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The Establishment Story of 1989 NCTM Curriculum and Evaluation Standards for School Mathematics: based on the perspective of history of U.S. Mathematics Education in the 1970s and 1980s

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This paper provides a review of the historical development story of the NCTM 1989 Standards based on perspective of history of U. S. mathematics education and research in the 1970s and 1980s. In contrast to other nations, the U. S. has always favored local over national control of education. But by 1983, mounting evidence of failures of U. S. education moved the authors of A Nation at Risk to recommend strengthened requirements, rigorous Standards, and higher expectations for all students. In response to A Nation at Risk, the NCTM began to develop the nation's first educational Standards. This paper satisfies the readers who desire to know the entire development story of the first Standards.

Key Words : Mathematics education, Curriculum, NCTM Standards

The publication of Curriculum and Evaluation Standards for School Mathematics of the National Council of Teachers of Mathematics (NCTM, 1989) in 1989 influenced not only the mathematics education community in the United States, but the abroad mathematics education community. Since the Standards were published, a number of international mathematics education researchers, educators, and educational administrators have excerpted the suggestions and guidelines from the Standards to support their own arguments. In particular, there may be no doubt that the 7th Korean school mathematics curriculum for K-12 was strongly influenced by the instructional focuses and mathematical big ideas in the 1989 NCTM Standards. The historical significance of the 1989 NCTM Standards in mathematics education has not declined even though the 2000 NCTM Standards, Principles and Standards for School Mathematics (NCTM, 2000), was published. Mathematics education research papers published until quite recently prove it

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that mathematics educational society considers the old version of NCTM Standards as a good resource to find out the suggestions and guidelines for effective mathematics teaching and learning.

In spite of the famousness of the 1989 NCTM Standards, however, little Korean mathematics educators know about the historical development story of the 1989 NCTM Standards. Therefore, this paper offers the brief review of historical development of Curriculum and Evaluation Standards for School Mathematics. This brief review will satisfy the readers who desire to know the entire development story of the Standards and intend to a new mathematics curriculum. I do not intend to introduce the entire history and contents of the 1989 NCTM Standards. Instead, I want to inform Korean mathematics education society that the 1989 NCTM Standards was a product of a multi-year consensus-building effort led by the nation's mathematics education researchers and teachers in the United States. To support this point of view, I address discussions such as following: What events and activities led to the establishment of the 1989 NCTM Standards? Who were the key individuals and groups involved in the Standards development? and What mathematics education research trends affected the contents of Standards?

I. The GENESIS OF THE 1989 NCTM Standards

Crosswhite, Dossey and Frye (1989) pointed out that the 1989 NCTM Standards might be seen as a continuation, a natural extension, of the commitment made a dozen years ago to reassert the leadership role of the NCTM in curricular reform. That renewed commitment was signaled by the release of Agenda for Action (NCTM 1980) at the Seattle meeting of mathematics educators and researchers in 1980 and had been reflected in a continuing emphasis on curricular concerns throughout the 1980s in NCTM's journals, yearbooks, supplementary publications, and convention programs. One of the specific motivations for Standards project was the recognition of the need for more specific criteria for evaluating the impact of curricular efforts growing out of Agenda for Action. On the other hand, certain people suggest that the report A Nation at Risk was (The National Commission on Excellence in Education, 1983) was a primary motivation of the development of Standards. This argument is reasonable because the report recommended that schools, colleges, and universities adopt more rigorous and measurable Standards and sparked, in fact, the Standards and reform movements. Therefore, I intend to look for the genesis of the 1989 NCTM Standards through investigating mathematics educational events and activities throughout the1970s and 1980s. Primarily, I refer to a historical paper by Lester and Lambdin (2003) to investigate the events and activities. The paper provides the information not only about the creation and development of the mathematics education research community, but also about research trends from the 1970s to 1980s.

II. The Mathematics Education Research Community : 1970s and 1980s

During the decade of the 1970s, the mathematics education research community began to take on a definite professional identity of its own, due in large part to the efforts and vision of a relatively small number of individuals based at Teacher College, Columbia University and the University of Georgia. For example, in 1975, five research workshops were held at the University of Georgia under the auspices of the newly created Georgia Center for the Study of Teaching and Learning Mathematics (GCSTLM). The mission of the GCSTLM was to promote sustained collaboration among researchers who had an interest in three areas of inquiry: concept development, problem solving, and teaching strategies. A particularly appealing feature of the Georgia Center working groups was that each group was open for membership to any researcher interested in the group's research agenda. Thus, for the first time, novice researchers were able to become participants in developing an active research agenda and in creating a mathematics-education-specific research program. For mathematics education researchers associated with the GCSTLM and its working groups, the mid-1970s to mid-1980s was a period of high energy and optimism (Lester & Lambdin, 2003). From this characteristic of the mathematics education research community, we can presume that the 1989 NCTM Standards was developed by collaboration of the nation's mathematics educators, including teachers, novice researchers and mathematicians, not by a particular expert research group.

In the 1980s, the mathematics education research community continued to mature, but in a distinctively different way than before. Specifically, this period saw the continued growth within the mathematics education research community of what sociologist Diana Crane termed an "invisible college", a relatively small group of scholars in the same field of study who established research priorities, recruited and trained students, maintained regular communication with each other, and developed procedures to monitor each other's work (Crane 1972, cited in Romerg 1992, cited in Lester & Lambdin, 2003). During the first half of the 1980s, several influential books and monographs related to mathematics education were published, and this proves the existence of invisible colleges within the mathematics education research community. The explosion of new books was an indication of the desire to make available collections of research paper on common themes and topics (Lester & Lambdin, 2003).

Building on Crane's notion of the invisible college, the NCTM's Research Agenda project, which was initially conceptualized in the early 1980s by the NCTM's Research Advisory Committee (RAC), endeavored to promote "the development of networks of researchers who address related problems in mathematics education." However, the proposal resulting from RAC's deliberations was tabled until 1985 because no funding

from the National Science Foundations (NSF) was available at that time. Ultimately, the NSF funded this project to identify needed research and establish some guidelines in each of four areas-teaching and assessing problem solving, effective mathematics teaching, learning and teaching algebra, and middle school number concepts. Working-group conferences, one in each area, were held during the first five months of 1987.

The previous historical background of the mathematics education research community support that the 1989 NCTM Standards was a continuation, a natural extension of the commitment made a dozen years ago to reassert the leadership role of the NCTM in curricular reform. The authority of the Standards rests not on any governmental mandate, but on the evidence and logic invoked by the Standards themselves.

III. Funding for the 1989 NCTM Standards Development

Beginning in the early 1950s and throughout the 1960s, federal agencies such the U.S. Office of Education, the NSF, and the National Institute of Education provided much-needed support for researchers interested in mathematics teaching and learning. Federal support continued in the 1970s, and served as the primary stimulus for the growing spirit of collaboration between mathematics educators and psychologists. However, the level of federal support during the 1970s was considerably less than the level of activity within the mathematics education research community would suggest. During the 1980s, drastic budget cuts in federal support for education during the first term of the Reagan administration (1981-1984) hastened the demise of many previously funded working groups and either delayed or prevented the start of various new initiatives.

The diminution of federal support resulted that the 1989 Standards project team was also not able to receive enough grants from the federal government. The project team did not intend so great a commitment-at least not in the early stages of planning. At that time, it did not seem financially feasible to use NCTM funds alone. The NCTM tried to find external funding for the Standards project. But the notion of national curriculum Standards was not attractive to most funding agencies. The project team did receive a small seed grant from the Atlantic Telephone and Telegraph Foundation, but it was not connected to other agencies' support for the project. Fortunately, even as the team's planning for the Standards project was under way, the financial condition of the Council improved dramatically as result of increasing membership and renewed national attention to education generally and to mathematics education specifically. As a result, the Board of Directors at the annual meeting in Washington, DC in 1986 made the commitment to pursue the Standards project independent of external funding. The Standards had been developed and distributed almost entirely with membership funds (Crosswhite, et al., 1989).

IV. Curriculum Reform Movements in the Mathematics Education before the 1989 NCTM Standards

During the 1980s, there were visible events and activities regarding to the mathematics curriculum reforms. The current reform effort in mathematics education has its roots in the decade of the 1980s and the national reports that focused attention on an impending crisis in education, particularly in mathematics and science (e.g., "An Agenda for Action 1980; "A Nation at Risk," 1983). It received further impetus with the publication by the NCTM of "Curriculum and Evaluation Standards for School Mathematics" (1989).

The NCTM Board's initiative for clearer focus on the future of mathematics education established Agenda for Action. Agenda expressed a vision that was endorsed by numerous groups, given relatively wide circulation, and used to guide NCTM publications and actions from 1980 until the release of Standards published in 1989. The Agenda went beyond recommendations concerning curriculum. Among the recommendations were calls for a wider range of student outcome measures, for teachers to demand of themselves a higher level of professionalism, and for the garnering of public support for mathematics education (Fey & Graeber, 2003).

Another important educational event was a report of A Nation At Risk (NCEE 1983). On August 26, 1981, Secretary of Education T. H. Bell created the National Commission on Excellence in Education, directing it to examine and report on the quality of education in the United States. The commission responded in 1983 with a report declaring:

Our Nation is at risk. Our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world... We report to the American people that while we take justifiable pride in what our schools and colleges have historically accomplished and contributed to the United States and the well-being of its people, the educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future as a nation and a people (NCEE, 1983).

The Commission developed a series of recommendations designed to improve the quantity and quality of education, including improvements to curricular content and the use of instruction time. The goals of these recommendations were to raise the Standards and expectations of the Nation's educational system, improve teacher preparation, and raise the level of reward and respect for teaching professionals (National Center For Education Statistics, 1995).

In mathematics education, the National Commission on Excellence in Education (1983)

suggested that the teaching of mathematics in high school should equip graduates to: (a) understand geometric and algebraic concepts; (b) develop appreciation for elementary probability and statistics; (c) apply mathematics in everyday situations; and (d) estimate, approximate, measure, and test the accuracy of their calculations. In addition to the traditional sequence of studies available for college-bound students, new, equally demanding mathematics curricula need to be developed for those who do not plan to continue their formal education immediately. These suggested mathematics topics are exactly the same to those that are commonly presented in the K-12 curriculum of the 1989 NCTM Standards. It is not surprising because the mathematics education researchers, who developed the previous suggestions in 1983, were asked by the NCTM to join the Standards project in 1989.

V. The Relationship between Research Trends in the 1970s and 1980s and the Recommendation of the 1989 NCTM Standards

I presume that Standards in the 1989 NCTM Standards were mainly influenced by research trends in the early half of 1980s because the start of the 1989 NCTM Standards development was in 1984. In order to examine my prediction, I will overview the research trends and research topics in the 1970s and 1980s, and then I will try to look for facts supporting my hypothesis.

In mathematics education, the decade from the 1970 to 1980 is commonly described as a "back to basics" era. That phrase suggests renewed emphasis on developing skills in arithmetic and algebraic calculation through instruction that features teacher exposition and student practice. The period was a much quieter period in school mathematics than the turbulent new math of the 1960s. But if one looks closely at the professional literature of that decade, it is easy to see signs of a continuing struggle for influence. In a variety of surveys and critical reflections, sectors of the mathematics education community looked back on the intentions and achievements of the new math movement in search of insight that would win the day for their basic points of view of emphasizing the importance of students' engagement in exploration and discovery through developing appropriative activities (Fey & Graeber, 2003).

In 1980, the NCTM published a book that its editor termed "our best effort to develop a definitive reference work on research in mathematics education"(Shumway, 1980, p. v cited in Lester & Lambdin, 2003). Research in the Mathematics Education provides us with insights into how the research domains expand during the 1970s. Eight chapters of the book were devoted to reviews of research focused on cognitive development, skill learning, concept and principle learning, problem solving, individual difference, attitudes, curriculum and instruction, and teaching and teacher education. Table 1 is an oversimplified encapsulation of research performed in the 1970s and 1980s. We can see topics of research in the 1980s are more specific and sophisticated than that of research

in the 1970s.

<Table 1> Research Trends and Research Topics in the 1970s and 1980s

1970s : "Back to the Basics": Mastery learning	***1980s : Problem Solving: Teacher Effectiveness***
- More traditional development of computational skills - Traditional instructional practices based on principles of behavioral psychology - Explicitly observerable student performance - Hierarchies of logical dependence among those behavioral objectives - Mastery of objectives - Greater accountability in educational institutions and more testing of students' achievement - Increased use of nationally standardized tests to assess students' progress - Effectiveness of teachers and schools - Behaviorist B. F. Skinner and Robert Gagne	- Perceived failure of mastery learning movement - Increasing sophistication of the nature of the research being conducted - What goes on in students'heads during problem solving or how students interact with one another during small group instruction - Complex and relativistic view of mathematics learning and teaching - Conflict between demands for effective teaching and problem- solving approaches
Georgia Center for the Study of Teaching and Learning Mathematics (GCSTLM,1975) • Concept development and problem solving teaching strategies	*Agenda Project(1980)* • Teaching and assessing problem solving • Effective mathematics teaching and learning • Teaching algebra and middle school number concepts
Research in Mathematics Education (1980)[2)] • Cognitive development • Skill learning • Concept and principle learning • Problem solving	*During the first half of the 1980s: Books by Invisible Study Groups* • Acquisition of mathematics concepts and process (Lesh & Landau 1983) • Addition and subtraction: A cognitive

• Individual difference • Attitudes, Curriculum and instruction • Teaching and teacher education *In 1980, Cooney* • New research area of study; teacher education	perspective (Carpenter, Moser, & Romberg 1982) • Children's Counting Types: Philosophy, Theory, and Application (Steffe, von Glasersfeld, Richards, & Cobb, 1982) • Conceptual and Procedural Knowledge: The Case of Mathematics (Hiebert, 1986) • Teaching and Learning Mathematical Problem Solving :Multiple Research Perspectives (Silver, 1985) *National Centerfor Research in Mathematics Science Education* (NCRMSE, 1987) • To identify the major components of classrooms that promote mathematical understanding for all students • Seven themes of Invisible study groups: whole numbers, quantities, algebra, geometry, statistics, assessment, and implementation of reform

Particularly, in the first half of 1980s and in 1987, themes of invisible study groups are very specific topics of mathematics like as whole numbers, addition and subtraction, quantities, algebra, geometry, statistics, assessment. These topics are almost the same with those of the 1989 NCTM Standards, which are commonly included in the K-12 curriculum. I infer that research of the invisible study groups had influence on the development of Standards in the topics.

Another result of this observation is that problem solving is an essential topic of research topic in the both 1970s and 1980s. Although the 1980s is commonly described as "problem solving" era, the birth of problem-solving research might have began in 1975 because a "Research Workshop on Problem Solving in Mathematics Education" was held at the University of Georgia in May of that year. This workshop brought together

2) The NCTM published this book, which provides insights into how the research domain expanded during the 1970s.

individuals who were already deeply involved in mathematical problem-solving research and, more than any other single event, stimulated a level of collaboration among mathematics education researchers that had not existed earlier (Lester, 1994). However, research emphases of problem solving were different throughout the era. Lester (1994) provided the aspects of problem solving that have been primary foci of interest from the 1970 to 1994 on the Table 2.

<Table 2> An Overview of Problem-Solving Research Emphases (Lester, 1994)

Dates	*Problem-solving research emphases*
1970-1982	Isolation of key determinants of problem difficulty; identification of characteristics of successful problem solvers; heuristic training
1978-1985	Comparison of successful and unsuccessful problem solvers (experts vs. novices); strategy training
1982-1990	Metacognition; relation of effects/beliefs to problem solving; metacognition training
1990-1994	Social influences; problem solving in context(situated problem solving)

According to the 1989 NCTM Standards, problem solving is the central focus of the mathematics curriculum, and it is a primary goal of all mathematics instruction and an integral part of all mathematics activity. Problem solving is not a distinct topic but a process that should permeate the entire program and provide the context in which concepts and skills can be learned. Students should share their thinking and approaches with other students and with teachers, and they should learn several ways of representing problems and strategies for solving them. That is, problem solving should mainly focus on a strategy training, which is a characteristic of problem solving in the 1978-1985. This fact indicates Standards regarding problem solving in the 1989 NCTM Standards are arisen from research tendency of the problem solving in the 1978-1985. From the previous observations of research tendency in the 1970s and 1980s, I conclude that Standards in the 1989 NCTM Standards were mainly influenced by research tendency between the late of 1970s and the early half of 1980s. Particularly, in the early 1980s, the research topics and research results of the invisible study groups influenced Standards of the 1989 NCTM Standards.

VI. The 1989 NCTM Standards' Influence on the Reform of Korean Mathematics Education Curriculum

The 1989 NCTM Standards clearly had an influence on the movement to reform mathematics education curricula in Korea. According to Hwang et. al. (2007), the 1989

NCTM Standards provided the direction for international mathematics education in the 1990s, and the 6th Korean mathematics curriculum framework, released in 1992, moved in very much the same direction, with its emphases on mathematical literacy, mathematical thinking and problem solving, the usefulness of mathematics education, the appropriate use of calculators and computers, and various assessments for all students. However, the sections of the 6th curriculum framework that specified ideas in more detail had a number of differences from the Standards.

By contrast, the 7th Korean mathematics curriculum framework, which was developed in 1997, did have a high degree of consistency with the NCTM Standards. One can see the influence of the NCTM Standards on the 7th curriculum framework in the typical grade-level organization and the attention to process as well as content. Before the 7th curriculum, the organization of grade levels in the Korean mathematics curriculum was based strictly on the three school level system (six grades in elementary, three in middle school, and three in high school). This traditional structure was changed to the connected 10-level grade system, from level 1 to level 10; the 1997 curriculum framework also instituted the so-called "national common standard curriculum," and the new grade level structure coincided with the 1989 NCTM Standards' grade level approach that diluted the distinction between school levels.

The NCTM Standards stress problem solving, communication, connections, and reasoning as the "process standards" for each of the levels (K-4, 5-8, 9-12), and this special emphasis on the four standards is also present at all grade levels in the 7th curriculum. In particular, the emphasis on communication and connections within mathematics is one of the important features showing that the 7th curriculum benchmarked the 1989 NCTN standards. While problem solving and reasoning had been emphasized in Korean mathematics curriculum since the 3th curriculum as anintegral part of mathematics, mathematics curriculum reformers had not given the same attention to connections and communication through the time of the 6th curriculum reform. The two special process standards were included in the 7th curriculum, however, and they have been emphasized in Korean mathematics curriculum ever since.

VI. CONCLUSION

In contrast to other nations, the U.S. has always favored local over national control of education. But by 1983, mounting evidence of failures of U.S. education moved the authors of A Nation at Risk to recommend strengthened requirements, rigorous Standards, and higher expectations for all students. This bold challenge to a complacent nation was followed by a drumbeat of headlines citing poor performance of U. S. students on international educational comparisons, especially in science and mathematics (Steen, 1995).

Independently, but also in response to A Nation at Risk, the NCTM began to develop

the nation's first educational Standards. These voluntary Standards were the product not of the federal government, but of a multi-year consensus-building effort led by the nation's mathematics teachers and mathematicians, which had been developed and distributed almost entirely with membership funds of the NCTM. That renewed commitment was signaled by the release of Agenda for Action at the Seattle meeting in the 1980 and had been reflected in a continuing emphasis on curricular concerns throughout the 1980s in the NCTM's journals, yearbooks, supplementary publications, and convention programs. One of the specific motivations for the NCTM Standards project was the recognition of the need for more specific criteria for evaluating the impact of curricular efforts growing out of Agenda for Action. Particularly, Standards in the 1989 NCTM Standards were mainly influenced by the research topics and research result of the invisible study groups in mathematics education research community between the late of 1970s and the early half of 1980s.

Therefore, the authority of the 1989 Standards rests not on governmental mandate, but on the evidence and logic invoked by the Standards themselves and the 1989 NCTM Standards quickly became the nation's premier example of educational "Standards"-a set of public expectations, rooted in research and practice, that are intended to raise the academic achievement of all students. In particular, the publication of the 1989 NCTM Standards strongly had an influenced on the reform movements of Korean mathematics curriculum in 1990s.

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Establishment Story of 1989 NCTM Curriculum and Evaluation Standards for School Mathematics

1970-80년대 미국의 수학교육 연구동향 및 활동에 기초한 1989년 미국 NCTM 규준집 편찬 역사에 대하여

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초 록

1989년 미국 수학교사협의회(National Council of Teachers of Mathematics)에서 「학교수학을 위한 교육과정 및 평가 규준집 (The Curriculum and Evaluation Standards for School Mathematics)」을 발간한 이후로 이 규준집은 미국 국내 뿐만 아니라 세계적으로도 수학교육학과 관련된 여러 연구에서 인용되어 왔다. 본 논문은 1989년 미국 NCTM 규준집이 미국의 일부 수학교육 단체에 의해 주도된 수학과 교육과정 개정 움직임이 아니라, 미국 내 국가 차원에서 수많은 수학교육학자들과 수학 교사들의 합의와 다년간의 노력에 의해 만들어진 거의 국가수준의 교육과정임을 역사적으로 보여주고 있다. 특히, 본 논문은 1970년, 80년대 미국 수학교육학 단체들의 연구동향이 1989년 NCTM 규준집 내용과 밀접하게 결부되어 있음을 보여줌과 동시에, 이 NCTM 규준집이 우리나라 제 6차 및 7차 수학과 교육과정에 어떤 영향을 미쳤는지에 대해 분석한 내용을 소개하고 있다.

주요용어 : 수학교육, 교육과정, NCTM 규준

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