Why Are U.S. Mathematics Students Falling Behind Their International Peers?

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Introduction

For more than 30 years, the United States has been concerned about the performance of their students in relation to their international peers. Since the appearance of Sputnik in the late 1950s, national leaders and educators have focused on the importance of helping U.S. students stay internationally competitive in mathematics. In 1964, the First International Mathematics Study was conducted, which gave us the first set of data as to how poorly the U.S. was performing in comparison to other leading industrialized countries. Almost twenty years later a second study was conducted, and about fifteen years after the second study came the third. All three of these international studies have shown the same results; the U.S. was not performing as well as their international competitors. The results of these studies have caused Americans to question their approach to the teaching of mathematics.

In this document I will be comparing the educational systems of the United States, France, and Japan. The reason for selecting these two countries in my comparison was that both countries outperformed the U.S. in all math subject areas on all three of the international studies conducted. I intend on identifying ways that the U.S. could improve their curriculum and procedures based on the information I have gathered on these two other countries.

Background

The First International Mathematics Study (FIMS) was conducted in 1964. This study included twelve countries, including the United States. It collected data on 13-year-olds and students in their final year of secondary school. The First Study was the International Association for the Evaluation of Educational Achievement’s (IEA) initial attempt to identify factors associated with differences in student achievement (Medrich & Griffith, 1992).

It wasn’t until about twenty years later, in 1981-1982, that the Second International Mathematics Study (SIMS) was performed. This Study was a comprehensive survey of the learning and teaching of mathematics in the schools of approximately twenty-four countries around the world. It was the results of this Study that “provoked considerable controversy when it revealed that American students were distinctly mediocre in mathematics when compared to their peers in most other countries” (Fowler & Poetter, 1999, p. 1). Such controversy encouraged the writing of several documents addressing educational reform and the need for national standards. Some of these documents included A Nation At Risk: The Imperative for Educational Reform, which was written to help define problems troubling American education and provide solutions and recommendations for educational improvement, The Underachieving Curriculum: Assessing U.S. School Mathematics From An International Perspective, which highlighted the findings of SIMS, and the NCTM’s Curriculum and Evaluation Standards for School Mathematics (1989), which made an attempt to create a set of standard to guide the revision of the school mathematics curriculum.

In 1995, the Third International Mathematics and Science Study (TIMSS) was performed. The study mainly focused on the participation of eighth grade level students, but also gained participation at the
fourth and twelfth grade levels. A total of 42 countries participated in the three grade levels and their achievement in Mathematics and science was examined. Two important documents that emerged a few years later as the result of SIMS and TIMSS, in which I would like to talk about more in depth, was the NCTM’s *Principles and Standards for School Mathematics* (PSSM) and the Mathematics Achieve Partnership’s *Foundations for Success: Mathematics for the Middle Grades* (FfS).

**PPSM and FfS**

From the results of the Second International Mathematics Study and also from the Third International Mathematics and Science Study, United States educators have seen a pattern among the top performing countries. The pattern is that most of these countries have nation-wide standards. Before the NCTM’s Standards of 1989 were released, the U.S. did not have such national standards. Hence, the production of the NCTM’s *Principles and Standards for School Mathematics* and the Mathematics Achieve Partnership’s *Foundations for Success: Mathematics for the Middle Grades*.

*Principles and Standards for School Mathematics* was intended to be a resource and guide for the decision makers who affect the mathematics education of students in PreK through grade 12 (NCTM, 2000). The document was produced by the National Council of Teachers of Mathematics (NCTM), an international professional organization committed to excellence in mathematics teaching and learning for all students. The NCTM’s three previous documents, Curriculum and Evaluation Standards for School Mathematics (1989), Professional Standards for Teaching Mathematics (1991), and Assessment Standards for School Mathematics (1995), were all important attempts by a professional organization to develop and articulate explicit and extensive goals for teachers and policymakers. The final document PSSM is a single resource that can be used to improve mathematics curricula, teaching and assessment. It is a hope of many that PSSM will give some direction for school curricula and that students will be challenged in a way comparable to international standards (NCTM, 2000).

In May 1999, Achieve and 10 reform-minded states announced the Mathematics Achievement Partnership (MAP), an extraordinary project designed to help states work together to raise expectations and measure results — using a common, internationally rigorous yardstick. MAP’s work is grounded in TIMSS, which presents a sobering picture of how well U.S. students perform compared to their peers around the world. They found from the results that U.S. students do quite well in fourth grade, average in the middle grades, and fall to the bottom of the international rankings by the end of high school. The *Foundations for Success: Mathematics for the Middle Grades* document released its first draft in June of 2001. It attempts to provide the framework for what American students need to know to meet their potential for learning challenging mathematics in the middle grades. The expectations found in the *FfS* document are rigorous and will not be achieved right away, but the potential is possible for U.S. students who, by the fourth grade, already are performing among the top students internationally in mathematics (MAP, 2001).

Both the *PSSM* and *FfS* documents have good intentions for U.S. math students. With time, both MAP and NCTM believe that the standards set forth in their respective documents are attainable and will help students to rise above the international average when in competition with their peers.

**Overview of Countries**
Japan

Japan has a national curriculum that all elementary and secondary schools must follow. The schools are headed by the Ministry of Education, which is an administrative body responsible for school education. The Ministry supervises and finances local boards of education. They also prepare and distribute a course of study that forms a standard curriculum that all textbooks must follow (Miyake, Nagasaki, 1997).

The school year begins April 1st and ends March 31st. Most elementary and secondary schools are in session for 35 weeks or 190 days. Public school students attend school Monday through Friday and two to three Saturdays per month. Elementary school students attend 6 hours per day M-F, while secondary school students attend 7 hours per day M-F. All students receive four hours of instruction on the Saturdays that they attend (Miyake, Nagasaki, 1997).

Class size in Japan is rather large. In the elementary schools, class size is an average of 29 students. The lower secondary school, equivalent to our middle school, has an average of 34 students, while the upper secondary school has a class average of 40 students (Miyake, Nagasaki, 1997).

Teachers in Japan must have a four-year bachelor’s degree, with several courses in educational theory and pedagogy as part of their degree (Miyake, Nagasaki, 1997).

The Japanese education system is based on the idea that all children have the potential to learn, and therefore the curriculum in all subjects is virtually the same for all students through lower secondary school. Therefore, neither elementary nor lower secondary schools group students by ability level. Students that have difficulty keeping up hire private tutors and attend after-school and weekend courses (AFT & NCISE, 1997).

Japanese students have a very strong commitment to hard work and excellence. Families and the school system instill a strong work ethic. From the very early grades, the curriculum is designed to build a disciplined commitment to hard work. Japanese students know that this hard work will pay off and this attitude is nurtured and reinforced from a very young age (AFT & NCISE, 1997).

The high schools in Japan must be applied to and one must take a rigorous entrance exam. Admission is based on course grades and on test performance. This process is very competitive, so students are usually guided by their teachers to apply where they will most likely be accepted. For the lower achieving students, they usually attend schools with a more vocationally oriented curriculum (AFT & NCISE, 1997).

Japanese students who plan on attending a college or university must pass a college entrance exam. They see their entire schooling as preparation for the examination. Students understand that these tests are important to their future and understand that job opportunities and career advancement is better for graduates of the best colleges and universities (AFT & NCISE, 1997).

France

Schools in France are headed by the French National Ministry of Education. It is the Ministry that defines educational goals, programs, levels of diplomas, and appoints teachers. It mandates the number
of hours elementary and secondary school students must spend in each subject at each grade level. For each subject, it outlines both general principles of instruction and specific concepts to be mastered. All students regardless of ability and achievement take the same national curriculum during their first five years of elementary school and the first two years of lower secondary school (the same as our grades 6 and 7). More than three-quarters of the students will continue through grade 8 and 9 with a common national curriculum (Servant, 1997).

The law states that the school year must be 36 weeks long. Primary school students have 26 hours of class per week, and lower secondary students have an average of 27 hours per week. At the secondary level, schools organize their time in various ways and the length of the day can also vary significantly during the week (Servant, 1997).

The average number of students in preprimary classes is about 27. Primary schools have an average class size of 23, lower secondary has an average of 25, and upper secondary has an average size of 22 in the public schools (Servant, 1997).

The basic requirement for primary and secondary teachers is a 3-year university degree. After obtaining their degree, preservice teachers must pass competitive examinations (Servant, 1997).

Students can earn the lower secondary diploma, brevet de college, at the completion of ninth grade. In order to earn this diploma, students must meet two requirements: complete four years of nationally prescribed common courses in the general track of lower secondary school, and sit for brevet exams in French, math, and history/geography. The diploma awarded is based in exam results and classroom performance in all subjects the last two years of lower secondary school. Students therefore have high motivation to take their coursework seriously since their course grades are of much importance in earning a diploma. Although the diploma itself is not a formal requirement, 90% of students take the exam. It appears that students must achieve a level of performance in their coursework equivalent to passing the exam if they wish to continue in the academic track at upper secondary school (AFT & NCISE, 1997).

Once in an academic track in upper secondary school, students have 3 more years to complete of schooling before going onto a college or university. In the first year of upper secondary school, students follow a common curriculum, which makes the course load quite heavy. Students have to be successful in this year in order to be promoted to the second year. This is not automatic, and approximately 78% move to the second year (AFT & NCISE, 1997).

If a student wants to go onto a university, they must earn the baccalaureat. This is France’s renowned secondary school diploma, which can only be earned by passing challenging national examinations at the end of 12th grade (AFT & NCISE, 1997).

United States

States have primary responsibility for education in the U.S. Historically, the federal government has played a limited role in areas such as curriculum and assessment. States and local districts have shared the majority of the responsibility in these areas, and each state has approached these responsibilities differently. Some states have defined a core curriculum and have developed statewide assessments. Others have entrusted local districts with these responsibilities. As a result of such a decentralized system, there has been a wide variation in curricula and performance expectations across the country (AFT & NCISE, 1997).
The U.S. does not have clear and rigorous standards. Therefore it is relatively easy for students to pass through the system. Students move from grade to grade without having to systematically demonstrate competency in any subject matter. Even though they take numerous standardized tests, their achievement on these exams does not usually affect their progress through the system (AFT & NCISE, 1997).

Most schools hold classes between the beginning of September and the end of May. The typical calendar year turns out to be 175-190 instructional days. The school week is Monday through Friday, and each day is approximately six hours long. In 1993-94 school year, the pupil-teacher ratios averaged 17 in elementary grades and 11 in secondary grades (Robeck, 1997).

Teachers may be certified in two different ways. The first way is to earn a four-year degree in education. The second certification can be obtained by earning an education certificate through one of two years’ study after a four-year degree in another area (Robeck, 1997).

The United States has the largest and most diverse postsecondary education in the world. Unlike Japan and France, U.S. students are not required to take common exams in order to gain admission into college. Since there is no single examination students must take, admissions officers use several tests in order to make their selections. These tests are the SAT I, SAT II, ACT, and AP (AFT & NCISE, 1997).

**SIMS Findings**

*The Underachieving Curriculum: Assessing U.S. School Mathematics From an International Perspective* report was intended to highlight the major findings of the Second International Mathematics Study. It is with this information, provided by this document, that I wish to compare the U.S. with Japan and France.

In Population A, which included seventh and eighth graders, Japan obtained the highest achievement scores of all countries in the study. The U.S. achieved slightly above the international average in computational arithmetic, and well below the international average in non-computational arithmetic. Achievement in geometry for the U.S. was among the bottom 25% of all countries. As for France, they scored well above the international average.

In Population B, which corresponded to the U.S. twelfth grades, Japan had the second highest achievement scores along with France achieving above the international average. As for the U.S. students, they scored below the international average. The achievement of the Calculus classes, which are the nation’s best students, was at or near the average achievement of the advanced secondary school mathematics students in other countries. The achievement of the U.S. precalculus students, which represent the majority of twelfth grade college-preparatory math students, was substantially below the international average. In some cases, the U.S. ranked with the lower ¼ of all countries in the Study and was the lowest of the advanced industrialized countries.

**Other Research Findings**

In all three of the International Studies of Mathematics, the results have been quite similar. The results from TIMSS show that in fourth grade, U.S. achievement is above the international average, in eighth grade, achievement is at or a little below the average, and by the last year of school, students’
achievement is well below the average. Anyone finding out this data would ask the same question, namely, why is there a continuous decline from elementary school through high school, and what can the United States do to better improve achievement?

In elementary school, the topics taught in mathematics are quite similar across the globe. Since U.S. students tend to get along well with the basics, when it comes to testing achievement, we usually perform above the international average (AFT, 1998).

The middle school years are where the research tends to show a sudden decrease in achievement. In eighth grade, our students are still studying topics that the rest of the world’s students have already mastered. “Mathematics instruction in the middle school years does not take previously taught content to more complex levels, nor does it introduce challenging material that prepares students for higher-level content in the eighth grade” (AFT, 1998, p. 4). Therefore, when countries such as Japan and France are moving onto topics such as algebra and geometry, the U.S. is spending considerable time on whole-number computation and fractions and decimals (AFT, 1998). The TIMSS study concluded that the mathematical content, in textbooks and in actual practice, in the U.S. compared to other countries is less advanced.

How Are Other Countries Attaining Their High Achievement?

Japan
Over the years, American schools are constantly being compared to Japan’s schools. They are considered to be a “powerhouse” over us. So we ask the question, why? What is going on in their schools that is not occurring in ours?

Japan’s cultural emphasis on mathematics is a huge factor. Parents and society have great concern over high achievement, so they regard this subject as very important. The home is considered a powerful educational institution. Parents provide the motivation for their children to succeed at very young ages. They provide private tutoring when their children are not performing as well as others, or when they need help with passing entrance examinations into college or university (Dutton, 1977).

Another factor of Japan’s success is how much time they spend in the classroom. School is in session 5-6 days a week. Therefore, students in Japan average at least 8 more hours of schooling a month than U.S. students (Miyake, Nagasaki, 1997). Research has also shown that Japanese students take more mathematics courses than American students do (Stigler, 1988).

Japanese superiority in math exists as early as kindergarten, and it is remarkable by the time the children reach fifth grade. The dominance of these students is not limited to basic computational skills but extends to nearly every math-related area that has been tested (Stigler, 1988). This supremacy can be credited to the amount of verbal explanation that occurs during a mathematics class. Japanese teachers constantly stop to discuss and explain the topic at hand. The teachers give, and ask students to give, lengthy verbal explanations of mathematical concepts and algorithms, opposed to American teachers who are more likely to stress participation in non-verbal activities or ask short-answer questions to lead students into a new topic. Japanese teachers not only explain more but also produce more complicated and abstract explanations than American teachers, especially in the first grade (Stigler, 1988).

Japanese classrooms appear to move at a move relaxed pace than American classrooms. Only teachers in
Japan were ever observed to spend entire forty-minute lesson on one or two problems. Japanese teachers seem not to rush through material but rather are constantly pausing to discuss and explain. They are well prepared, enthusiastic about helping children learn the topic at hand, and are continual in their efforts to secure pupil mastery (Dutton, 1977). The relaxed pace of learning in these classrooms, combined with the high level achievement, is a fact worthy of more reflection. Understanding takes time, and maybe spending that time in the early stages will lead to future benefits (Stigler, 1988).

The way Japanese schools evaluated students’ work is quite different from American schools. In Japan, if a student has produced an incorrect solution, they would be asked to present it to the entire class for discussion and correction. American teachers tend to evaluate work more privately than Japanese teachers. They were more likely to limit public evaluations simply to reporting how many problems were answered correctly (Stigler, 1988).

From Japanese observations, there were two important findings. The first one was that young children are competent of responding to, and understanding complex verbal explanations. The second finding was that it is possible to stress both concrete experiences and verbal explanations at the same time. In fact, it is possible that both are necessary to promote high levels of learning (Stigler, 1988).

**France**

France has also ranked above the United States in all three international studies. Researchers feel that the French example is potentially helpful to Americans for three reasons. The first is that they feel France is culturally closer to the U.S. than some other countries. Second, both France and the United States have very diverse populations. The third reason is that France has a relatively large gap between its upper and lower class, similar to the U.S. (Fowler & Poetter, 1999).

France has some practices and polices that benefit both advantaged and disadvantaged students. Children may enter preschool and attend an all day preschool program at the age of two. This is completely optional, however 90% are in attendance by the age of three. Even though the children play most of the day, the enrichment of language and the development of “rudimentary notions” on math are also part of the school day. The French believe that this highly developed educational program will help children from non-French speaking and poor homes enter first grade with a better chance for success in school than they would have had otherwise (Fowler & Poetter, 1999).

In French elementary schools, problem solving plays a central role in the teaching and learning of mathematics. “The French view the ability to understand and master math concepts in number and arithmetic, geometry, and measurement as keys for students to be able to solve problems that are new and about which students have little previous knowledge” (Fowler & Poetter, 1999, p. 12). In American schools, problem solving is typically viewed as doing “word problems” which challenge the student to pull out and isolate a math skill for operation. However, in France, they begin at early ages to advance mathematical thinking by teaching students to generate new methods for organizing and addressing a problem and for creating alternative solutions. Math skills are rarely taught in isolation from their relationship and application to genuine, life-like situations (Fowler & Poetter, 1999).

One way teachers evaluate student learning is through student notebooks. Each student has a separate notebook for each subject they have in elementary school. In their math notebook, students are expected to keep precise notes on math and document their math thinking about complex, well-situated problems.
from their own environment. The teachers, in turn, keep an ongoing record and dialogue with the students about math in their individual notebooks (Fowler & Poetter, 1999).

In French classrooms, students are expected to be attentive, conscientious, productive, thorough, and receptive. Observation of these classrooms have shown that these rules are held and taught in school and that this “regulative” discourse is strongly framed. Students, however, are also encouraged to be creative and interactive (Fowler & Poetter, 1999).

French teachers almost always use whole class instruction and expect every child to participate and to attempt to solve problems. They also organize each math lesson as a tightly structured “sequence” of activities that grow out of an initial, problematic situations. Most of the class time is devoted to whole group discussion and analysis of problems. The pace is very rapid and the students play an active role. When the time comes to working on individual notebooks, the students understand that they are to produce a solution to the problems and that, not only should they try to solve the problems correctly but also that their solution must be neatly presented and must correspond to a particular format (Fowler & Poetter, 1999).

French students spend most of their time in math class participating with the teacher in the development of concepts. When the students work individually, they usually “apply the learned procedures to new situations rather than either practicing routine procedures or inventing new ones” (Fowler & Poetter, 1999, p. 22).

Teacher recruitment and selection processes in France guarantee that knowledgeable professionals teach elementary mathematics. This is because the French school system that great mathematical learning takes place at young ages, and therefore, teachers have a very important role. The teaching is said to be strongly paced, and the teacher determines what the students will study and how rapidly they will progress while following the national curriculum. Historically, this strong pacing has been the major cause of a high retention rate in the elementary grades and into the middle grades.

Another reason why it is so important to have knowledgeable teachers is because teachers try to develop mathematical concepts rather than simply stating them. The French do not use a skill and drill approach to teaching mathematics. Their role includes acting as a discussion leader, selecting the sequence of problems to be studied and providing feedback to students (Fowler & Poetter, 1999).

**Conclusion**

Both Japan and France have national curriculums and nationwide assessments. President Clinton, in response to the poor showing of U.S. eighth graders on TIMSS, proposed that there be a voluntary national test of mathematics achievement of eighth grade students benchmarked to international standards (AFT, 1998). This proposal would at least attempt to encourage the U.S. to implement a national assessment as in the other two countries.

American students also need to have common curriculums. Both the PSSM and FIS documents are trying to accomplish just this. Research has found that the U.S. curriculum is dramatically differentiated at the eighth grade level. Four programs were identified in a research study, and each had extremely different math content. The U.S. curriculum is characterized by a great deal of repetition and review, with the result that topics are covered with little intensity (IEA, 1987).

American students need to become better problem solvers. Items on the international tests are open response and require that students show how they solve problems. U.S. tests are predominantly multiple-choice items that require little intellectual demand associated when determining an answer.
The French have a great deal to teach Americans about effective teaching and learning in schools. With the support of a focused national curriculum, appropriate pedagogy and assessment practices, and extremely knowledgeable teachers, French students develop math skills and problem solving abilities early in their educational careers. It is believed that as a result of their rigorous preparation in the early grades that French students consistently score higher on standardized tests (Fowler & Poetter, 1999).

The French example suggests that “one of the most effective ways to improve the teaching of mathematics in American elementary schools would be focus on teacher selection and educational processes. If the American states adopted policies which guaranteed that only people who are competent in mathematics and comfortable discussing it, raising questions about it, and helping children explore it taught in American schools, we would probably see a remarkable improvement in the mathematics achievement of American children within a generation” (Fowler & Poetter, 1999, p. 35).

References


