Journal of Mathematics Education at Teachers College

Fall – Winter 2010

A Century of Leadership in Mathematics and its Teaching

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The *Journal of Mathematics Education at Teachers College* is a publication of the Program in Mathematics and Education at Teachers College Columbia University in the City of New York.

This issue's cover and those of future issues will honor past and current contributors to the Teachers College Program in Mathematics. Photographs are drawn from the Teachers College archives and personal collections.

This issue honors Dr. Alexander P. Karp, an Associate Professor in the Program in Mathematics at Teachers College. A native of St. Petersburg, Russia who is the author of more than one hundred publications including textbooks used throughout Russia, Professor Karp represents Teachers College at meetings and conferences throughout the world as well as through his role as managing editor of the *International Journal for the History of Mathematic Education*.

Former Teachers College Professor and Mathematics Education Chair, Howard Franklin Fehr, was among the most influential mathematics educators of his era. Through his many international contacts, he was the organizer of conferences, projects, and publications including the Congresses of Mathematics Education, a seminal conference on Needed Research in the field, and curriculum initiatives including the Secondary School Mathematics Curriculum Improvement Study.

Aims and Scope

The *JMETC* is a re-creation of an earlier publication by the Teachers College Columbia University Program in Mathematics. As a peer-reviewed, semi-annual journal, it is intended to provide dissemination opportunities for writers of practice-based or research contributions to the general field of mathematics education. Each issue of the *JMETC* will focus upon an educational theme. Themes planned for the 2011 issues are: *Mathematics Curriculum* and *Technology*. *JMETC* readers are educators from pre K-12 through college and university levels, and from many different disciplines and job positions—teachers, principals, superintendents, professors of education, and other leaders in education. Articles to appear in the *JMETC* include research reports, commentaries on practice, historical analyses and responses to issues and recommendations of professional interest.

Manuscript Submission

JMETC seeks conversational manuscripts (2,000-2,500 words in length) that are insightful and helpful to mathematics educators. Articles should contain fresh information, possibly research-based, that gives practical guidance readers can use to improve practice. Examples from classroom experience are encouraged. Articles must not have been accepted for publication elsewhere. To keep the submission and review process as efficient as possible, all manuscripts may be submitted electronically at www.tc.edu/jmetc.

Abstract and keywords. All manuscripts must include an abstract with keywords. Abstracts describing the essence of the manuscript should not exceed 150 words. Authors should select keywords from the menu on the manuscript submission system so that readers can search for the article after it is published. All inquiries and materials should be submitted to Ms. Krystle Hecker at P.O. Box 210, Teachers College Columbia University, 525 W. 120th St., New York, NY 10027 or at JMETC@tc.columbia.edu

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Call for Papers

The "theme" of the spring issue of the *Journal of Mathematics Education at Teachers College* will be *Mathematics Curriculum*. This "call for papers" is an invitation to mathematics education professionals, especially Teachers College students, alumni and friends, to submit articles of approximately 2000-2500 words describing research, experiments, projects, innovations, or practices related to mathematics curriculum. Articles should be submitted to Ms. Krystle Hecker at jmetc@tc.edu by January 1, 2011. The spring issue's guest editor, Nicholas Wasserman, will send contributed articles to editorial panels for "blind review." Reviews will be completed by February 1, 2011, and final drafts of selected papers are to be submitted by March 1, 2011. Publication is expected in mid-April, 2011.

Call for Volunteers

This *Call for Volunteers* is an invitation to mathematics educators with experience in reading/writing professional papers to join the editorial/review panels for the spring 2011 and subsequent issues of *JMETC*. Reviewers are expected to complete assigned reviews no later than 3 weeks from receipt of the blind manuscripts in order to expedite the publication process. Reviewers are responsible for editorial suggestions, fact and citations review, and identification of similar works that may be helpful to contributors whose submissions seem appropriate for publication. Neither authors' nor reviewers' names and affiliations will be shared; however, editors'/reviewers' comments may be sent to contributors of manuscripts to guide further submissions without identifying the editor/reviewer.

If you wish to be considered for review assignments, please request a *Reviewer Information Form*. Return the completed form to Ms. Krystle Hecker at jmetc@tc.edu or Teachers College Columbia University, 525 W 120th St., Box 210, New York, NY 10027.

Looking Ahead

Anticipated themes for future issues are:

Spring 2011	Curriculum
Fall 2011	Technology
Spring 2012	Evaluation
Fall 2012	Equity
Spring 2013	Leadership
Fall 2013	Modeling
Spring 2014	Teaching Aids
Fall 2014	Special Students

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Exploring Motivational Factors for Educational Reform: Do International Comparisons Dictate Educational Policy?

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In mathematics education, utilizing international comparisons to support implementation of educational reforms has become increasingly common. With the advent of *Trends in International Mathematics and Science Study* (TIMSS), educational reform seems to have transitioned to a reactionary process rather than a calculated adaptation of current educational systems. These policy changes may be in response to a need to demonstrate international superiority, determined by these standardized tests. This paper explores the history of educational reform in Japan and Singapore to investigate possible connections between achievement levels and reforms each country made to their educational systems. Frank's Framework will be used to guide the analysis of their educational policies with a focus on how these countries use aspects of this framework to guide reform decisions, or if they use a narrow focus on the TIMSS results. These results can then be extended to the process of reform development in the United States.

Introduction

The rankings reported by international studies have captured the attention of educators in the United States, especially as these standings in mathematics and science become seen as a direct link to economic power in an increasingly global economy (Sato, 2009; Tan, 2010). Now in its fourth cycle, the international study known as TIMSS continues to collect and analyze data on mathematics and science achievement in several countries with the intention that the information reported every four years can be used effectively in "guiding educational decision making and practice in the areas of mathematics and science around the world" (Mullis, Martin, & Foy, 2008, p. 2). The most recent 2007 report includes an analysis of the progression of achievement scores, scaled for accurate comparison, of the 13 countries that participated in all four years: Korea, Singapore, Hong Kong, Japan, Hungary, England, Russia, United States, Lithuania, Cyprus, Bulgaria, Romania, and Iran (Mullis et al, 2008, pp. 46–48). In this section reported by TIMSS, the scaled scores can be utilized to determine the progression of achievement levels spanning all four years: 1995, 1999, 2003, and 2007.

Of the countries that participated in all four cycles of TIMSS, this paper will focus primarily on Japan and Singapore. The reason these two countries have been selected for this analysis stems from the recent fervor mathematics educators in the United States have for techniques developed in these two countries, namely, Japanese Lesson Study (Schumer, 1999; Stigler & Hiebert, 1997; Tsuneyoshi, 2004) and Singapore Math (Tan, 2010). Another reason to study these two in particular is due to the surprising trend found in the TIMSS 2007 report. With such increased interest in the educational innovations designed and implemented by these two countries, it is interesting to note that despite the acclaim they receive from the United States, scores for both countries have decreased significantly from 1995 to 2007. Meanwhile, the scores for the United States have increased significantly over the span of these four series of TIMSS (Mullis et al., 2008, pp. 46–48). Even though Japan and Singapore continue to score higher than the United States on these standardized tests, the decreasing trend in achievement scores for both of these countries calls for further inquiry.

Through the use of the comparative educational framework known as Frank's Framework, the concepts of theoretical adequacy, policy effectiveness, and empirical validity (Kubow & Fossum, 2007, pp. 272–273) of the educational reforms in Japan and Singapore will be reviewed systematically to determine the motivating factors influencing policy changes in each country. The concept of theoretical adequacy connects the desired outcomes with the educational reform strategy proposed. The consideration of policy effectiveness involves an analysis of the individuals involved in the process, as well as the feasibility of the program itself. Lastly, empirical validity necessitates the presence of prior research to ascertain the usefulness of such changes (Kubow & Fossum, 2007, pp. 272–273). The following table includes possible questions one may pose in each of these three aspects of Frank's Framework (Kubow & Fossum, 2007, p. 180). If the application of Frank's Framework does not validate the changes these countries have implemented, then the hypothesis that educational reform is motivated by the results of TIMSS, and therefore is purely reactionary, becomes a stronger claim and thus merits further research.

Table 5.1 Framework for Critique of Educational Reforms

Theoretical Adequacy	Policy Effectiveness	Empirical Validity
Is there a theoretical foundation for the proposed reform?	Is there support for this reform (e.g., public, governmental)?	Is there any empirical evidence regarding the reform?
What is the hypothesized relationship of the reform to its stated outcomes?	Will there be threatened interest groups that will attempt to sabotage it?	Is research available elsewhere regarding the successes of similar programs?
Are the claims being made in favor of the reform theoretically sound? plausible?	What are the resource allocation, teacher training, and cost requirements of the reform?	If research was conducted, how satisfactory was the research design?
What other factors might theoretically account for the observed outcomes?	Is it financially feasible? Cost effective?	What kind of claims and interpretations are being made of the research findings?
Is the reform program taking those factors into consideration?	How long will it take to implement it, and is enough time being given to adequately assess it?	Are the research findings unequivocal or ambiguous? What else might account for these findings?

Source: Adapted from Frank (1972) and Paige (1995).

Educational Reforms from 1995 to 2007: Applying Frank's Framework

Japan

Starting in the 1980s, Japan focused on the acquisition of mathematical skills through repetition and rote memorization rather than mathematical understanding through critical thinking and problem solving (Tsuneyoshi, 2004). This form of mathematics education demonstrated empirical validity as Japan "repeatedly scored near the top in international comparisons of mathematics achievement" (Stigler & Hiebert, 1997, p. 15). In 1996, the topics of higher-order thinking and problem solving were first introduced in a report by the Japan Central Council for Education, from which Japan's Minister of Education implemented a curriculum in 1998 that incorporated these topics. These recommendations encouraged constructivist learning in mathematics education rather than rote memorization and repetition, concepts closely resembling recommendations set forth by the National Council of Teachers of Mathematics (NCTM) (Fan, Wang, Cai, & Li, 2004; Schumer, 1999; Stigler & Hiebert, 1997).

The theoretical foundation for this change in curriculum was to minimize the stress placed on Japanese students, as stress became a cause for concern in the high-stakes testing environment that characterized the prior curriculum. Unfortunately, standardized testing remained, and thus the pressure that created the stress remained as well. The change in curriculum merely heightened the demand on a student's time, as reliance on the supplementary schools that taught the computational and algorithmic skills increased (Schumer, 1999).

When assessing policy effectiveness, it is important to consider support of the agents involved in the process of forming policy, as well as the feasibility of the policy itself (Kubow & Fossum, 2007). In terms of support, the Minister of Education in Japan acted as the main agent of change by implementing the reform policies from 1995 to 2007. Despite being a major leader in this process, pressures from other groups such as parents, students, and university professors (Tsuneyoshi, 2004) led to the dilution of the original policy from purely constructivist learning to a mixture of skill acquisition and constructivist learning.

By 1999, a push for a renewed focus on skill acquisition began to materialize; however, this movement did not gain much momentum until 2003 (Sato, 2009; Tsuneyoshi, 2004). At this stage in the educational reform process, the Minister of Education wavered on his commitment to support constructivist pedagogy fully and once again adapted the curriculum to combine skill acquisition with problem solving.

It is important to realize that the debate of 2005 likely limited the amount of time necessary to assess adequately the level of achievement possible under a constructivist reform. It is no coincidence that the debate grew in 2005, just one year after the publication of the results of the third cycle of TIMSS. The results of TIMSS could be interpreted as empirical validation for the failure of constructivist learning, as Japan's achievement scores on TIMSS dropped from 581 in 1995 to 570 in 2003.

Such a decrease in achievement levels created panic over the state of education in Japan, blaming the "crisis" on the new reforms (Tsuneyoshi, 2004) and thus catapulting the curriculum quickly back to skill acquisition pedagogy. This reactionary move reifies the argument set forth at the start of this paper that international assessments can be used to motivate and validate rapid changes, regardless of whether or not such change may be the best course of action to take in terms of educational reform. In

Japan's educational reform process today, the entities advocating skill acquisition seem to continue to gain momentum, touting the results of the TIMSS as proof of the need to move even farther away from constructivist learning and "back to basics" in skills and memorization.

Singapore

From the inception of TIMSS, Singapore has been a strong presence in leading the international rankings in mathematics achievement. Despite this strong performance on TIMSS, the government of Singapore set a different direction for their curriculum. As early as the 1980s, Singapore showed interest in the concept of problem solving as it was defined and envisioned by the United States and the United Kingdom (Fan & Zhu, 2007). This theoretical foundation of problem solving gained its support from the Minister of Education in Singapore, who precipitated the gradual shift toward inculcating problem-solving in all aspects of mathematics education in his 1997 policy, "Thinking Schools and a Learning Nation" (Fan & Zhu, 2007; Lee & Fan, 2002, p. 1; Yeo & Zhu, 2005;). The goal of the new direction for curriculum was to move education away from training students to be workers in a company, to training students to be entrepreneurs who could make money for themselves and by extension make money for the country (Lee & Fan, 2002).

In terms of policy effectiveness, it is clear that the Minister of Education was the primary agent motivating the process of educational reform in Singapore (Kubow & Fossum, 2007). Unlike the experience of the Minister of Education in Japan, the Minister of Education in Singapore met little resistance to his transition to a problem solving-based curriculum for mathematics education. Despite one small argument that he may have altered the curriculum excessively (Lee & Fan, 2002), the guiding principle of problem solving and its relationship to encouraging higher-order thinking continued to be supported and therefore remained the theoretical foundation of this change. The government demonstrated significant support for the reform through the creation of both assessments and textbooks that aligned with the goal of higher-order thinking in mathematics education (Fan & Zhu, 2007).

Despite the collective effort put into promoting problem solving in the curriculum, the Ministry of Education and the government continued to fail to define the concept of problem solving clearly enough to align their desired goal of encouraging higher-order thinking in students with the reforms they set in place. To improve this alignment, in 2000 a new national syllabus was created to motivate higher-order thinking. Once again, this attempt only led to the creation of more reform measures that failed to accomplish their goal (Lee & Fan, 2002; Li, 2007). As Singapore transitioned into 2007, the most recent syllabus derived by the Ministry of Education appeared to be more promising in achieving the goal of inclusion of higher-order thinking in its latest measures. With the development of even newer assessments and textbooks that move outside of testing rote memorization, emphasis is being placed on thoughtful analysis and investigation of problems.

Although Singapore has dropped in achievement as measured by TIMSS, from 609 in 1995 to a 593 in 2007, the fact that Singapore is continuing in its reform efforts despite this empirical measure is a testament to the fact that Singapore is in no way a reactionary country when it comes to international comparisons. This careful planning around a consistent theoretical foundation, the analysis of policy effectiveness, and the consistent check of the empirical validity of reforms lead one to believe that Singapore may finally realize its goals in the coming years (Fan & Zhu, 2007). It is clear that all aspects of Frank's Framework are being utilized over the course of years in Singapore with the expectation that the goal of improving higher-order thinking, and thus business potential, in all students in a progressively globalizing world (Tan, 2010) will eventually be realized.

Conclusion

The purpose of this paper is to highlight the fact that although educational reform can be guided by international results such as TIMSS, this measurement of success in education is just one of a much broader framework. This framework should be considered by countries developing and implementing new educational policy, or else they fall victim to the reactionary process instigated by these international comparisons. Currently the United States finds itself in the midst of a reform battle. From arguments about skill acquisition versus constructivist learning and to the recent direction of implementing a set of common core standards across the nation, the United States stands at risk of falling into the same international comparative trap as other countries, as TIMSS produces report after report.

To avoid falling into this trap, it is important to recognize the examples provided by both Japan and Singapore. Japan provides an example of a reaction-based educational reform process. As the achievement levels demonstrated on TIMSS dropped, Japan's policy shifted from skill acquisition, to constructivist learning, and finally to a mixture of the two methods in the hope of reclaiming their international standing. Very little consideration of theoretical adequacy or policy effectiveness existed, as no theoretical foundations were retained, nor did any agents lend significant support to the reforms to allow for time to assess the policies' successes and failures.

On the other hand, Singapore implemented curriculum change in response to a single goal, namely, developing higher-order thinking among their students. Once this theoretical foundation for mathematics education had been

set, a clear direction could be taken to guide policy development to support this effort further. In terms of support, the Minister of Education continues to remain steadfast in this direction, despite the results from TIMSS showing a steady decline. This consistency provides enough time to collect measures of empirical validity to determine the successes and failures of this curriculum.

Combining all three aspects of Frank's Framework, Singapore gains a deeper understanding of the effectiveness of its policy implementations than Japan can glean from its reactionary process. The cautionary tale is that as long as the focus is on the results of a standardized test, the focus is off what it means to educate students in mathematics. Until agreement can be made as to what mathematics education is trying to accomplish, placing such high value on international comparisons measured by a single standardized test seems detrimental to any educational system. It would be advisable to conduct further research on the theoretical adequacy, policy effectiveness, and empirical validity of the United States' current educational policies before altering them yet again in reaction to TIMSS.

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