Competitive Edge:
A Cross-National Examination of Comparative Advantage in Mathematics and Science

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Abstract

More than any other time in human history, the dawn of the 21st Century has witnessed the emergence of a global economy and the opening of international borders for free trade. These two factors have combined to engineer an unprecedented economic and technological competition among nations. Nations that will thrive in this competitive atmosphere must endeavor to maintain a comparative advantage over others. Sustaining a comparative advantage will be dependent on the availability of a skilled and efficient workforce.

Developing a skilled and efficient workforce is dependent on the quality of students produced through K-12 pipeline, especially in the core areas of science and mathematics. Mathematics and science are the vehicles for producing a skilled workforce needed to sustain a nation's competitive edge in today's global economy. As a result, many countries have turned to international assessments in mathematics and science as a way of measuring their future comparative advantage.

This paper examined the cross-national performance of fourth-, eighth-, and twelfth-grade students in the Third International Mathematics and Science Study (TIMSS) 1995, eighth-grade students in the TIMSS-Repeat 1999, and fourth- and eighth-grade students in the Trends in International Mathematics and Science Study (TIMSS) 2003. The TIMSS assessment data were used to identify nations that have a competitive edge in the critical areas of mathematics and science.

Data analyses portrayed interesting findings. The TIMSS 1995 data showed that in mathematics assessment, students from Singapore, Korea, Japan, and Hong Kong topped the world in both fourth and eighth grades. Korea, Japan, United States, and Austria led in fourth-grade science, and Singapore, Czech Republic, Japan, and Korea outperformed the world in eighth-grade science. In the TIMSS-R 1999, Singapore, Korea, Chinese Taipei, Hong Kong, Japan, and Belgium-Flemish led in mathematics in eighth-grade, while Chinese Taipei, Singapore, Hungary, Japan, and Korea outperformed others in eighth-grade science. Performance in the TIMSS 2003 followed a similar trend. Fourth-grade students in Singapore, Hong Kong, Japan, Chinese Taipei, and Belgium-Flemish outperformed the world. Singapore, Hong Kong, Japan, and Chinese Taipei were joined by England and the United States to lead in science. At the eighth-grade, Singapore, Korea, Hong Kong, Chinese Taipei, Japan, and Belgium-Flemish outsmarted the world in mathematics, while Singapore, Chinese Taipei, Hong Kong, Estonia, Japan, and Hungary led the world in science.

The Trends in International Mathematics and Science Study (TIMSS) is an ambitious international assessment that provides comparative data on student achievement among participating countries and benchmarking jurisdictions. The TIMSS 1995, 1999-R, and 2003 provide an array of data that may be analyzed and used to frame policy guidelines in education, especially in teaching and learning of mathematics and science.

The following recommendations, among others, may be of benefit to low performing countries in improving the achievement of their students in mathematics and science.

1. Low-performing nations should make their teacher education admission, curriculum, graduation, and certification requirements more challenging to teacher education candidates.
2. Teacher education programs should be designed with a fifth-year post certification internship. During the internship, novice teachers will be gradually introduced to the teaching profession. This is obtained in medical and some other health professions. Teaching is as critical as the medical profession.
3. Teacher education systems should establish new teacher induction and support programs. These induction and support programs should include seminars and workshops, mentoring, observing veteran teachers in classrooms, team teaching, peer interactions, and requiring new teachers to teach in less challenging classrooms. New teacher induction and support programs should be used as a means of reducing new teacher attrition rates, thereby increasing teacher retention.

Introduction

The emergence of a global economy and the opening of international borders for free trade have combined to engineer the drive for an unprecedented economic and technological competition among nations. Nations have come to realize that economic and political survival will depend largely on competitive advantage a nation commands over others. Sustaining a competitive edge will be dependent on the availability of a skilled and efficient workforce that a nation has at its possession.

The abundance of a skilled and efficient workforce at the disposal of a nation is dependent on the quality of students produced through K-12 pipeline, especially in the core areas of science and mathematics. Mathematics and science are the vehicles for producing a skilled workforce needed to sustain a nation's competitive edge in today's global economy. The value-added of mathematics and science to the quality of a workforce is obvious. Chubb and Moe (1990) stated that mathematics and science are crucial to the future of sophisticated technology and international competition.

As a result of the importance of mathematics and science in international competition, many countries have turned to international assessments in mathematics and science administered by the International Association for the Evaluation of Educational Achievement (IEA) as a way of measuring their future competitive edge.

The IEA is an independent, international cooperative of national research institutions and governmental agencies that is based in Amsterdam, Netherlands. Through its comparative research and assessment projects, the IEA aims to:

(1) Provide international benchmarks that may assist policymakers from participating countries in identifying the comparative strengths and weaknesses of their educational systems,

(2) Provide high-quality data that will increase policymakers' understanding of key school- and non-school-based factors that influence teaching and learning in participating countries,

(3) Provide high-quality data that will serve as a resource for identifying areas of concern and action, and for preparing and evaluating educational reforms in participating countries,

(4) Develop and improve educational systems' capacity to engage in national strategies for educational monitoring and improvement in participating countries, and

(5) Contribute to development of the world-wide community of researchers in educational evaluation (IEA, n.d.).

The IEA assessed the mathematics and science performance of fourth-, eighth-, and twelfth-grade students in 1995 (National Center for Education Statistics [NCES], 1996, 1997, 1998), for eighth-grade students 1999 (Gonzales et al., 2000) and for fourth- and eighth-grade students in 2003 and 2007 (Gonzales et al., 2004; Mullis et al., 2008) The assessments are used for cross-national comparison of mathematics and science achievement of students from participating countries.

Since 2003, the IEA mathematics and science assessment has been known as the Trends in International Mathematics and Science Study (TIMSS). The 1995 IEA assessment is known as the Third International Mathematics and Science Study (TIMSS). The 1999 assessment is known as the Third International Mathematics and Science Study- Repeat (TIMSS- R). The 2003 and

2007 assessments are known as the Trends in International Mathematics and Science Study (TIMSS).

TIMSS 1995

TIMSS 1995 is known as the Third International Mathematics and Science Study. At that time, TIMSS was the largest and most comprehensive comparative international study of education that had been undertaken. About a half-million students from 41 countries were tested in 30 different languages at five different grade levels to compare their mathematics and science achievement. Intensive study of students, teachers, schools, curriculum, instruction, and policy issues were also carried out to understand the educational context in which learning takes place. TIMSS was the first international examination to assess mathematics and science at the same time (National Center for Education Statistics [NCES], 1996, 1997, 1998).

TIMSS was designed to assess students' mathematics and science achievement midway through elementary school, midway through lower secondary school, and at the end of upper secondary school. Because children start and finish K-12 education at different ages, age and grade level were factors in deciding the students that were tested. Three populations of students were tested. Population 1 consisted of students in a pair of adjacent grades that contained most of 9-year-olds. The adjacent grades were grades 3 and 4 in the U. S. and most of the participating countries, grades 2 and 3, and grades 4 and 5 in some countries (NCES, 1997).

The students tested in population 2 were in a pair of adjacent grades that contained most of 13-year-olds at the time of testing. The adjacent grades were grades 7 and 8 in the U. S. and most of the participating countries, and grade 6 and 7 in a few countries. Population 3 consisted of students in their final year of secondary school, whatever their age. These students were in grade 12 in the U. S. and most of the participating countries, and grades 9-13 in some nations (NCES, 1996, 1998).

The 41 countries that participated in the 1995 TIMSS were Australia, Austria, Belgium (Flemish), Belgium (French), Bulgaria, Canada, Colombia, Cyprus, Czech Republic, Denmark, England, France, Germany, Greece, Hong Kong- SAR (Special Administrative Region), Hungary, Iceland, Iran- Islamic Republic, Ireland, Israel, Japan, Korea, Kuwait, Latvia- LSS (Latvia Speaking Schools), Lithuania, Netherlands, New Zealand, Norway, Portugal, Romania, Russian Federation, Scotland, Singapore, Slovak Republic, Slovenia, Spain, South Africa, Sweden, Switzerland, Thailand, and the United States (NCES, 1996, 1997, 1998, 1999).

TIMSS participating countries were required to assess students in population 2. Participation in populations 1 and 3 was optional. A total of 24 countries participated in population 1, all the 41 countries participated in population 2, and 21 nations participated in population 3 (NCES, 1999).

Fourth-Grade (Population 1) Performance in Mathematics and Science

A total of 26 countries participated in the Population 1 assessment. The participating nations were Australia, Austria, Canada, Cyprus, Czech Republic, England, Greece, Hong Kong –SAR (Special Administrative Region), Hungary, Iceland, Iran- Islamic Republic, Ireland, Israel, Japan, Korea, Kuwait, Latvia- LSS (Latvia Speaking Schools), Netherlands, New Zealand, Norway, Portugal, Scotland, Singapore, Slovenia, Thailand, and the United States (NCES, 1996, 1997, 1998, 1999).

The Table that follows shows the average scale scores of fourth-grade students from participating countries in mathematics and science.

Table 1

Nations' Average Scale Scores in Mathematics and Science (Grade 4)

Mathematics		Science	
Nation	Average	Nation	Average
Singapore	625	Korea	597
Korea	611	Japan	574
Japan	597	United States	565
Hong Kong	587	Austria	565
Netherlands	577	Australia	562
Czech Republic	567	Netherlands	557
Austria	559	Czech Republic	557
Slovenia	552	England	551
Ireland	550	Canada	549
Hungary	548	Singapore	547
Australia	546	Slovenia	546
United States	545	Ireland	539
Canada	532	Scotland	536
Israel	531	Hong Kong	533
Latvia- LSS	525	Hungary	532
Scotland	520	New Zealand	531
England	513	Norway	530
Cyprus	502	Latvia- LSS	512
Norway	502	Israel	505
New Zealand	499	Iceland	505
Greece	492	Greece	497

Table 1 (continued)

Mathematics		Science	
Nation	Average	Nation	Average
Thailand	490	Portugal	480
Portugal	475	Cyprus	475
Iceland	474	Thailand	473
Iran, Islamic Rep.	429	Iran, Islamic Rep.	416
Kuwait	400	Kuwait	401
International Average	529	International Average	524

Sources: 1. Martin et al. (1997). Science Achievement in the Primary School Years. Chestnut Hill, MA: Boston College. 2. Mullis et al. (1997). Mathematics Achievement in the Primary School Years. Chestnut Hill, MA: Boston College.

Notes:

1. The following Nations did not meet the international guidelines: Australia, Austria, Belgium-French, Bulgaria, Colombia, Denmark, Germany, Greece, Israel, Kuwait, Netherlands, Romania, Scotland, Slovenia, South Africa, and Thailand.
2. The international average is the average of the averages of the 26 countries.

The analysis of the 1995 TIMSS data at the fourth-grade level showed that the Asian Nations of Singapore, Korea, Japan, and Hong Kong, and the European Nations of Netherlands, Czech Republic, and Austria had the competitive edge in mathematics. In science, Korea, Japan, United States, Austria, Netherlands, and Czech Republic held the competitive edge.

Eighth-Grade (Population 2) Performance in Mathematics and Science

All the 41 countries that participated in the 1995 TIMSS were required to assess their students at the eighth-grade level. The countries were Australia, Austria, Belgium (Flemish), Belgium (French), Bulgaria, Canada, Colombia, Cyprus, Czech Republic, Denmark, England, France, Germany, Greece, Hong Kong- SAR (Special Administrative Region), Hungary, Iceland, Iran- Islamic Republic, Ireland, Israel, Japan, Korea, Kuwait, Latvia- LSS (Latvia Speaking Schools), Lithuania, Netherlands, New Zealand, Norway, Portugal, Romania, Russian

Federation, Scotland, Singapore, Slovak Republic, Slovenia, Spain, South Africa, Sweden, Switzerland, Thailand, and the United States (NCES, 1996, 1997, 1998, 1999).

The Table that follows shows the average scale scores of eighth-grade students from participating countries in mathematics and science.

Table 2

Nations' Average Scale Scores in Mathematics and Science (Grade 8)

Mathematics		Science	
Nation	Average	Nation	Average
Singapore	643	Singapore	607
Korea	607	Czech Republic	574
Japan	605	Japan	571
Hong Kong	588	Korea	565
Belgium- Flemish	565	Bulgaria	565
Czech Republic	564	Netherlands	560
Slovak Republic	547	Slovenia	560
Switzerland	545	Austria	558
Netherlands	541	Hungary	554
Slovenia	541	England	552
Bulgaria	540	Belgium- Flemish	550
Austria	539	Australia	545
France	538	Slovak Republic	544
Hungary	537	Russian Federation	538
Russian Federation	535	Ireland	538
Australia	530	Sweden	535
Ireland	527	United States	534
Canada	527	Germany	531
Belgium- French	526	Canada	531
Sweden	519	Norway	527
Thailand	522	New Zealand	525
Israel	522	Thailand	525

Table 2 (Continued)

Mathematics		Science	
Nation	Average	Nation	Average
Germany	509	Israel	524
New Zealand	508	Hong Kong	522
England	506	Switzerland	522
Norway	503	Scotland	517
Denmark	502	Spain	517
United States	500	France	498
Scotland	498	Greece	497
Latvia- LSS	493	Iceland	494
Spain	487	Romania	486
Iceland	487	Latvia- LSS	485
Greece	484	Portugal	480
Romania	482	Denmark	478
Lithuania	477	Lithuania	476
Cyprus	474	Belgium-French	471
Portugal	454	Iran-Islamic Rep.	470
Iran, Islamic Rep.	428	Cyprus	463
Kuwait	392	Kuwait	430
Colombia	385	Colombia	411
South Africa	354	South Africa	326
International Average	513	International Average	516

Sources:

1. Beaton et al. (1996). Science Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS). Chestnut Hill, MA: Boston College
2. Beaton et al. (1996). Mathematics Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS). Chestnut Hill, MA: Boston College

Notes:

1. The following Nations did not meet the international guidelines: Australia, Austria, Belgium-French, Bulgaria, Colombia, Denmark, Germany, Greece, Israel, Kuwait, Netherlands, Romania, Scotland, Slovenia, South Africa, and Thailand.
2. The country average for Sweden may appear to be out of place; however, statistically, its placement is correct.
3. The international average is the average of the averages of the 41 countries.

The analysis of the 1995 TIMSS data at the eighth-grade level showed that the Asian Nations of Singapore, Korea, Japan, and Hong Kong, and the European Nations of Belgium-Flemish, Czech Republic, and Slovak Republic had the competitive edge in mathematics. In science, Singapore, Czech Republic, Japan, Korea, Bulgaria, Netherlands, and Slovenia held the competitive edge.

Twelfth-Grade (Population 3) Performance in Mathematics and Science

A total of 21 nations participated in the twelfth-grade assessment. They were Australia, Austria, Canada, Cyprus, Czech Republic, Denmark, France, Germany, Hungary, Iceland, Italy, Lithuania, Netherlands, New Zealand, Norway, Russian Federation, Slovenia, South Africa, Sweden, Switzerland, and the United States (NCES, 1999).

The Table that follows shows the average scale scores of fourth-grade students from participating countries in mathematics and science.

Table 3

Nations' Average Scale Scores in Mathematics and Science (Final Year of Secondary School)

Mathematics		Science	
Nation	Average	Nation	Average
Netherlands	560	Sweden	559
Sweden	552	Netherlands	558
Denmark	547	Iceland	549
Switzerland	540	Norway	544
Iceland	534	Canada	532
Norway	528	New Zealand	529
France	523	Australia	527
New Zealand	522	Switzerland	523
Australia	522	Austria	520
Canada	519	Slovenia	517

Table 3 (Continued)

Mathematics		Science	
Nation	Average	Nation	Average
Austria	518	Denmark	509
Slovenia	512	Germany	497
Germany	495	France	487
Hungary	483	Czech Republic	487
Italy	476	Russian Federation	481
Russian Federation	471	United States	480
Lithuania	469	Italy	475
Czech Republic	466	Hungary	471
United States	461	Lithuania	461
Cyprus	446	Cyprus	448
South Africa	356	South Africa	349

Source:
1. Mullis et al. (1998). Mathematics and Science Achievement in the Final Year of Secondary School: IEA's Third International Mathematics and Science Study (TIMSS). Chestnut Hill, MA: Boston College
2. National Center for Education Statistics. (1999). Highlights from TIMSS-The Third International Mathematics and Science Study: Overview of Key Findings Across Grade Levels. Washington, DC: Author.

Notes:
1. The following Nations did not meet the international guidelines: Australia, Austria, Canada, Cyprus, Denmark, France, Germany, Iceland, Italy, Lithuania, Netherlands, Norway, Russian Federation, Slovenia, South Africa, and the United States.
2. The international average is the average of the averages of the 21 countries.

The analysis of the 1995 TIMSS data at the twelfth-grade level showed that the European nations of Netherlands, Sweden, Denmark, Switzerland, Iceland, and Norway had the competitive edge in mathematics. In science, Sweden, Netherlands, Iceland, Norway, Canada, New Zealand, and Australia held the competitive edge.

TIMSS 1999

TIMSS 1999, also known as TIMSS- Repeat or TIMSS- R, is the second in a series of mathematics and science assessments administered by the International Association for the Evaluation of Educational Achievement (IEA) since 1995. TIMSS- R is the successor to the Third International Mathematics and Science Study (TIMSS) of 1995. Unlike the 1995 TIMSS which assessed the mathematics and science knowledge of fourth-, eighth-, and twelfth-grade students, the 1999 TIMSS- R assessed the mathematics and science achievement of only eighth-grade students in 38 countries (Gonzales et al., 2000; Martin et al., 2000; Mullis et al., 2000).

TIMSS 1999- R was designed to provide trends in eighth-grade mathematics and science achievement in an international context. A representative sample of eighth-grade students from Australia, Belgium- Flemish, Bulgaria, Canada, Chile, Chinese Taipei, Cyprus, Czech Republic, England, Finland, Hong Kong- SAR, Hungary, Indonesia, Iran- Islamic Republic, Israel, Italy, Japan, Jordan, Korea- Republic of, Latvia- LSS, Lithuania, Macedonia- Republic of, Malaysia, Moldova, Morocco, Netherlands, New Zealand, Philippines, Romania, Russian Federation, Singapore, Slovak Republic, Slovenia, South Africa, Thailand, Tunisia, Turkey, and the United States participated in the assessment which was administered during the 1998-99 school year (Martin et al., 2000; Mullis et al., 2000).

The Table that follows shows the average scale scores of eighth-grade students from participating countries in mathematics and science.

Table 4

Nations' Average Scale Scores in Mathematics and Science (Grade 8)

Mathematics		Science	
Nation	Average	Nation	Average
Singapore	604	Chinese Taipei	569
Korea, Republic of	587	Singapore	568

Table 4 (Continued)

Mathematics		Science	
Nation	Average	Nation	Average
Chinese Taipei	585	Hungary	552
Hong Kong- SAR	582	Japan	550
Japan	579	Korea, Republic of	549
Belgium- Flemish	558	Netherlands	545
Netherlands	540	Australia	540
Slovak Republic	534	Czech Republic	539
Hungary	532	England	538
Canada	531	Finland	535
Slovenia	530	Slovak Republic	535
Russian Federation	526	Belgium- Flemish	535
Australia	525	Slovenia	533
Finland	520	Canada	533
Czech Republic	520	Hong Kong- SAR	530
Malaysia	519	Russian Federation	529
Bulgaria	511	Bulgaria	518
Latvia- LSS	505	United States	515
United States	502	New Zealand	510
England	496	Latvia- LSS	503
New Zealand	491	Italy	493
Lithuania	482	Malaysia	492
Italy	479	Lithuania	488
Cyprus	476	Thailand	482
Romania	472	Romania	472
Moldova	469	Israel	468
Thailand	467	Cyprus	460
Israel	466	Moldova	459
Tunisia	448	Macedonia, Rep. of	458
Macedonia, Rep. of	447	Jordan	450

Table 4 (Continued)

Mathematics		Science	
Nation	Average	Nation	Average
Turkey	429	Iran, Islamic Rep. of	448
Jordan	428	Indonesia	435
Iran, Islamic Rep. of	422	Turkey	433
Indonesia	403	Tunisia	430
Chile	392	Chile	420
Philippines	345	Philippines	345
Morocco	337	Morocco	323
South Africa	275	South Africa	243
International Average	487	International Average	488

Sources:

1. Martin et al. (2000). TIMSS 1999- International Science Report: Findings from IEA's Repeat of the Third International Mathematics and Science Study at the eighth grade. Chestnut Hill, MA: The International Study Center. Boston College

2. Mullis et al. (2000). TIMSS 1999- International Mathematics Report: Findings from IEA's Repeat of the Third International Mathematics and Science Study at the eighth grade. Chestnut Hill, MA: The International Study Center. Boston College

Notes:

The international average is the average of the averages of the 38 countries.

TIMSS 2003

TIMSS 2003 was the third in a series of mathematics and science assessments conducted by the International Association for the Evaluation of Educational Achievement since 1995. The aim of TIMSS is to improve the teaching and learning of mathematics and science by providing data on student achievement in relation to different types of curricula, instructional practices, and school environments. Additionally, it provides opportunity for participating countries to obtain comparative information about their students' achievement in mathematics and science

(Gonzalez et al., 2004; Martin, Mullis; Gonzalez, & Chrostowski, 2004; Mullis, Martin, Gonzalez, & Chrostowski, 2004).

Forty-nine countries and the four benchmarking participants (Indiana, United States; the Canadian Provinces of Ontario and Quebec; and the Basque Country, Spain) participated in the TIMSS 2003 assessment at the fourth-grade, eighth-grade, or at both grades. The participating countries were Argentina, Armenia, Australia, Bahrain, Basque Country of Spain, Belgium-Flemish, Botswana, Bulgaria, Chile, Chinese Taipei, Cyprus, Egypt, England, Estonia, Ghana, Hong Kong- SAR, Hungary, Indiana (United States), Indonesia, Iran- Islamic Republic, Israel, Italy, Japan, Jordan, Korea- Republic of, Latvia, Lebanon, Lithuania, Macedonia- Republic of, Malaysia, Moldova- Republic of, Morocco, Netherlands, New Zealand, Norway, Ontario Province (Canada), Palestinian National Authority, Philippines, Quebec Province (Canada), Romania, Russian Federation, Saudi Arabia, Scotland, Serbia, Singapore, Slovak Republic, Slovenia, South Africa, Sweden, Syrian Arab Republic, Tunisia, United States, and Yemen (Gonzalez et al., 2004; Martin et al., 2004; Mullis et al., 2004).

The Table that follows shows the average scale scores of fourth-grade students from 25 countries and 3 benchmarking participants in mathematics and science.

Table 5

Nations' Average Scale Scores in Mathematics and Science (Grade 4)

Mathematics		Science	
Nation	Average	Nation	Average
Singapore	594	Singapore	565
Hong Kong- SAR	575	Chinese Taipei	551
Japan	565	Japan	543
Chinese Taipei	564	Hong Kong- SAR	542

Table 5 (Continued)

Mathematics			Science	
Nation	Average		Nation	Average
Belgium- Flemish	551		England	540
Netherlands	540		United States	536
Latvia	536		Latvia	532
Lithuania	534		Hungary	530
Russian Federation	532		Russian Federation	526
England	531		Netherlands	525
Hungary	529		Australia	521
United States	518		New Zealand	520
Cyprus	510		Belgium- Flemish	518
Moldova, Rep. of	504		Italy	516
Italy	503		Lithuania	512
Australia	499		Scotland	502
New Zealand	493		Moldova, Rep. of	496
Scotland	490		Slovenia	490
Slovenia	479		Cyprus	480
Armenia	456		Norway	466
Norway	451		Armenia	437
Iran, Islamic Rep. of	389		Iran, Islamic Rep. of	414
Philippines	358		Philippines	332
Morocco	347		Tunisia	314
Tunisia	339		Morocco	304
Benchmarking Participants			Benchmarking Participants	
Indiana, U. S.	533		Indiana, U. S.	553
Ontario, Canada	511		Ontario, Canada	540
Quebec, Canada	506		Quebec, Canada	500
International Average	495		International Average	489

Sources:

1. Gonzales et al. (2004). Highlights from Trends in International Mathematics and Science Study (TIMSS) 2003.
2. Martin et al. (2004). TIMSS 2003 International Science Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades.
3. Mullis et al. (2004). TIMSS 2003 International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades.

Note:

International Average is the average of the averages of the countries and the benchmarking participants.

The Table that follows shows the average scale scores of eighth-grade students from 45 countries and 4 benchmarking participants in mathematics and science.

Table 6

Nations' Average Scale Scores in Mathematics and Science (Grade 8)

Mathematics		Science	
Nation	Average	Nation	Average
Singapore	605	Singapore	578
Korea, Rep. of	589	Chinese Taipei	571
Hong Kong- SAR	586	Korea, Rep. of	558
Chinese Taipei	585	Hong Kong- SAR	556
Japan	570	Estonia	552
Belgium- Flemish	537	Japan	552
Netherlands	536	Hungary	543
Estonia	531	Netherlands	536
Hungary	529	United States	527
Malaysia	508	Australia	527
Latvia	508	Sweden	524
Russian Federation	508	Slovenia	520
Slovak Republic	508	New Zealand	520
Australia	505	Lithuania	519
United States	505	Slovak Republic	517
Lithuania	502	Belgium- Flemish	516
Sweden	499	Russian Federation	514

Table 6 (Continued)

Mathematics		Science	
Nation	Average	Nation	Average
Scotland	498	Latvia	512
Israel	496	Scotland	512
New Zealand	494	Malaysia	510
Slovenia	493	Norway	495
Italy	484	Italy	491
Armenia	478	Israel	488
Serbia	477	Bulgaria	479
Bulgaria	476	Jordan	475
Romania	475	Moldova, Rep. of	472
Norway	461	Romania	470
Moldova, Rep. of	460	Serbia	468
Cyprus	459	Armenia	461
Macedonia, Rep. of	435	Iran, Islamic Rep. of	453
Lebanon	433	Macedonia, Rep. of	449
Jordan	424	Cyprus	441
Iran, Islamic Rep. of	411	Bahrain	438
Indonesia	411	Palestinian N. A.	435
Tunisia	410	Egypt	421
Egypt	406	Indonesia	420
Bahrain	401	Chile	413
Palestinian N. A.	390	Tunisia	404
Chile	387	Saudi Arabia	398
Morocco	387	Morocco	396
Philippines	378	Lebanon	393
Botswana	366	Philippines	377
Saudi Arabia	332	Botswana	365
Ghana	276	Ghana	255
South Africa	264	South Africa	255

Table 6 (Continued)

Mathematics		Science	
Nation	Average	Nation	Average
Benchmarking Participants		Benchmarking Participants	
Basque Country, Spain	487	Basque Country, Spain	489
Indiana, U. S.	508	Indiana, U. S.	531
Ontario Province, Canada	521	Ontario Province, Canada	533
Quebec Province, Canada	543	Quebec Province, Canada	531
International Average	466	International Average	474

Sources:

1. Gonzalez et al. (2004). Highlights from Trends in International Mathematics and Science Study (TIMSS) 2003.
2. Martin et al. (2004). TIMSS 2003 International Science Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades.
3. Mullis et al. (2004). TIMSS 2003 International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades.

Note:

1. International Average is the average of the averages of the countries and the benchmarking participants.
2. Palestinian N. A. is Palestinian National Authority.

Discussion

Student achievement is influenced by many factors, among which are teacher quality, new teacher induction and support, and teacher professional development. The education systems in the TIMSS participating countries revealed interesting findings in teacher quality, new teacher induction and support programs, and teacher professional development.

Teacher Quality

Teacher quality may be the most important factor that promotes student achievement. Teacher quality is largely related to the rigors of teacher education admission, curriculum, graduation, and certification requirements. The rigor of admission requirements determines the caliber of candidates admitted to teacher education programs or to any program for that matter. Compared to the low-performing countries in the TIMSS assessments, the high-performing countries have rigorous admission requirements. For example, Hong Kong and Japan require teacher candidates to sit for a National Subject Area Examination before admission to a teacher education program. In addition to the National Subject Area Examination, some universities in Japan have their own high-stakes examinations that teacher candidates must also take before admission to a teacher education program. In Korea, teacher candidates are admitted based on their performance on the Scholastic Assessment Test, teaching attitudes, and ethics. In the average- and low-performing TIMSS countries, admission requirements lack the rigor that is obtained in the high-performing countries.

Curriculum, graduation, and certification requirements vary in both high- and low-performing TIMSS countries. However, curriculum rigor is more challenging in high-performing countries than in low-performing nations. For example, in Korea teacher candidates are required to take more than 40 credits in their subject areas, and Hong Kong requires prospective teachers to have a minor in mathematics or science.

Teacher Induction and Support

The transition from pre-service teacher education to actual classroom teaching can be challenging and difficult. The challenging and difficult situation is a contributing factor for new teacher attrition during the first few years of teaching. As a result, teacher induction and support programs are used to provide beginning teachers the support needed during the transition from learning to teach to teachers of learners with the aim of reducing the new teacher attrition rate.

Teacher induction and support programs are more structured in TIMSS high-performing countries than in low-performing countries. For example, in Japan new teachers spend at least 90 days of their first year of teaching in teacher induction activities. The induction programs include in-school activities and out-of-school training, mentoring by veteran teachers, team teaching and observation, and interaction with peers. In addition, new teachers receive support from principals and other instructional staff. The support from principals includes placing new teachers in less challenging classrooms and in grade-levels that are seen as less critical to educational development. Also, it is customary to assign lighter teaching loads to the new teachers. All these measures are geared toward helping new teachers succeed (Nohara, 1997).

In the TIMSS average- and low-performing countries, teacher induction and support programs are less structured, non-mandatory, and less durable unlike in high-performing countries. In average- and low-performing countries, new teachers are placed in classrooms without recourse to how challenging classrooms have become. New teacher assessment may be viewed as fault-finding in low-performing countries rather than being an avenue for helping new teachers transition from teacher education to actual classroom teaching.

Teacher Professional Development

New teachers transition from teacher education to classrooms with limited knowledge (Ngwudike, 2001). Therefore, teacher professional development should be seen as part of the teacher professional continuum. Wang, Coleman, Coley, and Phelps (2003) found that in the TIMSS high-performing countries, beginning teacher induction and professional development are required. For example, Australia, England, Japan, and Singapore require new teacher induction, while in England, Japan and Korea professional development is required. In average-performing countries such as the United States, new teacher induction varies and professional development is provided mainly at the district and school levels.

Recommendations

The contrast between TIMSS high- and low-performing countries informs the following recommendations:

1. Like TIMSS high-performing countries, low-performing nations should make their teacher education admission, curriculum, graduation, and certification requirements more challenging to teacher education candidates.

2. Teacher education programs should be designed with a fifth-year post certification internship. During the internship, novice teachers will be gradually introduced to the teaching profession. This is obtained in medical and some other health professions. Teaching is as critical as the medical profession.

3. Teacher education systems should establish new teacher induction and support programs. These induction and support programs should include seminars and workshops, mentoring, observing veteran teachers in classrooms, team teaching, peer interactions, lighter teaching loads, and assignment to less challenging classrooms. New teacher induction and support programs should be used as a means of reducing new teacher attrition rates, thereby increasing teacher retention.

4. Teacher salaries should be higher or at least match the pay in other professions of similar training. This will increase the prestige of the teaching profession, thereby attracting more talented individuals to the profession. Moskowitz & Kennedy (1997) stated that teachers in Japan, Korea, and Chinese Taipei enjoy good pay and high status.

5. Teacher professional development should be viewed as part of a continuum of the teaching profession. Teacher education programs do not adequately prepare beginning teachers for all the challenges to be encountered in the classroom. Therefore, professional development should serve

as a vehicle for bridging that gap. Professional development should be used to introduce teachers to best practices in teaching and learning. Teachers should be a party in designing their professional development activities. The professional development activities should be based on the principles of adult learning and job-embedded, and should serve as a mechanism for increasing the competency of teachers by improving their professional skills and dispositions.

6. TIMSS provides an opportunity for countries to learn what works better in other education systems while improving the teaching and learning of mathematics and science in their own countries. What is learned from the TIMSS data may be used to enhance the education systems, especially in average- and low-performing countires.

Conclusion

The Trends in International Mathematics and Science Study (TIMSS) is an ambitious international assessment that provides comparative data on student achievement among participating countries and benchmarking jurisdictions. TIMSS conducts studies on a cross-national achievement in mathematics and science every four years. TIMSS collects contextual information on how mathematics and science learning takes place in participating countries. The next cycle of assessments will take place in 2011.

TIMSS 1995, 1999- R, and 2003 provide an array of data that may be analyzed and used to frame policy guidelines in education, especially in the teaching and learning of mathematics and science. The analysis of the contextual information collected by TIMSS may be used to understand the context in which the teaching and learning of mathematics take place in high and low achieving countries.

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