstrated or explained how to solve an example. The example was most likely to be simply procedural in the United States. In German classrooms, the concept was more likely to be developed than in the United States. The goal of the lesson in both countries appears to be to teach the student a method to solve the example and then have students practice solving examples on their own with the teacher offering assistance to those students in the room in need.

Japanese lessons appeared quite different. In the Japanese classrooms, problem solving comes first, then a sharing of methods of solving the problem, and then a joint effort to understand the underlying mathematical concepts. Other findings from the eighth grade mathematics classroom analysis were equally worthy of note. The coherence of the Japanese lessons provided connection and links to previous lessons as well as between different parts of the same lessons. The United States lessons showed the greatest discrepancy from the Japanese in coherence of lessons. Lessons in the Unites States were more frequently interrupted from outside and inside the class. United States lessons showed that more topics were attempted to be taught with much less depth of understanding as a goal.

The video samples also provided a comparison of what was being taught. The concepts being taught in the United States eighth grade classroom were likely to be taught in grade seven in other countries, while the concepts being taught in Japanese classrooms were likely to be taught in grade nine in the United States.

In general, the videotape analysis produced findings that the work that students did in the U.S. was somewhat similar to that done by students in Germany, but dramatically different from what, and how, students learned mathematics in Japan. United States students spent more than 90 % of their work time at their seats practicing routine procedures, while only 40% of Japanese student seat time was spent practicing procedures. The majority of Japanese student seat time engaged students in a deeper conceptual mathematical thinking. A conclusion reported by James Stigler, Department of Psychology at UCLA (U.S. National Research Center Report No. 7, December, 1997) is that the majority of American teachers gave responses that indicated that they "use" manipulatives and cooperative groups as well as other surface features of the current reform movements, but the evidence in the videotapes does not portray the deeper characteristics of the goals of the reform such a problem solving and developing conceptual knowledge.

In another article, in the same report, some myths about American students are dispelled. Researchers found that the amount of time spent in watching television does not vary greatly among students representing the U.S., Germany, and Japan. U.S.

teachers assign more homework than teachers in Japan and Germany. Additionally, United States teachers spend more time discussing that homework. This finding implies that the result of that discussion is a decrease in the amount of time left in the class for progressing to the next concepts. United States students actually report spending more time in mathematics and science classes than their counterparts in grade eight and spend about the same amount of time outside of class studying mathematics and science as students from Germany and Japan. Problems with student discipline were reported to be quite similar in Germany and the United States.

The lack of coherence in the design and implementation in the mathematics lessons presented in the United States is described in Characterizing Pedagogical Flow (1997). A clear logical coherence in curriculum is called for if the teaching and learning of mathematics and science is to improve in the United States. Most of the numerous curricula available in the United States are unfocused. Although national standards have provided broad parameters and state frameworks have for the most part followed national standards, local stakeholders have the right to choose curriculum in many cases. It is interesting to note that a great number of charter schools, which have their right to choose curriculum have looked for national models and have taken a core curriculum model such as the one developed by E.D.Hirsch, University of Virginia, as a common source.

The literature appears to echo the controversy that surrounds whether a national curriculum is the answer or if local stakeholders have the right to choose the curriculum for their children.

It is interesting to note that the national eighth grade test seems to be just as controversial an issue. If a national test were in place for eighth graders, would the test not prescribe a curriculum that would be taught to students so that they could pass the national test? The findings from the TIMSS indicate that Japanese students outperform United States eighth graders. Students in grade eight in Japan are preparing for a high-stakes examination which will determine if they will enter high school.

TIMSS describes the United States as atypical in terms of curriculum. The U.S. is one of the few countries involved in TIMSS without a national curriculum. The trend toward publishing national standards for content areas has been growing recently. The Standards for Curriculum and Evaluation for School Mathematics (1989) have had a significant impact on textbook publishers. Further evidence can be seen in individual state curriculum frameworks where the " Standards" are the guidelines for development. Science standards have not been in publication long enough to have had any significance (National Standards for Science Education published by the National Academy Press ,1996). Although they have been influential, it is not the same as prescribed curriculum. Indeed, the U.S. state curriculum frameworks such as that of Kentucky clarify that they are merely frameworks and it is the right for local communities to create curricula of their choosing. The Kentucky School Based Decision Making (SBDM) law grants that the right to choose curriculum policy to the local school council. (160.345)

An analysis of mathematics textbooks and curriculum across 50 countries can be found in a report about curriculum published as a report Many Visions, Many Aims: A Cross-National Investigation of Curricular Intentions in School Mathematics (1997). An analysis of science and mathematics curriculum in the United States published as A Splintered Vision: An Investigation of U.S. Science and Mathematics Education (1997). Splintered Vision portrays U.S. mathematics and science teaching as unfocused.

The work shows evidence obtained throughout the TIMSS study that numerous topics are covered in the classroom. However, few of these topics are taught to an extent that is sufficient enough that students learn them. These books offer the reader an opportunity to understand the differences in United States educational structure and to compare that structure with that of other countries. The Pursuing Excellence documents do that to the degree necessary to provide evidence of equating student populations.

Splintered Visions restates the before mentioned issue of the numerous curricula and how "splintered" curriculum is currently. Splintered Visions calls for a focus on what U.S. educators want from mathematics and science education as a first step toward improvement in the teaching and learning in these areas.

While the official reports and their related publications use the detailed statistics and numerous findings to continue to inform the American public, the politicians show that they too are acutely aware of the situation that TIMSS has brought to America's attention.

As new articles concerning TIMSS are being written almost weekly, President Clinton has restated his position in a news release from United Press International on March 16, 1998. He was quoted in the release: "We must mobilize all other Americans in a concerted effort, especially in math and science education....We can, and must, do better."

On March 21, 1998, Vice-President Gore joined Taco Bell in a ground breaking ceremony for a new Science Discovery Center in Orange County, California. During that ceremony, California Representative (R-47) said that our nation's future depends upon science education.

The press release by Dr. William Schmidt perhaps gives the most important insight into the twelfth grade students' results. He stated that the results should not have surprised anyone. He provided the reader with true insights that are not mentioned elsewhere. He brought to light the fact that a few years of specialized study in high school can not possibly overcome the weak foundations that are laid in the early and middle grades. He discusses the vast differences in what the "better" students in the U.S. study and what their counterparts in other countries study. He examines those details more closely in the report **"Facing the Consequences"** (1998).

Although the numerous articles available to the reader may vary in the depth of details in which they support their statements, one element runs throughout the literature. The United States must act upon the results of this study to improve mathematics and science instruction.

Chapter Four: Implications of TIMSS

Educators will no doubt be divided in their interpretations and what the implications of the TIMSS results mean. Among the implications are the need for better teacher preparation, the need for secondary students to take more rigorous classes, and the need for states to raise academic standards.

President Clinton would have colleges raise their expectations of elementary and middle grades teachers, citing that some teachers are completing teacher preparation programs with only three mathematics courses. He also calls upon states to strengthen requirements for teacher licensure.

U.S. Secretary Richard Riley calls upon high school students to take tougher courses. He also states in his official press release that students begin to lag behind in eighth grade as the TIMSS showed achievement of eighth graders to be close to the international average. He notes in that release that students often stop taking classes in mathematics and science after 10th or 11th grade.

While no one could possibly refute these statements, the important question becomes "How can the TIMSS findings be put to work to improve the mathematics and science programs in local schools?"

Can all of the responsibility be placed on teenagers to choose the more rigorous classes? In the March edition of Mathematics Education Dialogue, Secretary Riley states that mastering mathematics is more important than ever and that students need to take rigorous mathematics and science courses. Will such suggestions cause students to do so?

Having taught high school mathematics for twenty years, I believe that the students need a great deal of guidance to make such a choice. The responsibility for this guidance must be shared by all parents, teachers, counselors, and administrators.

The School Based Decision Making Council has the power to strengthen the school's requirements above state requirements. The fiscal implications of adding mathematics requirements certainly must be considered. Coupled with the fact that mathematics teachers are not in an abundance, the fiscal facet of increased requirements does not make it likely that SBDM councils will rush to increase requirements locally. Schools are most likely to offer higher-level courses if parents and students demand such classes. SBDM councils and school officials therefore might consider the long-term effects of offering higher-level classes as a means of obtaining a respected reputation for the school and a better record of student achievement. Block scheduling is worthy of investigation by SBDM members. Although block scheduling can relieve some of the stress of having enough mathematics teachers, the SBDM councils have the responsibility of determining if that mode of delivery actually increases learning. The research is easily accessed by Internet search of the topic.

An apparent implication of TIMSS findings for Kentucky policy makers is to inquire whether or not the Kentucky minimal requirements for high school graduation are sufficient. At present, the Kentucky Program of Studies requires three mathematics credits for graduation. In recent years those could have been in any mathematics subject. The Kentucky Program of Studies did offer a great variety and suggestions of classes that could be offered at the school. There were many courses that were of an arithmetic nature that a student could use toward high school graduation requirements. (President Clinton has recently urged that high schools eliminate their general tracks and replace them with advanced placement and tech-prep classes in his call for national standards for academic excellence.)

A proposal to increase Kentucky graduation requirements to four units of mathematics was suggested in 1996, but later reduced to three credits. As evidenced by the numerous draft versions of the Kentucky Program of Studies, the state recommendation for the study of mathematics has gone from four units of study for every student, to a unit of algebra and geometry with a third course that is vaguely ass described as "should" be of content higher than middle school mathematics. (A TIMSS finding was that state curriculum frameworks were vague.)

In his February 24 press release, in which he responded to TIMSS, Secretary Riley urged students to take four years of challenging curriculum including calculus and physics as a necessity in preparing to be internationally competitive. The new Kentucky Program of Studies does not include the words calculus and physics.

Students, parents, and school councils can certainly act locally to provide these classes to students.

Since it appears that United States student achievement in science is higher than in mathematics, the calls to action by national leaders have been for improvements in the nation's achievement in mathematics. Having this support is vital to improvement. Furthermore, the mathematics community is already focused on implementation of "standards". In fact, the National Council of Teachers of Mathematics Standards (1989) document is currently under revision. A Standards 2000 Update is now being written.

Most teachers have a "speaking acquaintance" with the national standards. Yet the TIMSS findings indicate that Japanese teachers actually use the principles set forth by the United States standards in their classrooms better than teachers in the United States. The next logical step would be for administrators to investigate the standards documents with perspective to the findings in TIMSS. The videotapes from TIMSS are available for purchase. Since professional development is a significant part of the Kentucky Education Reform Act (KERA), an immediate way to make use of the

TIMSS information would be to utilize the tapes for professional development events. For example, Kentucky teachers could see how teachers from other countries develop concepts. This would clarify the finding that United States teachers do engage in as much professional support time.

On the local level, it is important to understand that there is a possibility that the findings may not be representative of an individual school. What then would be the implications for parents? In order to determine how closely the findings match a school, two steps are necessary. One, obtain and read the TIMSS reports. Secondly, investigate the school's mathematics program. The National Council of Teachers of Mathematics publishes a review manual. In Kentucky, there are mathematics and science program reviews available to schools.

Perhaps the most important implication is the easiest to see, the easiest to implement as an improvement plan, and the quickest way to affect the students at the various grade levels. The finding that teachers in the United States do not develop concepts as thoroughly and do not connect the concepts to flow into one another is an important finding. Perhaps one remedy is to train teachers to self-assess their teaching more intensely. This would provide an excellent chance to employ case studies as a mode of on-going professional development. This can be accomplished with support of a Title I resource person, a central office staff member, an assistant principal, or another teacher in the building. The first step is to raise awareness of the need to develop concepts more thoroughly. A common complaint among teachers is why students do not remember what they "covered" the year, month, week, or even day before the present. Perhaps the TIMSS finding just answered that question for teachers. The finding that teachers do not develop concepts as thoroughly as their counterparts in other countries may be true in local schools as well.

As the TIMSS reports become more widely read and studied, there will surely be many inferences drawn from them. For now, federal leaders can maintain funding for mathematics and science education. Individual states can investigate their current frameworks for sufficient rigor. School districts can assess whether their teachers have adequate training and support. School decision making councils can evaluate their local mathematics and science programs.

Teachers can strive to improve their concept development strategies. Parents can instill in their students the need for a more rigorous course load. Students can take the responsibility of learning more mathematics and science. All stakeholders can take the responsibility of acting as if our students futures depend on this improvement, because it does.

APPENDIX 1

EMAIL RESPONSE GRANTING PERMISSION TO USE TIMSS DATA AS PART OF THIS STUDY

Appendix 1

Permission to quote the Pursing Excellence and all other official TIMSS reports.

Dear Joyce,

Not to worry: All TIMSS publications, as tax-financed items, reside in the public domain. They can therefore be cited, reproduced, and disseminated without concern for copyright law.

Sincerely,

Brian Thompson
TIMSS Customer Service
(202) 219-1333
timss@ed.gov

APPENDIX 2

SAMPLES OF THE TYPE OF DATA THAT IS AVAILABLE FROM THE PURSUING EXCELLENCE REPORTS

National Center for Education Statistics

APPENDIX 2

NATIONAL AVERAGE SCORES AND STANDARD ERRORS

TABLE A2.1
Mathematics and Science General Knowledge

The 95 percent "plus or minus" confidence interval around each nation's score is two times the standard error.

NATION	MATHEMATICS GENERAL KNOWLEDGE		SCIENCE GENERAL KNOWLEDGE	
	AVERAGE	STANDARD ERROR	AVERAGE	STANDARD ERROR
(Australia)	522	9.3	527	9.8
(Austria)	518	5.3	520	5.6
(Canada)	519	2.8	532	2.6
(Cyprus)	446	2.5	448	3.0
Czech Republic	466	12.3	487	8.8
(Denmark)	547	3.3	509	3.6
(France)	523	5.1	487	5.1
(Germany)	495	5.9	497	5.1
Hungary	483	3.2	471	3.0
(Iceland)	534	2.0	549	1.5
(Italy)	476	5.5	475	5.3
(Lithuania)	469	6.1	461	5.7
(Netherlands)	560	4.7	558	5.3
New Zealand	522	4.5	529	5.2
(Norway)	528	4.1	544	4.1
(Russian Federation)	471	6.2	481	5.7
(Slovenia)	512	8.3	517	8.2
(South Africa)	356	8.3	349	10.5
Sweden	552	4.3	559	4.4
Switzerland	540	5.8	523	5.3
(United States)	461	3.2	480	3.3

MATHEMATICS GENERAL KNOWLEDGE INTERNATIONAL AVERAGE = 500

SCIENCE GENERAL KNOWLEDGE INTERNATIONAL AVERAGE = 500

NOTE: Nations not meeting international sampling guidelines are shown in parentheses. See Appendix 1 for details for each country.

SOURCE: Mullis et al. (1998). *Mathematics and Science Achievement in the Final Year of Secondary School.* Table 2.1 and 2.2. Chestnut Hill, MA: Boston College.

TABLE A2.2:
Physics and Advanced Mathematics

The 95 percent "plus or minus" confidence interval around each nation's score is two times the standard error.

NATION	PHYSICS		ADVANCED MATHEMATICS	
	AVERAGE	STANDARD ERROR	AVERAGE	STANDARD ERROR
(Australia)	518	6.2	525	11.6
(Austria)	435	6.4	436	7.2
(Canada)	485	3.3	509	4.3
(Cyprus)	494	5.8	518	4.3
Czech Republic	451	6.2	469	11.2
(Denmark)	534	4.2	522	3.4
France	466	3.8	557	3.9
(Germany)	522	11.9	465	5.6
Greece	486	5.6	513	6.0
(Italy)	—	—	474	9.6
(Latvia)	488	21.5	—	—
(Lithuania)	—	—	516	2.6
Norway	581	6.5	—	—
(Russian Federation)	532	15.0	533	10.5
(Slovenia)	523	15.5	475	9.2
Sweden	573	3.9	512	4.4
Switzerland	488	3.5	533	5.0
(United States)	423	3.3	442	5.9

PHYSICS INTERNATIONAL AVERAGE = 500

ADVANCED MATHEMATICS INTERNATIONAL AVERAGE = 500

NOTE:

1. Canada experienced deviations from international study guidelines in physics, but not in advanced mathematics. See Appendix 1 for details.
2. Nations not meeting international guidelines are shown in parentheses. See Appendix 1 for details for each country.
3. — did not participate in the assessment.

SOURCE: Mullis et al. (1998). *Mathematics and Science Achievement in the Final Year of Secondary School.* Tables 5.1 and 8.1. Chestnut Hill, MA: Boston College.

APPENDIX 3 : NATIONAL AVERAGE SCORES AND STANDARD ERRORS

The 95 percent "plus or minus" confidence interval around each nation's score is two times the standard error.

	MATHEMATICS		SCIENCE	
NATION	AVERAGE	STANDARD ERROR	AVERAGE	STANDARD ERROR
(AUSTRALIA)	546	3.1	562	2.9
(AUSTRIA)	559	3.1	565	3.3
CANADA	532	3.3	549	3.0
CYPRUS	502	3.1	475	3.3
CZECH REPUBLIC	567	3.3	557	3.1
ENGLAND	513	3.2	551	3.3
GREECE	492	4.4	497	4.1
HONG KONG	587	4.3	533	3.7
(HUNGARY)	548	3.7	532	3.4
ICELAND	474	2.7	505	3.3
IRAN, ISLAMIC REP.	429	4.0	416	3.9
IRELAND	550	3.4	539	3.3
(ISRAEL)	531	3.5	505	3.6
JAPAN	597	2.1	574	1.8
KOREA	611	2.1	597	1.9
(KUWAIT)	400	2.8	401	3.1
(LATVIA (LSS))	525	4.8	512	4.9
(NETHERLANDS)	577	3.4	557	3.1
NEW ZEALAND	499	4.3	531	4.9
NORWAY	502	3.0	530	3.6

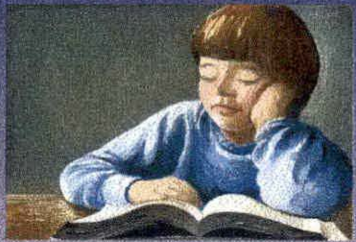
PORTUGAL	475	3.5	480	4.0
SCOTLAND	520	3.9	536	4.2
SINGAPORE	625	5.3	547	5.0
(SLOVENIA)	552	3.2	546	3.3
(THAILAND)	490	4.7	473	4.9
UNITED STATES	545	3.0	565	3.1

MATHEMATICS INTERNATIONAL AVERAGE = 529

SCIENCE INTERNATIONAL AVERAGE = 524

APPENDIX 3

BROCHURE CREATED TO DISTRIBUTE FOR THE PURPOSE OF SHARING INFORMATION FROM TIMSS LOCALLY

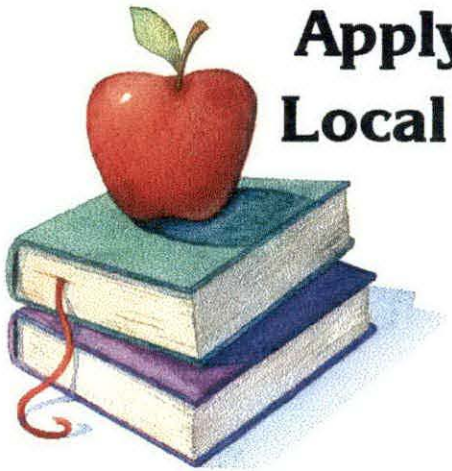


TIMSS reports provide an opportunity for Kentucky Educators to gain a broader and deeper perspective in mathematics and science education in the U.S.
Information for this document was obtained from the reports:
Pursing Excellence: A Study of U.S. Mathematics and Science Achievement in International Context
(1996) Eighth Grade
(1997) Fourth Grade
(1998) Twelfth Grade

United States National Research Center
Third International Mathematics and Science Study (TIMSS)
463 Erickson Hall
College of Education
Michigan State University
East Lansing, MI 48824-1034
http://ustimss.msu.edu/

National Center for Educational Statistics
Office of Educational Research and Improvement
U.S. Department of Education
555 New Jersey Avenue NW
Washington,DC 20208-5574
Contact: (202) 219-1395
http://www.ed.gov/NCES/timss

* The overwhelming majority of fourth graders in nearly every country indicated they liked math and science.
* Having educational resources in the home was strongly related to student achievement in every country.
* Almost universally, fourth graders spent more time learning math than learning science. Students reported studying math for about one hour outside of school each day.
* Despite reform movements, researchers found that traditional approaches still tend to prevail in classrooms around the world.
* Small group work is infrequent
* Textbooks remain the major source of presenting topics to students worldwide.
* U.S. students practiced routine procedures 86% of seat time; German students 89 % ; and Japanese students 41% .



Applying TIMSS for Local Improvement

by

Joyce Watson

The results of the Third International Mathematics and Science Study(TIMSS) will provide ambitious educators with data worthy of study for the next decade.The power of this study can be put to work to improve instruction in mathematics and science in our classrooms. We must study the findings and their implications for improvement for instruction for the most important students of all- ours.

TIMSS is....

* *The largest, most. comprehensive, and most rigorous international study of schools ever conducted. ***
* *A study of students in three populations and reported as results for grades 4,8, and 12.*
* *A statistically sound study of a half-million students in 41 countries*
* *A study of how students compare internationally in achievement in mathematics and science.*
* *a study which used questionnaires, videotapes, interviews, textbooks and curricular analyses for international comparison of fundamental elements of schooling.*
* *A presentation of significant findings that can serve educators to improve mathematics and science instruction.*

*** Pursuing Excellence (1996)*

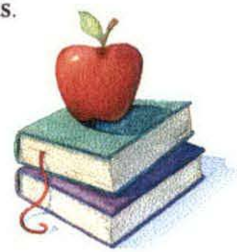
Key Findings of TIMSS include:

1. U.S. fourth graders achievement was above the international average in both mathematics and science.
2. U.S. eighth graders scored below the international average for mathematics of the 41 TIMSS countries.
3. U.S. eighth graders standing is near average in algebra, fractions, and data representations but compared less favorably in geometry and measurement.
4. U.S. eighth graders scored above average in science but not significantly different from Canada, England, and Germany.
5. U.S. eighth grade science students standing was above the international average in Earth Science, Life Science and environmental issues but just average in chemistry and physics.
6. U.S. twelfth grade students performed below international average of 21 TIMSS countries in both mathematics and science knowledge and outperformed students in only two countries.
7. U.S. performance in physics was the lowest of the countries which administered the physics assessment.
8. U.S. students' international standing was stronger at both the fourth and the eighth grade than in twelfth in both mathematics and science.
9. In general, science achievement was stronger than mathematics in each of the grade levels.
10. The U.S. had the least evident overall gender gap, although boys in grade 4 achieved significantly more than girls.
11. Students in grade 4 reported liking mathematics and science.
12. Japanese teachers led students to a greater degree of concept development of topics than their U.S. counterparts.
13. More topics were covered in the U.S. classrooms but less development of concepts and content was prevalent.
14. U.S. teachers reported familiarity with Standards and reform movements but videotapes indicate that Japanese teachers actually implement these methodologies to develop mathematical thinking and understanding.
15. Content taught in the U.S. in grade 8 resembles content taught in grade 7 elsewhere.

TIMSS stresses a key point that further analysis is needed to connect the numerous findings.

Some issues can be studied immediately at the local level.

* There is no national curriculum in the U.S.
  National Standards Documents and state curriculum frameworks can be a starting point. (Action: View a variety of textbooks and curricula . Identify what students are expected to learn.)
* Teachers and Principals can increase awareness of good teaching methods.
  Are the facts simply stated? Is there a depth of concept development? During this school year, identify one concept. Pretend you are demonstrating to a teacher all the good teaching methods you know. Do your all- time best.Observe student performance for differences in achievement.
* Use videotape examples of high quality instruction as well as written descriptions.
* Collaborate with colleagues for professional support.
  Choose concepts carefully so there is a logical connection. Develop concepts for understanding.
* U.S. secondary students are not required to take mathematics in the fourth year.
  Gather information and decide if your school has prepared students adequately for post secondary education.(Findings indicate that U.S. students might end mathematics study in the 10th grade.)
* Use data collected with Consolidated Planning
  Are there long-term trends in mathematics and science that require extra attention.? Implement a plan to address those trends.



References

Asimov, Nannete. U.S. Teens Rank Low in the World tests. (1998, February 25). The San Francisco Gate.

Baker, David P. Surviving TIMSS (1997) Phi Delta Kappan (pp 295-300)

Clinton Pushes Again on Math, Science. (1998, March 16). United Press International.

New Math and Science Scores Show the Need to Interest Kids in Science. (Company press release). (1998, February 25).White Plains, NY: PRNewswire.

Plomp, Dr. Tjeerd . (Press Release) Statement of TIMSS Primary School Years News. IEA and the Significance of TIMSS. (1997, June 10) United Press International

Riley, Richard W. (1998) Mathematics Equals Opportunity (Mathematics Education Dialogue). Reston, VA: National Council of Teachers of Mathematics

Riley Urges Students to Take Tougher Courses. (1998, February 25) Reston, VA: National Council of Teachers of Mathematics

Science Literacy is a Critical Factor for Future Success, Says U.S. Stakeholders (1998, February 24). Pittsburg, PA: PRNewswire.

U.S. Department of Commerce. (1997). America's New Deficit: The Shortage of Information Technology Workers.Washington, DC: Office of Technology Policy

U.S. Department of Education. National Center of Educational Statistics, *Pursuing Excellence*, NCES 97-198, by Lois Peak Washington, DC: U.S. Government Printing Office, 1996

U.S. Department of Education. National Center for Educational Statistics, *Pursuing Excellence: A Study of U.S. Fourth GradeMathematics and Science Achievement in International Context,* NCES 97-255, Washington, DC: U.S. Government Printing Office,1997

U.S. Department of Education. National Center for Education Statistics, *Pursuing Excellence: A Study of Twelfth-Grade Mathematics and Science Achievement in International Context,* NCES 98-049. Washington, DC: U.S. Government Printing Office, 1998

United States National Research Center. (1996) Third International Mathematics and Science Study (TIMSS): Report No. 7. East Lansing, MI: Michigan State University