

Changes in Mathematics Education during the Twentieth Century

Thesis

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Abstract

The goal of this research was to gain a deeper understanding of the changes of the mathematics education during the twentieth century. It is hoped that the knowledge gained from this research will help understand why some groups of students have some skill deficiencies in common. The knowledge also allows a prediction of future classrooms environments based on the cycles present historically. The mathematics education before the turn of the century is briefly overviewed to provide a background to the beginning of the reform efforts in the United States. The paper covers the reform movements known as the Chicago Movement, Life Adjustment, and up to and including the reforms based on the NCTM *Standards* in the 1990s. The future of mathematics education in the twenty-first century is discussed, based on knowledge interpreted from the various reforms of the twentieth century.

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Chapter One – Previous Views of Math Education

Before the twentieth century mathematics was mainly viewed in schools as a mental exercise – a way to develop the “muscles” of the brain. The “muscles” were various faculties such as memory, reasoning, observation, and will (Roberts 690). Education was mainly textbook based, “dominated by rote recitation of seemingly trivial factual information drawn at least loosely from the academic subjects” (Kliebard 3). The dawning of a new century, and technological advances that were taking place at the time, brought with it a call for change in education, with questions as to what method of education was appropriate, and how much math should be taught to the students. The twentieth century was ruled by the “fads” in education, and the rise of progressive education culminated in a force that ruled most of the twentieth century. Progressives were typically “educational experts” – those that specialized in educational philosophies, strategies, and programs instead of subject fields such as math or science. William Bagley, in 1926, stated:

In no other country are the education experts so influential. In no other country is school practice so quickly responsive to the suggestions emanating from this group. We may stigmatize our schools as “static,” “reactionary,” “slow to change,” – reluctant to adopt what we, in our wisdom, prescribe. But compared to other countries, ours is the educational expert’s paradise (Klein).

Chapter Two – The Chicago Movement

One of the first significant movements in mathematics education of the twentieth century is known as the Chicago Movement. It was jumpstarted by Eliakim Hastings Moore in 1902 when during a speech as president of the American Mathematical Society, he called for the “unification of pure and applied mathematics” and the linking of different subjects by organizing subjects such as algebra, geometry, and physics into understandable four-year courses (Kilpatrick, *Confronting Reform* 1). Moore believed that with the rising popularity of engineers and scientists, mathematical instruction should be tied in closely with the preparatory instruction of these professions, and that the training of future scientists and engineers had become a crucial justification for the teaching of mathematics. He also addressed the various “chasms” he observed that existed in mathematics: between pure and applied; research and school teachers; and between the “public’s foggy perception of mathematics and ‘the very high position in general esteem and appreciative interest which it assuredly deserves’” (Roberts 691). In order to resolve these “chasms,” Moore believed the way that mathematics was taught needed to be reformed on *all* levels, and his “laboratory method” played a pivotal role in his resolution strategy.

Moore arranged to have the laboratory method taught at the University of Chicago, and even arranged to teach the method himself during the introductory calculus course. The “laboratory method” consisted of teachers working with either individual or small groups of students, trying to instill the spirit of research and appreciation of fundamental science in each student by working on simple demonstrations, graphs, models, etc. of known concepts. Moore

mainly wished to have each student brought quickly to the use of powerful mathematical concepts, without having to master all the supporting technical details (Roberts 691). The “laboratory method” was time consuming, as Moore believed that important results found from research should be demonstrated in at least two different ways. Moore suggested that two consecutive class periods be allocated to these classes, as much of the class time was spent constructing drawings and making models and mechanisms.

The Chicago Movement ultimately failed; the “laboratory method” was not adopted by a majority of schools, mathematical subjects were not restructured, and Moore’s urgings to the AMS to recruit school teachers for membership were ignored. The University of Chicago returned to its pre-laboratory method within a couple of years of adopting it. It was found to be too labor intensive and complicated for the professors to administer (Roberts 692). Another reason for the failure was that the Chicago Movement did not receive much support from the mathematical community. Research mathematicians did not want to become involved in educational matters, and conservative mathematicians in the East believed that applied mathematics had no place in the secondary classroom. These mathematicians, namely David Eugene Smith, thought that the mental disciplinary power of geometry demanded that it be kept in a separate course, not combined with another subject (Kilpatrick, *Confronting Reform* 1). The only thing to make it through all the years and reform efforts from the Chicago Movement is the general mathematics course – a washed down version of Algebra I.

Chapter Three – Social Efficiency

The Vocational Education Movement came into being in response to the massive upsurge of school enrollments (as much as doubling every decade) during the time period of 1890 – 1920. With so many students now attending schools, there was more importance placed on preparing students for their future workplaces than for them to acquire an academic education. Courses that didn't offer much in the way of professional preparation for a majority of the population were deemed as "fluff" and only became required for the select few – those students that were predicted to become more than just the "average Joe."

To determine exactly what math the average student would need to learn in order to prepare for their future, students in one study were asked to follow their parents around for two weeks and write down mathematical problems that were encountered in the course of everyday tasks. It was found that most adults used little but the most elementary arithmetic, relegating most of mathematics as fluff and not necessary for the curriculum (Roberts 693).

One key element of social efficiency doctrine was to teach future citizens only those things that they needed in order to function effectively as adult members of society. Anything beyond that would be wasteful. Inevitably, this involved predicting one's future place in the social order and adapting the curriculum to the demands dictated by that social role (Kliebard 46).

Students, who were allowed the academic, or liberal, education, would be trained as efficient consumers or users, as they would be the ones with the money to take advantage of the products produced by the workers – those students given vocational training.

Progressivists were the main players in the Social Efficiency Movement, citing the studies of E.L. Thorndike as support for their reform efforts. “For good or ill, it was Thorndike who dealt the final blow to the ‘science of arithmetic’” (Klein). Thorndike doubted the value of mental training from mathematics and the possibility that any training that did occur transferred over to other activities; in essence, math just trained a person for math. Progressivist William Heard Kilpatrick became popular in the early 1900s when he began spreading his belief that subjects studied in school should be prioritized by practical value, or social efficiency. He thought that algebra and geometry should no longer be required of students as “mathematics is harmful rather than helpful to the kind of thinking necessary for ordinary living....we have in the past taught algebra and geometry to too many, not too few” (Klein). Another Progressivist, David Snedden, founder of educational sociology, said “Algebra...is a nonfunctional and nearly valueless subject for 90 percent of boys and 99 percent of girls – and no changes in method or content will change that” (Klein).

In 1915 Kilpatrick, along with several other educators, was asked by the National Education Association’s Commission on the Reorganization of Secondary Education to study and address the problem of teaching mathematics in high school. His report, *The Problem of Mathematics in Secondary Education*, was published in 1920 and recommended that only mathematics that had proven to possess a practical value be taught in high school, with the traditional math curriculum available only for the select few – those who would become “efficient consumers.” There was opposition to Kilpatrick’s report by the mathematical community, but not enough to stop the publishing of the report by the U.S. Commissioner of Education.

Vocational Education especially picked up steam when the issue began to be backed by business organizations. Organizations such as National Association of Manufacturers and the Chicago Association of Commerce dabbled in educational matters, believing that the success that was being had in Germany with its dual secondary schools should be duplicated in the U.S. Germany had two sets of secondary schools for its students, an academic school, and schools that specialized in vocational training for different jobs. Businesses viewed this as giving Germany a “leg up” so to speak in manufacturing goods, and didn’t want the United States to fall behind. Following these efforts, in 1918 the Commission on the Reorganization of Secondary Education released the *Cardinal Principles Report*, which contained what the commission believed what the seven purposes of secondary education should be: health, command of fundamental processes, worthy home-membership, vocation, citizenship, worthy use of leisure, and ethical character. These principles became the “highest wisdom in defining the curriculum of secondary education” (Kliebard 46). Notice the absence of academics in the seven aims of secondary education.

During the rise of social efficiency there was a renewal of the call for the AMS to take a greater part in mathematics education. Moore’s protégé, Herbert Slaught, approached the AMS to take over the journal *Mathematical Monthly*, and to recruit mathematical educators for membership. The AMS once again refused to take part in education, and suggested that Slaught create a society for those that had similar interests, resulting in the formation of the Mathematical Association of America, with *Mathematical Monthly* as its journal. MAA started off by forming the National Committee on Mathematical Requirements (NCMR) in response to Kilpatrick’s anticipated report. Unlike Kilpatrick’s committee, the NCMR consisted of

mathematicians, secondary teachers and administrators. The MAA also jumpstarted the National Council of Teachers of Mathematics in 1920, which urged that “curriculum studies and reforms and adjustments come from the teachers of mathematics rather than from educational reformers” (Klein). While the NCTM started off initially as an anti-progressivist organization, in later years it would become the leader in progressive educational reform.

Delayed by World War I, the NCMR’s report appeared in 1923 in the form of a 600 page book, *The Reorganization of Mathematics in Secondary Education*, also known as the *1923 Report* (Roberts 693). The NCMR took a defensive position on the subject of mathematics education, hoping to revive the view of mathematics as a mental exercise in high school. The *1923 Report* surveyed the curriculum of secondary schools in the United States, and compared it to that of other countries around the world. The psychology of learning math was discussed, and while the importance of studying math in its applications was observed, the report also pointed out its intrinsic values as well. Algebra was highlighted as a course necessary for every student, and sample curricula was recommended for secondary schools. The efforts of the MAA and NCTM were not very successful during this time, as a majority of high schools began dropping mathematics as a graduation requirement, and the requirement of mathematics in the ninth grade was even being questioned. The duration of the Vocational Education Movement was a dark period in mathematics education history, with the period of 1915-1940 sometimes called a “twenty-five year depression in school mathematics” (Roberts 694).

Chapter Four – Life Adjustment

Following the Vocational Education/Social Efficiency Movement, in the 1940s it became a bit of a scandal when Admiral Nimitz began complaining that military recruits lacked the math skills to perform simple tasks such as basic bookkeeping and gunnery (Klein). But even with these examples of the progressive agenda's shortcomings and the rising ire of the public, the spirit of the Vocational Education Movement was carried on into the 1940s in the movement known as Life Adjustment. In 1945 at a White House conference discussing the future of Vocational Education, Charles A. Prosser stated that while 20% of the student population were being well-trained through college preparatory programs and another 20% were successful in vocational training, there was another 60% of students that were not receiving adequate life adjustment training and were ill-prepared for everyday life (Kliebard 57). It was predicted that these students lacked the intelligence for college or skilled occupations, and would become the unskilled/semiskilled laborers - or their housewives. This group would need just enough of an academic education to apply to problems like consumer buying, taxation, insurance, and home budgeting (Klein). After Prosser's presentation the Conference Committee adopted the resolution, and the Life Adjustment Movement began.

In *Changing Course: American Curriculum Reform in the Twentieth Century*, life adjustment is defined as "an adequate program of secondary education for fairly complete preparation for all the areas of living in which life adjustment must be made, particularly home living, vocational life, civic life, leisure life, and physical and mental health" (57). This is a close replication of the *Cardinal Principles Report*, with similar terms and concepts being used. The

educational community, still of the progressive mind, responded enthusiastically to the Life Adjustment curriculum, and supported the use of it across the nation. For example, the Superintendent of Public Instruction of the State of Illinois felt that the test of a good school could be articulated as: "If the products of our school turn out to be healthy and patriotic citizens who are good husbands, good wives, good fathers, good mothers, good neighbors, good workers, good employers, wise spenders of income, wholesome users of leisure time and so forth, we know that our schools are good" (Kliebard 57).

The situation was escalated in 1949, when it was suggested that Life Adjustment programs be available for *all* students, in order for those students already in the programs not to feel singled out. This caused an uproar among colleges and universities, who had already opposed Life Adjustment. At least before this suggestion was made a small population of students were being prepared for college classes, now there would be no preparation at school for even more students, as only the ones able to afford outside tutoring would receive an academic education while in secondary school. Opponents of Life Adjustment declared that it was anti-academic at heart, in the sense that many of its programs sought to replace academic subjects with subjects built around so-called "areas of living." Schools not entirely in agreement with Life Adjustment offered its programs along with its academic courses. Parents objected to the movement in the belief that school was for education, and that students would receive life adjustment at home. There were also complaints about how students were chosen for Life Adjustment programs, the naysayers believing that schools didn't have the right to determine what future role a student would play in society. Needless to say, the public outcry coupled

along with the technological advances made during and after World War II brought an end to the Life Adjustment Movement and progressivism...for the time being.

Chapter Five – New Math

During the 1950s Progressive education became the subject of many jokes. Under the Progressivist agenda enrollment in high school math courses steadily decreased, despite an increase of enrollments in school. The period of New Math began in the 1950s and lasted almost into the 1970s. In *A Brief History of American K-12 Mathematics Education in the 20th Century*, the start of New Math is described as “the collision between the skills instruction and understanding...The disagreements between different entities of the New Math Movement were profound. Meetings between mathematicians and psychologists resulted only in determining that the two had nothing to say to each other” (6). In the beginning of the 1950s, mathematicians and school teachers began to work cooperatively to bridge the widening gaps between high school mathematics and college mathematics curricula. The movement was seen as a move away from the anti-intellectualism of the previous half century, and emphasized coherent, logical explanations for the mathematical procedures taught in schools (Klein). The New Math movement was technically not a single movement, but a time during which a variety of reforms took place in an effort to remodel the mathematics curriculum.

Major projects of the period included the publishing of textbooks by Max Beberman of the University of Illinois Committee on School Mathematics and the Commission of Mathematics created by the College Entrance Examination Board in 1955 that recommended curricula that would better prepare students for college. On a national level, these projects were for the most part ignored, until the event that changed everything. In 1957, the U.S.S.R. launched the Sputnik into orbit, making them the first country to put a person into outer space.

A sense of humiliation was felt across the U.S. that the U.S.S.R. had been first, and the “space race” began, ending with the moon landing. The shock of another country completing such a task as launching a person into orbit helped to jump start the New Math movement, with Americans calling for higher math and science education for their children. Parents were concerned that the school curriculum wasn’t reflecting the “explosive development in mathematics,” leaving the nation with a shortage of mathematically trained personnel (CONFRONTING REFORM 1-2).

In support of the New Math movement, Congress passed the 1958 National Defense Education Act to “increase the number of science, math, and foreign language majors, and to contribute to school construction” (Klein). Shortly following this was the spawning of committees charged with developing curricula by the major associations. The American Mathematical Society set up the School Mathematics Study Group (SMSG), an effort involving both math teachers and mathematicians, and the National Council of Teachers of Mathematics set up its own committee in 1959. Curriculum groups such as these were popular during the time of New Math, and some high school teachers even took to creating their own textbooks. The period of New Math also led to the modern Pre-Calculus courses in high schools, descending from the elementary functions and introductory analysis courses introduced at the time (Kilpatrick, Confronting Reform 956).

As the “new” began wearing off of the New Math fad, criticisms began to come forth. Some said that the curriculum was too formal, and that not enough attention was paid to basic skills. Another point held against the movement was that since the mathematicians leading the

reform efforts were primarily specialists in pure mathematics, more emphasis was placed on set theory and axioms, “not only as the content that was missing from the school curriculum but also as providing the framework around which to reorganize that curriculum” (Kilpatrick, *Confronting Reform 2*).

Morris Kline was a big opponent to the reforms, arguing that the efforts being made were replacing the “fruitful and rich essence of mathematics” with “sterile...pedantic details” (Kilpatrick, *Confronting Reform 956*). In his book *Why Johnny Can't Add: The Failure of the New Math*, published in 1973, Kline went so far as to say that the right direction of any reform effort in the future “should be diametrically opposite to that taken by the new mathematics” (Kilpatrick, *Confronting Reform 956*). Kline and 64 other mathematicians signed the paper *On the Mathematics Curriculum of the High School* in 1962, which was published in several of the popular math journals of the time. The paper criticized the reforms and set forth guidelines and principles that were felt to be more appropriate for high school students. This group of mathematicians wished to link school mathematics more with its history and concrete applications (what could be used on a daily basis), than to the abstract and formal side that would discourage the students that were not originally mathematically inclined.

E.G. Beagle praised the guidelines presented in the paper and believed that most were already reflected in the new textbooks. He also reprimanded the authors for not treating the different reforms taking place at the time as separate efforts with different ideals; their views came across as if it was one broad movement going in the wrong direction and rejected the whole thing (Kilpatrick, *Confronting Reform 956*). After New Math fizzled out in the late 60s and

early 70s, the term “New Math was tried and failed” was popular, but some studies found that most of the time reform efforts were actually never tried in the classroom. The reason had been suggested as being that most teachers of the time were not capable of the math that was being taught. A lot of the teachers during the New Math period had been educated during the previous progressive movements –only learning the basic skills that were thought needed to survive working life. A suggestion like this points to the question – are the New Math reform efforts (and any other reform movements for that matter) a valid idea that should be revisited in the future, or were they truly “tried and failed?”

Chapter Six – Open Education

In the 1970s the National Science Foundation continued to fund projects similar to those of the New Math reforms, but the time of New Math was over. Voices were raised in the call to go “back to the basics” in schools across the nation, bringing a new breath of life to the progressive movements of the first half of the century. An ultra progressive school named Summerhill in England was all the rage in the U.S., becoming the model for which all schools should be patterned after in the progressivist’s eyes. The movement that was spawned became known as Open Education, so named for the educational practices taking place at Summerhill. Students were allowed to decide what they wanted to learn each day by participating at activity tables, play corners, and reading centers.

Open Education wreaked devastation on students from lower income brackets and minorities, much like earlier progressive movements had. Those from the wealthier families could afford to provide a supplemental education to their children when at home, but the poorer students didn’t have that option since usually both parents were working or did not have much of an education themselves. Lisa Delpit, an African American educator from Philadelphia, said,

White kids learn how to write a decent sentence. Even if they don’t teach them in school, their parents make sure they get what they need. But what about our kids? They don’t get it at home... I have come to believe that the ‘open classroom movement,’ despite its progressive intentions, faded in large part

because it was not able to come to terms with the concerns of poor and minority communities (Klein).

In 1974, Bennett Elementary School in California, consisting mainly of minority and low income students, was ranked in the third percentile during the fourth year of participating in the “Open Structure Program.” Most of the students at the school were illiterate and barely knew a thing about mathematics. Seeing the failure of the program, Principal Ichinaga turned things around (the school was raised to the 50th percentile soon after) by setting up clearly defined and structured reading and math programs that included basic skills. Principal Ichinaga, 1974, “My school had been patterned after Summerhill. And that’s how bad it was! The kids used to make jello and bake cookies, and I used to tell the teachers, ‘Do you know what you’ve accomplished? You just gave them rotten teeth!’” (Klein).

By the mid-1970s, in an effort to combat the drop in education, most schools had created minimum competency tests that students were required to pass before graduation. Tests such as these were not a cure-all, since the standards of said tests had to be low enough for every student to have a chance to pass. Schools that emphasized traditional academics and discipline, also known as fundamental schools, were created for those that had a difference of opinion with Open Education supporters. Looking back on the Open Education movement, it is believed that the proliferation of schools modeled after Summerhill led to the increase of remedial courses required in the 1980s in high school and college (Klein).

Chapter Seven - PREPARING FOR THE STANDARDS

By the 1980s it was pretty obvious to all that the quality of math and science education was deteriorating. A report in 1980 by a presidential commission pointed to low enrollment in advanced mathematics and science courses and the general lowering of expectations – in school and in college. Test scores were hitting an all-time low by the mid-1980s. Another round of reforms started up in an attempt to fix the havoc wreaked by Open Education. The goal of most reformers was the development of students’ “mathematical power” – “what it means to be mathematically literate both in a world that relies on calculators and computers to carry out mathematical procedures and in a world where mathematics is rapidly growing and is extensively being applied in diverse fields” (Kilpatrick, *Confronting Reform* 957). But some of the reasoning behind the reform efforts of the 1980s was of the “well, everyone else is doing it” variety. It was believed that since all other industrialized countries had made the shift to an information society, the mathematics that students in the United States needed to know in order to be productive citizens, or to compete with citizens from other countries, in the next century had to change as well (Kilpatrick, *Confronting Reform* 957).

NCTM started off the reform efforts of the 80s, with the publishing of *An Agenda for Action*. This document proposed that problem solving should be the focus of school mathematics and that basic skills be redefined to extend beyond computation (Kilpatrick, *The Mathematics Teacher and Curriculum Change* 110). Many things recommended by the paper would be repeated in 1989 – such as national standards, de-emphasis of paper-and-pencil computation, increased access to computers and calculators (including in the elementary

school), and the use of manipulatives. The importance of calculus was also de-emphasized, an attempt to prepare the mathematical education community for a move away from calculus prerequisites like algebra, geometry, and trig; a cause which was furthered in the 90s, when textbooks “depended on student ‘discoveries’ that were incidental to solving ‘real-world problems’ instead of the systematic development of concepts” (Klein).

Following the publishing, the NCTM began to make suggestions and form committees to usher mathematics education along its desired trajectory. NCTM had supported the New Math reforms, but this is the first time it stepped up to become a national voice for teachers. Purportedly it was in response to the “widely perceived failure to change school mathematics during the New Math era and in part to counter the ensuing “back-to-basics” backlash of the mid-1970s” (Kilpatrick, *Confronting Reform* 957).

NCTM’s *An Agenda for Action* was shortly eclipsed in 1983 by *A Nation at Risk*, a report published by a commission appointed by the U.S. Secretary of Education to investigate the condition of education across the nation. The committee was shocked at the state of education, believing it “threatens our very future as a Nation and a people...if an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war” (Klein). The committee also found that remedial math courses in public colleges increased by 72 percent between 1975 and 1980 and that once again businesses and military leaders were complaining about the lack of mathematical skills (as well as other basic skills like reading) their employees had. *A Nation at Risk* did not discuss how these issues had happened, just pointed out that there were indeed issues. Enrollments in math

courses in high school were discussed: “We offer intermediate algebra, but only 31 percent of our recent high school graduates complete it...Calculus is available in schools enrolling about 60 percent of all students, but only 6 percent of all students complete it” (Klein).

Standardized tests were represented as a way to measure progress during the reforms – a method that had already proven inadequate when not used properly. Attention was also given to teachers in the report. Teacher shortages in math and science were addressed, with some thought given to how the problem could be corrected. The quality of teachers was also questioned, the thought being that there was too much focus on educational methods when being trained instead of an emphasis on specializations. The committee also urged math professionals to get involved in the process of textbook selection, even going so far as suggesting that they work cooperatively to upgrade the textbooks with more rigorous content themselves.

Chapter Eight – The NCTM Standards

Reformers in the mid-1980s and onward had a goal of helping students think more mathematically instead of doing repetitive computations with a paper and pencil. The basic idea behind the Open Education movement was reused, albeit in a more conservative manner. Child-centered discovery (constructivism) was pushed as the appropriate educational philosophy, where the teacher was more of a “guide on the side” than a “sage on a stage.” This means that a teachers’ primary function was to assist students reach their own conclusions, theories, and formulas by broaching the subject of mathematics in a way that is personal and practical to each student. “The teacher’s arbitrary assignment of the next ten pages in history, or nine problems in arithmetic, or certain descriptions in geography, cannot be felt by the pupil as a real problem and a personal problem” (Klein 2).

The idea of Constructivism is associated with the findings of Jean Piaget (known for his Developmental Stages of Learning) and Lev Vygotsky (mostly known for his theory of Zone of Proximal Development), and began as an epistemological position that a learner assimilates information and then adapts that information into a form that is useful. Reformers in the 80s stressed that students would learn the material better if they were actively constructing the knowledge rather than gathering it passively from the environment. A radical approach to this theory is that a learner is in an informationally closed system and cannot learn new information unless it is experienced on a first-hand, active basis (Kilpatrick, *Confronting Reform* 959). Constructivism does not go into the details of how a subject should be taught, beyond suggesting student investigations, group work, and handling manipulatives. Constructivism has

been thought of as a major revolution in the field of mathematics education on the equivalence of New Math in the 60s, but it is curious to note that the ideology is surprisingly similar to that of the progressive's beliefs in the first half of the twentieth century. Once again math is being separated into categories of what is useful for students and what is not, and being bent into "real-life situations," much like when students during the time of Social Efficiency were asked to follow their parents and find real-life problems that required math to solve.

In 1989 the NCTM published *Curriculum and Evaluation Standards for School Mathematics*, also known as the *Standards*, which was created by a taskforce that was formed in 1984 to create a set of guidelines for school mathematics programs for grades K-12 (Kilpatrick, *The Mathematics Teacher and Curriculum Change* 111). The *Standards* were successfully promoted as having been created from the bottom up with the input of mathematicians and math educators, but of the 24 members that had direct input into the writing of the document, only two were current K-12 teachers and there were no mathematicians (Klein). The other 22 writers were mostly education professors and instructors. There was not much in the way of new innovative views in the document, as it was mainly an elaboration of views from *An Agenda for Action*.

The NCTM *Standards* could not have picked a better time to have been published. At the 1989 Education Summit, at which President Bush Sr. was present, participants made a commitment to make U.S. students first in the world in mathematics and science by the year 2000 (a reappearance of the Space Race mentality) (Klein). The *Standards* had been published shortly before, and "coincidentally" became the national model for standards, endorsed by

influential organizations such as the AMS and MAA. The *Standards* were implemented nationwide through a collaboration of workshops, journal articles, conferences, and work with classroom teachers.

Sections of the *Standards* were devoted to particular standards for the grade bands of K-4, 5-8, and 9-12, including lists of topics that should receive more focus, and topics that should receive less focus. Many teachers took this to mean that concepts being de-emphasized could be disregarded all together, which has been evidenced in the current generation of students. One example is how paper and pencil fractional computations were discouraged in grades K-4 – the idea is to briefly introduce the students to working with fractions, but not to spend much time on it since it is easily handled by plugging the fractions into a calculator. In personal experience, it has been somewhat easy to spot students that have had these particular teachers during the popularity of the *Standards*, as there will be almost entire classes of students that are incapable of working with simple fractions such as $\frac{1}{2} + \frac{1}{2}$ without the use of a calculator. Teachers were further encouraged to leave the fractions to the calculator by not asking students for exact answers – rounding should be “good enough.” The de-emphasis on exact answers can wreak havoc on a student in later years as they rise up through mathematics courses, since being off by one decimal towards the beginning of an equation can sometimes throw the answer at the end of the equation off by a substantial amount. There was also a recommendation to decrease emphasis on Euclidean geometry and two column proofs, as “the availability of computer software and graphing calculators has made it easier than ever before to visualize relationships and test numerous cases of a generalization before or in place of

providing deductive justifications” (Kilpatrick, *Confronting Reform* 958). Calculators were promoted almost as a “miracle machine” by the NCTM:

The new technology not only has made calculations and graphing easier, it has changed the very nature of mathematics...appropriate calculators should be available to students at all times...the availability of calculators does not eliminate the need for students to learn algorithms...some proficiency with paper and pencil computation [needed] (Klein).

This is contradictory to the recommendations of the *Standards* for the early level grade bands, since by the time students mainly begin to use algorithms they have already become so dependent on the calculators they cannot function without them, almost like an infant addicted to the pacifier. Mathematics for its own sake was not encouraged either, in following with the ideas of constructivism, what students need to learn mathematically could be found just by working “real-world” problems – which can be interpreted as “do not teach them what they will not need when they become part of the workforce,” a similar concept that was expressed during the progressive periods of the first half of the twentieth century.

When the *Standards* were first proposed, educators ate them up. Textbook publishers began to label their textbooks as “standards based,” the National Science Foundation began funding projects to develop new instructional materials based on the *Standards*, and district and state curriculums (with the help of organizations such as the NSF) began aligning themselves with the much lauded NCTM and its *Standards* (Kilpatrick, *The Mathematics Teacher and Curriculum Change* 111). The NSF fell in line with the recommendations made in

the *Standards*, and by 1996 they clarified what constituted effective, standards-based education, in summation, that children should use manipulatives, mathematics and science are learned by doing rather than by watching, students should work together to find the solution to a problem, and students should use technology as much as possible (Klein). NSF had researched what would work best in the classroom before then, during projects such as “Project Follow Through,” and reached very different results than what was being presented as the foundations’ stance on constructivist programs. In the face of the popularity of the NCTM *Standards*, NSF chose to go with the flow, not only in conforming public schools to the *Standards*, but also going so far as to attempt to push the constructivist ideals up to the university level. The most notable example was the creation of a “reform calculus” book, also known as “Harvard Calculus,” that relied on calculators and minimized the requirement of high school algebra material.

In 1998 the National Academy of Sciences was asked by the U.S. Department of Education and the NSF to establish a committee to conduct a study on mathematics education (Kilpatrick, *The Mathematics Teacher and Curriculum Change* 112). The goals of the study were to integrate the “rich and diverse research” in Pre-K through eighth grade mathematics education, provide research-based recommendations for teaching, teacher education and curriculum, identify where research is needed, and to give advice and guidance to those involved in the education process, including parents (Kilpatrick, *The Mathematics Teacher and Curriculum Change* 112). The results were published two years later in the 480-page report *Adding It Up*, and a shorter copy was also dispersed to the superintendents of each school district across the nation. Even though the committee had not had the time or the resources to

fully investigate and research all parts of the curriculum, they still managed to make recommendations and address those parts. A major issue that had concerned the committee was how to describe the goals of mathematics learning. They decided on the term *proficiency*, and stated that the five strands of mathematical proficiency are conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition (Kilpatrick, *The Mathematics Teacher and Curriculum Change* 113). A student that had a productive disposition would view math as a useful and worthwhile subject while also believing in diligence and one's own efficacy.

In April 2000, the NCTM released *Principles and Standards for School Mathematics* (PSSM), a revision intended to address the complaints lodged against the 1989 *Standards*. Some of the more radical ideas from the *Standards* had been eliminated, and a slightly higher influence was placed on arithmetic algorithms and computational fluency. The grade bands were also split up even more, with bands Pre-K-2, 3-5, 6-8, and 9-12 (Klein). This time around the NCTM at least made the attempt of making it look like they were working with mathematicians, drawing commentaries from several, and with committees of the AMS and MAA. Ralph Raimi of the AMS served on the AMS committee and was also commissioned as an individual for input on the PSSM. Raimi:

NCTM solicited advice at large, and I know several who also attempted to link the mathematical world with the new document, but the effort was too little avail; the message – the 'vision' of PSSM – remains, in my vision, much the same as that of the original 1989 *Standards*. PSSM continues to abhor direct

instruction in, among other things, standard algorithms, Euclidean geometry, and the uses of memory. Though like its predecessor it has the word “standards” in its title, it is not a set of standards in the usual meaning of the term, for it refuses to say what exactly a child should learn in thirteen years of schooling. Long division? Quadratic formula? How to compute the quotient of two fractions? Proof of a theorem on inscribed angles? Trigonometric identities? PSSM will neither affirm or deny, lest it seem to dictate content (Klein).

Chapter Nine - MATH WARS OF THE 1990s

In the late 1990s the backlash to *Standards*-based education began to set in. Reporters began to complain about reform efforts, and terms like “fuzzy math,” “whole math,” and “new-new math” were being thrown about when describing *Standards*-based education (Kilpatrick, *The Mathematics Teacher and Curriculum Change* 111). Supporters of the *Standards* were quick to sling back terms like “parrot math” in description of the original, computational method of math education. Jokes and stories abounded during this time of children that had failed to learn even the basics while educated under the *Standards*-based education. The math wars of the 90s were in full swing before the turn of the twenty-first century. The math wars were basically about basic skill (the fundamentalists) vs. conceptual understanding (*NCTM Standards*), which really cannot exist without each other. Conceptual understanding cannot be separated from basic skills in mathematics, as it is not possible to teach conceptual understanding without the supporting basic skills, and basic skills in turn are weakened by lack of conceptual understanding (Klein).

Psychologists began to voice their opinions of the *NCTM Standards* during the math wars. Harold Stevenson:

In our view the *NCTM Standards* present a vague, somewhat grandiose, readily misinterpreted view of what American children should learn in mathematics...the view fails to meet what we would consider to be the meaning of ‘standards.’ Standards should involve a progression of accomplishments or competencies that are to be demonstrated at defined times in the child’s schooling. The *NCTM*

Standards give no indication (beyond four-year intervals) of the sequence with which the content is to be presented and are not helpful to the classroom teacher in designing lessons that meet the standards. The *NCTM Standards* list goals with which no one would be likely to disagree. Of course we want children to value mathematics, to be mathematics problem solvers, to be confident of their ability, and to be able to reason and communicate mathematically. Certainly students must develop a number sense, have concepts of whole number operations, and the other kinds of skills and knowledge indicated under NCTM's curriculum standards. But the published standards do not integrate these two important components: the general attitudes and mathematical skills (Klein).

Educator E.D. Hirsch Jr. found faults with the term "constructivism" in his book *The Schools We Need: Why We Don't Have Them*. The term as used by progressives implies that only constructed knowledge is truly "integrated and understood." Hirsch Jr:

It is certainly true that such knowledge is very likely to be remembered and understood, but it is not the case, as constructivists imply, that *only* such self-discovered knowledge will be reliably understood and remembered. This incorrect claim plays on an ambiguity between the technical and nontechnical uses of the term "construct" in the psychological literature... (Klein).

Education constructivists did not handle the criticisms well. In some cases critics were excluded from important events, or were not allowed to print articles in disagreement with the popular

educational method. The paper “Applications and Misapplications of Cognitive Psychology to Mathematics Education” was turned down after a “peer-review” by the *Education Researcher* when the authors sought publishing. The journal later agreed to publish a small segment of the paper critiquing situated learning, but the rest was omitted. Hirsch describes this as “unremarkable except that the three authors of the article happened to be among the most distinguished cognitive scientists in the world, John Anderson and two other colleagues at Carnegie Mellon, Lynn Reder, and Herb Simon. The latter happens also to be a Nobel Prize winner” (Klein).

A major point of contention in the math wars of the 90s were the *Standards*-based textbooks. In 1999, the U.S. Department of Education recommended a list of controversial math textbooks for schools. In protest, 200 mathematicians across the nation signed the Open Letter, requesting the withdrawal of the list of recommendations. Some protestors, including Hung-Hsi Wu, viewed the omissions of relevant formulas from specific textbooks as proof that teachers had no plan to introduce it to the classrooms. Others pointed out that just because it was omitted didn’t mean that it would not be introduced, for in their view, what was the point of trying to get a student to find the formula on their own (perhaps even creating a better one in their search) if the formula was just handed to them in the first place (Kilpatrick, *Confronting Reform 959*). Another difficulty presented with the textbooks was open-ended problems. The authors of such problems did not always think through the mathematics involved in the problem, creating an open-ended problem that was often poorly designed to the point of debilitating the students’ understanding of the concepts involved. There were common features among the textbooks and curricula that math educators and parents resisted. These

include failure to develop fundamental arithmetic and algebra skills, over-encouraging the use of calculators (calculators were even being added to some kindergarten lessons), and emphasis on student discovery work (sometimes to the exclusion of all else) with ineffectual guidelines for said discovery projects. Some topics were redundant from one grade level to the next, to the point of being over emphasized. On the other hand arithmetic and algebra were de-emphasized, along with mathematical definitions and proofs either missing entirely or being incorrect to the point of being better if they hadn't been included in the first place (Klein).

Hung-Hsi Wu was one of the leaders of the opposition to the constructivist approach. He claimed that there was “*too much* of this [constructivism] happening in the reform classrooms to the detriment of good education” (Kilpatrick, *Confronting Reform* 960). Wu also said, in 1997,

This reform once again raises questions about the values of mathematics education...by redefining what constitutes mathematics and by advocating pedagogical practices based on opinions rather than research data of large-scale studies from cognitive psychology. The reform has the potential to change completely the undergraduate mathematics curriculum and to throttle the normal process of producing a competent corps of scientists, engineers, and mathematicians. In some institutions, this potential is already a reality (Klein).

Probably the most effectual of Wu's arguments was that more mathematicians needed to become involved in mathematics education – helping to revise the *Standards*, improving the

training of upcoming teachers, and participating directly in curriculum change (Kilpatrick, *Confronting Reform 960*).

The reports produced by the Third International Mathematics and Science Study (TIMSS) threw the deficiency of the *Standards*-based education as it was into an even harsher light. In 1996 it was seen that eighth graders in the U.S. scored slightly below the international average in mathematics, but in 1998 it was shown that twelfth graders were among the lowest of the participating nations in mathematics. The eighth grade report showed support for the NCTM *Standards*, who suggested, without any experimental evidence, that if the *teachers* had correctly followed the recommendations of the NCTM, the U.S. would have scored higher in the study (Klein). Studying the evidence supplied by the twelfth grade report, on the other hand, it was becoming obvious that school mathematics seemed to be getting worse rather than better as the constructivist reforms picked up steam. The TIMSS data also showed that when compared to other countries, the curriculum in the U.S. is repetitive, unfocused, and undemanding – providing few opportunities for student to solve challenging problems and expand their mathematical skills (Hiebert 11-12).

The left hook of the math wars of the 90s was when California split away from the NCTM *Standards*. California had started out as a critical supporter of the *Standards*, but it soon became clear that the program was not going to work for their students. Many cities in California accepted the Urban Systemic Initiative grant; one of the many incentive programs designed to convert districts to *Standards*-based curriculum, and followed the NSF's recommendations. But along with the proof of a downslide in mathematical performance

provided by the TIMSS data, results from the National Assessment of Educational Progress (NAEP) released in February 1996 showed that while the nation as a whole had made some improvements, fourth graders in California scored below their peers in 40 other states (Klein). Adding to that evidence was the increase of remedial courses on college and university campuses in California.

Politicians became alarmed at the state of their students' education, and began to push for explicit math standards and a reworking the curriculum to include more focus on basic skills. By 1997 California had adopted, after some trial and error, a new set of mathematics standards that allowed teachers to use whatever teaching method best got the point across, as long as they taught along the required grade level content standards (Klein). The new set of standards was among the most clearest, coherent, and competitive in the nation. When evaluated in an independent study alongside other countries, the 1997 California standards ranked higher than even those of Japan. NCTM and other constructivist organizations did not take this well, pulling the "think of the children and how you are stunting their education" card and sometimes sinking down to insults aimed at the state during interviews and conversations (Klein).

California's split from the NCTM *Standards* also paved the way for mathematicians to get with the program and become more involved with the education of the nations' youth. Mathematicians were involved with developing the 1997 California standards, the mathematics framework, and selecting textbooks and professional development programs (Klein). Some mathematicians even went as far as writing textbooks for the next round of textbook adoption in 2001. California wasn't the only place that there was a type of "revolution." At the national

level mathematicians, including research mathematicians, became more and more involved, even participating in the parent organizations that sprung up during the 90s. The failures of the *Standards* in math education had opened up the way for parent organizations and mathematicians to have a greater hand in school policies.

Leaders of the parent organizations in opposition to the NCTM *Standards* usually had more experience in mathematics than that of the education professionals, not to mention the mathematicians that were involved with the organizations. “Among them were some of the world’s most distinguished mathematicians, in some cases with mathematical capabilities near the very limits of human ability. By contrast many of the education professionals who spoke of ‘conceptual understanding’ lacked even a rudimentary knowledge of mathematics” (Klein).

One example of the power of parents took place in 1991 in Princeton, New Jersey. A group of about 250 parents petitioned the school board for a more challenging math program in contrast to the vague and weak one already in place. Many teachers did not use textbooks, and when parents asked what was being taught in the classes, they were told that curriculum was not very important – the teachers were there to teach the children, not the subject. The parents were at first ignored, possibly because Princeton had test scores that were among the highest in the state. This was not because of the math program in the schools however; many of the parents were part of the Princeton University faculty, and provided tutoring and enrichment for their own children. The children in the district that did not have that opportunity did not fare well in the school environment. The parents who disagreed with the school district were labeled as “Curriculumists” and ended up starting the Princeton Charter

School in 1997, where focus was placed on the fundamental academic disciplines and encouraged academic achievement (Klein). Another school in Texas shut down the parents in its district that were opposing the *Standards* to the point of being sued after petitions were ignored and freedom of speech rights were hindered. Parent organizations became more prolific as time went on, some of the more popular ones included Mathematically Correct, HOLD, and MathChoice. Jaime Escalante is viewed as conveying parents' sentiments across the U.S. best in the movie *Stand and Deliver*, when he said "Whoever wrote [the NCTM *Standards*] must be a physical education teacher" (Klein).

Chapter Ten – What is in the Future for Math Education?

Even though the quote is from the 1920s, W.W. Charters perhaps says it best when he declared, “The history of American education is a chronicle of fads” (Kliebard 1). In the twentieth century, the pendulum swing between the two extremes of mathematics education was seen; from basic skill to conceptual understand to basic skill and back to conceptual understanding. The end of the twentieth century leaves mathematics education at an impasse, with a war being fought over where the pendulum will swing next, back to focus on the fundamentals, or maybe a slow decrease in the motion until a balance is struck between the two radicals. Educational professionals have held the reigns for most of the twentieth century in regards to school policy in mathematics, but events in the 1990s show a possible change on the horizon with the greater involvement of parent organizations and mathematicians. This change is reflected by the *No Child Left Behind Act*, instated in 2002 by President George W. Bush. “*No Child Left Behind* is based on stronger accountability for results, more freedom for states and communities, proven education methods, and more choices for parents” (U.S. Department of Education). The act aims to make sure all students, including the disadvantaged, achieve academic proficiency. Parental involvement in education is opened up by the issuing of state and district report cards to measure the progress of their children’s schools; parents are also allowed to transfer their children to another school within their district (which will also provide transportation) if their previous school has not met the state standards for at least two years in a row. NCLB also emphasizes using choosing educational programs and practices that “have been proven effective through rigorous scientific research” (U.S. Department of Education). This means that, in theory, schools and teachers will be using educational practices

that have been proven to work – not whatever practice is popular at that point in time. Even though some aspects need a little work, NCLB is a step in the right direction in discontinuing the continuous cycles from the twentieth century; bringing higher involvement for parents and demanding equal education for all students, no matter what their future role in society might be.

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