

The NCTM *Standards* from an Axiological Perspective

2006

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ABSTRACT

With the recognition of the significant role played by the NCTM *Standards* and the *Principles and Standards* within the history of mathematics education within the United States and internationally, it is necessary to consider the philosophical composition of this movement and address specific questions which naturally arise. Eclipsed by discussions of curricular content, philosophical concerns are often absent from contemporary discussions of mathematics education reform efforts. This investigation is accomplished by analysis of historic documents published by NCTM and other organizations endeavoring contemporaneous reform efforts within the United States. Herein, NCTM's interpretation of the *Good Citizen* and *Good Education* is analyzed and reported, and the findings are opened to serious inquiry and concerns.

The NCTM *Standards* from an Axiological Perspective

...the biggest surprise for me has been the unintended impact on both school mathematics in other countries and on other disciplines in the United States. None of us involved in preparing the *Curriculum and Evaluation Standards for School Mathematics* could have predicted the translation of this document into such languages as Spanish, Russian, and Japanese, and the parallel work in several other nations. (Romberg, 1998, p. 19.)

The national and international impact which the NCTM *Standards* (1989) and the NCTM *Principles and Standards for School Mathematics* (2000) have created make this reform effort ripe for philosophical investigation. This paper analyzes NCTM's philosophic position by considering the movement's historical foundation and connections with other contemporaneous reform efforts within the United States. Although educational reform movements are more typically analyzed based upon curricular recommendations, this investigation seeks to analyze NCTM's foundational philosophic beliefs.

Efforts to reform and counter-reform mathematics education have punctuated the history of the United States over the past four decades. Few movements, however, have had the profound and enduring effects as the NCTM *Standards* and its accompanying and historic documents (1980-1996) and the subsequent rewriting of the *Standards* known as the NCTM *Principles and Standards for School Mathematics* (Draft, October, 1998) and the NCTM *Principles and Standards for School Mathematics* (2000)—also recognized as *Standards 2000*.

Eclipsed by discussions of curricular content, philosophical concerns are often absent from contemporary discussions of mathematics education reform efforts. With the recognition of the significant role played by the NCTM *Standards* within the history of mathematics education, it is necessary to consider the philosophical composition of this movement.

Axiology is a field of philosophical investigation which considers the question: What is good or best for a person or a culture? Within the realm of educational philosophy, this question takes on a more specific form: What should be learned, by whom, and for what end? For the purposes of this paper, axiological concerns will be those which respond to questions respecting what is good to be taught and learned (“*good education*” or “*good curriculum*”) and what should be the role of people within society (the “*good citizen*”).

In sequential order, this paper considers the following: research methodology; historical orientation of the NCTM *Standards*; preliminary philosophic concerns; socio-political concerns affecting the development of the *Standards*; democratic schisms; axiological summary; and remaining questions and commentary. Within the latter sections, evidentiary documentation and historical concerns are reported, followed by opinions and commentary from the author of this research.

Research Methodology, Limitations, and Delimitations

Data for this qualitative investigation are found in four types of sources, and the order of primacy of these sources can be categorized as: (1) Primary Source of Highest Order, statements within NCTM reform documents (1980-2000); (2) Primary Source of Secondary Order, reform documents from other organizations (1975-2000) as cited within NCTM reform documents; (3) Secondary Source, firsthand or reported accounts of the opinions of those involved in the

development of the NCTM *Standards*; and (4) Secondary Source, scholarly historical analyses of school mathematics reform within the United States. Only the reform documents which were published in the name and under the auspices of NCTM will be considered to authoritatively represent NCTM's position and recommendations.¹

Problematic in the analysis of organizational documents are two factors. First, care must be taken to avoid personifying an organization and equating one viewpoint to many individuals. Organizational documents are generally written by committees; thus they, at best, represent the opinions of the writing teams rather than the organization as a whole, and may or may not adequately mirror the opinions of the entire organization, if such unified opinions exist. Second, organizational documents written over a period of decades may very well have been composed by far different writing groups. Therefore, beliefs of different writing teams may not be consistent. Nevertheless, with these concerns in mind, some degree of organizational and historic consistency must be necessarily assumed.

Within NCTM's historic reform documents there exist citations to many other historic documents authored and published by persons and groups affiliated with organizations independent of NCTM. Within NCTM's citations, there are many documents which are, in effect, a historic roadmap delineating philosophic evolution of the *Standards*. Therefore, to further understand NCTM's philosophic evolution and position, some of these historic documents affiliated with organizations other than NCTM are also considered informative and valuable.

PART I: HISTORICAL ORIENTATION OF THE NCTM STANDARDS²

Through the 1970s, emphasis on mathematical "basics" dominated pedagogy, textbooks, and curricular recommendations within the United States. Unfortunately, this was perceived to miss meeting the needs of students entering a more technologically complex workforce and culture (Crosswhite, 1990; NCSM, 1978). The modern mathematics education reform effort within the United States, recognized by the introduction of the NCTM *Standards*, owed its foundation to a seminal document, *An Agenda for Action* (NCTM, 1980) (Bishop, 1990; McLeod, et al., 1996). This short publication was a response to the advocates of the Back to Basics movement and it made a number of curricular and pedagogical recommendations for mathematics education for the 1980s in the United States (Crosswhite, 1990) that embodied the response of the mathematics education

¹Readers may cite additional documents and resources as essential to this investigation and others which should be omitted from consideration. While many of the recommended documents may have significant historic and philosophic merit and insight, those published outside of the auspices of NCTM are herein not recognized as authoritative.

²In preparation for axiological analysis, the historical analysis included in this section is only an outline of the many events surrounding the development of the NCTM *Standards*. For fuller examinations, other historic analyses should be considered (Bishop, 1990; Crosswhite, 1990; Crosswhite, Dossey, & Frye, 1989; Kilpatrick, 1997; Kilpatrick & Stanic, 1995; and McLeod, et al, 1996; Stanic & Kilpatrick, 1992).

community to pressures exerted on the U.S. through international technology and economics and through cultural and occupational inequities. *An Agenda for Action* provided a loose framework which recommended national policy changes in mathematics education and proposed specific positions on pedagogical issues; this demonstrated a significant departure in philosophy regarding the role of NCTM in political outreach and promoting educational policy (McLeod, et al., 1996).

NCTM's *An Agenda for Action* was followed by similar calls for reform of education within the United States by other organizations (CBMS, 1983a, 1983b; CFEE, 1986; MSEB, 1987; NCEE, 1983; Ralston, et al., 1988; Romberg, 1984a, 1984b). The National Commission on Excellence in Education produced one of the most influential publications in this genre, *A Nation at Risk: The Imperative for Educational Reform* (NCEE, 1983). Calling for reform, *A Nation at Risk* sought to mobilize a reluctant Reagan administration to support educational programs and change (McLeod, et al., 1996). Raising many parallel concerns, *Educating Americans for the 21st Century* (NSBCPEMST, 1983) claimed that students were inadequately prepared for an economy and culture which were increasingly more global and technocentric (Romberg, 1998).

Early 1989 brought the publication of a hard-hitting, politically motivated document calling for the need for mathematics education reform (Bishop, 1990). *Everybody Counts* (NRC, 1989), published by the Mathematical Sciences Education Board of the National Research Council, boldly proclaimed the need for reform and also described the Board's grave concerns for educational and societal equity. The publication date of *Everybody Counts* was carefully choreographed to pave the way for NCTM's planned publication of its reform document³ later that year (McLeod et al., 1996). Recommendations from many of the reform efforts through the 1980s requested the development of new objectives and standards-based curricular guidelines for mathematics education (McLeod, et al., 1996; Raizen, McLeod, & Rowe, 1997) and coalesced into the writing of the NCTM *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989), which describes itself as part "of the mathematics education community's response to the call for reform" (p. 1).

The publication of the *Standards* was heralded by Burson-Marsteller and Gallagher-Widmeyer (Crosswhite, Dossey, & Frye, 1989; McLeod, et al., 1996), two public relations firms working in conjunction with NCTM. Copies of the document were disseminated to United States House and Senate committees and to others holding important policy positions in state and federal government (Crosswhite, Dossey, & Frye, 1989). The NCTM *Standards* described a vision for K-12 mathematics which built upon NCTM'S role of national reform leadership initiated by *An Agenda for Actions* (Crosswhite, in Crosswhite, Dossey, & Frye, 1989). The document demonstrated a curricular shift from mathematical structures toward the practical mathematics of the workplace

³Bishop (1990) reported that some members of the NCTM's Commission on Standards for School Mathematics also served on NRC's Mathematical Sciences Education Board. Bishop promotes a theory of positive collaboration between the two entities, explaining the many common themes between the two documents. With this in mind, one must wonder if the publication of *Everybody Counts* was intended to make the harsh political statements with which NCTM agreed but would be hesitant to openly state, recognizing that such statements would hinder public acceptance of their recommendations.

(Atkin, et al., 1997).

The NCTM *Standards* was followed by two additional publications further addressing components within the reform effort, *Professional Standards for Teaching Mathematics* (1991) and *Assessment Standards for School Mathematics* (1995). NCTM then commissioned the writing of the *Addenda Series* (1991-1995) to fill in gaps and add pedagogical specificity and detail to the curricular recommendations contained in the three primary documents.

TIMSS was the next national concern to affect NCTM's curricular suggestions and vision.⁴ SIMS, the *Second International Mathematics Study* (1982), reported nominal successes in U.S. K-12 mathematical classrooms, while predicting the failure of U.S. education if the *status quo* were maintained (Crosswhite, et al., 1985, 1986; McKnight, et al., 1987; NRC, 1989). TIMSS (1994-1995), the *Third International Mathematics and Science Study*, reported significant mathematical deficiencies within eighth grade and twelfth grade U.S. students. The findings, while controversial, were nonetheless disconcerting and pointed to the great need for further efforts in mathematics education reform.

Due to national expectations for a response to TIMSS, some of the suggestions from those reporting TIMSS results may have affected the timing of the revision of the NCTM *Standards* and were addressed within the *Principles and Standards for School Mathematics: Discussion Draft* (NCTM, 1998). Clearly, however, it was NCTM's intent, during the writing of the original *Standards* to revise the documents a decade later (NCTM, 1989, 1998). The *Discussion Draft* of the *Principles and Standards for School Mathematics* entailed the first efforts of this revision.

Following the publication of NCTM's reform trilogy, NCTM undertook to revise the standards into a more cohesive document supported by additional research and classroom experience. This culminated in the publication of the *Principles and Standards for School Mathematics* (NCTM, 2000), also called *Standards 2000*.

PART II: PRELIMINARY PHILOSOPHIC CONCERNS

Philosophical Consistency Within the Standards

Historical investigation demonstrates NCTM's philosophical connections with contemporary reform efforts. The question, however, arises as to whether or not NCTM's reform effort (1980-2000) was itself held together by a unifying philosophical position. In part, the question may be answered by considering one more historical facet associated with the writing of the NCTM *Standards* (1989). Throughout the process of the writing of the NCTM *Standards*, Thomas Romberg distributed collected reading⁵ to those on the writing groups (McLeod, et al., 1996). Many of these documents were written and edited by Romberg (e.g., Romberg, 1983, 1984a, 1984b, 1987a, 1987b; Romberg and Carpenter, 1986; Romberg & Stewart, 1987). While no measurable role can be

⁴The selection of the TIMSS as a factor motivating NCTM's writing of the *Principles and Standards of School Mathematics* (2000) is based upon the numerous citations within NCTM documents (1998-2000) directly discussing the TIMSS. For more information regarding the TIMSS, see Beaton, et al., 1996; Harmon, et al., 1997; Mullis, et al., 1997; Mullis, et al., 1998; NCES, 1997a,b,&c; NCES, unpublished 1998; Schmidt, et al, 1997; Schmidt, McKnight, and Raisen, 1996; Silver, 1998; Stigler and Hiebert, 1997.

⁵ Historically, the required reading distributed by Romberg to members of the writing groups is not widely recognized. The author of this paper made this finding when previously investigating the history of the NCTM *Standards*. As a result of an ensuing conversation, Thomas Romberg forwarded to the author the reading list as well as a copy of most of the documents on the list. This data has proven invaluable in further research.

ascribed to the impact of these documents upon the directions of the project, it can be assumed that his standing as Commission Chair and the dissemination of these documents sought to promote dialogue and possibly to philosophically solidify the professional groups writing the *Standards*.

Few, if any, documents published under the auspices of NCTM evidence that NCTM is philosophically fractured, so the present study will assume that NCTM publications demonstrate some level of philosophical unity. NCTM charged the writing group of the *Principles and Standards* to develop a set of standards which would “build on the foundation of the original *Standards* documents,” (NCTM, 2000, p. ix). Thus one can infer a strong, if not complete, correlation between the two documents. In latter sections, more detailed analysis will further examine this question.

Axiological Statements Within NCTM’s Statement of Beliefs and Position Statements

NCTM’s website publishes a number of axiological statements within its Statement of Beliefs and Position Statements. These statements are intended to inform the public, educators, and policymakers about NCTM’s core beliefs and its positions on certain issues. Within these statements, however, three passages speak directly to axiological issues:

Every student deserves an excellent program of instruction in mathematics that challenges each student to achieve at the high level **required** for **productive citizenship and employment**. (NCTM, Statement of Beliefs, [On-line] 2000)⁶

All students have the right to a mathematics education that ensures **mathematical literacy** and the development of the concepts, skills, and dispositions necessary for a **meaningful and productive life**. (NCTM, Position Statement on Teaching Mathematics in the Middle Grades, [On-line] 1998)

Paths to continuing education and employment opportunities are often hindered by powerful social and institutional influences that discourage [underrepresented] students from studying mathematics. In our challenging and complex society, it is paramount that **all students** are considered **valuable resources** to be afforded the opportunity to **reach their full potential** and **contribute to society**. (NCTM, Position Statement on The Mathematics Education of Underrepresented Groups, [On-line] 1995)

These statements, taken in tandem with NCTM’s many other volumes of published reform documents, form a unified and cogent axiological position. Therefore, while these statements are succinct, if not overly terse, a body of publications demonstrates that these adequately summarize the axiological position of the NCTM writers on many points. These will be examined further in following sections.

Further axiological analysis of the NCTM *Standards* is, herein, undertaken after historical and socio-political foundations of the NCTM *Standards* are investigated. These foundations will assist to explain both what NCTM holds to be axiologically significant and why. Although a necessary oversimplification, for the purposes of this paper, axiological concerns will be those which

⁶Many quotations within this paper have text with bold face font. This bold face has been added by the author of this paper to emphasize certain aspects within the text.

define *good education* and the *good citizen*.

PART III: SOCIO-POLITICAL ISSUES AND THE NCTM STANDARDS

Within historical commentary concerning the development of the NCTM *Standards*, the greatest controversies appear in discussions of socio-political factors affecting the development of the *Standards*. Because these discussions are already fraught with controversy and contradictions among NCTM publications, historians, and participants in the development of the *Standards*, the present study relies on statements from NCTM publications over other opinions.⁷

The investigation of socio-political issues reveals multiple connections between reform documents published by NCTM and those published by other organizations within the United States.

Two factors support these connections. First, all extra-NCTM reform documents referenced within this paper were cited in NCTM reform publications—thus connoting NCTM’s agreement, whether tacit or explicit, with the content and recommendations of the documents from other organizations. Second, a significant number of the people affiliated with the development of the *Standards* were also affiliated with other organizations and their respective reform efforts. Bishop (1990) reported that “six members of the NCTM’s thirteen-person Commission on Standards for School Mathematics were also on the NRC’s Mathematical Sciences Education Board” (pp. 360-361). This cross-fertilization of personnel affiliated with multiple scholarly organizations and associations commonly occurred among many organizations promoting reform within the United States during the 1980s (McLeod, et al., 1996). Such cross-fertilization may explain why so many reform documents from various associations during this period shared so many foundational beliefs and underpinning goals.

ECONOMICS: International, National and Personal

Toyotashock, Equity, and Diminishing American Democracy

In the 1980s, Japan’s economic renaissance caused the United States to re-evaluate her position as an international economic superpower. “Toyotashock” (Bossé, 1995) denoted the concern of the U.S. that Japan was seemingly gaining economic superiority through technological advancements and becoming an international leader in mathematics education (CFEE, 1986; Crosswhite, Dossey, & Frye, 1989; Goodlad, 1995; McKnight, et al., 1987). The United States became enthralled by the entire Japanese educational/technological system and attempted to emulate those techniques which were acceptable to U.S. culture (NRC, 1989). However, much of the Japanese system could not be easily replicated in U.S. schools and industry. Bishop (1990) states that a “link is made in *Everybody Counts* [NRC, 1989] between the decline in general student achievement in mathematics and the decline in competitiveness of the U.S. economy” (p. 358) and that, through cross-participation of NCTM and MSEB members, both *Everybody Counts* and the NCTM *Standards* speak as one voice. Most historical analyses state that concerns for global and

⁷Analysis of historical commentary regarding the development of the NCTM Standards unearths unending discussions and lists of socio-political factors claimed to have affected the development of the Standards. However, this study is primarily concerned with those factors which are clearly recognized within NCTM reform documents. While a significant number of socio-political factors are discussed in this section, many more which do not specifically affect axiological interpretations of NCTM’s documents are deliberately ignored.

economic competitiveness was a significant issue within NCTM's discussions and document (Bishop, 1990; Kilpatrick, 1997; Stanic & Kilpatrick, 1992).

Throughout NCTM's publications, discussions abound demonstrating concern for global educational and economic competitiveness. Additionally, NCTM's publications and statements from those who participated in the development of the *Standards* indicate that NCTM supported the many extra-organizational calls for reform (1980s) and looked to them for both support and guidance (Crosswhite, 1990; McLeod, et al., 1996). This connotes that NCTM, to some extent, agreed with foundational concepts from extra-organizational publications, some of which unabashedly declared concern for the United States' weakening democracy through international economic competitiveness.

The 1980s entertained the argument: Since all U.S. citizens were inextricably wed to the national economy as consumers and, thereby, symbiotically interconnected with industry and local and national economy, U.S. economic concerns were shared by all citizens. Toyotashock (1980s) called for the enlistment for *all U.S. citizens* in the battle to regain international economic superiority. However, if all citizens were now involved in an international economic battle protecting the democracy of the U.S., educational, occupational, and economic equity would have to be promoted for all citizens. The focus on international economics during the 1980s, therefore, had the primary effect of dramatically opening dialogue concerning educational, societal, and occupational equity and opportunities.

Questions and Comments. Connecting U.S. mathematics education reform to international economic competitiveness naturally raises significant questions. Is being economically preeminent among all nations an adequately valuable goal for U.S. education? Should the second most economically powerful nation on Earth be considered a failure? If a nation's economy is strong but some individual citizens are still living in poverty, should she still be considered successful?

Certain issues become problematic when educational goals concentrate upon international economic competitiveness. First, meeting goals of economic success can naturally only lead to static and unprogressive goals of economic maintenance. Second, since definitions for *economic success* are at best ethereal, it is impossible to determine when *economic success* has been satisfactorily accomplished. Utilizing economic success as a goal for education leads the educational system to becoming trapped in a labyrinth of ill-defined goals.

As will be further addressed in latter discussions within this paper, few issues within U.S. educational reform efforts (1950s-2000) transcend the ubiquitous concern for the preservation of American democracy. Consistent within U.S. calls for educational reform are an alarmist tenor and a focus upon some pernicious enemy to democracy. Many reform efforts throughout the 1980s, including NCTM, strongly correlated U.S. democratic stability to international economic superiority. Consequently, one is forced to question if perceptions of democracy should be corralled within narrow economic frameworks. Would U.S. democracy languish if the nation found herself economically fractured? If so, shouldn't every economic recession be considered tantamount to the potential demise of democracy? Clearly, this should not be the case. While some may argue that protecting the U.S. economy effectively prolongs the social structure of capitalism, connecting the preservation of American democracy with economic concerns has little logical merit.

Employment in the Information Age

Tied significantly with concerns for the national economy throughout the 1980s, concerns for

the ability and opportunity of U.S. citizens to obtain meaningful employment propelled many of the national reform efforts within the U.S. (CFEE, 1986; CBMS, 1983a, 1983b; Johnson & Packers, 1987; NCTM, 1989; NCEE, 1983; NSBCPEMST, 1982, 1983).

Writers of the NCTM *Standards* held dualistic concerns for the strengthening of a perceived weakened and unstable U.S. economy and the enlistment of all citizens in this battle. Atkin, et al., (1997) report that “The NCTM standards project portrays mathematics as a collection of concepts and procedures to be mastered if students are to be productive citizens and literate workers in the next century” (p. 50)

Technological concerns and the public’s recognition of the arrival of the “information age” had significant roles in solidifying the universal appeal of mathematics reform in the 1980s and 1990s (CFEE, 1986; CRMST, NRC, 1985; Johnson & Packers, 1987; MSEB, 1990; NCEE, 1983; NCTM, 1986, 1989; NRC, 1989; NSBCPEMST, 1983; Nickerson, 1988; OTA, 1988; Pappert, 1987). Educators readily cited reform publications which promoted work environments of the information age as those where all employees, from janitors to senior scientists, had to be computer literate due to the culture’s newly emerging dependence on computers and technology. Many believed that it would be difficult to employ those with limited computer skills (Johnson & Packers, 1987; MSEB, NRC, 1990; NCEE, 1983; Nickerson, 1988; OTA, 1988). Therefore, the need for reform was recognized as a need to reinvestigate the mathematical education of the entire future workforce.

Questions and Comments. While the above observations of NCTM’s focus upon education for the sake of employment may have few detractors, some concerns surface when citations from both NCTM and contemporary education reform documents are considered in more depth.

[It] is increasingly difficult for the poorly educated to find jobs. **A growing number of permanently unemployed people seriously strains our social fabric.** A heavily technology-based economy will be unable to invest vast sums **to maintain people who cannot contribute to the nation’s productivity.** (CFEE, 1986, p. 14)

Analysis demonstrates that some NCTM writers strongly concur with the preceding statement, as one of NCTM’s position statements declares that “all students are considered **valuable resources** to ... **contribute to society.**” (NCTM, [On-line] 1995). NCTM values individual employment as it positively contributes to society as a whole and perceives that the individual is expendable for the sake of the nation. This is considered in more detail in the following section.

The preceding quotations immediately lead to many grave concerns. Is it a proper goal of mathematics education reform for citizens to possess requisite mathematical skills to be economically productive to the culture without being economically burdensome to others or the government? Should the primary concern for individual education and training be to ensure that a few do not inconvenience the whole? Should the worth of a person be solely based upon his/her ability to financially contribute to the national economy and whether he/she contributes to, or burdens, the national economy? Great care must be taken before answering these questions. Following considerations will further shed light on this issue and these questions.

Interconnection Among Personal and National Economics and Employment

Strong connections exist between the NCTM *Standards* and business. “Three of the four new social goals [within the *Curriculum and Evaluation Standards*] serve business needs.”

(Roitman, 1998, p. 38). NCTM reform documents strongly conjoin the notions of personal and national economics. Although NCTM writers make a singular claim that their mathematical focus is not narrowly upon mathematics education as a tool to gain employment (NCTM, 1989, p. 4), the vast majority of NCTM's documents belie this assertion. NCTM's own 1989-1998 publications, and contemporaneous publications from other professional organizations, indicate that concern for student's respective future employment is founded upon a concern for the national economy (CFEE, 1986; CBMS, 1983a, 1983b; Johnson & Packers, 1987; NCTM, 1989; NCEE, 1983; NSBCPEMST, 1982, 1983). The economic success of individuals is correlated to the economic success of the nation (Meiring, et al., 1992).

The strength of the connection between personal economics stability (meaningful employment) and *success in life (full participation in society)* made within NCTM reform literature is undeniable. Too numerous to cite are the statements within NCTM reform documents which argue that a person's underemployment is tantamount to the failure of gaining *success in life* and his/her limited financial resources denies him/her the opportunity to *participate fully within society* (e.g., Meiring, et al., 1992, pp. 3,4-5; NCTM, 1989, pp. 3,4,130; NCTM, 1980, pp. 17-19; Romberg, 1998, p. 9). This correlation of personal economic success with national economic strength is logically consistent within a reform movement which recognizes the symbiotic nature of the producer/consumer role of individuals within a national structure. However, some additional statements within NCTM's reform documents paint a less than flattering picture of the correlation that NCTM makes between a person's employment and their value to society.

Lack of competence in mathematics beyond arithmetic now limits an individual's opportunity for **success in life** and . . . for **full participation in society**. . . . Lack of success in high school level mathematics and beyond now eliminates graduates from all but **the most menial dead-end jobs**. (Meiring, et al., 1992, p. 3)

Questions and Comments. The designation, within some NCTM reform documents, of some occupations as "menial" and "dead-end" successfully denigrates those who, either by choice or necessity, make their living from those occupations which NCTM describes as such. The vision of some NCTM's writers seemingly judges occupations solely upon the basis of salary; other factors concerning quality of life, occupational enjoyment and satisfaction, minimal stress, and time for family and recreation seem to be absent from their evaluation. Democracy within the United States calls to *life, liberty, and the pursuit of happiness*, allowing citizens to follow the careers which they please, irrespective of other's opinions about what salary range constitutes *success in life*. Granted, some U.S. citizens are forced into various job tracks due to lack of education and training. However, even in these cases, many have freely chosen their educational path, and almost all, if desired, have opportunities for additional education, retraining, and career advancement.

EDUCATION: Equity and Mathematical Literacy

Excellent and Equitable Education for All Students

NCTM writers mirrored the opinions of many concurrent U.S. school reform efforts and documents suggesting the need for universal instruction and a removal of the inequitable practice of tracking and unnecessarily extensive differentiated curriculum (AAAS, 1982; BMS, 1986; Johnson & Packers, 1987; Malcom, 1984; Meiring, et al., 1992; NCTM, 1980, 1989, 1998, 2000; NCEE, 1983; NRC, 1989; NSBCPEMST, 1983; Oakes, 1990; Romberg, 1983). Stake and Raizen (1997), however, state that some disagreed with NCTM writers' emphasis on equity: "Issues of equity and

student diversity was not specifically addressed in the documents, however, leading some to criticize them on that ground” (p. 148).

Education reform within the 1980s simultaneously called for both equity and excellence in education (Johnson, 1990; Malcom, 1984; McLeod, et al., 1996; NSBCPEMST, 1982; Secada, 1989). This meant that all students should receive the best possible education, which some argued had previously been reserved solely for upper-track students. Few would deny that NCTM writers unwaveringly support the notion that excellent mathematics education is universally needed by all students (NCTM, 1991, p. 4; NCTM, 2000, p. 3, 4, 7, 13) and some argue that equity issues are some of the most significant principles within NCTM’s reform efforts (Haimo, 1998; Johnson, 1990; McLeod, et al., 1996; Secada, 1989)

NCTM’s historical documents demonstrate a significant evolution in their published position concerning tracking. Although the writers of NCTM reform documents stated that varying student needs required different pedagogical techniques, the 1989 *Standards* fell short of dogmatically castigating the practice of tracking (Stake & Raizen, 1997). Modern statements from the *Principles and Standards* (2000) strongly denounce tracking and recognize the needs for differentiated curricula and pedagogy for different students. Simply put, NCTM writers support differentiating the instruction according to student need without minimizing content, which would thus create inequities associated with previous reform movements. (See NCTM, 2000, pp. 12, 368-369).

Questions and Comments. While controversies regarding other axiological concerns are more philosophical in nature, arguments concerning the foundation of equity take on a more pragmatic form. While developing this present analysis, the author had numerous opportunities to discuss the findings with public school mathematics teachers. Commonly teachers responded that they had little time to concern themselves with such philosophical platitudes when students were incapable of basic arithmetic computations. Teachers did not contest the philosophical appropriateness of individualized instruction for students with individualized learning styles and needs; they simply contended that in the day-to-day duties of classroom instruction a foundational focus on equity and individualism is pragmatically unrealistic.

In the defense of NCTM and contemporary U.S. educational reform efforts, however, it should be stated that democracy would argue for equity among its citizenry with much more verve than it would argue for individual and national economic success, as previously considered. However, the equity supported by *all men being created equal* is far from the socialistic equity which some would promote.

Mathematical Literacy and Societal Participation

Mathematics has become a critical filter for employment and full participation in our society. We cannot afford to have the majority of our population mathematically illiterate: Equity has become an economic necessity. (NCTM, 1989, p. 4)

NCTM further develops its position promoting the interconnection of citizenry with economics and employment by integrating mathematical literacy with societal participation. NCTM writers correlate “full participation in our society” with the notion of an informed electorate, capable of comprehending increasingly complex technical and economic issues (NCTM, 1989, p. 4). In an article discussing the fundamental beliefs of the writers of NCTM’s *Curriculum and Evaluation Standards*, Romberg stated:

Teaching mathematics to “all students” emphasizes the fact that all students need to

be mathematically literate if they are to be productive citizens in the twenty-first century. ... If students are to be mathematically literate and productive citizens in the twenty-first century, our belief is that all students need to have a good mathematics background. (Romberg, 1998, p. 9)

Romberg further stated that “mathematical power means having the experience and understanding to participate constructively in society” (1983, p. 37). NCTM writers concur and state that “Graduates of high school mathematics programs must have the high degree of mathematical literacy needed to function effectively in society” (NCTM, 1998, p. 271)

An Agenda for Action (NCTM, 1980) began the construction of an axiomatic foundation characterizing “a meaningful and productive life” and the role and responsibility of the “productive citizen” within the democratic culture of the U.S. NCTM’s 1989-2000 seminal documents continually delineate mathematics as a tool designed to further develop reasoning skills within the nation’s electorate and provide citizens the requisite skills to vote rationally on complex technical and economic issues. By empowering citizens to intelligent voting, this mathematical literacy in turn protects democratic ideals. The writers of NCTM’s publications also continue to create a juxtaposition which implies, if not categorically states, that correlations exist between mathematical literacy and the ability of individuals to become “self-fulfilled, productive citizens.”

Calls for reform in school mathematics suggest that new goals are needed. All industrialized countries have experienced a shift from an industrial to an information society, a shift that has transformed both the aspects of mathematics that need to be transmitted to students and the concepts and procedures they must master if they are to be **self-fulfilled, productive citizens** in the next century. (NCTM, 1989, p. 3)

NCTM’s axiological position does not exist in a vacuum; other reform efforts mirror the concern and language for intelligent and effective citizenship. *Everybody Counts* (NRC, 1989) discusses the “mathematical thought required for intelligent citizenship” (p. 9) and states that “All students need to leave secondary school well prepared mathematically for leading intelligent lives as productive citizens. ...” (p. 49). The Mathematical Sciences Education Board concurs and states, “Citizens who cannot properly interpret quantitative data are, in this day and age, functionally illiterate.” (MSEB, NRC, 1990, p. 8) NCTM, therefore, holds firm to the notion that the best education is the mathematical content appropriate to ensure that all students can reach their potential within an ever-changing, technological society.

Questions and Comments. Most disconcerting within NCTM’s opinions regarding *self-fulfilled, productive citizens* is the notion that economic success is tantamount to *success in life*. While some may argue that a concern for individual economic success is valid within a capitalistic paradigm, capitalism itself is not necessarily consistent with democracy. While *life, liberty, and the pursuit of happiness* are inextricably linked to U.S. democracy, it is questionable whether financial success should be considered an innate component of basic rights of U.S. citizenry. Additionally, many U.S. citizens place higher value on extra-economic aspects of life; for these, materialism may even seem morally corrupt. It is questionable if any organization purporting to seek the promotion of U.S. democracy has the right to prescribe any singular factor outside the realm of *life, liberty, and the pursuit of happiness to success in life*. To promote that which is extra-constitutional may well be anti-constitutional and, in turn, anti-democratic.

Consistent with the alarmist tenor through which reform efforts state their concerns, reform efforts focusing upon one subject area specialization self-servingly promote national weaknesses

within their subject area as the potential demise of the nation. While from a public relation standpoint this may be successful, it can often be recognized as less than intellectually honest. Connecting *societal participation*, therefore, to mathematical literacy may be somewhat disingenuous. This connection creates two questionable implications. First, mathematics literacy singularly determines a person's ability to participate within society. Second, literacy within all other subject areas is subordinate to mathematics literacy. Thus despite an individual's successfulness within other extra-mathematical fields, he or she cannot participate within society without also being mathematically literate.

PART IV: DEMOCRATIC SCHISM – ECONOMICS AND EDUCATION

Within NCTM's reform literature, when the previous analyses of the two areas of economics and education are juxtaposed, common themes can be readily recognized. These themes coalesce into discussions regarding the preservation of democracy within the United States and potential societal schisms which may arise if current economic and educational inequities are not abated.

Based upon historic reform documents published within the U.S. during the 1980s, it would be impossible for analysis to overemphasize the nearly universal focus upon preserving democracy within the United States through ensuring equity within both educational experiences and occupational possibilities. Much of the prose surrounding the significance of the *status quo* within education and its impending peril upon democracy within the United States carried an alarmist tenor and dogmatically denounced existing educational and social practices as inequitable and in philosophical opposition to democracy. Grave concern arose that inequities in education and mathematical literacy would lead to a societal schism between the literate and the illiterate which would eventually destroy democracy (CFEE, 1986; Malcom, 1984; MSEB, 1990; NCEE, 1983; NCTM, 1989; NRC, 1989; NSBCPEMST, 1983; Oakes, 1990).

Apart from economics, the social and political consequences of mathematical illiteracy provide alarming signals for the survival of democracy in America. ... We are at risk of becoming a divided nation in which knowledge of mathematics supports a productive, technologically powerful elite while a dependent, semiliterate majority ... find economic and political power beyond reach. Unless corrected, innumeracy and illiteracy will drive America apart. (NRC, 1989, p. 14)

A common perception of the 1980s recognized that the very fabric of democracy within the United States was in jeopardy of being torn by the stress of educational, societal, occupational, and economic inequities and injustices (CFEE, 1986; MSEB, 1990; NCEE, 1983; NCTM, 1989; NRC, 1989; Oakes, 1990). NCTM's movement was consistent with other school reform efforts seeking to maintain democratic stability within the United States by diminishing existing inequities.

If all students do not have the opportunity to learn [a common body of] mathematics, we face the danger of creating an intellectual elite and a polarized society. The image of a society in which few have the mathematical knowledge needed for the control of economic and scientific development is not consistent either with the values of a just democratic system or with its economic needs. (NCTM, 1989, pp. 8-9)

NCTM's publications, as well as many other concurrent reform efforts and publications, recognize that mathematics literacy is itself a natural societal filter which can create inequities between those who are literate and those who are not (AAAS, 1982; CFEE, 1986; NCTM, 1989;

NRC, 1989; Oakes, 1990; Steen, 1988). Many contemporaneous reform documents argue that while mathematics should assist all citizens to meet their greatest potential, lack of mathematical literacy filters out many from meaningful employment. Therefore, whether or not one attains mathematical literacy determines which side of the cultural schism he or she will live. The social schism and inequities formed by some U.S. citizens attaining mathematical literacy while others do not is held by NCTM as anti-democratic and injurious to the future of United States democratic culture.

A society in which only a few have the mathematical knowledge needed to fill crucial economic, political, and scientific roles is not consistent with the values of a just democratic system or its economic needs. (NCTM, 2000, p. 5)

Questions and Comments. Some of the preceding and following quotations demonstrate ardent and, at first blush, controversial axiological statements within NCTM's publications. Nevertheless, when the transcendent axiological presupposition is the maintenance and protection of democracy, these impassioned opinions become more commonsensical and can be recognized as necessary to accomplish a goal. While some may question if the promotion and protection of democracy should be the primary focus of any mathematics education reform effort, others may argue that no goal is more vital in U.S. schools. Thus the promotion of democracy, as a significant educational goal within U.S. schools, should be anticipated.

The axiological emphasis on the preservation of the United States' democratic culture so permeates NCTM's publications that it effectively guides many of NCTM's principles and curricular suggestions. Further examination of NCTM reform documents, however, reveal extensions to these notions which rightfully raise alarm.

Education is closely linked to preserving our democratic ideals. ... The growth of an **underclass of the long-term unemployed** ... is intolerable. Aside from the attendant welfare dependency, crime, and social unrest, the notion of large segments of our society limited in their opportunities to **participate fully in the mainstream of American life** runs contrary to the principles that our nation represents. (Meiring, et al., 1992, pp. 4-5)⁸

NCTM, herein, implies that the existence of an "underclass of the long-term unemployed," with a subsistence provided by "welfare dependency" leading to "crime and social unrest" is incongruous with full societal participation. Therefore, NCTM writers define mathematical literacy as adequate mathematical knowledge requisite to allow citizens to provide economically to the nation without burdening the nation with their needs.

Mathematical competence is vital to every individual's **meaningful and productive life**. ... All reasonable means should be employed to assure that everyone will have the foundation of mathematical learning essential to fulfilling his or her potential as a **productive citizen**. (NCTM, 1980, pp. 17-19)

⁸The publications written by Meiring, et al. (1992) state that their opinions should not be interpreted as official positions of NCTM. Some readers may contend that Meiring, et al. (1992) and other citations place too much emphasis upon the works of tangential documents over specific NCTM reform documents. However, the Addenda Series has an extremely significant role within the entire 1989-2000 reform effort and should not be dismissed too quickly.

Axiological connections seemingly exist within NCTM reform literature between the notions of *success in life* and *full participation in life*—a full participation which is impossible by those employed in *the most menial dead-end jobs* (Meiring, et al., 1992, p. 3). Therefore, connecting this *full participation in society* with *self-fulfilled, productive citizens* NCTM writers’ statements imply that it is only possible when employment adequately provides an individual with a salary which allows the individual to productively provide to the nation without being an economic burden to others.

Mathematical literacy is vital to every individual’s meaningful and productive life. The mathematical abilities needed for everyday life and for **effective citizenship** have changed dramatically over the last decade. ... By removing the “computational gate” to the study of high school mathematics ..., we are able to **afford all students more opportunities to fulfill their mathematical potential and participate throughout their lives as productive members of our society.** (NCTM, 1989, p. 130)

The significant connections between NCTM’s opinions regarding economics and those of education create an intersection of views which raises the concern for socially productive citizens to be meaningfully employed, gain success in life, and become self-fulfilled.

Admittedly, it is the role of a reform movement to emphasize its content above all others. Furthermore, it is common for subject-specific reform movements to promote literacy within their field as tantamount to a panacea for societies ills. Nevertheless, to equate *mathematical literacy* to *meaningful and productive life* as a *productive citizen* able to *participate throughout their lives as productive members of our society* may far exceed the valuation which most people would place upon mathematics literacy. Beyond this, NCTM strongly implies that *meaningful and productive citizenry* is impossible without *mathematical literacy*. Clearly, there are many citizens of the United States who lead *meaningful and productive lives*, who are *effective citizens*, and who *participate fully in the mainstream of American life* who lack mathematical literacy, as defined by NCTM. Far too strident are NCTM’s claims in this area. The alarmist portrayal of the potential schism within democracy which will occur if all citizens do not acquire some degree of mathematical literacy may be little more than a literary tool employed by writers desiring to garner national support for their cause.

PART V: AXIOLOGICAL SUMMARY

Many of NCTM’s axiological statements are coalesced into the following statement.

All students have the right to and deserve an excellent program of mathematical instruction leading to mathematical literacy. This literacy produces opportunities for employment producing the potential of leading a meaningful and productive life, which entails reaching their full potential and contributing to, and fully participating within, society.

NCTM holds the position that *meaningful employment* is necessary for every citizen to become a *productive member of society* and attain *success in life*. According to NCTM, *good education* is that which provides the mathematical literacy leading to equitable opportunity for students to become meaningfully employed. This employment leads to a person being self-fulfilled, gaining success in life, and being able to participate fully within society. When opportunity for meaningful employment through *mathematics literacy* is absent, inequity interferes with an

individual's opportunity *to fully participate within society* and to *become self-fulfilled*. Through this meaningful employment, the *good citizen* supports or adds to the national economy without creating any additional burden to society and becomes a productive member of society.

PART VI: REMAINING QUESTIONS AND COMMENTARY

American Democracy in a Global Society

Over the past decade, a curious international respect and interest for the NCTM *Standards* (1989-2000) has developed. Many nations are considering NCTM's conceptual framework to reform education and enhance curriculum and instruction. This creates an intriguing paradox: The preservation and promotion of U.S. democracy is an axiological foundation of the *Standards*, and yet many nations throughout the globe are clearly anti-U.S. while others are not democratic in governance. How then could these nations who are contrary in either governance or vision subscribe to NCTM's tenets? As this phenomenon continues to unfold, the evolution of internationally-hybrid adaptations of NCTM *Standards* must naturally develop.

The interest in the NCTM *Standards* by other nations raises fascinating philosophical questions. First, is the axiological focus and connection with promoting and preserving U.S. democracy within the *Standards* purposely overlooked by other nations? Do they recognize a separation between philosophical foundations and curricular recommendations? Do they interpret the purpose of preserving U.S. democracy as implying the preservation of their own governmental structures? Second, are anti-U.S. and non-democratic nations unaware of the connection of the *Standards* with preserving U.S. democracy? Has NCTM lacked clarity in its reform documents and failed to unambiguously articulate its philosophic foundation? Or has it had an even more covert rationale: to be adequately circumspect in order to garner an international following? These questions should be addressed by both the public and NCTM in order to define NCTM's interpretation of the future of mathematics education both in the United States and throughout the world.

Standards 2000 – Antiseptic Axiology?

When specifically concentrating upon axiological statements, the history of NCTM's reform documents (1989-2000) takes interesting turns. As previously demonstrated, the NCTM *Standards* (1989) and its partner documents (1991-1995) created a solid axiological foundation. Some initially ambiguous statements were refined by the latter documents to form a body of literature which is axiologically well-defined. The publication of the *Draft of the Principles and Standards for School Mathematics* (1998), however, complicated this investigation. Notably absent from the *Draft* were the more strident axiological statements found in the 1989-1995 documents. While a significantly more student-centered curriculum and axiology replaced the opinions within previous documents, the absence, or significant minimization, of phrases like "menial dead end jobs," "the growth of an underclass," and "self-fulfilled productive citizens" leads one to question if NCTM and participants on the writing teams of the *Draft* felt that the previous language was too abrasive and was to be avoided. In comparison with NCTM's 1989-1995 reform documents, the *Draft* seems axiologically antiseptic. More precisely, the *Draft* replaces harsh language with language which is more palatable and adds a component of student-centeredness arguably unparalleled by any other mathematics education reform effort.

Although the *Draft* omits the harsh language and axiological statements of previous

documents, no statement within the *Draft* repudiates previous harsh statements. Does this imply that the writers of the *Draft* (1998) and the *Principles and Standards* (2000) so completely accept the validity of previous axiological statements that they assume that readers of the newer documents will see them as natural extensions of previous documents?

While the *Draft* may be considered axiologically antiseptic, the *Principles and Standards* cannot be so described. Reintroduced within the language of NCTM's most modern reform document are phrases and comments which define societal participation and "intelligent citizenship." Nonetheless, the *Principles and Standards* are not nearly as dogmatic as are the 1989-1995 documents. This modern axiological cleansing, however, is far from complete. Still embedded in NCTM's recent belief and position statements are phrases such as "productive citizenship," "a meaningful and productive life," and "reach their full potential and contribute to society."

Critics may be quick to argue that these comments and concerns fail to consider the evolution of writing groups and differing socio-political factors affecting writing groups from the mid-1980s and the late 1990s. Clearly, the multiple sets of writing groups encountered variances in economic culture, external criticism to NCTM's work and vision, and many other socio-political factors. It is beyond the scope of this paper to parse with minute detail distinctive affective issue encountered by each writing group.

CLOSING REMARKS

Summarily, NCTM's connections among mathematical literacy, individual and national economic stability, success in life, and societal participation remain somewhat disconcerting and warrant further philosophical examination. Educators at every level have a professional responsibility to fully consider all aspects of any proposed educational reform. This is certainly the case in mathematics. It is not anti-reform for educators to carefully and critically examine novel ideas which are to be adopted in their classrooms. Neither is it anti-NCTM to analyze and understand the philosophical assumptions in NCTM's published literature. Axiological questions within educational reform are never trivial. What should be taught, to whom, and to what end is of grave importance to all.

It is hoped that this brief investigation has assisted to reveal components of NCTM's axiological position which are only recognized after documentary analysis. It is also hoped that the combination of comments and questions provided by the investigator sheds additional light on existing philosophical concerns within the NCTM *Standards* reform effort.

References

- American Association for the Advancement of Science [AAAS] (1982). Education in the Sciences: A Developing Crisis. Washington, D.C.: American Association for the Advancement of Science.
- American Association for the Advancement of Science [AAAS] (1982). Science for All Americans. Washington, D.C.: American Association for the Advancement of Science.
- Atkin, J. M., Kilpatrick, J., Bianchini, J. V., Helms, J. V., & Holthuis, N. I. (1997). The changing conceptions of science, mathematics, and instruction. In S. A. Raizen & E. D. Britton (Eds.), Bold Ventures: Volume I: Patterns among U. S. Innovations in Science and Mathematics. Boston: Kluwer Academic Pub.
- Beaton, A. E., Mullis, I. V. S., Martin, M. O., Gonzales, E. J., Kelly, D. L., & Smith, T. A. (1996).

- Mathematics Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS). Chestnut Hill, Mass.: Boston College, TIMSS International Study Center.
- Bishop, A. J. (1990). Mathematical power to the people. Harvard Educational Review, 60, 357-369
- Board on Mathematical Sciences [BMS] (1986). Mathematical Sciences: A Unifying and Dynamic Resource. Washington, D.C.: National Academy Press.
- Bossé, M. J. (1995). The NCTM Standards in Light of the New Math Movement: A Warning. Journal of Mathematical Behavior, 14, (2) 171-201.
- Carnegie Forum on Education and the Economy [CFEE] (1986). A Nation Prepared: Teachers for the 21st Century. Report of the Task Force on Teaching as a Profession. New York: Carnegie Corporation.
- Committee on Research in Mathematics, Science and Technology, National Research Council [CRMST- NRC] (1985). Mathematics, Science, and Technology Education: A Research Agenda. Washington, D.C.: National Academy Press.
- Conference Board of the Mathematical Sciences [CBMS] (1983a). The Mathematical Sciences Curriculum K-12: What Is Still Fundamental and What is Not. Report to the NSB Commission on Precollege Education in Mathematics, Science, and Technology. Washington, D.C.: CBMS.
- Conference Board of the Mathematical Sciences [CBMS] (1983b). New Goals for Mathematical Sciences Education. Report of a conference sponsored by CBMS, Airlie House, Warrenton, VA. Washington, D.C.: CBMS.
- Crosswhite, F. J. (1990). National standards: A new dimension in professional leadership. School Science and Mathematics, 90, 454-466.
- Crosswhite, F. J., et al. (1985). Second International Mathematics Study: Summary report for the United States. Washington, D.C.: National Center for Education Statistics.
- Crosswhite, F. J., et al. (1986). Second International Mathematics Study: Detailed report for the United States. Champaign, IL: Stipes Publishing Co.
- Crosswhite, J., Dossey, J., & Frye, S. (1989). NCTM Standards for school mathematics: Visions for implementation. Arithmetic Teacher, 3, 55-60.
- Goodlad, J. (1995). Schooling U.S.A. In I. M. Carl (Ed.), Seventy-five years of progress: Prospects for school mathematics (pp. 3-17). Reston, VA: National Council of Teachers of Mathematics.
- Haimo, D. T. (1998). Are the NCTM Standards Suitable for Systemic Adoption. Teachers College Record, 100, 1, 45-65.
- Harmon, et al. (1997). Performance assessment in IEA's Third International Mathematics and Science Study. Chestnut Hill, MA: Boston College.
- Johnson, H. C. (1990). How can the Curriculum and Evaluation Standards for School Mathematics be realized for all students?. School Science and Mathematics, 90, 527-543.
- Johnson, W. B., & Packers, A. E. (1987). Workforce 2000: Work and workers for the twenty-first century. Indianapolis: Hudson Institute.
- Kilpatrick, J. (1997). Confronting reform. American Mathematical Monthly, 104, 955-962.
- Kilpatrick, J. (1992). A history of research in mathematics education. In D. Grouws (Ed.), Handbook for research in mathematics teaching and learning (pp. 3-38). New York: Macmillan.

- Kilpatrick J. & Stanic, G. M. A. (1995). Paths to the present. In I. M. Carl (Ed.), Seventy-five years of progress: Prospects for school mathematics (pp. 3-17). Reston, VA: National Council of Teachers of Mathematics.
- Lampert, M. (1990). When the problem is not the question and the solution is not the answer: Mathematics knowing and teaching. American Educational Research Journal, 27, 29-63.
- Malcom, S. M. (1984). Equity and Excellence: Compatible Goals. Washington, D.C.: American Association for the Advancement of Science.
- Mathematical Sciences Education Board, National Research Council [MSEB-NRC] (1990). Reshaping school mathematics: A philosophy and framework for curriculum. Washington, D.C.: National Academy Press.
- Mathematics Sciences Education Board, National Research Council [MSEB-NRC] (1987). The Teacher of Mathematics: Issues for Today and Tomorrow. Proceedings of a Conference. Washington, D.C.: National Research Council.
- McLeod, D. B., Stake, R. E., Schappelle, B. P., Mellissinos, M., & Gierl, M. J. (1996). Setting the standards: NCTM's role in the reform of mathematics education. In S. A. Raizen & E. D. Britton (Eds.), Bold Ventures: Volume 3: Case studies of U. S. innovations in science and mathematics education (pp. 13-132). Boston: Kluwer.
- McKnight, C. C., Crosswhite, J., Dossey, J., Kifer, E., Swafford, J. O., Travers, K. J., & Cooney, T. J. (1987). The underachieving curriculum: Assessing U.S. school mathematics from an international perspective. Champaign, IL: Stipes Publishing Co.
- Meiring, S. P., et al. (1992). A core curriculum-making mathematics count for everyone: Addenda Series, grades 9-12. Reston, VA: National Council of Teachers of Mathematics.
- Mullis, I. V. S., et al. (1998). Mathematics and science achievement in the final year of secondary school. Chestnut Hill, MA: Boston College.
- Mullis, I. V. S., Martin, M. O., Beaton, A. E., Gonzales, E. J., Kelly, D. L., & Smith, T. A. (1997). Mathematics achievement in the primary school years: IEA's Third International Mathematics and Science Study (TIMSS). Chestnut Hill, MA: Boston College, TIMSS International Study Center.
- National Center for Education Statistics [NCES] (unpublished 1998). The TIMSS videotape classroom study: Methods and findings from an exploratory research project on eighth grade mathematics instruction in Germany, Japan, and the United States. Washington, D.C.: National Center for Education Statistics.
- National Center for Education Statistics [NCES] (1997a). Pursuing excellence: A study of U.S. eighth-grade mathematics and science achievement in international context. Washington, D.C.: National Center for Education Statistics.
- National Center for Education Statistics [NCES] (1997b). Pursuing Excellence: A Study of U.S. Fourth-Grade Mathematics and Science Achievement in International Context. Washington, D.C.: National Center for Education Statistics.
- National Center for Education Statistics [NCES] (1997c). Pursuing Excellence: A Study of U.S. Twelfth-Grade Mathematics and Science Achievement in International Context. Washington, D.C.: National Center for Education Statistics.
- National Council of Supervisors of Mathematics [NCSM] (1978). Position statement on basic skills. Mathematics Teacher, 71(2), 147-152.
- National Council of Teachers of Mathematics [NCTM] (1980). An agenda for action:

- Recommendations for school mathematics of the 1980s. Reston, VA: National Council of Teachers of Mathematics.
- National Council of Teachers of Mathematics [NCTM] (1986). The impact of computing technology on school mathematics. Report of a Conference. Reston, VA: National Council of Teachers of Mathematics
- National Council of Teachers of Mathematics [NCTM] (1989). Curriculum and evaluation standards for school mathematics. Reston, VA: The National Council of Teachers of Mathematics.
- National Council of Teachers of Mathematics [NCTM] (1991). Professional standards for teaching mathematics. Reston, VA: The National Council of Teachers of Mathematics.
- National Council of Teachers of Mathematics [NCTM] (1992). The road to reform in mathematics education: How far have we traveled?. Reston, VA: National Council of Teachers of Mathematics.
- National Council of Teachers of Mathematics [NCTM] (1995). Assessment standards for school mathematics. Reston, VA: The National Council of Teachers of Mathematics.
- National Council of Teachers of Mathematics [NCTM] (1998). Principles and standards for school mathematics (draft). Reston, VA: The National Council of Teachers of Mathematics.
- National Council of Teachers of Mathematics (1995). Position Statement: The mathematics education of underrepresented groups [On-line]. Available: http://www.nctm.org/about/position_statements/position_statement_05.htm
- National Council of Teachers of Mathematics (1998). Position Statement: Teaching mathematics in the middle grades [On-line]. Available: http://www.nctm.org/about/position_statements/position_statement_12.htm
- National Council of Teachers of Mathematics (2000). NCTM Statement of Beliefs [On-line]. Available: <http://www.nctm.org/about/beliefs.htm>
- National Council of Teachers of Mathematics [NCTM] (2000). Principles and standards for school mathematics. Reston, VA: The National Council of Teachers of Mathematics.
- National Council of Teachers of Mathematics, The Eisenhower National Clearinghouse for Mathematics and Science Education [NCTM-ENC MSE] (1996). A perspective on reform in mathematics and science education. Washington, D.C.: U.S. Department of Education.
- National Commission on Excellence in Education [NCEE] (1983). A nation at risk: The imperative for educational reform. Washington, D.C.: U.S. Government Printing Office.
- National Research Council [NRC] (1989). Everybody Counts. Washington, D.C.: National Academy Press.
- National Science Board Commission on Precollege Education in Mathematics, Science, and Technology [NSBCPEMST] (1983). Educating Americans for the twenty-first century: A plan of action for improving the mathematics, science and technology education for all American elementary and secondary students so that their achievement in the best in the world by 1995. Washington, D.C.: National Science Foundation.
- National Science Board Commission on Precollege Education in Mathematics, Science and Technology [NSBCPEMST] (1982). Today's problems, tomorrow's crises. Washington, D.C.: National Science Foundation.
- Nickerson, R. (Ed.) (1988). Technology in education in 2020: Thinking about the non-too-distant future. Reston, VA: National Council of Teachers of Mathematics.

- Oakes, J. (1990). Multiplying inequalities: The effects of race, social class, and tracking on opportunities to learn mathematics and science. Santa Monica, CA: Rand Corporation.
- Office of Technology Assessment [OTA] (1988). Technology and the American transition. U.S. Government Printing Office.
- Papert, S. (1987). Information technology and education: Computer criticism vs. technocentric thinking. Education Researcher, 16, 1
- Raizen, S. A., McLeod, D. B., & Rowe, M. B. (1997). The changing conceptions of reform. In S. A. Raizen & E. D. Britton [Eds.], Bold ventures: Volume I: Patterns among U.S. innovations in science and mathematics. Boston: Kluwer Academic Pub.
- Ralston, A., et al. (1988). A Framework for Revision of the K-12 Mathematics Curriculum. Task Force Report submitted to the Mathematical Sciences Education Board, National Research Council. Washington, D.C.: National Research Council.
- Roitman, J. (1998). A Mathematician Looks at National Standards. Teachers College Record, 100, 1, 22-24.
- Romberg, T. A. (1998). Comments: NCTM's Curriculum and Evaluation Standards. Teachers College Record, 100, 1, 8-21.
- Romberg, T. A. (1987a) Standards: Goals, Knowledge, Work and Technology. Paper prepared for the NCTM Commission on Standards for School Mathematics.
- Romberg, T. A. (1987b). The NCTM Standards for School Mathematics: Some initial ideas. Paper prepared for the NCTM Commission on Standards for School Mathematics
- Romberg, T. A. (1984a). Curricular reform in school mathematics: Past difficulties future possibilities. Paper prepared for the Fifth International Congress on Mathematical Education (ICME 5). Adelaide, South Australia, Australia.
- Romberg, T. A. (1984b). School mathematics: Options for the 1990s. Chairman's Report of a Conference. Washington, D.C.: U.S. Government Printing Office..
- Romberg, T. A. (1983). A common curriculum for mathematics. Individual differences and the common curriculum: Eighty-second yearbook of the National Society for the Study of Education. Chicago, IL: University of Chicago Press.
- Romberg, T. A. & Carpenter, T. P. (1986). Research on teaching and learning mathematics: Two disciplines of science iniquity (pp 850-873). In M. C. Wittrock (Ed.) Handbook of research on teaching: A project of the American Education Research Association, (3d ed.). New York: Macmillan Co.
- Romberg, T. A. & Stewart, D. M. (Eds.) (1987). The monitoring of school mathematics: Background papers, V. 1-3. Madison, Wis.: Wisconsin Center for Education Research, University of Wisconsin.
- Schmidt, W. W., McKnight, C. C., & Raisen, S. A. (1996). A splintered vision: An investigation of U.S. science and mathematics education. Boston: Kluwer
- Schmidt, W., et al. (1997). Many visions, many aims: A cross-national investigation of curricular intentions in school mathematics. Hingham, MA: Academic Publishers Group
- Secada, W. G. (1989). Agenda setting, enlightened self-interest, and equity in mathematics education. Peabody Journal of Education, 66, 22-56
- Silver, E. A. (1998). Improving mathematics in middle school: Lessons from TIMSS and related research. Washington, D.C.: Department of Education.
- Stanic, G. M. A. & Kilpatrick, J. (1992). Mathematical curriculum reform in the United States: A

- historical perspective. International Journal of Educational Research, 17, 407-417.
- Stake, R. E. & Raizen, S. A. (1997) Underplayed issues. In S. A. Raizen & E. D. Britton [Eds.], Bold ventures: Volume I: Patterns among U. S. innovations in science and mathematics. Boston: Kluwer Academic Pub.
- Steen, L. A. (Ed.). (1988). Calculus for a New Century: A Pump, Not a Filter. MAA Notes No. 8. Washington, D.C.: Mathematical Association of America.
- Stigler, J. W. & Hiebert, J. (1997). Understanding and improving classroom mathematics instruction: An overview of the TIMSS video study. Phi Delta Kappan 79 (1), 14-21