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The Development of Secondary School Mathematics Education in the United States, 1950-1965: Origins of Policies in Historical Perspective

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THE DEVELOPMENT OF SECONDARY SCHOOL MATHEMATICS EDUCATION IN THE UNITED STATES, 1950-1965: ORIGINS OF POLICIES IN HISTORICAL PERSPECTIVE

by

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VITA

The author, Mary Margaret Grady Nee, is the daughter of James Joseph Grady and Margaret Sullivan Grady. She was born March 15, 1940, in Chicago, Illinois.

A resident of Chicago's Lake View community, she attended Our Lady of Mount Carmel Elementary School. After graduation, she received her secondary education at The Immaculata, a private girl's school directed by the Sisters of the Blessed Virgin Mary.

In September 1958, Mrs. Nee entered Mundelein College in Chicago. After four years she received her Bachelor of Arts in Mathematics cum laude in June 1962. While attending Mundelein, she was treasurer of the Student Council, treasurer of the Student Benefit, president of her Junior Class, member of the Student and Faculty Honors Seminar, vice-president of her Senior Class and elected member of Kappa Gamma Pi, National Honor Sorority.

In June 1962, Mrs. Nee was granted a full scholarship in mathematics at Loyola University of Chicago, enabling her to complete her Master of Arts in June 1964. Also in September of 1962, she began teaching mathematics for the Chicago Public Schools at Sullivan High School. Mrs. Nee was married to Dudley W. Nee in 1967. While on leave, she had two sons Laurence and James Nee. Returning to the Chicago Board of Education, she taught at several city high schools. Mrs. Nee is presently teaching at Von Steuben Science Center. Through graduate courses at the University of Illinois in Chicago, Mrs. Nee enriched her background and expanded her mathematics and pedagogical knowledge.

In the summer of 1985, Mrs. Nee received a Frye Fellowship at the University of Chicago. The following summer she co-chaired the mathematics section of the "Smile Program" at Illinois Institute of Technology. In September of 1986, she began her doctoral studies at Loyola University of Chicago.

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CHAPTER I

PROGRESSIVE REFORM AND PEDAGOGICAL PRINCIPLES BUILD A FOUNDATION FOR 1950s

The history of the secondary school mathematics reforms of the period 1950-1965 began earlier at the turn-of-the-century with the progressives who sought changes in American public schools. Among the progressive leaders were Joseph M. Rice, Francis W. Parker, John Dewey and Charles W. Eliot. Their efforts to base learning on activities and discoveries that led to understanding and abstraction anticipated the reform efforts within mathematics education. The elimination of rote learning and the use of the laboratory, critical thinking, discovery method, comprehension, abstraction and generalization were all essential elements in the reforms of mathematics education. To understand the background and origins of these elements within mathematics education, the progressives' contributions will be discussed in historical perspective.

The major historical developments of the mid-twentieth century placed an awesome demand on the human mind for technical knowledge, scientific discovery, futuristic calculations, and data analysis. Imperative to America's continuation as a leader in the scientific community was the well prepared student in mathematics and science. Not only the academically superior student had to be challenged, but also the average student needed to be better prepared for the ever changing job market.

Changes were being demanded from within and without the educational community. Many, within education, saw that merely "adjustment" to life's routine activities would not be sufficient to prepare students for the modern world. The secondary educational system had to face new demands to prepare students for a new technologically-orientated world.

There were so many stresses placed on the educational community by the social and political forces of a post war-America that only a united national effort could effectuate the needed change and reform. The politician, college professor, secondary teacher, scientist, administrator and the public addressed the crisis. As policy statements were expanded, modified and reformed, a foundation had been developed for the new concepts and new methodologies. New ideas did not develop within a vacuum but were an outgrowth of educational investigation and reform. The principles used to support reform were produced by many significant educational forces such as university research, private foundations, professional investigations, and federal support.

In-depth investigation, research and reform were critical to the growth and development of mathematics education which occurred from 1950-1965. However, the tendencies to reform were already well established in the historical context of American public education. Research and reform have been essential to the growth of the American educational system. Both modification and restructuring of content and methodology have long been factors in the shaping of a constructive and productive educational system. The historic origins of progressive reform must be viewed as the early model of effective educational change. For progressives at the turn-of-the-century, innovative educational policy changes began with the genuine concern of the political and educational leaders who saw and understood pressing student and societal needs.

The approach, methods, and ideals of the progressives established the foundation for the development of policies which dramatically modified educational principles and mathematics education in America. The pressures and needs of both the individual and society inspired the activist to seek reform. To fully understand the expansion, reform, and development of pedagogical views which caused a revolution in mathematics education in the mid-twentieth century, we must comprehend the policy of reform established by the early progressive movement.

As the mushrooming cities of the 1880s created tremendous pressures on urban life, they also anticipated the challenges of the future. As the telephone replaced backyard conversations, American life picked up the pace; small town awareness became large city anonymity and the intimate work placed changed to the indifferent factory.[1]

For progressives, many ills in society needed reform. Commercial avarice had to give way to protective laws to protect persons. Jane Addams, speaking before the National Child Labor Commission in 1904, said:

> A school which fails to give outlet and direction to the growing intelligence of the child to widen and organize his experience with reference to the world in which he lives, merely dresses his mind in the antiquated precepts and gives him no clue to the life which he must lead.[2]

Progressives were activists who wanted both the individual and government to remedy the evils of society. Now America's conscience was becoming sensitive to its needs. However, the needed changes were incorporated into the common life of its citizens. To achieve permanent reforms, the reform impulse needed to be accessible to the masses. Many progressives saw education as the way to encourage reform. To effectuate change through education, education itself had to change. This was but a retold concept developed by Pestalozzi and Froebel who saw education as the means to deliver society from accumulated injustice.

The theory of reform became action through the efforts of well-educated, socially-minded young liberals such as Addams, Mead and Cubberley. They were motivated with a new Christian zeal. They possessed a real affection for the social and educational well-being of their fellow citizens.[3]

The progressive journalists such as Rice, Page, Sinclair and Sandburg were bold and idealistic advocates of change who by investigative reporting examined America's political, economic and educational systems. These journalists stimulated the general progressive movement by their articles that appeared in easily available inexpensive magazines and newspapers such as Forum, Philadelphia Inquirer, and McClure's. According to one historian, "In encouraging the movement for reform no influence was greater than that of the popular magazine."[4]

Such a magazine was the Forum, edited by Walter Hines Page. Page hired exciting progressive writers like Jane Addams on social reform, William James on philosophy, Henry Cabot Lodge on politics and Joseph M. Rice on education. Joseph M. Rice, educated at Jena, Germany, studied Herbartianism under Wilheim Rein. Here, he learned that education was a science and teaching a true profession. The traditions and pedagogical teachings of the German education system greatly influenced Rice. The philosophical ideas of Rousseau and the humanitarian concerns of Pestalozzi had a tremendous impact on him.[5]

Rice conducted a scientific investigation and printed his results in a series of articles in the Forum, which appeared from October 1892 to June 1893. As the articles were presented, the strengths and the deficiencies of each school system were documented so as not to be attributed solely to the personal criticism or bias of the author. He recorded his observations long before he made his conclusions and recommendations.

Rice's reports cried for reform. He saw children's potentials stifled from expression. He witnessed lessons that were never enriched by the child's personal experiences. He observed teachers who were poorly prepared with little incentive to continue professional growth. However, Rice was most concerned with the dull drill and memory work of the general lesson. He watched as arithmetic lessons were taught abstractly and by rote.[6] Whenever possible Rice included in his articles examples of creative thinking, using students' experiences to broaden the educational situation. He encouraged educators to structure and to be directly accountable for curriculum. He believed that teachers should be hired on their qualifications and scientific preparation rather than political patronage or favoritism.[7]

To better understand the reform impulse that motivated Rice and other progressives we must examine the ideals of progressivism. Colonel Francis Wayland Parker was hired in the 1870s by the School Committee of Quincy, Massachusetts, headed by John Quincy Adams, grandson of President John Quincy Adams. Both John and Charles, his brother, felt that the Quincy schools needed reform since they had become mechanical and routine. They believed that school funds were wasted while the quality of schooling remained poor.[8]

In this local school system, Parker encouraged the introduction of Pestalozzi's object lesson, the abolishment of rote learning, the writing of compositions, and the restructuring of the teaching of arithmetic. Parker's importance was established, his early innovations in elementary arithmetic methodology were linked with his basic belief that all concepts must be truly meaningful to be learned. He believed there was a tremendous gap between the rote lessons which demanded that mathematics students memorize details and the need to solve the simplest word problems by using basic problem-solving techniques. Parker wanted the practical approach stressed where the student would use the "object lesson" and focus on a practical situation.[9] His work anticipated the experimental reforms of mathematics education achieved by University of Illinois Committee on School Mathematics (UICSM) in the mid-twentieth century. Using the discovery techniques, students within UICSM project's approach, drew conclusions and formulated generalizations which produced a better understanding of mathematics concepts.

G. Stanley Hall, who had taught John Dewey at Johns Hopkins University, knew Colonel Parker's work and considered his approach refreshing. It was not surprising that John Dewey adopted the concept of activity as vital for educational growth. While Parker used his school as a learning workshop, it was Dewey who wrote about laboratory schools in <u>School and Society</u> showing their importance as a component in the educational structure. Both Dewey and Parker wanted memorized lessons replaced by educational processes which stressed thinking and doing. During the 1950s, the mathematical laboratory and discovery method were essential in the reform ideas of mathematics education. In the classroom situation the students were given materials to assist their better understanding and to visualize the mathematics concepts in relation to their own life.

Besides the research and new pedagogical theories of educational leaders, various professional organizations made their contributions to assist educational reform and expansion. As early as July 9, 1892, the National Educational Association appropriated $2,500 to arrange conferences with Dr. Charles W. Eliot of Harvard University as chairman to investigate secondary education. Through the department of the interior with William T. Harris, as Commissioner of Education, the Committee of Ten planned to review the entire field of secondary education through its nine subcommittees which represented each high school subject.

The subcommittee on mathematics met at Harvard University, Cambridge, Massachusetts, on December 28, 29 and 30, 1892, and was chaired by Simon Newcomb, a professor at Johns Hopkins University. This committee, one of the earliest on record, unanimously agreed that change in the teaching of mathematics was necessary.

The mathematics committee, chaired by Simon Newcomb, submitted five reports dealing with the teaching of arithmetic, algebra, concrete and abstract geometry as well as a report of their findings. The other members of the mathematics committee were:

William E. Byerly, Professor, Harvard University, Cambridge, MA, Vice Chairman.

Arthur H. Cutler, Principal of a Private School for Boys, 20 East 50th Street, New York City, Secretary.

Florian Cajori, Professor, Colorado College, Colorado Springs, CO.

Henry B. Fine, Professor, College of New Jersey, Princeton, NJ.

W.A. Greeson, Principal of the High School, Grand Rapids, MI.

Andrew Ingraham, Swain Free School, New Bedford, MA.

George D. Olds, Professor, Amherst College, Amherst, MA.

James L. Patterson, Lawrenceville School, Lawrenceville, NJ.

T.H. Safford, Professor, Williams College, Williamstown, MA.

Here we find a committee composed of college professors, secondary teachers and administrators. They identified areas within secondary mathematics which needed modification. This investigation and subsequent report would serve as a model for years to come.

The subcommittee on mathematics recommended that, "The method of teaching should be throughout objective, and such as to call into exercise the pupil's mental activity."[10] It still maintained the importance of accurate reckoning with speed and skill. This was extended into numerical coefficients with algebra. After years of general algebra, required for all, the subcommittee recommended an introductory course in plane and solid geometry. They were quoted as saying, "Boys going to a scientific school might profitably spend a year on trigonometry and some of the higher parts of algebra, after completing the regular course in algebra and geometry."[11]

The subcommittee believed that mathematics was a valuable mental discipline in itself. Although the mental discipline concept was then current, it was later challenged as a reason for studying this subject. It was better that the student understand new principles which might be applied to future problems. This was to be done through a gradual increase from easy problems to problems containing a combination of the ideas rather than difficult or complex problems.

As for the teachers, the mathematics conference held that they should use more concrete forms (objects) in the lessons so that the pupils would comprehend more clearly. The student must understand literal expressions and algebraic language. They wanted the distinction between identities and algebraic equations clarified with a great amount of drill given to solution of equations.

As for demonstrative geometry, the committee wanted the students to understand size, shape and space; and to essentially see the importance of axiomatic structure of a deductive body of knowledge. The subcommittee members discussed the merits of a pure geometrical approach to teaching versus a numerical method with mensuration as an essential part. While they realized that the presentation of geometric proof was complicated for many, still the teacher should instill the elementary ideas of logic to the student.[12]

The subcommittee's recommendations remained a guide for mathematics education in American secondary schools for years. It was able to characterize the methodology of teaching, to specify the curriculum, and to structure the critical value of language, logic and deductive reasoning. This was the guide that the American high school followed as it confronted the demands of the mid-twentieth century.

The early progressives saw American public schooling, with its faults, as the system which had the responsibility to teach the children of America and to prepare them as citizens able to function in the demanding society that was growing and ever changing. Their approach to the methodology of teaching and the content of the curriculum reflected this view. John Dewey, (1859-1952), understood the scientific approach to education and related his views of education to Thomas Huxley's Elements of Physiology by seeing an organism (person) as an interdependent and relative unity which created its experience from environmental situations.[13]

In January 1896, the Laboratory School of the University of Chicago was begun with John Dewey as director, Ella Flagg Young as supervisor of instruction, and Alice Dewey as the principal. Here, emphasis was placed on activity and demonstration. Dewey wanted his students to think and act so as to learn and gain knowledge. This was a great experiment in education for Dewey wanted the students to think for themselves and to choose a task, under the guidance of the teacher, which would then be analyzed and discussed.[14]

In his book The School and Society, Dewey saw the very changes of society affecting education. As the labor on farms was changing, the introduction of manual training and hands-on experiences were necessary in school. He wanted to unify education, its subjects and its training.[15]

In Experience in Education written in 1938, Dewey stated he saw the progressives causing a dichotomy in education. The progressives believed that individuals in school should have common shared ideas which, if developed, would lead to communication. This communication would lead to a true community, integrating the home, family and neighborhood. Dewey saw intelligence as social while curriculum existed in three stages organized around making or doing, the extension of time and space, and the use of the scientific method. He believed that one would forget facts but the method of problem solving would remain and would be transferable throughout life.

John Dewey saw the traditionalists as persons who had failed to develop an educational philosophy based on experience. In traditional schools, the structure and curriculum of the school were also separate from the daily experiences of the child and divorced from the environment.

Dewey's essay "Ethical Principles Underlying Education" published in 1897 examined the moral responsibility of the school in society. For Dewey, the child had to be instructed as an organic whole who should be prepared to become a productive part of United States' society. These values remained constant with Dewey throughout his productive life. Although the progressive movement moved in several directions, Dewey's emphasis on the unity of the child and society remained consistent throughout his pedagogical work.[16]

In The School and Society (1899), Dewey characterized the school as an "embryonic" society. He used the scientific method within his Laboratory School where the student had an opportunity to frame an hypothesis, test it, then to accept or reject the consequences of action. He wanted the student to be an involved, active participant in this scientific atmosphere.[17]

Dewey was greatly opposed to the dualism which separated everyday life from learning. The traditional curriculum appeared fixed, not flexible to individual's needs, nor responsive to the unique variation of one's personal experiences or environment. Robert M. Crunden said,

> Dewey instituted the solving of problems as the key to children's educational growth, and insisted that moral and educational values could only be generated in the process of solving the problems posed by modern society as the child actually encountered them.[18]

Dewey believed in reason and in democracy. For him, the school community was an extension of the individual's own life and personal experiences.

Essential to the mathematics reforms were Dewey's philosophical concepts. He saw the need for educational reform as a direct result of the technological advances of transportation, telegraph and telephone, and rapid and improved communications. With these inventions, the exchange of ideas was much more extensive and extremely rapid. Dewey felt these technological advances had been instrumental in bringing about a new intellectual revolution that would affect education. Dewey said, "Knowledge is no longer an immobile solid; it has been liquefied. It is actively moving in all the currents of society itself."[19]

To adjust to this modern society remained for Dewey, a key issue in education. To achieve the proper balance, the school must work with, adjust to and draw from the student's environment and daily life. Dewey continued,

> It is our present education which is highly specialized, one sided and narrow. It is an education dominated almost entirely by the medieval conception of learning. It is something which appeals for the most part simply to the intellectual aspects of our nature, our desires to learn, to accumulate information and to get control of the symbols of learning; not to our impulses and tendencies to make, to do, to create, to

produce, whether in the form of utility or of art.[20]

These issues of intent and structure formulated a truly progressive approach to education. Through the experimental work at the laboratory school with hands-on experience and the scientific approach to daily lessons, Dewey developed the strategies which would characterize his theory.

The cultivation of the child's own imagination was not a unique or separate part of a child's life. The child's imagination was the very medium in which he or she lived. Thus, in school, instructions should appeal to children's imagination and subjects should become instruments to cultivate imagination. To be a cultured adult, the child must know nature and society. Dewey stated,

> When nature and society can live in the schoolroom, when the forms and tools of learning are subordinated the substance of experience, then shall there be an opportunity for this identification and culture shall be the democratic password.[21]

Dewey wanted the child to grow into a cultured adult by awakening the child's creative spirit to the realities of nature and society.

With his teachers from the laboratory school, he formulated questions from which the school program could be organized.

> 1) What can be done and how can it be done, to bring the school into closer relation with the home and neighborhood life . . . ?
>
> 2) What can be done in the way of introducing subject-matter in history and science and art, that

> shall have a positive value and real significance in the child's own life . . . ?
>
> 3) How can instruction in these formal, symbolic branches--the mastering of the ability to read, write and use figures intelligently--be carried on with every day experience and occupations to their background and in definite relations to other studies of more inherent content, and be carried on in such a way that the child shall feel their necessity through their connection with subjects which appeal to him on their own account . . . ?
>
> 4) Individual attention: This is secured by small groupings--eight or ten in a class--and a large number of teachers supervising systematically the intellectual needs and attainment and physically well being and growth of the child.[22]

Dewey saw numbers as the investigation of measurement. Through measurement with hands on experiences, the workshop concept would become the center of the mathematical teaching unit. This practical measurement of physical objects would offer an excellent experience for mathematical activities, leading to abstract concepts and rules. The theory of the "science of numbers" was set aside in favor of seeing relationship with numbers and the measurement of real things. Dewey's four points above become a strong pedagogical model for progressively minded teachers to follow. These were positive suggestions constructed to eliminate the rote-memory work within education criticized by Rice and Parker.[23]

Dewey devised a three stage developmental program grouped as follows: stage one, from ages four to eight; stage two, from eight to eleven; and stage three, from twelve through fourteen. During the second stage, the students would learn calculating as well as intensified reading and composition. However, during the third stage, the student would be instructed in the sciences and their special position in human progress. The student would expand his or her calculations into a deeper study of mathematics which included algebra and geometry. Throughout these stages, Dewey's school remained constant in its focus on problem-solving which is still a key today to intensified mathematics.[24]

Although Dewey made only a few direct references to mathematics, they were significant. Dewey said, "The child should study his commercial arithmetic and geography, not as isolated things by themselves, but in their references to his social environment."[25] The unification of school, the entire learning experience, with the whole of the child's community and family life was a basic principle of Dewey's view of the relationship between school and society. Dewey was not alone in maintaining this interlocking of one's approach to teaching with practical applications. During the early period of the century, Guy Wilson wrote with his associates a text on teaching of the new arithmetic. In this text, they stated that the basic and dominating aim of arithmetic in the schools is to equip the child with useful skills for business.[26] However, Dewey's perspective was different for it was centered around the child's present experience and not aimed at some distant future period in the child's life.

Other progressives became more and more concerned with social changes and the school's place within the changes. George S. Counts in his book asked the question, Dare the Schools Build a New Social Order? Counts believed in social reconstructionism basically rooted in pragmatism. For him, education was to create a new society, that embraced science, technology and ideals of democracy. He believed that schools must be designed to stimulate social planning and a basic reform of life.[27]

In Secondary Education and Industrialism, Counts argued that American educational reforms had not adjusted to the realities of the industrial civilization of the twentieth century. The reforms of schools--pedagogical, curricular or methodical--must be united with the needs of society. He believed isolated modifications of the schools without the fundamental support of society, integrated with America's social goals, would do little to reform American society. Education would never fulfill a role as a leader in American life without this support.[28]

Many progressives became very active in the support of vocational education within secondary school. Charles Prosser supported teaching utilitarian skills in high school. The high school was to prepare the vast majority of students, around 60 percent, to adjust to life. They were entitled, as Americans, to this preparation. College preparatory advocates, such as Bestor, vehemently opposed Life Adjustment as anti-intellectual. Vocational educators tended to support it. This was a major point of controversy.

Five regional meetings on Life Adjustment were held from April to November of 1946 with representatives from thirty-five states and the District of Columbia. The consensus of these meetings held that the American high school was failing to provide education to prepare the students to adjust to life. A Commission on Life Adjustment Education headed by Benjamin Willis, then superintendent of Yonkers, N.Y., was begun and operated until 1951. This commission represented a powerful force to translate educational theory into practices and to expand educational opportunities to America's children.[29]

The fifteenth yearbook of the National Council of Teachers of Mathematics (NCTM), The Place of Mathematics in Secondary Education, included the report of "The Commission to Study the Place of Mathematics in Secondary Education." The members of the commission included representatives from NCTM, and the Mathematics Association of America (MAA), and "The Commission on Secondary School Curriculum of Progressive Education Association" (PEA). This joint report recommended a two track system for the college-bound and for the terminating high school student. It emphasized spiraling of instruction and included presentations to strengthen logical thinking, and symbolic language as well as computation and space perception. It stressed the utility of the skills as well as the training for life in clear, logical thinking. These concepts were closely aligned with the progressives' views and also with some aspects of the Life Adjustment Movement.[30]

Gradually, the beliefs changed so that the "Second Report" of the Commission of Post War Plans of 1945 strongly held that mathematics must no longer be regarded as a tool. This view was basic to the extension and development of mathematics and to mathematics education. For the question now arose, "What mathematics should we teach?" Should the center be on the children's needs, future adult usage, or the inner meaning and relationship of the subject? "There is a very real sense in which the emphases of meaningful arithmetic were in the spirit of modern math of the period to follow."[31]

George Counts stressed that individual excellence must embrace the whole child. He said, "The achievement of intellectual excellence is a long and exacting process, requiring severe and sustained discipline."[32] To achieve this, Counts saw the importance of professional guidance within an organized educational system. He stated that the mind was a cultural product and needed specific tools to develop. The first tool was language, the mastery of linguistic arts. The second tool was number and the third was science. Counts stated:

> In the last analysis our industrial civilization rests upon mathematics. Without it contemporary man would be forced back into some simple form of agrarian society . . . . Its devotion to precision is a quality of mind, moreover, which should be cultivated unceasingly in all relations and departments of life.[33]

Counts, a gifted progressive educator, recognized that mathematics was a critical element which was fundamental to an educational system.

Another factor in the crisis of education was addressed in 1946 at the Chautauqua Conference which dealt with the critical shortage of teachers. The Oxford Conference of 1947 considered ways of improving effective teaching. During the Bowling Green Conference of 1948, professional standards for teachers were investigated. The participants at the Bowling Green Conference hoped their results would promote study and research as well as stimulate the growth of inservice teacher education.

The Bowling Green Conference specifically recommended that the specialized high school teacher, such as the mathematics teacher, should have a broad preparation in the content areas they were to teach. They recommended that 30 to 40 percent of a teacher's college preparation be spent on the academic field which they would teach. They suggested that 36 hours out of a college program of 120 hours be devoted to the area of expertise they would teach.[34]

The staging for mathematics reform was in place by the 1950s when many debates over progressive education occurred. The tension in the educational climate within the

United States was reaching an apex. Was the concept of life adjustment sufficient or should the curriculum return to the traditional academic studies? The demands of a modern technological world raised questions about the educational system since it would influence generations to come. Scientists and mathematicians saw deficiencies in American education. The criticism of curriculum inadequacies were put forth by people such as Arthur Bestor, Mortimer Smith, and Admiral Hyman Rickover.

In December 1952, Arthur Bestor was invited to present a paper before the American Historical Association by its president, James C. Randall. This paper was titled "Anti-Intellectualism in the Schools, A Challenge to Scholars." Bestor warned,

> Anti-intellectual conceptions have led, in many instances, to public school curricula in which intellectual training has been pushed into the background, to teacher certification laws and rulings that dangerously under emphasize training in the subject area to be taught, and to pronouncements to the effect that the intellectual criteria employed by schools and scientists are inapplicable to the public schools.[35]

Bestor reached large numbers of people within the educational community who were not included in the established commissions. His books attacked what he regarded as a climate of anti-intellectualism in American education. The educational community was in a crisis and under attack to reform. Bestor wanted teachers to be liberally educated and expert in their academic specialization. For him, secondary schooling needed to stress intellectually interesting and academically challenging classes to arouse student involvement and achievement.[36]

Mortimer Smith, through the Council for Basic Education, advocated enriched academic programs, more concepts in the curriculum, and the addition of new data and techniques to raise the academic standards of democratic education. To this end, the council sponsored publications, studies and conferences.[37]

In the 1950s, the International Assessment of Education (IAE) gathered data worldwide. Here, the strengths and weaknesses of American programs were identified. The findings of the IAE on curriculum and on increasing time on academic studies were very important. In the technical era after World War II, students needed a revitalized secondary school program with a reformed curriculum that emphasized on fundamental subjects like mathematics. However, many issues raised contained variables such as the quality of instructors, textbooks used, and student's study time which were difficult to evaluate.[38]

Admiral Hyman Rickover traveled and made speeches for four years prior to writing Education and Freedom. He spoke often of his concerns about America's educational system and the crisis in the world. "Whenever man makes a major advance in his age old efforts to utilize the force of nature, he must simultaneously raise his education, his techniques, and his institutions to a higher plateau."[39]

Rickover maintained that creative people must lead the nation or there will be eventual stagnation. He felt that our nation's schools emphasized "know how" rather than fundamental principles. He cited the phenomenal concepts of classical Greek and Roman cultures and the marvels of a liberal education as supported by John Henry Newman in his The Idea of a University. Rickover wanted the intellectual powers of each child developed to its highest levels because he believed "the future belongs to the best educated nation."[40]

The great impact of technologically accelerated growth began in the 1950s. A vast historic transition had begun, stimulated by technology and world pressure. In a very few years scientific ideas became reality. From the discovery of the atom to its powerful release in Los Alamos, New Mexico, was about thirty-five years. While the first solid-fuel missiles were opening the vast reaches of space itself, American education faced a technological world which grew ever closer together. As the critics viewed the inefficiencies in our American education, the challenges of the scientific and political world demanded changes in mathematics and science education.

The educational arguments that began the 1950s were placed in a national political setting filled with the events related to the aftermath of World War II and the fears of a guarded peace. The Russians, our allies during the war, were now viewed as a growing enemy in the Cold War.

The United States passed laws to aid its devastated European allies so they would be stalwart guards against the rising red threat. In particular, the Marshall Plan passed in 1948 was designed to rebuild the economies of Western Europe.

However, fears generated the right wing extremes of Joseph McCarthy and his anti-communist crusades. McCarthy attacked the educational community for being soft on communism. He wanted it to return to the three R's. The progressives' reforms were viewed with suspicions while many leaders like Dewey and Counts were attacked.[41] Loyalty oaths were required now of many citizens. In 1947, President Truman inaugurated a program to keep the government free of subversives. Public Law 831, an Internal Security Act, was passed by the Eighty-first Congress. The fear of subversives and communists extended beyond the government and into the business and educational communities.[42]

A national policy for aid to education had so far failed to gain federal government authorization. Truman had supported the concept in his campaign of 1948 but little materialized. The sectionalism throughout our nation along with pressing fears of a strong federal control over education prevented the passage of federal support. There was no doubt that enormous strides had been achieved when the nation had united during the war. By pulling together the nation's talents, resources and finances, tremendous growth in many fields had been accomplished. This realization gave great support and impetus to the growing opinion that the federal government must involve itself in the nation's educational system. In May 1948, the Senate passed Bill S2385 to establish a National Science Foundation (NSF) with a board of twenty-four members, eminent in fields of science and education. John R. Steelman, presidential adviser projected that a starting budget of $20 million would expand to $100 million after ten years.

World War II had curtailed the education of many and taken the lives of other young people. Many left education and research to work within industry. The nation needed to find a way to replenish the supply of these scientists and educators, and it had to support a restructuring of research for science and mathematics. However, the structure had to be a compromise between the starvation days of independent research and the wartime regimentation with almost inexhaustible funds. The real power of the proposed foundation appeared to be in its ability to decide what areas to tackle such as medical research, mathematics, physical sciences and engineering. However, 1948 was not the year for NSF.[43]

The NSF new bill appeared to resolve the issues which halted its passage in the summer of 1947. The redesigned bill of 1948 was "to meet the objections that impelled President Truman to veto last year's measure."[44] The new measure allowed the foundation to do military research and to choose its own subdivisions of specialization. The new bill identified special research cancer, polio and degenerative disorders as among the Foundation's areas of interest. However, this bill was not enacted in 1948, because the power of federally supported research still was a concern.

In July 1950, legislation that authorized the National Science Foundation, P.L. 507, was passed by the Eighty-first Congress. In Scientific American, the foundation was described as an agency unprecedented in American history which would challenge able youth to work in basic science. "The Foundation is charged with two main functions: 1) support of basic scientific research, 2) development of the nation's resources of scientific manpower."[45] There was no question that the public acceptance and the governmental enthusiasm which permitted its passage was a direct outgrowth of the dramatic success of wartime research.

This new departure marked the beginning of an era of expanding research and development which was critical in reforming mathematics education in the United States. The creation of the NSF for research and education was a benchmark in the expansion of mathematics reforms in the 1950s. Within its first year a Policy Committee for Mathematics was established which assessed the educational needs and prepared a budget for future work of the NSF. This committee, chaired by A.A. Albert, included members from such leading mathematics organizations as the American Mathematical society and the Mathematical Association of America.[46]

The establishment of NSF was a critical focal point from which a new era in mathematics education developed. This new era was built upon the educational foundation of progressive reforms. The historical events within the educational community during the first half of the twentieth century prepared a fertile ground upon which the nucleus of new and exciting ideas found growth. The pedagogical views of Dewey and Counts established principles and policies which united education and the community. The school and its environment were interdependent. To make them both profit and grow, an awareness of their interrelationship must be a conscious reality. By 1950, American society recognized the potentials of controlled atomic power. The thrust of solid-fuel missiles into space and the impact of the challenges placed before mathematics and science education a magnificent adventure. Fertile ideas, with public support and government funding, awakened a creatively productive era in mathematics education.

The private foundations were instrumental in supporting vital research in education. The entire educational community profited from the financial support and encouragement provided by the Rockefeller, Carnegie and Ford Foundations. These foundations also contributed to the research necessary for reform of mathematics education. Chapter II discusses their role in relation to these reforms.

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CHAPTER II

FOUNDATIONS SUPPORT RESEARCH

The mathematics education reforms were assisted and supported by the extensive research done through the efforts of private philanthropic funds. Chapter II provides a brief history of the various funds' development. Among their purposes were to advance knowledge, to further development of America, to strengthen the American economy, and to assist humanity. While the federal government during World War II had supplied critical funds for research, after the war private foundations were vital in America's continuing research effort. Conant's research on the American high school and the curriculum changes suggested by the College Entrance Examination Board (CEEB), established the need to change mathematics education. The contributions of the Carnegie, Rockefeller, and Ford Foundations were significant to the research which encouraged reforms of mathematics education.

In the early decades of the twentieth century, as part of the broad reform movement of the progressive era, demands for social reforms placed intricate demands on education. To change an educational structure, which had its curricula dictated by various colleges for years, to a new democratized structure reflecting the demands of the new urban-industrial society, was a tremendous task. To remove drill and memorization and to broaden the educational experiences of the child were the goals of many progressive educators. Reformers saw the schools as instruments of individual change in the student, as well as producing changes in society.

From the same industrial setting which created the diversity of urban social needs, arose the industrial giants who as captains of industry accumulated vast personal wealth. In his Gospel of Wealth, Andrew Carnegie set forth his principles that wealth must work to elevate all of humanity, and should establish philanthropic trust funds to support meritorious projects, especially projects dealing with education.[1]

Thus, he established his Foundation for the Advancement of Teaching in 1905 under a New York State Charter. In 1906, this foundation, incorporated under an Act of Congress, was created to support teachers' pension funds. The Carnegie Foundation's principal purpose was "The advancement and diffusion of knowledge and understanding among the people of the United States and of the British Dominions and Colonies."[2] For many years it concentrated on the support of teacher training and basic research programs within higher education. When Carnegie established his foundation a cordial letter was sent to him by Rockefeller, who said,

> I would that more men of wealth were doing as you are doing with your money, but be assured your example will bear fruits and the time will come when men of wealth will more generally be willing to use it for the

good of others.[3]

Following his own recommendation in 1902 John D. Rockefeller formed the General Education Board for educational philanthropy. In 1913 he had set aside vast funds to advance humanity and its welfare through the Rockefeller Foundation. One of its first research programs was to fight the hookworm problem throughout the world.

With these two foundations firmly in place, many others were established in the next decades which supported improvement of human needs and future development. However, the key to the foundation's success was that its leaders be persons of ability and vision. No one could possibly establish permanent guidelines to direct such funds as they developed over the future years. Therefore, the governing board had to keep abreast of world needs and make responsible decisions that would support causes in an ever changing society. Raymond Fosdick, who recalled his early days with the Rockefeller Foundation, stated that it was wisely administered and that the foundation was free to determine its own function in society.[4] He also stressed that a "foundation is not only a private philanthropy; it is affected with a public interest and is in a real sense a public trust."[5] Under creative leadership, a foundation had to support the right efforts to expedite research and to develop new ideas. Their work depended on their ability to form foundations which would adapt to the needs and changes of the world.

John D. Rockefeller stated that the purpose of his foundation was the improvement of the well being of humanity throughout the world. He saw that his belief in the advancement of knowledge was maintained in the daily working of the foundation. This was accomplished by generous grants to universities and research institutions. As the foundation grew in strength, its ability to choose its research project effected the credibility of a project.[6]

In 1933, as an example, the Carnegie Foundation made grants totaling $70,000 and the Rockefeller's General Education Board contributed more than one million dollars to an intensive curriculum study. The Eight Year Study, which had many off-shoots, was basically under The Commission on Secondary School Curriculum directed by the Progressive Education Association (PEA). According to Lawrence A. Cremin, "This torrent of money obviously strengthened the PEA. Foundation funds had a way of sweetening programs then, as now--but it also accelerated its transformation into a professional organization."[7] Later when foundation funding was withdrawn in 1941, the PEA, completely dependent on this aid, found no other funding.

In 1935 the General Education Board and the Rockefeller Foundation supported a project on the general college (junior college). This project identified the kind of students attending college, the attitude of the students, and the merits of the program. The general college received an excellent appraisal by its students who would not have been accepted in four year universities. This research sold the concept of the junior college not only to the public but also to many educators. The general college concept was used after World War II as a model for the necessary expansion of colleges after the GI Bill increased enrollments.[8]

As the crisis in education began to grow after World War II and as the technological needs of the nation expanded exponentially, another foundation was established which would possess, by far, the greatest monetary assets. The Ford Foundation began to spend large amounts in 1950 when it distributed over $24 million in grants which related primarily to education. Founded by Henry and Edsel Ford, the purpose of this fund was "to advance human welfare by trying to identify problems of importance to our nation and the world and by supplying funding on a limited scale for effects directed at their solution."[9]

Although foundations, at the beginning of the 1950s, were viewed as symbols of public assistance, they met with much confusion and distrust. Some critics accused the Ford Foundation of being an establishment for dangerous communists. Others speculated that it was created as a tax exempt organization to protect the control of the Ford Corporation by the family members. Both of these issues were investigated by Congress and the foundation's reputation was cleared. Whether the issues were real concerns or episodes induced by the political climate was debated by the press, politicians and the public. There is no question that the Ford Foundation was created so that stock, received as an inheritance, would not have to be sold to pay income or death taxes. In this way, the Ford Foundation differed from the Rockefeller and Carnegie funds which were established well before the existence of income taxes.[10]

In the original Report of the Study For the Ford Foundation on Policy and Program which sought ways of intelligently using the vast resources of the Ford Foundation, many professionals assisted in its construction and organization. They appreciated, in this difficult time, the benefits which the fund would generate. They sought to define human welfare, to evaluate existing problems of mankind, to propose specific programs to solve these problems, and to construct the needed organizational structure.[11]

The committee stated that the Ford Foundation needed to propose strategies to strengthen the American economy as well as promote American democracy. Another major program area of research was the development of education. This statement of purpose regarding education was included:

> The Ford Foundation should support activities to strengthen, expand and improve educational facilities and methods to enable individuals more fully to realize their intellectual, civic, and spiritual potentialities; to promote greater equality of educational opportunity; and to conserve and increase knowledge and enrich our culture.[12]

When the report listed specific activities its authors included "the improvement of conditions and facilities for scientific and scholarly research."[13] They also wanted to improve the quality and quantity of teachers in all levels of education. The shortage of qualified teachers was particularly acute. Both government and industry sought solutions for their manpower needs within the educational community. The demands caused by the increased enrollments of the post-war college population now also created tremendous pressure. The Ford Foundation was able to study and to analyze the issues.

The first year of Ford Foundation's existence was centered on organization. They established a board of directors and three individual funds--the Fund for the Advancement of Education, the Fund for Adult Education and the East European Fund. The educational funds received more than $10 million in 1951. The financial aid was directed to support the concept of a liberal education and to provide assistance in supporting experimental research. However, the Ford Foundation would not give grants for building programs, operating expenses, or endowment funds.[14]

As early as 1951, the Ford Foundation provided 250 fellowships to young teachers to improve their skills. Educational leaders in Arkansas with the assistance of the Ford Foundation investigated changing teacher colleges into liberal arts colleges to modify the preparation of teachers. Although no specific mathematics programs were listed, the independence of the foundation allowed great variation in funding to occur as needs were identified. Paul Hoffman, president of the Ford Foundation in 1951, stated that the "Ford Foundation cannot solve many of them [problems], but by patience, persistence and humility the Foundation may in the course of time be of some use to humanity."[15]

The members of the program planning committee of the Ford Foundation saw the need to revitalize education. As a policy, they were firmly committed to enriching the educational experiences of students. They wanted to encourage the development of students' thinking and citizenship skills. They made a strong statement in support of research and educational enrichment and provided funds for publication of meaningful results. This commitment was actualized in the Ford Foundation's support of mathematics teacher institutes in the 1950s. They believed that inventive practices, methods and procedures would be especially helpful for elementary and secondary schools.[16]

The planning committee maintained that administrative flexibility was essential since no one could predict the future. Original programs would be created as new opportunities and situations occurred in society. As new discoveries and issues arose, the foundation, under its directors, would adjust its support and concentration to fulfill its basic creed to benefit humanity.[17]

After the first three years of Paul G. Hoffman's presidency, H. Rowan Gaither was appointed president in 1953. For tax purposes in 1953 the Ford Foundation's assets were listed as $417 million but its real value in the earnings of Ford Motors was $2.5 billion. The foundation recognized the shortage of skilled teachers and supported four experiments which would assist in their training. A program in Arkansas received $559,600 to improve discussions between the public schools and the colleges in that state. Harvard University worked on an internship program within the public schools to assist the professional training of teachers. In Michigan, support for further dialogue between colleges and the public schools was provided through the Fund for the Advancement of Education. Stated in Ford Foundation Annual Report of 1952:

> As steps toward the improvement of teachers now in service, the Fund awarded some two hundred and fifty fellowships for further study by college teachers and in 1952, expanded its fellowship program to high school teachers.[18]

This began Ford Foundation's strong support of teacher institutes in mathematics.

In the early 1950s the Rockefeller Foundation sponsored grants to research "analytical and experimental techniques developed in physical science, i.e., chemistry, physics and mathematics."[19] In 1951, only limited funds were provided for mathematical biology projects at the Massachusetts Institute of Technology and in Mexico. However, little effort was made to support extended research in mathematics or mathematics education.

As a matter of general practice, since its founding in 1913, the Rockefeller Foundation, through its annual reports, has publicly reported its policies and expenditures. However, on April 4, 1952, the House of Representatives passed resolution 561 which created a committee to investigate the Rockefeller Foundation's tax exempt status. Appearing at a November 18, 1952, hearing in Washington were the president of Rockefeller Foundation, Dean Rusk and the former president Chester I. Barnard. They reported from the Rockefeller Foundation annual reports which specified the expenditures of the fund. These meetings resulted from criticism that the Ford Fund was receiving considerable subsidies. Little was found to damage the productive research and support the fund provided over the years. The Rockefeller Foundation had, throughout the middle 1950s, concentrated on medical research, medical education and public health. It also maintained an outside cultural interest in the performing arts. In 1957, the Lincoln Center in New York received $7,500,000 while public health and medicine received $8,300,000 out of a fund with assets around $492,000,000. The history of funding by the Ford Foundation showed considerable support of medical and natural sciences as well as aiding developing institutions in foreign countries to investigate indigenous problems.[20]

Keeping to its fundamental purpose, the Carnegie

Foundation, during the early 1950s, continued its practice of funding projects which advanced and diffused knowledge. It supported training and research projects within higher education. Oliver C. Carmichael's report, as president of Carnegie Foundation, cited James B. Conant of Harvard who reviewed problems in teaching science to non-science majors in college. To Conant, the well-educated individual as an integral part of a modern complex society needed to "see how laws united facts and concepts united laws to form the orderly world of science."[21] His concern that able college students understood science and mathematics would only be achieved if they received a better secondary education in these fields.

Early in 1951, the Carnegie Foundation originally funded the University of Illinois Committee on School Mathematics which was "to investigate problems concerning the content and teaching of high school mathematics."[22] This program hoped to identify the weaknesses in secondary mathematics programs which did not sufficiently prepare the students for later studies nor fulfill their life long needs.

John W. Gardner, who was president of Carnegie Foundation by 1954, wanted the trustees to establish a new direction and a new pattern of activities for the Carnegie funds. He stressed the need to investigate, discuss, and research the educational problems which were evident in American secondary schools. When problems became evident at one educational level, soon the interdependent relationship of the educational system caused difficulties at other levels. In the Fifty-Third Annual Report of the Carnegie Foundation, American colleges and universities were investigated. This report, The Education of College Teachers, revealed that the intensity of problems stemmed from an acute shortage of professors. A 1956 National Science Foundation report indicated that there were, some 196,000 full-time college professors in the United States; projections for 1970 suggested a need of 495,000 full-time professors. Much of the shortage was in mathematics and science. Now it was time to awaken the undergraduate to the benefits of the teaching profession.

The long standing arguments over the merits of liberal education versus teacher preparation classes needed to be replaced with a requirement that present teachers encourage future teachers. The university, society and government needed to unite to raise the teaching profession's standards. As a helpful suggestion, The Education of College Teachers stated that good teachers should have: a skill, technique and methodology for teaching; a basic knowledge of the concepts of educational philosophy; experience such as student teaching; and an understanding of the wide scope of what education must be.[23]

The College Entrance Examination Board was another private agency which was active in directing research and suggesting modification within secondary mathematics program. Established to assist in the selection of high school students, this organization inquired into the programs offered students while in high school and investigated the content of the secondary program. Far beyond suggesting curriculum restructuring or course recommendations, they created innovative programs to stimulate and direct education policies throughout America.

In the College Board's Annual Report of 1954-55, the Advanced Placement Program was listed as a new venture. James B. Conant and Admiral Rickover agreed that this program was a boon to the talented high school student. "In 1955-56, its first year as a program of the CEEB, it served 1,299 students from 104 schools."[24] Within its original construction were these requirements: careful identification of students, selection of an advanced curriculum to prepare students, and recruitment of spirited teachers with the ability to teach college material.

It was from the Kenyon Plan with the Three-School-Three College Study in the early 1950s that the Advanced Placement Program developed. The Kenyon Plan involved twelve colleges and twenty-six high schools in an attempt to allow talented students to learn at a "rate commensurate with their ability."[25] It offered tests in eleven areas, including mathematics in 1953. In spring of 1954, the first Advanced Placement (AP) examinations were written.

Education Testing Service in Princeton directed the faculty of Kenyon Plan schools, who created the tests, to write a report with an evaluation and conclusion about AP tests. These results were positive. It was viewed as a way for the universities to help secondary schools and to improve American education. Mainly, talented and able students would not waste time and would be challenged by new dimensions in their education. Charles R. Keller was the first College Board Director of the Advanced Placement Program. In 1957, he was succeeded by David A. Dudley who encouraged universities to recognize the merits of student success on the AP examinations. Harvard University and Radcliffe College, at the start, granted sophomore standing to students who were successful in three or more subjects. The AP concept, fundamental to the encouragement of the high school student and program, grew so that more colleges and universities granted advanced status to successful AP students.[26]

In addition to the leading American foundations--Rockefeller, Carnegie and Ford--a new federal government foundation was established in the early 1950s. The National Science Foundation (NSF) was created by Congress with the expressed purpose of supporting American science. President Truman, on November 2, 1950, announced the appointment of a twenty-four man board which would supervise and select projects for the NSF. This board was made up of leading citizens from business and industry as well as outstanding educators. Truman named Chester I. Barnard, president of the Rockefeller Fund, and Charles Dollard, president of the Carnegie Fund, to the National Science Board to administer the NSF. The structure of a ruling board, its ability to select special projects and its budgeting control was parallel to the philanthropic funds begun at the turn of the twentieth century. Also included on this first board were eight presidents of universities such as Howard, Johns Hopkins, Harvard and Wyoming University. As specified by law, the NSF board could create whatever subdivisions it chose and not be restricted to a pre-organized list. Here was a flexibility which would allow various future research to be funded.[27]

The NSF held that colleges and universities were the logical places for research and inquiry. However, universities' funding from endowments felt the pressure of increased research expenses and the loss of able researchers to the competitive market of American industry. Therefore, the original purpose of NSF was to strengthen the university where basic research and the education of future scientists occurred.[28]

Provisions were included in NSF to grant scholarships and fellowships to directly educate future scientists. Under the NSF charter, broad guide lines were established. It was required "to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences."[29] With a limited time for organization, it was able to distribute its first fellowships and scholarships by the fall of 1952.

Another responsibility assigned to NSF by Congress was "to initiate and support basic scientific research in the mathematical and physical, medical, biological, engineering and other sciences."[30] The priorities of the NSF were directed to research projects, scholarships and fellowships and to developing a national policy for promoting research. In 1951, the appropriation for NSF was $225,000, but by 1955 this figure grew to $12,225,000. Throughout this expanding period, the foundation had a great freedom to distribute the support and grants where the NSF felt scientific progress would best be achieved.

From 1953 when two summer institutes were supported by NSF, the number grew to four in 1954. Of the four, three were for college teachers. Of these three, two were in mathematics. The remaining fourth institute for high school teachers of mathematics was held at the University of Washington. By 1955, nine institutes were funded by grants from NSF of which three were in mathematics in Oklahoma, Wisconsin and California.[31]

Kenneth Brown, a mathematics specialist who wrote many articles on Inservice Education, said, "The present mathematics institutes have the original objective of providing a situation where teachers can work on their own problems in teaching mathematics and enjoy it."[32] These institutes were relaxed, informal and socially appealing to attract and to motivate the mathematics teacher.

Under the direction of Public Law 530 passed by the Eighty-third Congress, the Commission of Intergovernmental Relations formulated a Study Committee on Federal Responsibility in the Field of Education with Adam S. Bennion, chairman. This committee's report specifically listed: lunch program, vocational program, construction support, public library aid and federally affected areas that demanded support. Among its findings were that enrollment was skyrocketing, the acute need of qualified teachers, shortage of classroom space, and the demands of expensive programs and equipment. This report stated, "Progress in education is most meaningful if it has the endorsement of the community."[33] However, the general conclusion with which some members did not concur, was "that Federal aid is not necessary either for current operating expenses for public schools or for capital expenditures for new school facilities."[34] Absent from the report was NSF and its newly established support of secondary teacher institutes.

At the Fiftieth Annual Meeting of the Carnegie Foundation for the Advancement of Teaching, the trustees discussed liberal arts and a liberal education. By liberal education, they included those university programs which prepared a wiser, more cultured person rather than the skilled professional. Even within the liberal arts school, one trend seemed to encourage specialization. The uniquely modern approach to elective courses created a fragmentation within the formal college setting.

In their report they affirmed that any liberal education was supposed to provide knowledge useful to all people. This includes: self knowledge, knowledge of human behavior, knowledge of the physical world, of other cultures, an historical view of human achievement, and knowledge of philosophy and religion. From a liberal education, one develops a competency to think critically and to possess a true intellectual discipline. As a result, liberal education must produce a good, wise and mature person. Thus, they concluded a liberal education should be developed in the pre-college years. "The liberal arts are certainly, at present, a strong feature of the curriculum of most good high schools. They should be a strong feature of all high schools."[35] In order to expand the student's knowledge of the physical world, a strong foundation in mathematics was a necessity.

There was a struggle within colleges as they debated content versus method in liberal education. There needed to be a range of subjects such as "languages, literature, philosophy, the creative arts, the social sciences, mathematics and the natural sciences."[36] The role of science and mathematics should be specified for both the science and non-science majors. A student should know challenge within his early college years and not just repeat high school courses. All that a college can provide is an environment in which a student can develop and educate himself.[37]

Essential to any college education was the critical role of the professors. The Carnegie Fund's Annual Report of 1957-58 investigated professors' education. Projections by the NSF in 1970 said some 495,000 full-time faculty members would be needed, a growth of 300,000 over the 1956 figures. There was no doubt that an increase in student enrollment would pressure colleges to develop graduate programs. Graduate students prepared in scholarship and love of teaching hopefully would become the college educators for tomorrow. The university should reward the professor for good teaching, original research, and publication. Graduate schools would produce the college teachers who would prepare the secondary educators needed to revitalize and to reform the American educational system. This revitalization could only be achieved if the professor understood the mathematics and scientific concepts required in modern secondary education.[38]

Another study, funded by the Carnegie Corporation, administered by Educational Testing Service of Princeton, was conducted by James Bryant Conant. He was educated at Harvard, taught chemistry and served as president of

Harvard. Conant served on the Manhattan Project during World War II and held leadership roles during the Eisenhower years.

Following a distinguished career in education and his appointment as Ambassador to the Federal Republic of Germany, Conant devoted his educational expertise to the service of his country. He prepared a comprehensive study of the American high school begun in 1957. This study, The American High School Today, took two years to complete. Comprehensive high schools, a peculiarly American phenomenon, sought to educate all adolescents but high schools needed reform.

Conant emphasized that equality of opportunity was vital to America's democratic ideals. His report recommended strategies to improve education through curriculum change and reorganization. James W. Gardner, president of the Carnegie Corporation, said, "Mr. Conant, after a lifetime of distinguished contributions to the nation, has in this study made his greatest contribution of all."[39]

From America's early history, Thomas Jefferson's equality meant political equality and the absence of an aristocracy with a fixed position in society. For the nineteenth century American, the concept of equality expanded to include opportunity. With the rise of tax-supported public schools, the common school was given the task of satisfying the needs of a diverse population while offering opportunities to all. Conant attributed the important changes in education in the twentieth century to the passage of child labor laws, and the tremendous need for an educated populous. These changes made the American high school a fundamental part of the nation's educational system.

Conant specified three main objectives of the comprehensive high school as:

> first, to provide a general education for all the future citizens.
>
> second, to provide good elective skills immediately on graduation.
>
> third, to provide satisfactory programs for those whose vocation will depend on their subsequent education in a college or university.[40]

Conant was concerned about revision of mathematics, language and science programs. In the average high school, about 15-20% of its students were truly academically talented. These students, Conant felt, needed special encouragement. He found in high school many boys studied a total of seven years of combined courses in mathematics and science. However, these were not equivalent for the academically talented girls and many were not working hard enough. Conant said, "As I discussed with teachers and guidance officers the work of the more able students, I became more and more interested in the programs of the academically talented."[41]

A key element, in Conant's The American High School Today, was his list of specific recommendations for the

American high school. Although as a general graduation requirement he suggested only one year of mathematics and one year of science, Conant wanted electives to be available to improve skills and facilitate academic advancement. Ability grouping should be used, but be flexible enough to vary from subject to subject. To encourage students to attempt a challenging program, he recommended a weighted grade for difficult subjects. His key was to have a diversified program offering reading laboratories as support for the slower student while providing programs for the academically talented.[42] To achieve this wide program, he sought to enlarge the individual high school while reducing the actual number of schools from 21,000 to 9,000. Only in the eastern states, were schools established for academically talented students. For Conant this was only a regional solution. The high school which could group its students academically would be able to develop its students' talents. Through proper guidance, placement in accelerated programs such as those of the College Board, avoided boring students while challenging their talents.[43]

Conant's report stimulated educational ideals and policies that recaptured the progressive spirit of Rice, Dewey and Counts. His argument for the reinforcement of skills supported the earlier efforts of Prosser to prepare students for life. Conant's demands that secondary education challenge and prepare college bound students reiterated the concerns of Bestor, Rickover and Smith. He challenged the public to support policies to strengthen educational opportunities for America's high school student. Conant said,

> I conclude by addressing this final work to citizens who are concerned with public education: avoid generalizations, recognize the necessity of diversity, get the facts about your local situation, elect a good school board and support the efforts of the board to improve the schools.[44]

In 1958 a Special Studies Project of the Rockefeller Brothers Fund of the Rockefeller Foundation attempted to investigate future problems of American society. This project, The Pursuit of Excellence, was divided into seven panels studying the educational system. One panel, concentrating on curriculum, recommended that academically talented students must study three or four years of science and four years of mathematics. The panel wanted courses improved and modernized. Society, whether through institutions or the government, should support the individual's creativity. If it identified and assisted the talented individual, society itself would be regenerated. This panel was chaired by John W. Gardner, president of Carnegie Foundation for the Advancement of Teaching who replaced James R. Killian, Jr. as president. Killian went on to be special assistant to President Eisenhower.[45]

The Pursuit of Excellence - Education and the Future of America identified several general trends that were influencing American society. One discussed the population of school age children which in 1955 was 30.4 million between 5-14 years of age and some 11.2 million between 15-19 years. Projections indicated by 1975 there would be 41.9 million between 5-14 years and another 18.7 million between 15-19. This represented a 37 percent increase in the younger group and a 67 percent increase in the older.[46]

As a result, the report warned of enrollment pressures on educational institutions. There would be a great population increase in metropolitan areas and an increase in the range and complexity of the tasks of all social organizations. At the same time, with the explosive rate of technological advance, the schools needed to prepare students to efficiently use their talents in the modern world.[47]

One issue that was developed was the needed balance between equality and excellence in a democratic society. It was hoped that a realization that individuals differ in motivation and capacity for achievement necessarily existed. In the spirit of Jefferson's view of equality which viewed persons as "equal in enjoyment of certain familiar legal, civil and political rights,"[48] America emphasized equality of opportunity. To support the talented, the government must not restrict the definition of excellence nor limit its achievement. Excellence need not be limited to native intelligence or capacity, but viewed as the person's enthusiasm, motivation and diligence.

With regard to education, The Pursuit of Excellence stated that informal education included family, church and state while the formal structure was the organized educational system. Basic to school life was the emotional maturity and moral guidance of the home. The report stated that "education is vital element in the strengthening of our society."[49] However, the critical shortage of well qualified teachers, especially in chemistry, physics and mathematics, weakened education's potential for meeting the needs and unparalleled demands of a growing scientific society.

The teaching profession was critical since education can be only as good as the teachers. Thus, a new supply of quality teachers with extensive formal preparation was needed. The government and society should assist this preparation and financially encourage teachers. If we truly want high calibre scientists, mathematicians and engineers, we need quality teachers to educate them. The scientist need to be liberally educated while other educated people must be literate in science as well.

The Carnegie Foundation funded other projects which directly related to mathematics, such as the work done by the College Entrance Examination Board. In August of 1955 the CEEB was begun with the financial support of the Educational Testing Service and the Carnegie Foundation. The CEEB undertook a complete investigation of The Mathematics Curriculum in the Secondary School to better appraise their testing services. The Commission on Mathematics of CEEB included many leading mathematicians and educators from universities and high schools.

Thus, began a careful investigation of what should be studied in secondary schools by bringing together learned professionals. Through scrutiny, research and recommendations, the Commission on Mathematics structured a new mathematics program. The commission stated that "Mathematics is a living, growing subject. The vitality and vigor of present day mathematical research quickly dispels any notion that mathematics is a subject long since embalmed in textbooks."[50]

The Commission on Mathematics formulated a nine point program for a college preparatory program. These points included specific curriculum concepts such as: sets, functions, relations, inequalities, solid and coordinate geometry and vectors. However, it also included more abstract goals for its educational program such as improvement of deductive reasoning, extended use of unifying mathematical ideas, and a strong preparation in both skills and concepts. Participating in the deliberations were Frank B. Allen of the National Council of Teachers of Mathematics (NCTM), Max Beberman of University of Illinois Committee on School Mathematics (UICSM), Edward G. Begle of School Mathematics Study Group (SMSG), G. Baily Price of Mathematical Association of America (MAA) and many professors of leading universities.[51]

The commission acknowledged the new and exciting developments in mathematical logic, statistics and probability. The transformation of algebra as a body of mathematical structure was a new advance which was developed in secondary schools. Calculus had a new role. Published in 1959 Conant in The Child, The Parent and The State agreed that calculus was vital. Conant said,

> Many of the most striking advances of our age, for example, the development of supersonic flight and the launching of earth satellites, depended directly on the expert application of fluid dynamics to which calculus is absolutely fundamental.[52]

However, the commission stated that mathematics need not be reserved for engineers and scientists. The demand for a well prepared mathematics student was now apparent in business, industry and government. The commission's new program was not to uproot the traditional curriculum but to suggest revisions in keeping with the current research. It also suggested summer institutes, conferences and improvement of instruction for mathematics teachers. For the accelerated mathematics student the CEEB, worked extensively on the development of an Advanced Placement Program.

As the 1950s drew to a close, American life not only faced the fear of a Russian enemy but also the challenge of Soviet technical advances. The quickening of dramatic political concerns and of public awareness of the Russian superior space adventure with Sputnik, stimulated greater support for education in the United States. With the

National Defense Education Act (NDEA) of 1958, the federal government reversed its steadfast position and supported direct aid to specific educational programs. Now, Congress was willing to fund programs for education, especially in mathematics and science. The philanthropic foundations again made their contributions for research and institutes.

Conant's The Child, The Parent and The State examined the fears and dangers associated with federal support of education. His historical references to Plato's position that education and society must unite, gave evidence that the idea was not new. He quoted Khruschev's decree that Soviet education must produce citizens highly competent in technology while insuring a stable domestic social order. However, he advised American educators, in the desire to expose all to advance mathematics and science, not to weaken the structure, nature and depth of these fields. For this was a real danger.

Conant saw, as he traveled and researched his report, that the pressures of Congress and political levels were not the particular concerns of the public. He did not detect a sense of public urgency in most areas. What was needed was a strong general support. "For the academically talented there should be courses in physics, chemistry and twelfth grade mathematics."[53]

Conant wanted the nation to mobilize to educate those with talent and interest to be scientists, mathematicians and professional leaders. "We need engineers who are first rate engineers [and that means with capacity to handle mathematics]."[54] The able student must elect four years of mathematics. "There is no antithesis between providing a sound general education for all American youth and improving the training of the academically talented."[55]

Washington's involvement in education had grown since the Morrill Act, the Smith Hughes Act, and the G.I. Bill. Washington provided various building grants, supplemental replacement funds for federal properties not receiving local taxes, the 1953 extension of National Science Foundation's summer institutes and the 1958 National Defense Education Act. However, more federal money was needed for reforms not sufficiently funded by local taxes. If America wanted educational opportunities for all its children, it needed federal funding for, even with state support, local taxes could not support this needed reform. Conant wrote that the American high school had been institutionally developed by the close of the twentieth century but its greatest work remained to create "insurance for the preservation of the vitality of a society of free men."[56]

Both in the Rockefeller Report, The Pursuit of Excellence and in the Carnegie Reports by Conant, there were calls for the maximum development of each person. Education must supply equality of opportunity for all while providing growth for academically talented mathematics and science students. The Carnegie Corporation granted funds for a joint conference for the National Education Association and the National Council of Teachers of Mathematics to prepare a program for the academically talented in mathematics at the secondary level.

An integral part was a program to identify the talented student by using school guidance and counseling programs as early as elementary school. The student needed to think critically, to perform quantitative reasoning, to visualize spatial relations and to deduce logically. The Conference on Mathematics For the Academically Talented Student (CMATS) recommended grouping, frequent testing and flexible changes of groups. Academic arguments over old or new mathematics were useless, but general emphasis on improvement of creative programs was vital. These programs, led by skilled teachers, included curriculum innovations, assisted critical thinking and developed deductive reasoning. This report strongly supported the Advanced Placement Program.[57]

The CMATS reported on creative and innovative developments in mathematics education and the expansion of inservice education, workshops and summer institutes. The conference also acknowledged the important work in progress such as the UICSM under Max Beberman and the SMSG Group under Edward G. Begle. It cited these two groups as extremely beneficial to school systems wishing to develop or to restructure a mathematics program. Educational administrators were encouraged to arouse teachers' interest to support new programs and to assist the talented student. The teacher must be personally interested, mathematically talented, and rich in mathematical knowledge. With inservice education and summer institutes, the teachers increased and refreshed their knowledge. As stated in the conclusion of the report on the talented student, "Indeed, this country's future and well being of its citizens depended in no small measure on the mathematical product of our schools."[58]

The wide diversity of research funded by philanthropic foundations provided data and incentive to reform and to modify existing policies in American education. When the national government made its commitment to assist education, a wealth of knowledge as well as a structure of investigation had been established through the efforts of these private funds. The recommendations of their research projects included abstract concepts on improving critical and deductive thinking, broader mathematics requirements for the secondary student, modification of college preparation for future teachers, summer institutes for continued development of teachers, curricular revision in keeping with modern society and guidance, and incentives and placement for the students to study mathematics and science. The educational community had sought ways to achieve needed reforms and policy modification. The private foundations had provided funding to research, investigate and project the necessities that education must be willing to fill. Now, at the close of the 1950s, the tremendous power of the federal government acknowledged and assumed a significant position in America's educational future.

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The membership of the Commission on Mathematics of CEEB:

Albert W. Tucker, Princeton University, Chairman

Carl B. Allendoerfer, University of Washington

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Howard F. Fehr, Teachers College, Columbia University

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Frederick Mosteller, Harvard University

Eugene P. Northrop, University of Chicago

Ernest R. Ranucci, Weequahic High School, Newark, New Jersey

Robert E.K. Rourke, Kent School, Kent, Connecticut

George B. Thomas, Jr., Massachusetts Institute of Technology

Henry Van Engen, Iowa State Teachers College

Samuel S. Wilks, Princeton University

There were many outstanding educators who participated in the commission's deliberations. Among the active members who gave valuable assistance were:

Frank B. Allen, Chairman, Secondary School Curriculum Committee, National Council of Teachers of Mathematics

Max Beberman, Director, University of Illinois Committee on School Mathematics Project

Edward G. Begle, Director, School Mathematics Study Group

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S.S. Cairns, Professor of Mathematics, University of Illinois

Robert L. Davis, Member, Committee on the Undergraduate Program, Mathematical Association of America

George E. Hay, Professor of Mathematics, University of Michigan

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CHAPTER III

THE GROWTH OF NATIONAL SUPPORT AND THE FEDERAL GOVERNMENT'S ROLE IN MATHEMATICS EDUCATION

This chapter, examines the contributions of professional organizations and government to revitalize mathematics education. The foundation formed through early research, had begun a national effort to reconstruct mathematics programs in American schools. Gradually through the expansion of the National Science Foundation (NSF), private research, university programs, professional investigations, NSF summer institutes and inservice education for teachers, the national support for new developments in mathematics education grew. The Congress of the United States enacted legislation which provided increasing federal assistance and support to respond to the crisis in mathematics education.

Throughout much of the history of the United States an interdependent structure of checks and balances, states rights and an emphasis on home rule, severely restricted the involvement of the federal government in education. However, two major crises in the mid-twentieth century, the depression of the 1930s and World War II, stimulated a unified federal effort to overcome national problems. Franklin D. Roosevelt attacked the economic crisis of the 1930s through executive intervention by establishing innovative reforms known as the New Deal. Within the first hundred days in office, Roosevelt designed and secured passage through Congress of many reforms: Emergency Banking Relief Act, Federal Deposit Insurance Act, National Recovery Act and Unemployment Act, Civilian Conservation Corp, Public Works Administration and other measures. These acts established a new direction for the federal government to finance and supervise projects for the betterment of the whole nation.

The very survival of the United States was threatened by the Japanese attack on the fleet at Pearl Harbor on December 7, 1941. This event dramatically characterized the existing threats to the United States and other free governments throughout the world by the tyrants Hitler, Mussolini and Hirohito. World War II united the United States.

The American people were taught many things during World War II, but one of the most important was that a united national effort was an awesome and powerful force. This national power, effectively placed, had successfully retooled a nation for war and supported its allies and strengthened the cause of freedom in the world. Through federal effort, the scientific community was financed to devise new technological developments. The Manhattan Project, Oakridge Tennessee and Los Alamos were federal projects which supported scientific research.

After the war, efforts were slowly directed to educational issues. Public Law 584, The Fulbright Act, was passed by Congress so that American students could study abroad. It authorized the President of the United States to appoint a board to choose participating schools and award scholarships. This scholarship program offered students an opportunity to further their education while minimizing expenses.[1]

In March of 1947, Truman's Loyalty Order was passed by Congress which allowed the government to investigate applicants for civil service jobs and for any governmental work. An internal fear of communism established the motivation to investigate our own citizens. The passage of this law established a legal way of checking for disloyalty. While treason, sabotage, espionage and sedition were legitimate concerns of government, the wide extension of the term loyalty often stimulated cruel and heartless personal attacks on individuals in all areas of American life, including education. This gave rise to the witch hunts of the 1950s led by Senator Joseph McCarthy of Wisconsin.[2]

After the death of Franklin D. Roosevelt, President Truman extended many of the social, economic and foreign policies of the New Deal. He addressed unemployment, unfair employment practices and new housing developments. He signed the Fulbright Act which extended educational opportunities in foreign countries to American youth. In his twenty-one point program of 1945, submitted to Congress, he urged the creation of a National Science Foundation.

In the election campaign of 1948, Truman was elected on a platform which included support of federal aid to education and containment of the Soviet threat. Senator Robert A. Taft, the Republican leader in the Senate, after years of opposition, reversed his position and supported federal aid to education. However, Taft's bill, which passed the Senate was blocked in the House of Representatives. Central to the issue of federal aid was the basic concern of an equal distribution of federal funds to black and white schools as well as the question of parochial schools' rights to such funds.[3]

In 1947, Truman vetoed the first attempt to form the National Science Foundation. By 1948, the revised bill replaced the military division of NSF with a military liaison committee which would permit NSF to do research only on the direct request of the military. The planning committee was to coordinate U.S. science activities. This form of the bill allowed the NSF boards to construct the divisions it desired, but encouraged the NSF to do extended research in cancer, polio and degenerative disorders. The NSF would have a governing board of twenty-four members with a director appointed by the president.[4]

On May 5, 1948, the Senate passed the legislation which established the NSF. Through extended compromises, the long awaited support for science through research grants, loans to non-profit organizations and fellowships or scholarships to the individual was law. Only through consulting would the NSF deal with the Secretary of Defense. The full time president of the twenty-four man board, received a $15,000 a year salary. The first budget represented about $20 million, but projections suggested a budget of $100 million within ten years.

Prior to the establishment of the National Science Foundation, the main sponsors of American scientific research had been industry, the government, the universities and the foundations. Industry had done its research mainly to further profits. Government departments, like industry, sought research to support their special causes. This left foundations and universities to sponsor traditional research. However, the funds had been limited but now, with the strength of the federal government, the NSF's chief purpose was research.[5]

The nation faced a manpower shortage, especially of educators in mathematics and science. Many outstanding minds were lost to the defense and industrial sectors. During World War II, the American scientists were brigaded under the command of the Office of Scientific Research and Development (OSRD). Over two thousand projects funded by $300 million involved researchers in the nation's war effort. By the end of the war, with projects on atomic bomb, radar and rockets underway, the funding ran into a billion dollar enterprise. Many opposed the military use of science as a threat to the integrity of research. Now, scientists wanted diversified sponsorship for research. Thus, the National Science Foundation became a compromise for research between academic freedom with no financial support before the war and the wartime regimentation with federal funds.[6]

In his detailed article in Scientific American, Alfred Winslow Jones said,

> The greatest of the Foundations considerable powers is that of deciding just what jobs to tackle. Certain obvious divisions --
>
> 1. Medical Research
> 2. Mathematical, Physical and Engineering Sciences
> 3. Biological Science
> 4. Scientific Personnel and Education
>
> are suggested by Congress, but even these are not insisted upon.[7]

By November of 1950, President Truman had appointed the twenty-four man board. Chester I. Barnard, president of the Rockefeller Foundation, and Charles Dollard, president of the Carnegie Corporation, were but two of our national leaders willing to serve. Leading educators and members from industry accepted this appointment to lead the new NSF and direct its efforts to support scientific research.[8]

One of the fundamental principles for the creation of

NSF was the federal government's desire to strengthen basic research in colleges and universities. The government wanted a balance between higher education and scientific research. Through its scholarship and fellowship, the NSF wanted to replace the generation of scientists whose education was curtailed by the war. The return to civilian life of the many soldiers, after World War II, changed the issue to one of finding positions for them. It was found that the GI Bill had increased the number of college graduates slightly, but not necessarily in critical fields. Therefore, the NSF needed to identify, recruit and finance promising students in mathematics and science.

Director of the Office of Scientific Personnel of the National Research Council, M.H. Trytten, wrote that the National Science Foundation had the unprecedented challenge to recruit able youth for work in basic science. The very acceptance of NSF's role was a departure from previous government positions. There was no doubt that acceptance of NSF was a direct result of the national effort which supported the successes of wartime research. The charter of the new National Science Foundation stated it was "to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences."[9] Trytten believed the NSF would be the most significant agency in the federal government.

Many diverse roles would be assumed by the National

Science Foundation due to the flexibility established by the original charter. For example, in 1946, the government's roster of scientific personnel had lapsed. For a while the roster was included in the National Scientific Register Project, headed by James C. O'Brien of the National Security Resource Board. The project's main purpose was to identify manpower shortages and to recommend measures to increase their numbers. This project to encourage new mathematicians and scientists was placed under the direction of the NSF. With this flexibility, the NSF would direct and support the integration of the new, innovative and creative concepts of research into American life through a stimulation of projects within both the educational and scientific communities.[10]

The leadership of NSF was critical in uniting the efforts of pure research, educational reforms and applied technological advances. Much assistance was needed to incorporate the recent findings of pure mathematics into college and secondary education. Even the unification of abstract mathematics with applications was an area that needed extensive effort.

A leading mathematician, Edmund Whittaker, wrote in 1950 that "pure mathematicians had become more rigorous and applied mathematicians less inhibited."[11] What the mathematicians, like Whittaker and Bertrand Russell, sought was a conformity, through mathematics, in all possible worlds.

The theory of relativity and the extension of logic had drastically reshaped human intellectual conception of the world in the first half of the twentieth century. A new system of mathematical logic was developed by Alfred North Whitehead and Bertrand Russell. They asserted that Peano's system showed that all pure mathematics could be built on a fundamental, logical structure.

The work of these researchers in pure mathematics created the swell of enthusiasm to restructure mathematics education into a more logical system. To change mathematics education from a series of rote steps and procedures to a new logical understanding which revealed basic inter-relationship, was now demanded and NSF funds provided the means to undertake the research and reforms. This inter-relationship within mathematics precipitated the new reforms in mathematics education.

The applied mathematicians with their discoveries of atomic theory, theory of relativity and rocket theory were experiencing a period of creative freedom. The expanding amount of human discovery and knowledge was exponentially creating a diversity of new facts which required educators to rethink what was essential to mathematics and what might be replaced with newer concepts. The exciting growth of new ideas needed to be introduced to American students so that they could profit from these new concepts.[12]

The National Education Association was extremely concerned about the shortage of teachers in the critical areas of mathematics and science. They also realized that inservice education was needed to expand and to enrich the present teacher's knowledge. As early as 1948, the Chautauqua Conference was called by the National Commission on Teacher Education and Professional Standards to discuss the critical shortage of teachers. In 1947, the Oxford Conference considered ways to improve teaching and the Bowling Green Conference of 1948 addressed professional standards for teachers. The Commission hoped that these conferences would promote study and research as well as stimulate the growth of inservice teacher education.

One of the Chautauqua's recommendations was that high school teachers, such as mathematics teachers, have a broad preparation in the specific content area they were to teach. They specified that 30 to 40 percent of a future teacher's preparation time in college be spent on the academic field which they would teach. This suggested that thirty-six credit hours out of 120 hours of undergraduate studies be devoted to their area of content expertise.[13]

A 1951 report to the National Society for the Study of Education (NSSE), chaired by G.T. Buswell, stressed the importance of arithmetic, as a major part of the quantitative thinking in society. Buswell believed "that competence in quantitative thinking is the first order of importance in education."[14] Arithmetic, as a product of thought, should not be taught within a vacuum, but should be united with more abstract, logical mathematical thought. This report emphasized the need to better prepare mathematics teachers and to continuously support their development through in-service training.

The report cited several important reasons for increased interest in the mathematics education for the secondary student. Among them were:

> 1. The present high school graduates are weak in their ability to think quantitatively.
>
> 2. They are also weak in computational skills.
>
> 3. Teachers questioned the traditional placement of specific topics in the junior high school and secondary curriculum.
>
> 4. The awareness that the traditional program can not satisfy the needs of the entire, diverse high school population.[15]

However, conditions existed which prevented the broadening of the mathematics program. The lack of materials, the need for enthusiastic teachers, and the existing objections to teaching consumer problems within mathematics class were cited. The NSSE report found teachers willing to expand their knowledge. Some teachers saw great worth in working with the student of limited mathematical background or with a psychological block against mathematics, but wanted assistance in learning how to reach these students.

Other problems dealt with the smaller high school which had difficulties in offering a wide program to their students. However, the use of laboratory techniques or grouping expanded the possible offerings to students. All agreed that a more diversified mathematics program for the senior high school was essential.[16]

In Theories of Learning Related to the Field of Mathematics, the National Council of Teachers of Mathematics collected research and studies which investigated how the human mind stores mathematical knowledge. It was hoped that this book would assist the classroom teacher in his or her understanding of how to create a better learning situation. This was an area critical to mathematics education.

Howard F. Fehr, an educator at Teachers College, Columbia University, stated that learning is concerned with physiological changes in the body as well as psychological modifications. Fehr said, "Human learning is defined as a change in behavior acquired through our own experience."[17] Learning is far more than a reaction to some stimulus which travels via the nerves to the brain. The human was conditioned to receive this stimulus or message and was prepared emotionally to react based on all his inherited and environmental conditions. Beyond this all human learning must be directed towards a goal. Fehr said, "Our task in education is to create such experiences and situations that will enable a student to reconstruct his behavior towards goals desired by both himself and his teacher."[18]

Mathematicians and mathematics educators were involved in research to develop new mathematical concepts, curriculum revision, and teacher effectiveness. They investigated learning behavior to identify classroom procedures that would effectively lead to good learning situations. Another issue was the fair testing of students for proper placement. One's ability to make judgments was a vital element in intelligence. Binet defined intelligence, in this way, to test how one performs certain mental tasks. These tasks included the ability to remember, to reason, to form relationships, to generalize, and to abstract.

Dewey was also concerned with intelligence which he considered acting with an aim and using meaningful activities to reach it. Central to Dewey's view was the ability to relate the present conditions or activities to any future goals. In many ways, Dewey's laboratory approach, through directed action, encouraged learners to form general concepts through discovery. He viewed intelligence as one's ability to solve problems, to reason, and to learn.

Educators have attempted to explain how one thinks. In Plato's Meno, we have a classical presentation of how one thinks and how one learns. In 1910, Dewey in How We Think revealed his concerns about how we learn. Mathematics educators investigated Dewey's Complete Act of Thought as a way to improve creative thinking. There were five steps suggested by Dewey which could be applied within mathematics education. They included: being presented with a problem, analyze the situation, create a hypothesis, formulate hypotheses and verify findings.[19] The views of Binet, Dewey, Plato and others were investigated by mathematics educators who sought to improve learning situations. Further research revealed many factors influenced the student's response to a well formulated lesson.

Many of these issues were brought to bear on what mathematics educators considered the variables necessary to produce effective reform. Fehr said, "In the learning of mathematics, the power with which an individual can make generalizations, abstractions, logical organizations and relate these to a purposeful action, determines his ability."[20]

Here are some of the elements which Fehr considered as the foundation of learning theory:

1. Student awareness daily of a goal is needed.
2. Cognitive learning involves association.
3. Experimentation must be goal directed.
4. Patterns evolve with study.
5. Physical and mental activity are vital to learning.
6. Praise, success and rewards lead to student encouragement.
7. Abstractions are drawn from meaningful situations.
8. Transference of past learning in new situations represents much of learning.
9. Facts and skills are necessities to learning.
10. No success brings dislike of the subject, the teacher

and learning.

Another important consideration in mathematics was problem-solving and its implications within the classroom. Within problem-solving the very existence of a question was a necessity. Since life is full of changes, problem-solving was considered vital and should be extended beyond the classroom. Many things in life demand an analysis of a quantitative structure. Therefore, all students, to be better prepared for daily life must understand and learn problem-solving within mathematics. From lessons in problem-solving involving useful social situations, industrial activities and the routine of daily life, the student was exposed to a variety of mathematical applications. While, research had not established the existence of a true transfer of training, the development of understanding, logic, and deduction had many applications.[21]

Through its journal, The Mathematics Teacher, the National Council of Teachers of Mathematics asked its members for detailed contributions on new practices in mathematics. Many wrote articles supporting laboratory teaching techniques in mathematics education. Mathematics laboratories provided for individual experimentation through manipulations of materials or objects which hopefully would lead to a better understanding of mathematical facts and abstract concepts.

Mathematics laboratories required equipment, but teacher preparation was vital to determine the goals of the laboratory lesson. Given proper space and time, the student also required a guide or worksheet to organize the laboratory activities and to evaluate the project. From rather informal laboratory settings, an untold amount of learning did occur. Built into the project method was the development of a student's interest and capacity to independently think. This was a direct step to learning demanded throughout the mathematics reforms.[22]

Many research reports requested improved teacher preparation and stressed the critical need for inservice education for mathematics teachers. The National Science Foundation began in 1953 to sponsor summer institutes. These were structured to increase the competency of mathematics and science teachers.

High school and college teachers gathered together to examine the recent concepts in their fields and to develop new methods of classroom instruction. These teachers would form a communications link to their colleagues and establish a new enthusiasm for their students. Only one institute in 1953, at University of Colorado, was in mathematics. In 1954 there were four institutes sponsored by the National Science Foundation. Three of these institutes were in mathematics and one in physics. Two mathematics institutes were conducted, one at the University of North Carolina and the other at the University of Washington. Another in Oregon, was a concurrent institute. These institutes for high school teachers were funded by the Fund for the Advancement of Education.

A typical summer institute differed essentially from regular summer classes. The staff was from a wider geographic area. While the stress was on subject matter, efforts were directed to increasing the teachers' efficiency in communication with their students. Besides lectures, many discussions shared the teachers' own ideas and experiences. The settings were attractive with pleasant living conditions while expenses were minimal. Stipends were available to twenty or thirty persons who otherwise could not afford to attend.

In the summer of 1955, nine institutes were funded by the National Science Foundation. Of these nine, three were in mathematics at Oklahoma A and M College, the University of Wisconsin at Madison, and Stanford University. Detailed information on the institutes was carried by professional journals such as The Mathematics Teacher. The NSF invited universities and colleges to send their proposals for 1956 summer institutes for review. All projections indicated that the summer institutes would continue to expand.[23]

One advantage of institutes and workshops was their ability to extend the education of a teacher. They were informal, relaxed and social so they would attract and motivate the teacher to attend. Kenneth Brown said, "The present mathematics institutes have the original object of providing a situation where teachers can work on their own problems in teaching mathematics and enjoy it."[24] The contact and discussion with other teachers allowed a sharing of ideas, methods and problems. There was great merit in uniting and expanding views on such issues as problem-solving. Any valid evaluation of an institute must be done as a group, not as the individual achievement of any teacher. Workshops and conferences have been of great service to mathematics teachers. Usually a workshop lasted three to eight weeks with grades given and credits awarded. There were no grades in an institute and stipends were provided.

A conference required less of the participants' time and usually charged a small fee. The merit of these approaches was in the work and growth achieved by each teacher and the usefulness of the educational materials and ideas presented. These institutes and workshops were announced on a regular basis in The Mathematics Teacher and were funded by National Science Foundation.[25]

To organize and to distribute an analysis of various projects and research in mathematics education, Kenneth Brown, a specialist in mathematics, prepared several bulletins for the Office of Education. He felt that the newer approaches emphasized the need for the students to understand the content of mathematics. The introduction of the new mathematics created a desire to restudy and to reorganize the entire mathematics program. As late as the mid-1950s many of the newer high school textbooks contained very few practical problems and a vocabulary less mathematical in nature than desired. Brown recognized that the present students, as adults, would need a greater mathematical knowledge. This need would be true not only for the college bound individual but also for professional and semi-skilled workers who did not attend college.

Brown's analysis cited some forty elementary high school algebra textbooks which used nine different approaches or methods of teaching the one concept, signed numbers. Signed numbers were taught from the discovery method using direct numbers to a simple "guess and check" method. However, no definite results could be provided in favor of a specific system.[26]

It appeared that parents and teachers supported students who expressed interest and talent in mathematics. Contests encouraged better mathematics students to continue their education. For the longer one studied mathematics, the more the student's competency increased. For all concerned, critical thinking still remained a difficult concept to teach and to activate. Although the teaching of critical thinking was time consuming in the classroom, it remained vital to develop in mathematics and science.

Much of the direction in curriculum reforms attempted to achieve the correct balance between modern concepts and traditional methods. Students were found to be weak in understanding, in ability to estimate, and in verbal application of processes. However, many reports have shown that the mathematics teachers were the force that inspired the pupil to continue his mathematical education. From this analysis, some 111 research projects were investigated. With a summary of the problems, detailed procedures as well as the findings and conclusions, Brown's bulletin was a significant source of information on mathematics education.[27]

Two leading mathematicians, Carl B. Allendoerfer and Cletus O. Oakley, wrote their new book, The Principles of Mathematics, "with the conviction that large parts of the standard undergraduate curriculum in mathematics is obsolete."[28] They concluded that many mathematics educators had failed to incorporate modern knowledge into their teaching. The secondary student had nothing more modern than the works of Descartes and Euler. If the college student still remained aloof from modern topics, how would the secondary student ever be taught the modern concepts?

Such topics as sets, groups, fields, Boolean Algebra, limits, probability and statistics, stressed fundamental logical concepts so that one would understand the nature of a proof. Very significant was the relationship of abstract mathematics to concrete applications. Abstract groups were introduced to illustrate logical method and modern concepts.

An extension of groups led to abstract field theory using a set of elements with two binary operations. The study of algebra was basically the study of the properties of a field.

Allendoerfer and Oakley concluded that not all of mathematics can be mastered through a process of finite steps or calculations. Thus, the student needed to understand the infinite and the notion of a limit. These were basic to the application of mathematics to modern science and to extend mathematics into Calculus. No longer would the old calculators of the past be adequate to analyze the data in this technological era.[29]

To orchestrate the structural concepts of modern mathematics while developing a spirited lesson filled with clever methods based on the student's needs but always goal oriented was the awesome responsibility of the mathematics teacher. Vincent J. Glennon said, "The heart of all good education is, as always, good teachers and good teaching."[30]

The question in the mid-1950s was, are today's teachers prepared? It was argued that the United States needed to take the same strong stand in support of teacher education that was taken in support of national defense. With this support was implied a strong financial backing by government. This included federal and state funding as well as support from business, industry, private foundations and a generous loan plan to support teacher education.[31] The

NSF was very active in supporting teacher education in mathematics and science.

The National Science Foundation also conducted research to consider the effects of government support on colleges and universities. It questioned if such funding effected customary teaching and research activities. While the government spent millions on technological developments in universities, it provided very little for research and education in the sciences. Another question was, how might government encourage research and education in the sciences? The results provided substantial information to both the government and higher education.[32]

The expansion of the work done by National Science Foundation was tremendous. It served as an authority for information for our government and the science community. The NSF was to support research in mathematical and physical sciences and to award fellowships and scholarships. The considerable freedom given NSF to decide how its support should be distributed, promoted scientific progress nationwide. In 1951, NSF appropriations were $225,000 with a $3,500,000 budget by 1952, the first year of grants. By 1958, Congress appropriated $40,000,000. The number of grants in mathematical or physical sciences were only 28 in 1952, but 308 in 1956. In 1954, there was but one institute funded by NSF for high school science teachers but in 1957 some ninety were held. The invaluable benefits of these institutes for teachers of secondary mathematics and science were quickly recognized. In 1956-57, the foundation established some year long institutes for high school teachers.[33]

Dael Wolfle, a leading member of the scientific community, outlined the following NSF policy-forming responsibilities:

> 1. To develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences.
>
> 2. To appraise the impact of research upon industrial development and upon the general welfare.
>
> 3. To evaluate the scientific research programs undertaken by agencies of the Federal Government.[34]

Congress expected the NSF to establish national policy as well as investigate and appraise research. This was to be done through modification of existing policies. The foundation might recommend a change of direction based on investigation of successful achievements. Through these varied means, the foundation would generate changes and improvements in policy and suggest future options. The NSF supported detailed studies of occupational problems such as shortages of persons skilled in mathematics, physiology and psychology. Wolfle stated that the studies were "useful to members of those fields in a variety of policy decisions, in planning educational programs and in assessing current developments."[35]

President Truman in his budget message for 1952 told congress: "The foundation will formulate a broad national policy designed to assure that the scope and the quality of basic research in this country are adequate for national security and technological progress."[36]

In keeping with the growing national support of education, a new department of Health, Education and Welfare (HEW) was created in 1954. The Federal Department of Education was originally instituted in 1867, but in 1868 it became the Office of Education, an agency of the Department of the Interior. Changing its name from office to bureau to again office, it remained a part of the Department of the Interior. As of 1953, the Office of Education was transferred to HEW and Samuel M. Brownell was appointed Commissioner of Education. Brownell begun his work listening to the suggestions of American educators and functioning in accord with the broad interpretations established by Congress.[37]

The Department of Education broadened its field of endeavor as time passed. In 1954, under public law 531, the Cooperative Research Program of the United States Office of Education was authorized by Congress. However, the actual funding was delayed until 1957. The Cooperative Research Program funded some three hundred completed projects, but only seven dealt with mathematics. One of these seven was done by Max Beberman, director of the University of Illinois Committee on School Mathematics. This work, <u>A Comparison</u>

Between Two Kinds of Secondary Mathematics Courses with Respect to Intellectual Change, dealt with critical thinking. Beberman's research attested to the necessity of developing critical thinking within a pre-college mathematics program. The ability to critically think was to be a strong goal of the mathematics reform program. Beberman, like John Dewey, wanted the students to think, to reason and to deduce. Beberman's work also stressed that a command of mathematical language, deductive logic and continuous analysis were vital elements to achieve the goal, the development of critical thinking.[38]

As a specialist in mathematics, Kenneth E. Brown was sent to the Nineteenth International Conference on Public Education at Geneva in July, 1956. Representatives of the seventy-four participating nations devoted their time to three topics: school supervision, the teaching of mathematics in secondary schools, and the recent progress in education. Brown summarized the reports on mathematics which desired to make mathematics more meaningful. There were modifications in mathematics curriculum, textbooks, and specialized teacher preparation. However, the United States was the leader in providing inservice education for mathematics teachers. Almost all countries had a shortage of mathematics teachers, except the USSR. The shortage of teachers was attributed to the lack of prestige for the teaching profession and the attractive incentives in scientific and technological industries. Thus, the United States government was well aware of the shortage of mathematics teachers in 1956 and the American position relative to USSR. America's greatest advantage was the extensive inservice program and summer institutes sponsored by National Science Foundation.[39]

To increase the output of individuals skilled in mathematics, an even stronger support, philosophically and financially, was needed. What was of critical importance was a wider public acknowledgement that a crisis existed and that Americans wanted to improve mathematics education. A spark was needed to fuse the work of the researchers in mathematics education to realistic national goals. The support of the public, through the enormous power of the federal government, had to become a reality in mathematics education. However, the long journey had begun earlier in the 1950s with the establishment of the National Science Foundation, and the linkage of education with America's defense.

The National Commission on Teacher Education and Professional Studies in June of 1951 held a conference at Palo Alto, California. The name of its report was Teaching: A First Line of Defense. The report of this conference stated, "that education is defense, that the schools are indispensable factors in our security."[40] Another point was that the teaching profession must be upgraded, especially in national emergencies. The suggestions for recruiting qualified teachers included adequate salaries, student teaching experiences, scholarships and extra compensation for teachers in mathematics and science. However, the best recruiting agent was and always will be a good teacher. To improve the classroom, suggestions were given to develop the laboratory technique and to adjust the curriculum to the community's needs. The recommendations included improvement of materials and curriculum, but strongly encouraged inservice training, workshops and educational endeavors to expand the knowledge and methods of professionals in secondary education.[41]

The linkage of advancement in science and mathematics education to national security was not an obtuse concept, but an outgrowth of Cold War concerns and the warnings of educational critics like Bestor, Smith and Rickover. A national asset, upon which we build our future, was the talents and potential of our youth. By encouraging students to study mathematics and science, education was providing for society the future citizen capable of leading the technological world. Counts earlier asked _Dare The School Build A New Social Order_? Now, society realized schools were to prepare students or the fundamental scientific improvements appearing in American life would not continue. A logical structure began to be reinforced. Technology grew from discoveries in science. The progress of scientific knowledge depended on mathematicians and scientists doing research.

The basic source of the education of future mathematicians and scientists was the universities and colleges. However, college students did not become interested in mathematics and science without the stimulation, developmental concepts and skills established in secondary education. Creative talents and the diversity of work needed to be encouraged by the National Science Foundation but critical funding was mandatory.

Success in research was the product of good ideas. Ideas were generated in the brains of individuals, and no one was really certain how this happened. However, the probability of new ideas arising would be increased by finding well trained people, allowing them to attack a problem, discussing with peers their conclusions, and providing facilities and finances to stimulate imaginative thought. Both educators and researchers in mathematics and science needed this situation for development. Could the federal government provide more substantial means, remained a fundamental question.[42]

At the Parkland Conference of the National Educational Association (NEA) in 1956, the improvement of teacher education was again addressed. Such educational conferences supplied valuable data to improve the educational program for teachers of secondary mathematics. The mathematics teachers needed an academic specialization, professional methods, and student teaching experience. An ongoing inservice program was stressed to continue teacher development. This conference stated that 1955-1965 would be critical years in which teachers would gain professional status.[43]

The National Educational Association pointed out that "the role of the federal government in education has steadily increased."[44] The NEA was concerned that significant policy changes would happen. While it approved of federal assistance in the form of construction, grants for educational research, improvement of libraries and aid for teachers' salaries, NEA wanted further study of the effect federal money was having on research.

Interest in scholarly research was not a new role for the National Educational Association. Over the years, it had become a prestigious and influential association of educators. Through its reports, publications, and the NEA Journal, it nationally publicized recent developments, experiments, and advancements in education. The Educational Policies Commission of the NEA over the years had issued the following reports:

> The Unique Function of Education in American Democracy (1937)
>
> Education of All American Youth (1944)
>
> Education for All American Children (1948)
>
> Moral and Spiritual Values in Public Schools (1951)
>
> Education of All American Youth -- A Further Look (1952)

Manpower and Education (1956)[45]

Manpower and Education had established that a critical shortage of mathematics and science teachers existed in American society. It also pointed to curricular and in-instructional deficiencies in these areas.

As research continued in mathematics, the question if education was keeping pace remained unanswered. There were new concepts in mathematics, and the high schools needed to adjust the mathematics curriculum accordingly. Research on curriculum gave evidence of a general dissatisfaction at the secondary level. A study was inaugurated by the Commission on Mathematics of College Entrance Examination Board.

The Office of Education reported in 1956 that only two-thirds of high school students took Algebra while over one-fourth of the schools did not offer Geometry. Curriculum revision was not sufficient. New techniques must challenge all students to truly learn mathematics. Veryl Schults, from the public schools of Washington, DC, said, "Never before has there been so much experimentation, interest, cooperation and activity in mathematics and such a determination to have the teaching of mathematics meet the needs of the age which it serves."[46]

Begun in August of 1955 with the financial aid of the Carnegie Corporation, the Commission on Mathematics of the College Entrance Examination Board (CEEB) made national contributions to mathematics education. Albert W. Tucker of Princeton University chaired the commission which studied the content of the secondary school mathematics program. The CEEB hoped to influence secondary curriculum by bringing together concerned mathematicians and educators.

The Commission's new program was not to uproot the traditional curriculum, but to revise it in keeping with the current research. Although suggesting specific recommendations for each mathematics area such as Algebra or Geometry, the Commission wanted a flexible program to adjust to individual student needs. The emphasis on manipulations, characteristic of Thorndike's work, was viewed as an obstacle to reforming mathematics education. Understanding, not memory, stimulated students to think critically and to analyze.

The Commission on Mathematics repeated earlier efforts of Rice and Dewey to remove rote and drill work and to develop logic and critical reasoning within mathematics lessons. The program must teach concepts and skills for all students. The college-capable student needed an understanding of structure and logical deductive reasoning as did the regular student. Mathematical structure was developed through a systematic organization using undefined terms, such as set, definitions, axioms and deduction to formulate new truths or concepts. To achieve success, the well prepared teacher's leadership was critical.[47]

Within the framework of the Cold War, Nikita

Khruschev threatened to bury America. However, President Eisenhower's administration had not been able to pass needed legislation to improve education. Congress still feared strong federal intervention in education. There was a stalemate! Something was needed to stimulate action. Americans were surprised when this stimulus came from abroad.

After October 4, 1957, when Sputnik was launched by the USSR, the politicians linked education to America's National Security. Educators, like Bestor and Smith, with influential citizens like Rickover, believed federal aid could be a non-threatening force in education. Therefore, after Sputnik, federal aid gained support to become a national policy in education. Admiral Rickover said: "The powerful thrust of Sputnik's launching device did more than penetrate outer space. It also pierced the thick armor encasing our complacent faith in America's present and future technological supremacy."[48]

On November 6, 1957, President Eisenhower conferred with the Commission on Education regarding an education bill for 1958. Eisenhower met with Lyndon B. Johnson who chaired the Preparedness Investigation Subcommittee of the Senate. This subcommittee requested information from mathematics and science educators. The educators requested laboratories, equipment, teacher institutes, grants, scholarships and curricular development. The leaders of Congress, Sam Rayburn of Texas, Speaker of the House, and Joseph Martin of Massachusetts, Republican Minority Leader, worked carefully to unite the Congress and to pass this legislation. Representative George McGovern, Democratic Senator from South Dakota, asked that Arthur Bestor's recommendation that anti-intellectualism be removed from the public schools be considered in writing the bill.[49]

President Eisenhower said, in his budget message on January 13, 1958:

> I am recommending an expanded program for the National Science Foundation and a new program for the Department of Health, Education and Welfare. These programs will be closely coordinated. The foundation is promoting science education and training primarily through grants to universities or fellowships to individuals. The program for Department of Health, Education and Welfare will strengthen our general educational base, complement the activities of NSF and be channeled mainly through grants to states. This budget proposed appropriations of $140 million for NSF in 1959, more than three times the amount authorized.[50]

Through Eisenhower's message, educators were encouraged to see an expanded interest in the mathematics and science students, in content and method of secondary programs, in teacher training and inservice programs, and in grants and fellowships for advanced training.

In his Message on Education, January 27, 1958, President Eisenhower said, "American education faces new responsibilities in the cause of freedom."[51] Since NSF under the National Science Board worked significantly for the improvement of United States education in the sciences, Eisenhower demanded a fivefold increase in the educational activities of the NSF. The knowledge of mathematics and science teachers must improve through inservice education and summer institutes. In addition, improvements were sought in arousing student interest, creating new educational techniques, and restructuring mathematics programs.

Dael Wolfle, executive officer of the American Association for the Advancement of Science, wrote in Science February 1958, about the diversity in the nation's educational activities and the national policies. He warned, of an existing tendency "to confuse strategy with tactics." Wolfle continued "this confusion leads to overemphasis on short term objectives and to consideration of individual education changes rather than an overall program."[52]

Careful and meaningful planning must happen so that educational policies will become integrated with the national goals. The arguments of federal versus state responsibilities must be solved since policies must be established to finance needed educational improvements. Wolfle said,

> The problem of using education as a maximally constructive force in national and international policy [not just military policy], while at the same time preserving traditional values, poses an exciting challenge to political and educational statesmanship.[53]

Carol Elliott, a member of the Education and Labor Committee, wrote to Judge R.E. Kelton of Alabama September 2, 1958, the day the bill was signed, "I really think the bill is a landmark and will take its place alongside the Northwest Ordinance and the acts creating our land grant colleges."[54]

This famous education bill, H.R. 13247 to P.L. 85-864, known as the The National Defense Education Act, was signed September 2, 1958. In the general provision of the bill it stated that,

> we must increase our efforts to identify and educate more of the talent of our Nation. This requires programs that will give assurance that no student of ability will be denied an opportunity for higher education because of financial need; will correct as rapidly as possible the existing imbalances in our educational programs which have led to an insufficient proportion of our population educated in science, mathematics, and foreign languages and trained in technology.[55]

With the passage of the National Defense Education Act, it became the policy of the federal government to assist education. Under Title III of this law, $70 million was appropriated for each of four years to state agencies which fostered loans and provided new equipment for mathematics, science and foreign language education. Title IV authorized National Defense Fellowships for graduate programs. Funding went to the individuals accepted into the program as well as the university providing the program.[56]

The educational reformers and mathematicians now had the support of federal funds to revise philosophies, policies and the curriculum. These would stimulate the needed changes in mathematics education in America. However, the specialists knew that funding alone could not make America lead in scholarship, creative research or in scientific achievements. The funding would provide ways of focusing our efforts. Quickly a premium was placed on trained intelligence which had ideas to offer. They turned to many independent studies completed in the early 1950s under the National Science Foundation. They sought the wisdom of leaders in mathematics and education. They learned from worldwide critical efforts to discover, support and reform mathematics education.

In 1958, the Organization for European Economic Co-operation was established. The American members were Edward G. Begle, Howard F. Fehr, Saunders MacLane, and Robert E.K. Rourke. These men addressed the question of educational needs to prepare citizens for the scientific, technological and economic demands in the world.

Edward G. Begle, a leading mathematician and educator, quoted the leaders in the new mathematics. Professor Jean Dieudonné of France said, "Finally, in all these, experimental mathematics, the language and notation, now universally in use, should be introduced as soon as possible throughout pre-college work."[57]

In his report to the Organization for European Economic Co-operation Begle said,

> We need a better curriculum. Next, we need to help our teachers improve their training in mathematics, so that they can teach a better curriculum. Finally, we need to make our courses more interesting so that we can attract more students into mathematics and keep them longer.[58]

Another mathematician at the Organization for European Economic Co-operation, Paul Rosenbloom, had shown how a skilled teacher, using personal enthusiasm, could arouse student interest in mathematics and science. The knowledgeable teacher could stimulate and awaken the talents of the student to an unparalleled lever of creativity. Dr. Marshall H. Store, professor from University of Chicago, said, "It is imperative that we find remedies for these defects in our elementary mathematical education if we are ever to accomplish what we need to do in the secondary schools."[59]

The gulf between the university and the high school had to be closed. No longer could the abstract thinking done by the mathematician remain apart from the broader educational picture. Somehow, this critical thinking should be presented in a visual and creative form to the secondary student. With better preparation, the student would understand what was ahead in mathematical thinking. However, both sides of the chasm had joined together to improve thinking and curriculum. The well prepared teacher was vital to show how a mathematical process works and even to why it works. No longer can manipulation be sufficient. A true understanding of concepts was now a must.[60]

Tremendous advancement in mathematics education had been made since Truman's administration had first suggested the National Science Foundation. This organization was born in a time that possessed a strong fear of federal governmental controls of education. Education, like many areas of

American life, was questioned about its loyalties to American principles and about military motivations stimulating research. These issues were set aside as critics demanded reform and support for education, especially in mathematics and science.

Many professional organizations such as the National Education Association, the National Council of Teachers of Mathematics and the College Entrance Examination Board sponsored research and provided information which clarified the dramatic needs in mathematics education. This educational research formed the foundation upon which the national effort began to build its massive restructuring plan. Through gradual expansion of the National Science Foundation, private research, professional investigations and NSF summer institutes for teachers, national support for the new developments in mathematics education grew.

Certainly Sputnik, the catalyst which awoke a nation to its position in the world's technological race, forcefully demanded reforms in mathematics education and scientific advancements. However, Sputnik's main contribution was the stimulation of public support for educational reform of all mathematics and science education. Like Rice's writings in the journal, The Forum, the satellite, from the USSR, presented unmistakable facts that American educational efforts must be accelerated and enriched to meet the requirements of the future.

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CHAPTER IV

UNIVERSITY OF ILLINOIS COMMITTEE ON SCHOOL MATHEMATICS -- A MODEL PROGRAM

The University of Illinois Committee on School Mathematics (UICSM) was a vital leader and model in the reform of mathematics education. This chapter, will trace the development of the University of Illinois project under the direction of Max Beberman, as it expanded into a well known American mathematics program concerned with the curriculum, the student and the teacher. Vital to the generation of policies in mathematics education, UICSM projects united the college professors and secondary school teachers in a developing, experimental program. An early leader in mathematics reform, the UICSM's contributions provided for unique changes in America's secondary mathematics education. Effectuating change itself was one of UICSM's greatest achievements.

Contrary to popular opinion, not all reforms and regeneration of mathematics education began with the extensive funding of research programs through federal provisions. Some began very quietly within university settings as research to promote a better educational experience for the university's own students. One of the first was the University of Illinois Committee on School Mathematics developed in 1952.

The new and creative developments in mathematics education began during the post World War II years as America addressed social, humanitarian and educational issues. Many educational issues, such as reform of mathematics education, were reexamined for existing strengths, fundamental weaknesses and developmental needs. Critics cited American educational problems as a widespread national crisis that must be addressed. The educators argued about philosophical ideals, goals and objectives. In the early 1950s, critics such as Bestor, Rafferty and Rickover attacked what they regarded as progressive extremes.

However, both the critics and defenders of the educational system realized that a united effort was vital to improve education for the future. As the issues were faced, the university researcher, the mathematician, the mathematics educator in secondary schools, and community members formed the coalition that was greatly needed to reform mathematics education. If the United States' leadership in the scientific community was to be maintained, then it needed to prepare America's students for the future. All projections revealed that this future would require innovative and creative ideas born from research done by talented and trained minds. The educational atmosphere to develop such creative minds required an expanding subject matter content, new pedagogical concepts, well designed programs and enthusiastic well prepared teachers.

To better understand the growth of the newly emergent programs of secondary school mathematics, an investigation of one program, UICSM will be analyzed. The early work of this committee anticipated other mathematics projects, workshops and summer institutes. UICSM was a model, with its varied adventures and contributions to mathematics education, for the ones that followed.

The Illinois Committee was established in 1951 at the request of the deans of education and engineering and the head of mathematics department. A small committee was asked to investigate and recommend means of improving the competency of beginning students in engineering programs. Max Beberman (1925-1971) a teacher in the University High School, a laboratory school at Illinois, was appointed as director of UICSM. If the colleges desired a mathematics student to be fully capable of sustaining Calculus in the freshman year, then secondary school preparation was critical and must be fully examined. Originally funded by the University of Illinois, the UICSM received two three-year grants of nearly a half-million dollars from the Carnegie Corporation.[1]

The core of the UICSM staff remained with the projects for many years. This included Herbert E. Vaughan a mathematician from the Department of Mathematics of University of Illinois. Gertrude Hendrix, William T. Hale, Eleanor McCoy and Max Beberman were members of the University High School faculty at Illinois. Another contributor to the textual materials was Bruce E. Merserve, a professor of mathematics at Montclair State Teachers College in New Jersey. Later writings in mathematics established him as a leader in mathematics curriculum.[2]

Max Beberman stressed basic principles in all his work with secondary students. He wanted them to think, to comprehend and to abstract. His approach to mathematics was via abstract generalizations. Beberman encouraged the student to think, to draw conclusion and to take short cuts. He expanded abstract notation and concepts using modern mathematics making the College Entrance Examination Board recommendations appear very modest, even traditional by comparison. In a high school mathematics book he wrote with Vaughan, Beberman stated, "We hope you will find that learning mathematics is often a matter of partly understanding an idea, learning about it by using it, understanding it better in the light of ideas you get later and so on."[3]

The very heart of UICSM's purpose was to awaken the teaching community to the abstract ideas, structure and language of mathematics which was missing from rote, practice material then currently used in secondary mathematics. In the UICSM's program, structure of mathematics required the student to observe a systematic organization using undefined terms, definitions, axioms and logical deduction to generate new concepts. Beberman said,

> The University of Illinois' project for the improvement of the teaching of secondary school mathematics seeks to bring mathematics into the teaching of mathematics, and to encourage the learner to discover as much of the subject as time and circumstances will permit.[4]

As the director, Beberman's view of mathematics permeated the work of UICSM. If the secondary school student was to comprehend mathematics, then it was essential to realize that the subject matter of mathematics consisted of abstractions. These abstractions were not just symbols, but demanding entities which possessed no physical reality. From a few examples of a concept, such as examples of number five, one learned to recognize instances of abstraction of "fiveness." This would lead to a comprehension of the abstract or general view.

To comprehend the lessons and the abstractions of mathematics, the student had to understand the language and symbols of mathematics. Beberman characterized the current mathematics education as an attempt to teach the student valid means of manipulating symbols without any meaningful awareness of the abstractions. It was his hope that the work of UICSM would change this deficiency in mathematics education.

In writing and preparing materials, Beberman placed a great deal of emphasis on abstraction rather than on symbols. Too many textbooks presented mathematics as recipe type of manipulations with clever terms such as: "borrow," "carry," "cancel" or "invert and multiply." Beberman desired mathematical continuity, a flow of logical ideas, within the secondary mathematics education which came from understanding, associating and deducing. Using the discovery method and UICSM materials containing exercises designed to clarify and to develop the awareness of mathematical abstraction, Beberman subjected new materials to the most demanding test, the actual use in a classroom setting with constant evaluation by students, staff and supervising personnel.[5]

Howard F. Fehr, of the Teacher College, Columbia University, saw that effective learning of mathematics required the building of an ever wider and broader foundation of concepts. Even the simple idea of division in arithmetic must extend throughout algebra until the concept was extended to the ratio of $\frac{\Delta x}{\Delta y}$ within Calculus. The abstraction of division was but one concept that seemed basic to elementary manipulation, but often was not understood as an abstraction critical for advanced mathematical principles.

In any learning situation, the teacher needed to guide the student's sensory experiences and stress the importance of concepts as well as skills. These were all interrelated to the development of problem-solving. There was no fixed magical sequence. Key again to the clarification and utilization of any new curricula or material was the presence and direction of the knowledgeable, pedagogically aware and enthusiastic mathematics teacher. Fehr's views supported Beberman's ideas for UICSM.[6]

The National Council of Teachers of Mathematics continued to provide members with research information designed to improve mathematics education. The published articles examined motivation, sensory learning, formation of concepts, learning theory as well as language and drill within mathematics. Kenneth B. Henderson and Robert E. Pingry, mathematics professors at the University of Illinois, Urbana, developed the theory and practical classroom procedure for problem-solving in mathematics. They identified the steps as: (1) having a question to answer or problem to solve, (2) defining a sustained activity to lead to a goal, (3) blocking outside distractions, and (4) thinking how to attain a goal. We can see a parallel approach with Dewey's Complete Act of Thought. Henderson and Pingry stated,

> Mathematicians are well aware of the role played by the concepts and generalizations in the deliberative process in problem-solving. It is these abstractions which make it possible to restructure or reorganize past experience and bring it to bear on the problem at hand. There is no substitute for an understanding of relationships manifested by the possession of concepts and generalizations.[7]

Thus, the work of Beberman's UICSM to develop the student's ability to form abstractions within secondary mathematics education was a concept accepted by other faculty members at University of Illinois.

Early in his own professional career while teaching at Florida State University, Max Beberman stressed the theoretical description of a literal number as a symbol for an element of a set. For him literal number was defined as a variable represented by a letter which symbolized an abstract quantity. If the teacher approached the student with this view of the literal number, then the anticipated result was that the literal number would become a more meaningful concept for the student. From this realistic understanding of the literal number, the student would comprehend not only the nature of the abstraction, but also utilize the symbol of the literal number within equations and scientific formulas.[8]

Gertrude Hendrix, a member of the University High School, a laboratory school for the College of Education at University of Illinois, and a member of UICSM was also a professor at Eastern Illinois State College. She added to the importance of developing a logical concept for students. With this skill, the student would also have an invaluable tool to assist in the solution of indirect proofs. Hendrix saw developmental stages in the understanding of logical concepts with teachers assisting their students through these stages. First the student needed a problem. Then, deductive logical equivalent statements were to be formulated for a better understanding of the problem. In order to structure these statements, the student needed to comprehend tautologies as well as truth tables. Hendrix worked with UICSM to develop a curriculum which stressed logical concepts, such as a literal number and developed exact language using a discovery approach to generate new ideas and enthusiasm from the students.[9]

Several number examples led the student to discover a general relationship. An example would be as follows:

Nine is greater than eight.

Eight is greater than five.

Leads to the conclusion that nine is greater than five.

Several examples would allow the student to make the following generalizations:

> If a, b, and c are literal numbers which are elements of the set of Reals, then if a is greater than b and b is greater than c the conclusion is a is greater than c. Although mathematics is a deductive logical system, induction, seeing many examples and drawing conclusions such as the above has a vital role in creativity and the discovery method.

One concern that needed to be addressed was the question of which students were to be identified to participate in mathematics education programs such as UICSM. Howard F. Fehr responded that any mathematics program which was "based on individual excellence, on the opportunity of each individual to excel to his highest capacity has great promise of successfully meeting American democracy ideals."[10] Equality of opportunity for all students demanded that no restriction be applied to students who exhibited interest, talent and motivation to expand their mathematics education. If smaller schools did not offer a wide selection of mathematics classes or if teacher preparation and knowledge limited an indepth investigation of advanced concepts, the various school districts in the United States needed to reform educational policies and the structure of secondary schools to enhance the opportunities of all students.

Howard F. Fehr stated, "The experimental program at the University of Illinois will have force in changing college preparatory programs from a traditional to a modern one both in spirit and concept."[11] In addition the UICSM program attempted to increase the number of less able students enrolled in mathematics classes. UICSM's major efforts were to develop textual materials to improve student attitudes towards mathematics and to generate teacher enthusiasm. According to Fehr, "These and other practices are giving us a workable set of criteria for establishment of a program in mathematics education for all."[12] Fehr wanted all students to study mathematics according to their ability and not to be forced into any one track.

Fehr wanted each secondary school to provide four years of high school mathematics with various groupings or tracks. Above all, Fehr stressed that a student must understand content in order to advance because mathematics was an organized structure of knowledge which demanded skills and concepts to improve one's understanding. He also considered it vital to know mathematics because so many quantitative situations existed in daily life and within other academic fields. Mathematics was both a way of thinking that described the universe and also an area of knowledge that was intrinsically valuable.[13]

Beberman stated, in his Harvard lecture of 1958, that some 1,700 students had participated in UICSM's program. They represented a dozen pilot secondary schools from Illinois, Missouri and Massachusetts with forty participating teachers. Although some six years into the program, Beberman still considered his classroom courses as being under developed. He believed that any new curriculum must not be developed within a vacuum, but it must consider the practical needs of the student and the expectations of the traditional courses. However, to really understand mathematics, the student needed to use the discovery method and develop precise language. With precision of language, the student would have the ability to explain his discoveries.

To illustrate the concept of precise language, Beberman discussed the mathematical entity, number, since he believed mathematical instruction was "frought with linguistic difficulties."[14] It was critical that the student knew the logical distinction between a number and a numeral. The number is the abstract concept or idea while the numeral is the symbol which characterizes the idea. Aware of the logical distinction, the student would have little difficulty accepting the use of letters in algebraic statements. Perhaps the student would then question what truly was a number.

Basic to the UICSM program was the use of the discovery method. After content was selected, the writers then developed directions for the teachers and lessons for the students to assist in the discovery of principles and rules. This was used in the development of signed numbers. A student found it much easier to identify and use numbers than it was to know and to verbalize the concept of a number. Only with skill in precise language can a student give a clear verbalization to his discoveries. Since verbalization of the discoveries was difficult, UICSM recommended delaying it. Beberman considered this recommendation an important characteristic of UICSM's program.

The discovery method was used in the solving of equations and in the manipulation of algebraic expressions. Once the procedure revealed generalizations, the students were required to develop short cuts to expedite a rapid solution. Discovery method's main drawback, however, was that it required time to develop. Another criticism centered on the pre-college examination requirements which tested mainly skills. Beberman, however, held fast to his belief and cited the criticism of college professors that conventional preparations were not producing able students in mathematics.[15]

One of the strengths of UICSM's program was the continual revision of the textbooks, teaching methods and ineffective techniques. The program maintained close communications with the pilot schools through written reports of the teachers using the program, staff conferences, results of student testing and supervisors' views. UICSM was a combined effort of the university staff research mathematicians and the participating secondary teachers. With the dedication of all participants and the support of the University of Illinois and the Carnegie Corporation, Beberman, as director of UICSM, developed, researched, laboratory tested and evaluated a significant program in mathematics education.[16]

M. Eleanor McCoy, Teacher Coordinator of UICSM, revealed that by 1958-59 some thirty-three additional schools were participating in the program. The UICSM program was used in Barrington, Blue Island, Elmhurst, Gurnee, Pekin, St. Charles and the University High School, all in Illinois. The Principia Upper School in St. Louis, Missouri and the Newton School in Massachusetts also used UICSM. Most in the <u>First Course</u> were ninth graders in a pre-college mathematics curriculum. McCoy stated that UICSM was begun "because of the belief that improvement was necessary in secondary school mathematics curriculum."[17]

UICSM had a two-fold task to develop materials and to train teachers. Through revision of materials and updating improvements, it created a changing curriculum with new units as the need arose. Through inservice workshops, summer institutes and conferences, excellent communications continued to help teacher development.

In writing, the staff members sought to develop mathematical consistency, student interest, and the necessary skills needed for basis concepts. Throughout the material, two considerations were fundamental, precise language and use of the discovery method. From UICSM courses the distinction between number and numeral, allowed the use of letters and their manipulations in mathematical expression to be easily understood.[18]

At the University of Illinois in 1958, there existed three programs for teacher training: one, for the teaching of mathematics, another for teaching mathematics and physical science, and a third for the supplementary training of secondary school mathematics teachers. The third program was developed to alleviate critical shortages of mathematics teachers and to improve teacher knowledge and effectiveness. Within the third program, the first two required courses developed axiomatic structure and the real numbers. The third course was on modern algebra while course four was on foundations of calculus. The fifth and sixth courses were on theory of function and an introduction to complex variables. The seventh and eighth discussed pedagogical views and curriculum reforms such as UICSM. Later the third program which provided supplemental teacher training at the University of Illinois became in 1957-58 an academic year institute for the secondary school mathematics teachers, supported by National Science Foundation with some thirty-four teachers attending.[19]

In the School Review, December 1957, the contributions of project staff of UICSM were discussed. They prepared textbooks, teacher commentaries, and teaching programs. The program had originated initially from the university's concern to improve the mathematical competency of engineering students. The first freshman class instructed by UICSM was taught in 1952-53. Again, the staff stressed a consistent program, ideas of interest to students, and task development. Such a program was designed to lead to concepts necessary to learn mathematics. Despite its efforts, UICSM developed theoretical units which did not meet with complete success. Such an ambitious high school program demanded skilled teachers. UICSM learned that many mathematics teachers were not prepared academically to teach contemporary mathematics having received the college preparation well in advance of the modern developments.

By 1957, a four year course sequence for secondary schools had been developed by UICSM. However, this curriculum was always being revised or modified. The First Course had been reissued four times based on teacher input and experimentation results. Since projects for the construction of mathematics curriculums were few in number, UICSM created unique precedents and guided many later projects as a model. Fundamental to the content development was the discovery method and student freedom to explore. With freedom to approach a new situation, the students exhibited real creative ideas manifesting a true talent in mathematics. However, because it was writing and revising material as well as assisting teachers, the staff at UICSM was extremely pressured.

Many professional groups requested materials, both textual and teacher commentaries. Often staff members were asked to deliver presentations about the discoveries of UICSM. With the cooperation of supervisors, the participating teachers, due to extended class preparations, were released from other secondary teaching duties. The unique program, begun at University of Illinois to satisfy an internal university need, appealed to more as its work became known through professional journals like Educational Leadership and the NCTM journal, The Mathematics Teacher. It seemed that UICSM had become a model for projects which would assist teacher preparation and curriculum changes.[20]

Cited as a modern approach to high school mathematics, UICSM was highlighted in Scientific America in May 1958. There was a revolution in mathematics education which would lead to the restructuring of existing programs in order to provide understanding and consistency to mathematics education. The UICSM had a very modern, axiomatic approach to curriculum changes with Max Beberman, a teacher at the University High School and Herbert E. Vaughan, a mathematician at the University of Illinois. In 1958, the primary funding of UICSM was from the Carnegie Corporation. Through the discovery method and abstract generalization, UICSM sought to stimulate greater student interest. The program in 1958 was viewed as experimental. The critics felt it was possibly too time consuming, too abstract and too difficult, but Beberman and UICSM were searching for a new and exciting approach to secondary mathematics. Some critics felt it was too soon to judge UICSM, but also feared the program would be best directed to the gifted student.

Here is a sample lesson from UICSM's Project for the Improvement of School Mathematics.

A. Teacher Commentaries

The concept to be developed is that of union. Note the following about the subcommittees listed:

1. there are pairs with no members in common (e.g., Food, Finance),

2. there are pairs with some members in common (e.g., Food, Games),

3. the Tickets Committee is a proper subset of the Finance Committee,

4. the Prizes Committee and the Side Show Committee are the same set of students,

5. the Rides Committee is the empty set.

B. Student Text

The freshman class at Zabranchburg High School is planning a carnival. Each class member had a chance to volunteer for any of the subcommittees of the Carnival Committee. No two of the students who signed up for committee work have the same first name, so we can list the subcommittee members by using only first names. If the same name appears on more than one subcommittee list, that just means that the same student is on more than one subcommittee.

Here are lists of the carnival subcommittees:

Construction	Food	Games	Finance
Al	Don	Al	George
Bill	Hal	Hal	Julie
Don	Laura	Laura	Margie
Frank	Nancy	Pam	Sue

Tickets	Prizes	Side Show	Rides
George	Charles	Charles	(No one volunteered.)
Margie	Ed	Ed	
	Julie	Julie	
	Kathy	Kathy	

Answer these questions on your work sheet.

1. How many subcommittees is Bill on?

2. How many subcommittees is Laura on?

3. One student is on three subcommittees. Which student is it?

4. How many students are on the Finance Subcommittee?

5. How many students are on the Rides Subcommittee?

C. Check Your Answers

Bill is on 1 subcommittee.

Laura is on 2 subcommittees.

Julie is on three subcommittees.

4 students are on the Finance Subcommittee.

0 students are on the Rides Subcommittee. (Your

answer is also correct if you wrote a "no" in the blank.)[21]

Morris Kline, a professor of mathematics at the Courant Institute, New York University, a strong critic, did not see the abstract approach as attracting more students. Kline wanted more concrete applications and use of physical experimentations. W.W. Sawryer, an English mathematician, supported Kline's views. Other approaches had been developed by the Mathematical Association of America (MAA) and by the Commission on Mathematics of the College Entrance Examination Board (CEEB). The Commission on Mathematics of CEEB begun in 1955, attempting to influence most of America's schools, appeared conservative especially in comparison with UICSM. The Commission on Mathematics of CEEB, by the nature of CEEB's nationwide responsibilities in testing college bound students, exercised considerable power. The commission had begun in 1958 to distribute, in pamphlets, some results and ideas. These would generate new curriculum changes as well as textbook revisions. However, Commission on Mathematics, unlike UICSM, did not produce textual materials.

With the financial assistance of the National Science Foundation (NSF), the summer institutes and inservice education of mathematics teachers were expanding. There were ten planned in mathematics for the summer of 1958. These institutes used the modern approaches to reform cited by MAA, CEEB and UICSM. However, a new program at Yale, called the School Mathematics Study Group (SMSG), was also having a significant impact on mathematics education because of its distinguished membership and considerable financial support.[22]

Bruce E. Merserve was an early contributor to UICSM. Merserve wrote about the new look in mathematics that emphasized concepts and techniques to clarify and simplify older mathematical approaches. This was not an easy undertaking since the new content and new approaches demanded greater teacher knowledge, experience and enthusiasm. In many ways, the challenge was producing a revolution in mathematics education.

Merserve said "that modern mathematics is concerned with mathematical systems and the interpretations of these systems as a model of other systems and of the various aspects of the physical universe."[23] At the heart of such a development was the concept of the set, logical deductions and mathematical proof. The concept of a set, developed by Cantor at the end of the nineteenth century, was used as the starting principle of mathematics. Understood as a grouping or collection sharing a common characteristic, the set was associated with various number groupings. Moving from a known concept using association and deduction as well as axioms, the mathematical proof was utilized. Terminology and abstraction were essential in modern mathematics. Merserve also stressed the importance of probability and statistics. The inclusion of probability and statistics by Merserve extended well beyond the recommendations of UICSM's program.

The work of UICSM was praised by professional organizations such as The National Council of Teachers of Mathematics (NCTM) for its approach in reforming mathematics education and the materials it produced. Merserve was not the only mathematician who used the term revolution when considering the progress in mathematics. G. Bailey Price, chairman of the Department of Mathematics at the University of Kansas, believed that the mathematics revolution was possible because of the tremendous advance in research and the development of automation. Modern machines required theoretical and analytical procedures in their use. These were elements included in mathematics education to assist man's need to organize and analyze data for digital computers. Therefore, revisions of curriculum should emphasize logic and understanding. Stress on the structure and deductive character of mathematics must be united with techniques and skills to solve problems. Price wanted better teacher preparation, improved methodology of instruction, greater inservice education and the consolidation of smaller high schools to allow for a wider selection of classes in mathematics.[24]

Kenneth E. Brown, a specialist in mathematics at the U.S. Department of Health, Education and Welfare, recognized the critical need for the improvement of school mathematics and attested to it by pointing to the support provided by various private foundations and the National Science Foundation. Brown cited the UICSM study under Max Beberman. As he wrote, the UICSM in 1960 had distributed materials and had conducted experimental classes in twenty-five states with over two hundred mathematics teachers using UICSM for some 10,000 students. This growth was made possible because the activities of UICSM were carefully organized, tested and revised. UICSM also filled a void in many school systems that desperately needed to revise their mathematics education.[25]

In April 1961, the U.S. Office of Education granted funds to Max Beberman (UICSM) and Laurence Stolurow (Department of Psychology at University of Illinois) for a comparative study of the principles of programming mathematics. Some two hundred students used programmed texts. In preparing the material both mathematics specialists and learning theory specialists were consulted. The difficulty was to translate the enthusiastic presentation of a creative teacher into the typeface of a printed page. How to make the material interesting and varied for students' needs was a critical problem. Beberman did not see programmed texts as replacements for teachers, but as alternative work used during teacher peparation periods or while individuals received special assistance. Programmed texts were regarded as teacher aids. Like Socrates' dialogues with his students, the key was in the formation of leading questions. Again revisions were suggested as feedback arrived from pilot schools.[26] On April 1, 1962, the UICSM project received a National Science Foundation grant which aided the production and distribution of programmed versions of UICSM material, provided summer institutes for 324 teachers, and aided in the recruitment of staff and consultants.

Using the same course topics as Unit I of High School Mathematics, the programmed instruction course was developed and used by 580 students during the fall of 1962. The material was designed to be used with teacher assistance so it anticipated student problems and extensive remediation based on students' responses to questions. The text allowed the student to explore new topics using intuition in his solution without a formal lesson. "Branching," a term in programmed learning, described a process based on each of a variety of responses to a question. After each chosen response a specific set of instructions would be given. In UICSM programmed instruction "Branching" was incorporated within the material so that specific responses developed a sequence of topics to follow.[27] Beberman considered the programmed text as a teaching-aid, a new art using self-instructed material. Beberman believed that "the analysis of subject matter which must be made during programming is an invaluable aid in carrying out the major function of

UICSM, the development of new mathematics curriculum."[28]

Beberman asked for assistance and advice to find applied mathematicians who would spend three to five years developing applications for secondary mathematics education. Since the applications would be diversified, UICSM's board urged including many specialists who would spend only two weeks with UICSM. Then, the UICSM staff would develop the actual material from the suggested applied material.

The board recommended an annual idea-generating session. The members of summer institutes were asked to consult with UICSM's staff throughout the year for better communication and future developments. It was also suggested that UICSM, which had contributed "to mathematics education through educational research,"[29] also might draw from the advances in science education, cautiously, without becoming dominated by science.

In the proposal for funding a second year 1963-64 project from the National Science Foundation, Max Beberman included a detailed analysis of the project's work. His proposal presented critical reviews of the programmed materials and the preparation of revised material.

On February 14-19, 1963, at Monticello, Illinois, the UICSM held a conference funded by NSF on the role of applications of mathematics in the secondary school mathematics curriculum. From 1951 through 1962, UICSM had produced textbooks based on curriculum reforms for grades nine through twelve. With the aid of NSF this program was expanded to include seventh and eighth grades. Now UICSM was looking for applications to illustrate mathematical principles, to reveal the practical use of mathematics and to teach subject matter related to the mathematical content. The UICSM utilized the talents of applied mathematicians and scientists, gaining knowledge and direction for an approach to the application of mathematics for the secondary student.

In his remarks to the Monticello Conference, Max Beberman stated that the purpose for UICSM was to restructure college preparatory mathematics, so that after three or four years of secondary work a student would begin Calculus as a freshman in college. Approaching the real number deductively while retaining the essential prerequisite, the UICSM expanded and explored new advances in mathematics education.

Critics of the work of UICSM, like Kline of New York University, believed it was not a program designed for all students. However, Beberman said that,

> Courses must be designed with provision not only for future college students, whether or not they go into fields using mathematics and its applications, but also for students ending their formal education at the high school or trade school level.[30]

Beyond content, structure and methodology, Beberman stressed the need for a development of pedagogical methods. An investigation of the introduction of applications into the secondary mathematics curriculum formed the guidelines of the Monticello Conference. Published by the NSF, its proceedings contained suggestions to mathematics teachers on ways of presenting the application of mathematics. These recommendations were extensive from leading scientists, industrial leaders, engineers and university professors.

Joachim F. Weyl, from the Office of Naval Research, presented his paper, "Mathematics in our Children's Time," which developed the link established between our national prosperity and education. He maintained that technology requires people to be educated competently in science and mathematics is an essential ingredient. Through mathematics, a description of phenomena would be possible which was invariant, consistent, and a dependable approach to structure and theory.

Weyl saw student acceleration possible through the use of the computer. Mathematical specialists and practitioners of mathematics were in demand. Therefore, he supported the inclusion of applications, like Newton's basic laws of mechanics, to open the vistas of the possibilities in mathematics.[31]

Weyl believed that neither the traditional curriculum nor the experimental approaches like UICSM or SMSG had regenerated or done enough for the secondary mathematics student. The real world involved trials and errors which expanded the human experience. The mathematics student, too, often saw only the perfect results within a totally complete system. The student should realize "that mathematics is not infinitely proved, infinitely precise, and if you've got an equation, everything is explained."[32] The adventure into unexplored areas, using a discovery technique, would awaken the extent of what might possibly happen in a life situation in business, research, engineering and mathematical development.

At the Monticello Conference, Albert A. Blank, from the Courant Institute of Mathematical Science, believed that UICSM had anti-linguistic tendencies since UICSM gave the student few applications. He believed "that linguistic transference from one realization to another is part of application."[33] As mathematics developed, the elegance of language was important and language brought consistency and unity to mathematics. Thus, application should be included in all elementary mathematics for it was a positive demonstration of the abstract theoretics of mathematics.

Stephan P. Diliberto, Department of Mathematics, University of California at Berkeley, believed problems arose in mathematics education because of a seniority system for secondary teachers and the refusal to remove obsolete material from high school curriculum mathematics. He believed that no one was better or of a high stature for being a pure mathematician or scientist rather than an applied practitioner. The university professor stood no higher than the high school teacher in the role of communicating knowledge and techniques to the student. Diliberto maintained that all contributed to the growth of secondary school mathematics and played their unique role in its development.

For far too long, the secondary school curriculum was stagnant, without experimentation. However, the efforts of UICSM and SMSG brought serious investigations and changes in mathematics curriculum. Possibly "that a change has been made is far more significant than the actual changes proposed."[34] This opened the possibility of other experiments and programs. Professor Kline attacked the SMSG program which resulted in interesting replies by Edward Begle of SMSG. The very discussion opened new explorations and awakened dusty corners of many minds.

In the development of the classroom lesson, Beberman was concerned about the element of time and the limits it produced on student discovery of concepts. Alternative solutions gave real evidence of creative thinking. However, in the name of efficiency he thought that the teacher must direct the variation of possibilities. This time was needed for development of mechanical dexterity and manipulations. This dichotomy was and remains a substantial problem within mathematics curriculum.[35]

Frederick Mosteller, a member of the Center for Advanced Study in Behavioral Science at Stanford on leave from Harvard University, recommended a variety of mathematical exposures at the secondary level by compressing material and deleting obsolete topics. Mosteller stated that:

> Every stage of mathematical teaching plays three roles simultaneously: firming the understanding and improving the skills taught earlier, introducing fresh topics appropriate to the students' level, and laying the groundwork for later generalizations.[36]

To assist future psychologists, sociologists and political scientists acquisition of the general structural concepts of mathematics education would be more useful than specific manipulations. The concept of a variable was basic to thinking about social science problems. A "variable," within mathematics education, led the student to the concept of a function. In turn, a function was a mapping such that for every element in the domain, the replacement set for the variable, there is a corresponding element in the range, the solution set for the variable. A function fulfilled an enormous role in quantitative investigations. The concept of "curve fitting" data which creates a specific algebra expression or functional notation was presented as a necessary skill for modern social scientists.[37]

One continuing problem in mathematics education has been the gap that exists between true mathematical ideas and the presentation of the idea through mathematics symbols. The concept of function characterized this problem since it was often only utilized and demonstrated through countless examples. Prior to the mathematics reforms, the concept of function was not emphasized. In the reformed mathematics, the discussion of the essence of a function was characterized as vital to mathematics and science, then its nature needed to be developed. The secondary school curriculum, under the skilled direction of a well prepared teacher, needed to explore these critical concepts of mathematics education.

A great deal of discussion occurred about the pedagogical value of using the discovery method. Arnold E. Ross, Department of Mathematics at University of Notre Dame, stated, "It is quite clear that an imaginative and well trained teacher is the key to success of any effective program which attempts to provide a significant interaction between mathematics and science in our school activities."[38]

UICSM's efforts to introduce into secondary mathematics school curriculum a wealth of topics addressing mathematics applications went beyond the recommendation of practical topics related to science, business or industry. The reports of the Monticello Conference supported the fundamentals of language, structure, logic and consistency which were well established by UICSM. Through the publication of the findings, UICSM again provided mathematics educators with encouragement, knowledge and support to continue to explore the possibilities.

As an example of work in progress, Beberman cited the 1963 UICSM-NSF summer institute with projections for another 1964 program. These developed new material, using three hundred participants as sounding boards for both the content and pedagogy of UICSM project. The participants were also recruited to field test new materials.

UICSM worked with "Plato" a computer based teaching system at University of Illinois. By using "Plato" the student would discover a generalization as he or she worked through various exercises. Another innovative area of UICSM project was development of a series of training films for algebra teachers. Throughout the project, there were constant revisions and extensions of course content. It was hoped that a senior high school course would approach Euclidean and analytic geometry using vectors.

Extensive work was done by Max Beberman to organize and direct the working practices of UICSM and also to develop the projections needed for future proposals. His goals for June of 1964 included efforts to revise seventh grade algebra and vector geometry and devise units on mathematical applications. These materials were tested in 1964-65 at the University High School.[39]

Throughout the period of the reforms of mathematics education, many issues and arguments arose. The new mathematics was not a total replacement of traditional approaches nor could it obliterate all of the difficulties and problems faced by the secondary students as they attempted to learn mathematics. Students, staff and parents were confused and disarmed by the merit and direction of these curriculum revisions and new instructional approaches. However, Beberman stated, "In looking at the content of the new programs for grades 9-12, I am impressed more by the attempt to organize the traditional subject matter along logical lines than by the inclusion of new subject matter."[40]

Beberman believed the essential element within mathematics education reform was to integrate sound principles with meaningful pedagogy. By developing learning situations organized around logical consequences with the discovery method, interested students would be able to establish a continuity and to acquire understanding in mathematics.

Among the objections to the new programs, was the question of whether or not the student understood the concepts and process rather than the merit of new subject matter. A valid criticism was the issue of the time needed to develop greater understanding for the student as well as technical skills. In addition, teacher preparation would be especially difficult if proper textbooks were not available. Max Beberman said,

> The recent developments in high school mathematics education have not been concerned with replacing old subject matter with new subject matter. The primary task has been that of finding a matching between sound mathematics and sound pedagogy. The job has just begun.[41]

A tremendous amount of effort and time had been devoted to UICSM's project from its origins as an investigative project for the University of Illinois to its extension as a committee for curriculum improvement as well as its role in developing a National Science Foundation's summer institute. These institutes, workshops and inservice training programs, addressed some of the "manpower" shortages in education explored in the National Education Association. The Carnegie Corporation funded a study begun in 1961 by James B. Conant which also addressed The Education of the American Teachers. He investigated the historical developments of teachers' education from the advent of the nineteenth century normal school to the post-Sputnik emergence of schools and colleges of education in universities. Were methods classes prepared by professors of education worthless today? Were professors of academic fields too far removed from educational methods to prepare teachers? To the general public, which entered the arguments in the post-Sputnik era, there appeared too much philosophical criticism and too little cooperation among educators. Conant cited the School Problems Commission from Illinois which acted as a watchdog for teacher accreditation. The commission wanted more academic professors to participate in and to assume responsibility for the quality of teachers.

Conant's recommendations included teacher participation in programs like UICSM. However, his sample revealed that about 20 percent of teachers had attended at least one institute. Conant said, "A greater knowledge of the subject matter is a need of many teachers today and the need will continue for years to come."[42] Conant believed along with providing practice-teaching experience that the colleges needed to work to improve individual state requirements for teaching. However, Conant stressed the vital role of in-service education and summer institutes such as those sponsored by UICSM to keep teachers well informed about changes in curriculum and modifications of pedagogical methods. According to Conant, teachers, who continued their education in course work and through self direction, should be rewarded financially.[43]

Under Commissioner Francis Keppel, a bulletin, _Inservice Mathematics Education_, was published by the Office of Education. It summarized what projects were available in 1964 for teachers of mathematics. To show how to begin an inservice program, Keppel described the plan and growth of UICSM's workshops and institutes. In addition, the various state departments of education and the U.S. Office of Education provided consultants to develop inservice programs.

Another Illinois program applauded by Keppel was the Illinois Inservice Workshop for Elementary School Mathematics. The workshop began in 1958 was a response to suggestions made in a report called _The Teaching of Mathematics_. This report was prepared by the Mathematics Study Group of the Planning Committee for the Allerton House Conference on Education in Illinois. Over a nine year period, about $90 million was provided by NSF so that nearly 30,000 teachers of mathematics could attend NSF institutes. One of the original projects which was an excellent plan for other institutes was the innovative work of UICSM.[44]

The merits and contributions of UICSM were again included in An Analysis of New Mathematics Programs prepared by NCTM. This analysis was first suggested in 1959 and the completed report in 1964 included eight mathematics programs. The investigation analyzed the mathematics programs in regard to their topics, structure, vocabulary methods, concepts and skills, proof, social application and evaluation. The comments on UICSM were written by its director, Max Beberman.

From UICSM's origin in 1952, its major concern was the content and teaching of high school mathematics through "the development of instructional materials and their experimental trial in the schools." Beberman stated, "We have introduced some new content, rearranged some of the traditional content, and have developed many promising pedagogical techniques and approaches."[45]

At first, the materials were only available to teachers who directly participated in UICSM. After 1958 the books were distributed more widely in the hope that teachers using them would have knowledge of the program or the supervision of an UICSM experienced person. The UICSM Newsletters updated material, contained sample tests, and introduced articles on the teaching technique of UICSM topics. Beberman strongly recommended that teachers using UICSM continue to study and to grow. He advised the teachers to regard the individually bound units as one book entitled High School Mathematics, an integrated book with sequential development.

In reviewing the UICSM program, Beberman emphasized that while social applications were included throughout the units, mathematical principles were of primary importance. While the UICSM materials did not differ greatly from traditional algebra in content, they did have a unique approach and technique in mathematics education. This fact was supported by the position given mathematics structure within UICSM. Detailed attention was given the development of the properties of rational numbers, deductive proof and logic. The rigors of UICSM were carefully presented throughout its work on mathematical vocabulary and concepts. However, to Beberman, a fundamental concept of UICSM's project was the principle of student discovery. Beberman stated, "UICSM holds to the belief that the learning process is deepened by presenting a sequence of activities from which students may independently recognize some desired knowledge."[46]

The evaluation of Units 1-4 of UICSM was conclusive. For the analysis maintained that the unit tests were well validated by years of use and the responses of pilot schools. However, Unit 5 lacked social applications and relied heavily on essential background of set theory from Units 1-4. Units 6, 7 and 8 had no evaluative instruments nor objective evaluation of the material within the unit.

Extensive distribution of UICSM materials never occurred. By the 1960s, the UICSM project's work was taken over by the School Mathematics Study Group, which had been established in 1958. UICSM established a widely accepted model for mathematics education reform. It is primarily remembered today as a project for curriculum reform of mathematics education. However, UICSM contributed widely to structure, logical development and deductive proof within existing mathematics. Its newness was in the organizational and continuous presentation of both traditional and recent mathematical concepts. UICSM stressed the discovery method, characteristic of Dewey's and Parker's early work. Through rational deduction and personal awareness, the students acquired mathematical truths. The student was not given rote, dry mathematical facts to absorb, but formulated and understood abstract concepts.

The Second International Proceedings of the Second International Congress on Mathematic Education in 1969, reaffirmed the general approach to mathematics reform used by UICSM. A.G. Howson stated that,

> Experts on mathematics education cannot be expected to emulate their mathematical colleagues [or even their mathematical selves] by presenting new proofs or new theorems . . . . Primarily they bring their experience, their personal judgment and accounts of their work in the classroom.[47]

The UICSM staff, consisting of university mathematicians, mathematics educators and secondary teachers, collaborated, bringing together their knowledge and experiences to develop classroom materials to improve the approach, the content and the teachers of secondary mathematics.

At the International Congress on Mathematical Education, Hugh Philips, of the School of Education, Macquane University, Australia, in his "Developments in Mathematics Education" believed "curriculum should be process orientated and methods should be heavily discovery learning based."[48] This affirmed the position of UICSM that the discovery method was critical to developing the experimental work within the curriculum, techniques, pedagogy, and teacher preparation aspects of mathematics education.

The outstanding contributions to mathematics education achieved by UICSM under Max Beberman reached far beyond curriculum revisions. Very evident from the textual materials produced were the structural strengths of this revolutionary attempt to revitalize secondary mathematics education. With emphasis on the discovery approach to the classroom lesson, UICSM wanted students to understand the basic importance of language, logic, and consistency within the whole of mathematics. Through the combined efforts of university and secondary educators who united with mathematicians, scientists and business people, UICSM discussed, developed and actuated an experimental approach to secondary mathematics which was tested by pilot schools, revised, rewritten and retested. As Beberman said the purpose of UICSM was to improve secondary mathematics education, "to bring mathematics into the teaching of mathematics, and to encourage the learner to discover."[49]

Among UICSM's expanded efforts were to: clarify mathematical language, emphasize logical equivalence, develop continuity within mathematics, expand teacher preparation and inservice education, introduce programmed learning, and enrich mathematics education through expanded applications of mathematics. Any one of these contributions was a noteworthy achievement. However, as Diliberto stated, UICSM brought to mathematics education serious investigation. From such investigation, change was possible. Change moved from a desirable goal to an actual accomplishment. This contribution removed the whole of the mathematics community from a sluggish existence. Stagnation in mathematics education need never happen again. Mathematics educators accepted the need to remove, revitalize and reform. The very fear to change the existing approaches and curriculum of mathematics education was removed with the innovative experimental programs of UICSM.

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CHAPTER V

SCHOOL MATHEMATICS STUDY GROUP
-- A NATIONAL PROGRAM

The foundation for reform of secondary mathematics education gradually was laid, event by event. Following a period in which mathematics was viewed as a utilitarian subject which emphasized the computational skills needed by consumers and industry, the reformers of 1950s identified needs, experimented with innovations, and stimulated positive change.

In 1951, the University of Illinois Committee on School Mathematics (UICSM) began with a university-centered concern for well prepared engineering students. From a university funded program, expanded by Carnegie funds, the UICSM projects identified and addressed the critical need of reforms in secondary mathematics education. Discontented with the substance of the traditional course and its emphasis on skills rather than understanding, the UICSM formulated a diverse program that involved additions and deletions to the curriculum and the development of language, logic and deduction. UICSM prepared inservice and summer institutes to increase the mathematics teacher's knowledge and to train them practically. With the research stressing applications within mathematics and the use of programmed texts, UICSM developed exciting prospects for mathematics education. UICSM used experimental innovation, tested new ideas within the classrooms of pilot schools, and revised their materials according to test results and teacher comments. All of these steps contributed to the planning and achievements of the School Mathematics Study Group (SMSG) as it began in 1958.

SMSG also profited from the extensive work of the Commission on Mathematics of the College Entrance Examination Board (CEEB). Long before the actual publishing date of 1959, the results of some four years of investigations were well circulated to mathematics educators. Begun in 1955 by a recommendation of the Committee on Examination of CEEB, the Commission on Mathematics studied the curriculum and the materials in the questions on its college entrance examination. The CEEB, had to meet the need of the colleges they served, the students they tested and the demands of our nation's technological future.

As individual university research continued, the National Science Foundation from 1953 on actively supported summer institutes and inservice education of the nation's teachers. However, there was a critical shortage of teachers. Robert G. Bone, president of Illinois State Normal University, stated, "For September 1956, there was a demand for 227,500 additional teachers at all levels in this country."[1] In addition, a serious need existed for preparing future college professors to educate secondary teachers as well as to educate researchers. The teaching profession required sufficient specialized subject matter to prepare mathematics and science teachers while also providing a liberal education to broaden their experience and instruction in pedagogy. However, well prepared teachers also needed a continuous upgrading of the knowledge and teaching techniques that inservice education and summer institutes provided. With such aid, the initiative and enthusiasm of the knowledgeable teacher would benefit students.

The needs were identified in mathematics education, the reform had begun with UICSM, CEEB and the expansion of National Science Foundation (NSF) institutes, but concern remained among secondary and college educators and professional mathematicians. The public remained aloof, seeing the discussions as more academic arguments not immediately affecting daily life. After the passage of NSF, the issue of a federal role in education was gaining support. However, the politicians remained reluctant to change a steadfast right of local control of education. If the crisis in education was as wide and as serious as indicated, the massive power of the federal government must be brought to attack this threat to our nation's future. On October 4, 1957, the shock of Sputnik awoke the nation's concerns about our educational system, especially in mathematics and science.

In the New York Times a week later an article appeared entitled, "Satellite Called Spur to Education," stating that Sputnik had "shattered the nation's smug complacency about its schools and colleges."[2] Massive changes were needed to revitalize America's education system. To restore prestige was not sufficient, our nation could no longer treat education as a second-class enterprise. The extraordinary reality of this technological age placed education as a primary necessity in the struggle to maintain our democratic life and prepare the individual and the nation for its future. With this view, cost became a secondary issue for urgency of educational reform was primary.

National publicity grew as popular magazines such as Life carried extensive articles on education. Undoubtedly the schools needed reform; however, this problem was ignored by the nation for too long. Not enough teachers, schools, equipment, modern curriculum and innovative methods of instruction were now identified as public problems. James B. Conant's The American High School Today on secondary schools was published for all to read.

Comparisons were made between American and Russian students with Stephen Lapekas and Alexei Kutzkov as examples. The American Stephen Lapekas was a student at Austin High School in Chicago. Although Stephen hoped to attend college, he approached his secondary education with a relaxed attitude as he proceeded through a flexible curriculum. Alexei Kutzkov, a student at Moscow School 49, USSR, worked in a "harsher intellectual setting,"[3] but was determined to go to college and become a physicist. Alexei followed a standardized curriculum which was like an obstacle course and was two years ahead of Stephen academically.

In facing America's educational mediocrity, many deficiencies were identified. Among them were students who avoided difficult mathematics and science courses, parents who were lax in encouraging study habits and academic goals, a society which encouraged too much leisure time, and educators who stressed the child's personality and adjustment to life. Dewey, his ideas being gravely distorted, appeared as leading American education astray. The cries of Rickover, Bestor and Smith demanded a return to fundamentals. Understanding and enjoyment led to a good learning situation, while rote lessons, criticized earlier by Rice and Dewey, dulled the child and his potential.[4]

At a Conference addressing Mathematics and Science Education in U.S. Public Schools, James R. Killian, special assistant to the President for science and technology gave the keynote address. He stressed that the development of scientists would occur as education improved in mathematics and science. Very early in mathematics and science leaders needed to be identified and talented students to be encouraged.[5]

In discussing education, Reuben G. Gustavson, president of Resources for the Future, stated its purpose was to give mankind a tool and facts to understand the physical and social environment. To achieve this purpose, humanities should be joined with the study of mathematics and science. One of the most substantial ways of improving teacher's education was through summer institutes and inservice education.[6]

M.H. Trytten's paper on "Mathematics and Science Education in the USSR" revealed that half of the Soviet curriculum was spent on mathematics. While Russian teachers received an excellent preparation and national respect, they were able to motivate their students and to advance their own educational levels.[7]

Another contributor to the conference on public schools, Professor Howard F. Fehr of Columbia University, cautioned teachers, who felt insecure about the new material, that their own knowledge must be expanded and enriched. He warned that some crash programs, without support, might do more harm than good for our teachers. If the teachers were themselves poorly prepared, then their students could not possibly advance.

In February 1958, the Conference on Mathematics and Science made recommendations for the development of mathematics and science education. Here is an outline of their guidelines:

1. Mathematics and science must be considered not as a

tool, but as liberal arts disciplines.

2. Mathematics and science must be viewed as methods of inquiry as well as bodies of knowledge.
3. Mathematics and science education must be improved.
4. Mathematics and science curriculum must be reformed.
5. Mathematics and science teachers require continuous training.
6. Mathematics and science equipment must be upgraded.
7. Mathematics and science students must be given every opportunity to develop their talents.
8. Mathematics and science students must be provided the counseling and guidance to encourage further study and career goals.[8]

On February 21, 1958, the National Science Foundation sponsored a conference in Chicago which investigated the supply and needs of research mathematicians. On February 28, 1958, in Cambridge, Massachusetts, the Mathematics Meeting of National Science Foundation headed by Mina Rees examined mathematics curriculum. On April 3, 1958, Professor Brauer formed a committee of distinguished college teachers and research mathematicians who would cooperate with high school teachers "to improve the quality and presentation of mathematics."[9]

Improving the quality and delivery of mathematics instruction was the intention of the operational committee at the University of Illinois, UICSM, headed by Max Beberman.

Herbert E. Vaughan, at the university, along with Gertrude Hendrix, William T. Hale and Eleanor McCoy from the University High School, had taught newly created mathematics classes in pilot high schools. Above all considerations regarding the content of the curriculum, Beberman wanted students to understand mathematics. He tried to translate this policy into operational terms. He wanted unambiguous language.

Precision of language was according to Beberman vital to comprehend any mathematical entity. The student should play an active part in the development of mathematical concepts and procedures. Use of physical interpretations so that the student discovers the algorism was a vital part of Beberman's New Math.[10]

The very first workshops were suggested in a report The Teaching of Mathematics in Illinois, published in April of 1958. Now with the passage in 1958 of the National Defense Education Act (NDEA), consultants could be appointed statewide. Illinois chose to concentrate its efforts on the improvement of mathematics instruction under Title IV of the National Defense Education Act. In Illinois, a fundamental pattern was structured which united the university professor and researcher with high school teachers. Above all, communication links based on mutual need and respect were established between all levels of education.[11]

Educators such as Asa S. Knowles continued the pleas to strengthen our educational programs. After 1957, the science dreams became reality. Our nation, while demanding educational opportunities for all students, had the task of challenging the gifted. Knowles stated, "Education has now become an instrument of national policy."[12] The nation needed to respond to the presidential demands for financial support of new educational programs. He believed this demand would only be a temporary role for the federal government. In his article in Phi Delta Kappan, he urged the nation to establish ways to encourage the teaching of mathematics and science, its research, and its reform. He wanted quality teaching to encourage more students. He also thought that the communications between the secondary school and the university must improve. Knowles stated, "Mathematics is essential to the understanding of science and to expand one's knowledge in the twentieth century."[13]

The comparisons of American education with that of foreign nations, the rising public concerns along with the conferences on public education, mathematics reforms and revisions, established a whirlwind of activity. Investigation of the needs of mathematicians and the experimental advances of Beberman's UICSM formulated the research data which constructed, along with the recommendations of the Commission on Mathematics of CEEB, the background from which the leaders of SMSG drew. Therefore, an examination of the contributions of four of these, Commission on the Undergraduate, Commission on Mathematics of CEEB, Advanced Placement Program and the Secondary School Curriculum Committee revealed their integral part in the development of mathematics education and the start of SMSG.

A great amount of research had occurred by 1958. Begun in 1954, at the University of Kansas, the Committee on the Undergraduate Program (CUP) was circulating its material. One book, Universal Mathematics, integrated intuitive discourse and logical analysis of mathematics. The Collected Reports of CUP was printed in 1957. CUP's relationship of mathematical theories to the natural universe was a new approach in 1957. CUP saw, as an example, the idealization of a physical object in the domain of concepts as the point which could extend to lines, planes and space. Proof was a very important part of CUP which approached it from experimentation, deduction, intuitive reasoning and from the natural universe.[14]

Another extensive project was the Commission on Mathematics of the College Entrance Examination Board which was appointed in 1955. The purpose of the commission was to recommend modifications, improvements and modernization of secondary curriculum, as it looked forward to the end of the twentieth century. It was under the direction of Albert W. Tucker of Princeton University and funded first by Educational Testing Service and then by the Carnegie Corporation. The commission stated that, "Mathematics is a living growing subject. The vitality and vigor of present day mathematical research quickly dispels any notion that mathematics is a subject long since embalmed in textbooks."[15]

The changes recommended by the Commission on Mathematics included the removal of obsolete material, better teacher preparation, and inclusion of recent mathematical developments. Although public concern had arisen since Sputnik, the USSR was not the cause of the existing crisis in mathematics education. The need of all "college-capable" students, representing the majority of secondary students, must be addressed. However, any expansion of curriculum must not only consider the preparation needed for applications throughout life, but also consider mathematics as a creative body of human knowledge. For the very talented student, the development of a strong Advanced Placement Program leading to Calculus in senior year was supported and encouraged.[16]

The Advanced Placement Program began in 1951 with faculty members of Kenyon College and financed by the Fund for the Advancement of Education. According to early research, able students wasted time in secondary schools and needed a challenge. In 1953, some eighteen schools sent students to take the first experimental examinations. In October 1954, reports of these tests approved their design and suggested an expansion of the program. The syllabus for mathematics involved a change in sequence of classes and an intensive course of study. Cornog, a contributing member, stated, "The objective of an intensive course is not busy-ness but a depth and mastery of the subject."[17] The needed revision to achieve this mastery within the mathematics curriculum proved stimulating to the secondary teacher.

The revisions recommended by The Commission on Mathematics of the CEEB presented logistical problems to the school administrator who needed to identify staff and to devise schedules to facilitate its implementation. The administrator had to recognize that the advanced work for mathematics had to begin in either eighth grade or the student had to work at an accelerated rate. With some reorganized material, the student needed more time in class. The 1953 proposals from CEEB wanted expanded deductive thinking in tenth grade, algebra, trigonometry and analytic geometry in eleventh grade and analytic geometry with calculus in twelfth grade.[18]

The Commission on Mathematics of CEEB recommended six specific areas for revision:

1. Emphasize the fundamental concepts of algebra.
2. Examine the use of deductive reasoning.
3. Remove rote memorization.
4. Replace obsolete topics with current ideas.
5. Include statistics, set theory and axioms of algebra.
6. Down play isolated trick solution.

For mathematics to become "modern" structure and understanding were significant elements that required emphasis. Secondary mathematics educators needed to work in articulation with colleges and universities.[19]

The National Council of Teachers of Mathematics (NCTM) established a Secondary School Curriculum Committee in 1955 which worked over a four year period on mathematics curriculum and instruction. Its work culminated in written recommendations for improvement of secondary mathematics education. The studies of NCTM revealed an urgent need to update the programs in mathematics. Ten sub-committees were established addressing a variety of issues including: aims and place of mathematics, providing for the gifted, nature of mathematical thought and revision of content. With the NCTM large membership, the circulation of such recommendations received national attention.[20]

The results of the NCTM Secondary School Curriculum were published in May 1959, in The Mathematics Teacher. The NCTM conference was chaired by Frank B. Allen. The set of objectives listed a better balance between understanding concepts and manipulative techniques. The content was to be broadened with an emphasis on learning experiences to enhance understanding and to stimulate interest.

Within this atmosphere of activities, renewed interest, and communications among mathematicians, researchers, mathematics educators and university professors, the School Mathematics Study Group (SMSG) began. The SMSG was the direct outgrowth of two mathematics conferences, one in Chicago February 21, 1958, and second in Cambridge, Massachusetts, on February 28, 1958, both sponsored by NSF. Questioning the issue of the shortage of mathematics teachers and the reform of mathematics curriculum, a committee was established to address the problems. However, of greater significance was the uniting of research mathematicians and teachers of mathematics on a single project. SMSG, with an initial grant from NSF of $100,000 given on May 5, 1958, was under the leadership of Yale University with Edward G. Begle (1914-1978), of the mathematics department, as director.[21]

In December 1958, Edward G. Begle stated, "The main purpose of the School Mathematics Study Group (SMSG) is to develop a curriculum and teaching materials based on the best available knowledge of mathematics pedagogy and the needs of our society."[22] In planning SMSG Begle realized no one can predict the future or what career a student may finally choose. However, if SMSG emphasized understanding, but maintained skills the program could lead the student forward, prepared for the technological age.

Through the efforts of professional mathematicians and mathematics teachers, SMSG was to address curriculum reforms that were sound in pedagogy and mathematics. SMSG realized that no one text or set of conclusions could be the final or best for all. The first formal meeting was June 23 through July 18, 1958, at Yale University with about forty participants. Five sub-committees were formed, one each for grades nine, ten, eleven and twelve with the remaining committee to work on grades seven and eight. Many individual units were written and with the cooperation of University of Maryland Junior High School Project a variety of materials was prepared for seventh and eighth grades.

Although the original student population appeared as the "college-capable" group from which future scientists and engineers would appear, "SMSG has no intention of neglecting the slower students."[23] All students must have the opportunity to continue in their mathematics studies. It was hoped that course material, if made more intuitive and taught at a slower pace, would be valuable for the slower student.

SMSG had hoped to write monographs on special mathematical topics to enrich present class material. Begle also wanted SMSG to make suggestions regarding teacher preparations and inservice. However, Begle stated if a "teacher of mathematics is given a mathematically and pedagogically sound text much could be accomplished."[24]

The amount of scientific and professional literature that was being produced prompted President Eisenhower to direct NSF to co-ordinate scientific information. The President's Science Advisory Committee wanted NSF to organize the work of over ten federal agencies engaged in abstracting, translating and preparing technological material and educational findings. The funds were given NSF by Title IX of National Defense Education Act.[25]

In May 1959, Begle wrote about SMSG's early days, outlining its purpose and direction. Begle saw the world needing more and more mathematical knowledge. To prepare the student, a new structure and understanding were required within secondary education. Begle stated,

> The fundamental aim of SMSG is to improve the teaching of mathematics in the secondary school, to persuade more students to study more mathematics, and to ensure that the mathematics they study is appropriate to the world of today.[26]

The SMSG planned to achieve its aims through the improvement of mathematics curriculum.

Projects like UICSM had developed a considerable amount of material on grades nine through twelve, but the teachers also needed to be trained for such radical changes in curriculum. Through the combined efforts of the National Council of Teachers of Mathematics, Mathematical Association of American and the American Mathematical Society, the SMSG received support and assistance in getting funding from NSF. The program at the University of Maryland provided materials which were used by SMSG. Begle stated in 1959, "The SMSG thus faces an enormous task."[27] However, SMSG listened and sought guidance to prepare high quality materials for secondary students and to expand teacher preparation and in-service education.

Another important conference sponsored by NSF was held in 1958, but the findings were not published until 1961. This conference was called by the Organization for European Economic Co-operation and the members of the American committee were: Edward G. Begle, Howard F. Fehr, Saunder MacLane and Robert Rourke. It was imperative to find remedies in elementary and secondary schools. The abstract mathematics of the researchers must be made visual with an improvement in curriculum and content.

Professor Marshall H. Stone of the University of Chicago addressed the Organization for European Economic Co-operation with his lecture on "Reform in School Mathematics." Stone said, "There are many unmistakable signs that we are on the brink of important, even radical changes in a mathematical curriculum."[28] However, the task was enormous and difficult within a system providing universal education for all its students. The expense of offering diverse courses at the individual ability levels had hindered creative mathematics planning. The pre-college and terminal secondary student must have a practical mathematics education to meet the requirements beyond the secondary school. The work demanded by Stone included not only a reformed curriculum and greater teacher preparation, but also the improvement of pedagogical methods.[29]

Edward G. Begle presented his report on textbooks to the Organization for European Economic Co-operation. He described the work in progress at SMSG which was receiving considerable aid from the federal government:

> We need a better curriculum. Next, we need to help our teachers improve their training in mathematics, so that they can teach a better curriculum. Finally, we need to make our courses more interesting, so that we can attract more students into mathematics and keep them there longer.[30]

Begle also wanted the rich information from non-English materials translated to provide topics for summer institutes to broaden the teacher's knowledge.

One of the first research projects done on the work of SMSG was conducted in 1960-61 by Roland F. Payette. The research discovered that students in conventional mathematics programs did not achieve consistently higher test scores in scholastic aptitude and knowledge of mathematics than the SMSG prepared students. However, SMSG students acquired a considerable broader extension of their mathematical ability. SMSG materials were successfully learned by students from a wide ability level.[31]

The federal support for mathematics education grew after the National Defense Act passed the Senate on August 22, 1958. President Eisenhower signed it on September 2, 1958, which authorized over one billion dollars in federal aid. Title III was directed to strengthen science, mathematics and language instruction. From the extensive studies done, many supported by NSF, an academically weak mathematics program was apparent, "Only one out of three [high school students] takes intermediate algebra; one out of eight trigonometry."[32] Over seventy million dollars was provided under Title III for equipment and remodeling. While Title VI provided for language teacher education, the NDEA acknowledged that early appropriations were made to NSF teacher institute for mathematics and science. Under Title IV, fellowships were established to assist graduate education in mathematics, science and languages.

In the light of the energy created to reform mathematics, to do research, and to provide the financial forces of the private sector, the university, industry and federal aid, the SMSG project received both encouragement and publicity to disseminate its work. The breath and depth of its influence on policy in American mathematics education was generated through the actual courses, materials and monographs produced by SMSG as well as the outstanding participating members: Begle of Yale, Fehr of Columbia, Morse of Michigan, Price of Kansas, Albert of Chicago, Illinois and with Allen of Lyons Township and Swain of New Trier Township both also in Illinois.

One of the first published works of SMSG, called <u>Mathematics for High School</u> contained an innovative unit on the Elementary Functions for the twelfth grade. The user was cautioned about the unevenness of presentation caused by a writing team, but it followed the recommendation of the Commission on Mathematics of CEEB with modifications. Chapter I detailed set theory, symbolism and logic believing that many students would not be familiar with these concepts if this was their first experience with SMSG. The work of Gregor Cantor on set theory assisted in unifying the structure of mathematics while establishing a means of approaching mathematical infinity.[33]

In the SMSG Intermediate Mathematics an in-depth investigation included: logarithms and exponents, permutations and combinations, sequences and series, vectors, trigonometry and algebraic structure. The content material to be covered in class was extremely extensive, even for the well prepared teacher. However, two members of the writing panel, Allen and Swain, were high school teachers from the suburban Chicago area and were experienced with the secondary student's ability and capacity. The presentations were new especially in the functional approach to the development of logarithms and exponents. This functional approach was needed to prepare the students for the treatment of the topics in the newer calculus texts such as Calculus and Analytic Geometry by G.B. Thomas.[34]

Howard F. Fehr of Teachers College, Columbia University, continued to ask questions of the reformers of mathematics education. He shared the concerns of his peers as he expressed the opinion that any reforms needed to be "mathematically sound, societally important and pedagogically feasible for our time."[35] For Fehr, reform should investigate the appropriate content, encourage participation of large numbers of secondary students and develop well prepared teachers. Fehr identified three essential educational goals:

1. Mathematics as a liberal education--freedom of the mind.
2. Mathematics as a basis for living and work--as the people's necessary tool.
3. Mathematics as propaedeutics--as foundation for university study.[36]

Some reform groups have discussed these points. However, their findings were not yet distributed to the teachers at large.

In this period of our nation's awakening to the crisis in education following Sputnik, Herman Rosenberg cautioned that the sense of urgency would lead to hasty actions based on fallacies. In preparing curriculum, it was wrong to demand that all students take more and harder mathematics. In recruiting, it was not only necessary to select carefully new mathematics personnel but also to retain the better teacher within education. In teacher preparation, it was inappropriate to eliminate schools of education as training areas for new teachers. Good teachers required knowledge of content in mathematics and good pedagogical procedures.[37]

SMSG was able to withstand the critics, while noting their suggestions, to draw ideas from useful sources and to produce a wealth of materials. SMSG produced over twenty-two volumes in its <u>Studies in Mathematics</u>, from 1958 its first writing sessions until 1972. Over the years a variety of issues were discussed. In Volume IV, Louis Gordon translated a Russian Geometry text by B.V. Kutuzov written in 1954. This volume revealed that function theory, set theory, group transformation and projective geometry were integrated topics in the Russian curriculum.[38]

Volume VI in the number system stated in the preface, "Mathematics is fascinating to many persons because of its utility and because it presents opportunities to create and to discover."[39] SMSG in Volume VII developed an Intuitive Geometry in 1961. Here the concept of numbers was held as important as computation. The earlier Volume V on Concepts In Infinite Geometry discussed ideas and concepts using modern notation. By 1961, Volume VIII of SMSG studies was devoted to recent developments in undergraduate programs in mathematics. The contributions of SMSG in the early 1960s were diversified and far beyond the label of curriculum reforms. The particular content of each of these books was filled with enthusiastic approaches to new topics. For the mathematic teacher, a wealth of ideas were provided to encourage development of the classroom lesson. To the educator, SMSG produced a functioning program prepared by research experts and educators that was far beyond the pleas for reform. SMSG had written, printed and circulated the summation of the efforts of the individual participants producing materials far and above the efforts of any individual productions. This verified the mathematical axiom that a whole was greater than its parts.

A conference held in Chicago on Future Responsibilities for School Mathematics in February 1961 under SMSG was financed by NSF. The purpose of this conference was "to consider ways of continuing the work which SMSG had begun."[40] The tremendous assets derived from close communications among researchers, the universities, and secondary mathematics educators, needed to be continued. A major presentation was given by M.H. Stone of the University of Chicago on the "Future of Mathematics Education." Stone's presentation stimulated discussion which led to specific recommendations for SMSG including testing the material on students. Stone cautioned SMSG to investigate psychological issues dealing with the students.

A subgroup of SMSG, having a continuous plan and rotating membership, was formed to monitor the evolving and rapid changes in mathematics. Both UICSM and SMSG had full-time groups operating throughout the year. The work of SMSG, UICSM and the Commission on Mathematics of CEEB remained essentially in urban centers but this must change.

Means needed to be found to disseminate the curriculum improvements of these groups. The NCTM sponsored regional conferences for administrators, but additional conferences were needed to reach the non-urban areas. The Mathematics Association of America must expand its Visiting

Lecture Program so that teachers, university faculty and school administrators could be informed. Future responsibilities of SMSG included the publication of its experimental textual materials into commercial books. SMSG supported the inclusion of applications of mathematics in the secondary program as well as experimental equipment such as teaching machines. A key responsibility of SMSG was to continue its support of teacher education programs.[41]

At the conference, February 1961, most felt that the original goals of SMSG were attained. However, SMSG would continue work on its sample texts and monographs on special topics.

> The primary goals of SMSG should be to foster research and development in the fields of curricular content and mathematics teaching and to take whatever steps it can to promote the widespread adoption of established advances in either course content or pedagogy.[42]

SMSG would develop material for other than college-capable students in mathematics education and continue, as did UICSM, to train teachers to use new material through in-service and summer institutes.

In addition to more conferences and the publication of SMSG materials, the future demanded that SMSG organize a booklet, to present to a teacher considering SMSG's program, which would specify the aims and purpose of the SMSG approach. Another responsibility of SMSG, was the creation of evaluation instruments.

Listed as participants in this SMSG Conference were forty-seven outstanding leaders in mathematics education including: Allendoerfer, Beberman, Begle, Fehr, Price, Rees, Stone and Tucker. Many listened and observed the work of SMSG because such people shared their ideas, theories and efforts.[43]

In Mathematics Teacher, December 1962, recommendations were given to improve secondary mathematics. For college preparatory courses, the recommendations of Comission on Mathematics of CEEB and Secondary School Curriculum of NCTM were stressed. The experimental work of UICSM and SMSG was praised. In the area of remedial mathematics little had been done, but SMSG had a study underway. All students needed to understand the structure and language of mathematics. With the guidance of an experienced well prepared teacher much was accomplished.[44]

In that same issue, Edward Begle announced a National Longitudinal Study of Mathematical Abilities under SMSG funded by NSF. Richard Alpert a psychologist from Harvard University joined Begle, Beberman and others to prepare an extensive battery of tests. The study was to extend for five years. Starting with a test to inventory the student's mathematical knowledge, later tests would monitor their progress. Wanting to measure far more than skills, Begle also wanted to measure the understanding of mathematics. Therefore, new ideas in measurement were required.[45]

Another article printed in The Mathematics Teacher, described a comparative study of SMSG, an outgrowth of the older UICSM project, and traditional classes. Using the Roseville Public Schools in St. Paul, Minnesota, some 172 students were assigned to either traditional or SMSG classes. A random sample of seventh and eighth graders revealed that seventh grade SMSG students scored slightly higher than the traditionally prepared students, while the eighth graders mean was higher with the traditional approach. In grade nine, no significant difference existed, but the SMSG students did better on the grade ten results. The results showed no advantage for classes using SMSG materials. However, the tests themselves were questioned. To prepare a better tool, SMSG was to develop tests which better examined the purposes of the SMSG program.[46]

During 1963 more volumes were printed in the SMSG series _Studies in Mathematics_. Volume IX was a course for elementary teachers and Volume X was devoted to _Applied Mathematics in the High School_ which included a series of lectures by Max M. Scheffer who stressed mathematics as cumulative not scraps of information. A third, Volume XI called _Mathematical Methods in Science_ was written by George Polya who also developed Volume XI with astronomy. Volume XII was for junior high school teachers to expand their mathematical language, set theory and enthusiasm for mathematics and Volume XIII provided an _Inservice Course in Mathematics for Primary School Teachers_.

From these volumes clear evidence was present which revealed SMSG was concerned with far more than curriculum. SMSG sought to educate and prepare mathematics teachers. The educational community was extremely aware of the projected acute teacher shortages. In the ten year period (1955-1965) total school enrollments would move from 38,000,000 to 51,500,000, a 36 percent increase. Secondary school enrollment would grow from 7,400,000 to 11,900,000, an increase of 60 percent. This growth alone demanded over 90,000 new teachers each year. However, the Educational Policies Commission's report stated, "In the class of 1955 slightly more than one-half of those who were prepared to teach science actually became science teachers in the nation's high schools."[47] It was also imperative that experienced teachers were encouraged to remain in teaching and expand their knowledge and methods. Educational Policies Commission's Manpower and Education further stated, "The fact that teacher shortages constitute a crucial hindrance in supplying essential education for meeting manpower needs makes the teacher shortage a matter of concern for all who deal with manpower."[48] Thus, the National Education Association supported efforts to recruit new teachers, to retrain able teachers and to reeducate teachers. These were made realities through projects like UICSM and SMSG.

Manpower shortages were projected for basic research, engineering, technology, health services as well as general education. While in mid 1950s, the elementary school shortages were a reality, the high schools also were beginning to feel the shortage. To fulfill the need for future scientists and engineers, the demand for secondary mathematics teachers was accelerating. Thus, the work of SMSG to encourage and to interest students in the field of mathematics was directed to a particularly vital need to educate trained persons. Through its efforts, SMSG did much to encourage and to support mathematics teachers. SMSG extended assistance through enriched materials, teacher commentaries and inservice education.[49]

After the Congress passed the National Defense Education Act in 1958, national interest centered on education, especially in mathematics and science. The adequacy of the subject matter of mathematics and science needed to reflect the rapid growth of technological development. Studies, such as Qualifications and Teaching Loads of Mathematics and Science Teachers, prepared by U.S. Office of Education and National Science Foundation, provided valued information to mathematics projects supplying data and facts which dramatized the crisis. This study, concentrated in Maryland, New Jersey, and Virginia, interviewed teachers with at least one secondary class in mathematics. The study reported details on credits, schedules and preparation time for classes. Astonishingly 7.1 percent of the 799 teachers had no college mathematics and were usually assigned to teach general mathematics classes. It was encouraging that 487 of 799 teachers took calculus or more advanced courses. However, over one-quarter of them studied these subjects prior to 1940, which was prior to the atomic era in mathematics and science.[50]

Statistical evidence accumulated by the federal government verified that extraordinary means must be developed to remedy this desperate situation. When, asked to state their greatest need, the mathematics teachers disclosed "that they needed more college mathematics classes."[51] Basically 80 percent wanted mathematics classes and 20 percent wanted classes in teaching of mathematics. This finding greatly supported the work of workshops, institutes and inservice educational programs in mathematics, funded by NSF such as UICSM and SMSG. The competency of the teacher needed to be raised through experimental and developmental projects. Thus, the secondary mathematics students would reap the benefits. The research supported that a "positive relationship between the number of credit hours obtained in a major field and the teacher's field of greatest competence is in harmony."[52] Therefore, the fundamental need to supply such class was apparent.

To serve the mathematics teachers was a focal point within SMSG. However, this was not limited to the improvement and to the distribution of new curriculum materials or to the development of an updated continuous teacher education program. Communication of the accomplishments and research with SMSG was a critical area necessary to expand the teacher's information. The publication and dissemination of available materials, inservice training and regional meetings were announced in the SMSG's own Newsletter.

In SMSG Newsletter No. 1 the objectives for the entire project were best recorded. Acknowledging the demands for greater mathematical achievements and applications, the SMSG program stated, "It is important that mathematics be so taught that students will be able in later life to learn the new mathematical skills which the future will surely demand of many of them."[53] SMSG believed a new curriculum was necessary to attract capable students and to prepare teachers for the new challenge. Through this Newsletter vital information was distributed nationwide on the gradual progress and developments of SMSG. The lines of communication, essential to the success of SMSG, were well established by a simple, but informative house journal.

In March 1960, the Newsletter No. 4 outlined, in detail, the plan for SMSG. In the original meetings of the presidents of MAA, AMS and NCTM at Yale in 1958, the basic objectives included more mathematical knowledge for the world in this technological era. The teaching of mathematics would be significantly advanced. SMSG achieved improvement of mathematics curriculum, attracted the best to mathematics and assisted the teachers. This issue of Newsletter included an outline of the projects. The first, written at the University of Michigan in 1959, concentrated on seventh and eight grades. The second project was to restructure the mathematics program for secondary schools stressing concepts, logic and understanding. Monographs were written to supplement high school mathematics programs. Teacher training materials were of critical importance in the outlined plan. The 1960 list of projects included a major effort to work with the less academically able mathematics student. A general revision of the entire elementary mathematics program was established as a goal since the early foundations were critical to later development. SMSG also wanted to prepare special materials for the gifted child to awaken and challenge his talent. Along with an announcement that texts would be available by the next year 1961, the Newsletter stimulated nationwide interest in the future of this new organization.[54]

Many topics and issues were presented by SMSG through its Newsletter, and some were of special interest like "Psychological Factors in Mathematics Education" in 1963. They discussed many independent variables which effect the student such as text, teacher, parents, past performance, interest, ability, peers and school environment. Also, the students' attitude toward their own ability and to mathematics itself directly influenced the students' motives.

The report on psychological factors suggested mathematical performance directly related to personal attitudes, anxiety, self-concept, expectations and parents. While these factors may not be within the mathematics teacher's power to control, the teacher needed to be aware of these to fully appreciate the student's position in the mathematics classroom and to creatively develop the student's abilities.[55]

The mathematics teacher was to pay attention to the psychological determinants of a successful mathematics program. The future demanded better prepared teachers, acutely aware of the student, able to assess the variables, and willing to experiment. Very clearly stated in 1963, the SMSG project recognized a "need for communicating to parents the nature of their impact on their children's mathematics education."[56]

From 1960 to 1976, a total of forty-three Newsletters were printed. The last issue was in August of 1976. Some announced meetings, included revision of materials, and recommended inservice courses. Newsletter No. 5 (November 1960) and Newsletter No. 19 (September 1964) were devoted to inservice recommendations and summer institutes. However, a complaint was that not enough time nor money was devoted to recruiting and training leaders for these inservice education programs.

Newsletter No. 21 (May 1965) announced a series of monographs, known as the New Mathematical Library (NML).

They were to disseminate good mathematics, awaken the interest of the gifted student, and describe mathematical activities. They were not textbooks but provided supplemental topics or selected chapters for class discussions. The books were designed to increase in difficulty as the reader progressed. The Newsletter included samples of the books to encourage teachers to order them and reminded them that NDEA funds could be used for their purchase. The teachers were reminded to ask school librarians to order these books.[57]

The diversified topics of the Newsletter offered readers challenges to investigate, programs to follow, in-services to attend and monographs to order. This communication tool did a great deal to popularize SMSG's efforts and materials. SMSG was before the mathematics community, establishing itself as a nationwide program, funded by NSF, which had a reform product to offer mathematics education. Looking at the tremendous outpouring of materials, mathematics teachers identified SMSG as a positive, active program which offered assistance to them and their students. SMSG extended far beyond their first purpose of preparing an improved mathematics curriculum. As the nation redirected its major funding in 1965 through the efforts of President Johnson's Great Society, the SMSG printed Volume XIII of Studies in Mathematics on primary schools. Studies delved, for the first time, into the problems of the culturally deprived child.[58]

It is important to remember that President Kennedy wanted new legislation which would increase the quality and availability of education. Kennedy said, "A free nation can rise no higher than the standard of excellence set in its schools and colleges."[59] He asked Congress to pass a National Education Improvement Act. Kennedy felt that educational reform and funding was a vital national interest, but he could not gain legislative support. Kennedy cited the National Defense Education Act as having demonstrated "that Federal support can benefit national education goals without leading to Federal control."[60] This desire to expand and upgrade educational training institutes and to improve the teachers knowledge and skill, never passed Congress.

It was in the Eighty-ninth Congress that so much was accomplished. President Johnson described this Congress, " . . . as the greatest in American history . . . from your committees and both houses have come the greatest outpouring of creative legislation."[61] Johnson felt the laws would be passed to fund ideas.

> We must demand that our schools increase not only the quantity but the quality of American education. For we recognize that the Nuclear Age problems cannot be solved with horse and buggy learning. The three R's of our school system must be supported by the three T's--teachers who are superior, techniques of instruction that are modern, and thinking about education which places it first in all our plans and hopes.[62]

Congress passed the Elementary and Secondary Education Bill, an outstanding piece of legislation, which addressed the establishment of human and social equality within the schools.

The reforms now addressed the deprived child. The focus faced the question of bias in curriculum, testing and school organization. The pressure of the anti-Viet Nam War movements also affected schools so that national self-doubts clouded the earlier goals of Johnson's Great Society program. The earlier demands for excellence within the reform of mathematics education in curriculum, recruitment, teacher preparation, and motivation, no longer seemed a priority. They were set side for a humanistic investigation of our nation's educational needs.[63]

SMSG investigated in 1965-66 the "culturally deprived" child who still received far too much rote learning which led to further deprivation. SMSG believed students must understand why mathematical process works as well as how it works. A great deal of effort was spent attempting to learn about the child, an approach long neglected by SMSG, and to facilitate a program which would provide better mathematics instruction. As a result, three appendices were included in the SMSG book, <u>Inservice Course in Mathematics for Primary School Teachers</u>. The first described the SMSG program, the second explained language and mathematical learning, and the third was a repository of observations and testing of other children.[64]

In what SMSG called Chapter O, SMSG described the culturally disadvantaged child, identified by:

> low economic status and lack of participation in middle-class culture . . .

> The culturally disadvantaged group consists mainly of urban slum-dwelling people . . . inclusion of such marginal subsistence groups as segregated rural Negroes, dwellers in the depressed areas of Appalachia, and many American Indian groups.[65]

SMSG listed as contributing factors: physical living conditions, hostility of the environment, child-parent relationship, scheduling of time, and lack of pre-school learning experience.

The list did not address many factors which contributed to the students' lack of interest, motivation and enthusiasm, but the list, for the first time, acknowledged the existence of the tremendous number of variables influencing students. The child presented with the most improved curriculum, taught by the correctly trained caring teacher, supplied with new materials and equipment, can only learn mathematics when he was prepared to learn. This preparation included the most basic of human needs, proper food, shelter and clothing, enriched with encouragement and a realization that future goals were possible.[66]

In a rather impersonal way the SMSG project noted some characteristics of culturally-deprived children. These children had a low self-image, limited verbal expression, undeveloped sensory skills, such as identification, eye-hand co-ordination and auditory discrimination, and little goal motivation. The very realization of these variables, identified the mathematics student as an individual with special needs. The child brought to his classroom considerable personal baggage which contributed to his attitudes about mathematics and to his motivation to study it. SMSG erred by not including human concerns until late in the program, well after the textual materials and monograph were prepared. It was hoped that modifications of the material would make SMSG materials suitable for all children.[67]

The implication was clear that teacher's attitude was extremely important in the early years. The teacher had to realize and adjust the program when the disadvantaged student appeared to have little prior pre-school learning. The teacher was to maintain a warm and supportive relationship with all students especially those who found the authority of the school so removed from their extended family. The teacher's knowledge of the child was, for the first time in SMSG, included as a major contributing factor, in a child's mathematical education, right along with curriculum, mathematical talents or interest and teacher preparation.[68]

The National Council of Teachers of Mathematics established in 1959 the Committee on Analysis of Experimental Mathematics Programs which investigated over a five year period the unique characteristics of eight revision projects. SMSG was one of these four programs working mainly on secondary mathematics education. The Boston College Mathematics Institute (BCMI), begun in 1953, had as its purpose the re-education of high school teachers in elementary contemporary mathematics. This remained a local investigation with no evaluation tool to verify its success. The UICSM was established in 1951 and served as a model for many projects to follow establishing logic, language and understanding as focal points of the UICSM project.

A small project, The Developmental Project in Secondary Mathematics at Southern Illinois University followed, but developed only two texts presumably for ninth grade. This project's material had very little circulation and very little influence. The fourth project, SMSG, had a national distribution of its work and was the leading developer of reformed mathematical material for secondary schools.[69]

The SMSG project was identified as beginning in 1958 at Yale under the directorship of Edward G. Begle. The purpose, as stated in The Analysis of New Mathematics Programs, was to achieve a level in the student's mathematics education so that at any point in later life the new mathematical skills required would be easily learned. This was to be done by improving curriculum, by attracting able students to mathematics, and by helping teachers. The list definitely agreed with the written aims originally given by SMSG.[70]

The language of SMSG's program was judged to be sophisticated and precise, stressing logic and abstractions. SMSG included social applications and appeared to be correctly written for the level intended. The Analysis of the New Mathematics Program stated that the algebra text was very good, uniting the abstract with the practical. The geometry text also received a high mark because it stressed structure and contained much algebra. Elementary functions text was satisfactory for an introductory level of study. Credit was given SMSG for its excellent preparation enabling the student to handle so sophisticated a topic.[71]

In response to the analyses written by the committee of NCTM, Edward G. Begle stated, "These analyses of SMSG texts for grades seven through twelve will be very encouraging to the authors, since they indicate that the authors succeeded in doing what they set out to do."[72] SMSG was to explore new mathematical discoveries and to improve mathematics education so that these ideas would best be presented to the student.

As identified in The Analysis, by the NCTM, the SMSG Supplementary and Enrichment Series was excellent. An investigation of the pamphlet on Functions revealed many characteristics which were unique and well presented. The unit, Functions, was intended to be used after two and a half or three years of sequential mathematics. Functions began, as many SMSG units, with a background section on set theory which was easily set aside if the student already understood the topic.

SMSG approached the definition of a function through examples relating to mathematics and other fields. As the written discussion continued, the vocabulary was precise leading to a gradual discovery of the concepts of an association and function. Only then was the formal definition given: "If with each element of a set A there is associated in some way exactly one element of set B, then this association is called a function from A to B."[73] The symbolic representation of a function was also shown: $f:x \rightarrow f(x)$ leading to further abstractions.

For the experienced mathematics teacher, educated prior to the establishment of structural foundation through set theory, such a pamphlet was a radical departure from traditional textual material which often contained disjointed algebraic skills. Building an understanding on the existing and discovering the possible was the uniqueness of the new approach to mathematics education. A gradual movement from the simple idea to abstract concept stirred the imagination and creativity on both sides of the teacher's desk.

Within a companion commentary, SMSG provided valuable assistance to support even the novice with the new approach to mathematics. Written in almost a conversational style, the teacher was offered a variety of techniques to be used in teaching the concept, function. There were excellent examples and approaches to clarify the concept as well as to build the student's understanding. Within a short period of time the innovations of SMSG were incorporated within commercial textbooks marketed nationwide and enthusiastically accepted.[74]

The numerous volumes produced by SMSG established positive evidence that SMSG's purpose, to reform the mathematics curriculum, was actualized. For in reality, SMSG established a wealth of curriculum reforms which won the support of commercial publishers who saw not only the educational merits of Begle's illustrious group of mathematicians and mathematics educators, but also the marketing powers of SMSG's leaders. As the public and nationwide demands for an improvement of mathematics education supported by the National Science Foundation and the National Defense Education Act continued, the commercial producers of books, equipment, and materials willingly supplied the demand.

Within the enthusiasm of the creative atmosphere of SMSG project, the stress was on a program based on individual growth and achievement according to the student's ability. Hopefully, a balance between understanding concepts and mastering skills would achieve true improvement in mathematics. It was not until Volume XIII that other personal issues, dealing with the student, family, community and self-concept, finally were considered by SMSG. Unfortunately the first impression lasted the longest, for SMSG had been characterized as a pre-college program too closely identified with the gifted mathematics student and too neglectful of the below average student. Few remembered that SMSG found that many truly talented mathematics students were not challenged by the approach of SMSG. The recommendations of the Commission on Mathematics of the CEEB were guidelines for SMSG, but the writers and evaluators considered all secondary students encouraging them to grow in knowledge and in interest for mathematics.

From the widespread distribution of its findings, from the influence of its workshop and institutes, and from the enthusiasm of mathematics teachers, the reform efforts of the 1950s and early 1960s characterized a new policy of federal support for a nationwide program to address educational issues. Changes occurred slowly but directly in education. These changes began first in the minds of the researcher, matured in hopes of mathematics educators, supported by national funding, accepted by the secondary school system and encouraged by political leaders as essential to our democratic life in America.

More than curriculum reform had been achieved. The stimulation of both student and teacher to grasp the new and to understand and to apply it, encouraged further work between the professional mathematician and mathematics educator. A definite course of action had been established by the earlier work of UICSM and by the achievements of SMSG. The policy was established that with combined efforts and the tremendous financial backing of federal funds dramatic changes were possible within mathematics education. Any periodic crisis in education, addressed and fought as mathematics reforms were done in 1950-65, would not for long remain a crisis.[75]

Begle's own commentary on SMSG, written ten years after its origin, maintained that SMSG had a responsibility to the future. He wanted a continuous exploration of the fundamental principles underlying mathematics education along with publicity for SMSG projects' textbooks. Later SMSG included work for the remedial elementary student and a limited program for the gifted. A special panel, supported by NSF, translated the material into Spanish.

After the writing was completed, SMSG wanted to view the entire secondary program as a whole. This was not to be a revision of its earlier material, but realistic involvement of applications within the unified program. This time, however, SMSG wanted any curriculum revisions to be approached experimentally with extensive evaluation. The monographs prepared were excellent, teacher institutes were significant, and programmed learning was available. The Educational Testing Service studied the achievement of students using SMSG material. Later a more extensive evaluation was done by National Longitudinal Study of Mathematics Abilities. Begle stated his analysis in 1968:

> It is apparent that each of these activities has been aimed directly at some aspect of the goals and objectives of SMSG. It is equally apparent that together they come nowhere near a complete fulfillment of these goals and purposes. There is much left to be done.[76]

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CHAPTER VI

IMPACT OF THE NEW SECONDARY SCHOOL MATHEMATICS AND RESPONSES TO THE REFORM

Chapter Six will examine the wide scope of reforms and the position of both supporters and critics. The impact of the new secondary school mathematics altered policies. Of major importance to the historical development of policy changes within mathematics education were the accomplishments of America's mathematics projects. It was through the unified efforts of mathematicians and mathematics teachers that the aims, purposes and writings of the mathematics projects formulated a national approach to teaching mathematics. Through inservice training institutes and the distribution of materials, America became aware of the tremendous reform efforts and accepted the achievements as the long sought after changes needed in mathematics education.

As the 1950s drew to an end, the acknowledgement of the need of reforms in mathematics education was well established. Already reforms were being done through early model programs like the University of Illinois Committee on School Mathematics (UICSM). The design, productive achievements, experimentation and revisions had been in progress since 1951. First established and funded by the University of Illinois, later receiving financial support from the

Carnegie Fund, National Science Foundation and National Defense Education Act, the UICSM created a pattern for other mathematics projects to emulate.

The Commission on Mathematics of the College Entrance Examination Board (CEEB) structured revisions for mathematics education which had national implications since an expanding number of colleges used the CEEB testing service. If colleges accepted the test results, secondary schools to articulate with colleges needed to adapt preparatory programs to implement the guide lines. Other pragmatic forces such as the demand to prepare the students to function effectively in America's scientific and technological era supported and encouraged the mathematics reforms.

The National Council of the Teachers of Mathematics (NCTM) in 1959 had made specific recommendations for reforming the Secondary School Curriculum. NCTM developed a prestigious criterion, written by experts, which provided a wealth of suggestions, approaches and concepts for a new mathematics education.

The School Mathematics Study Group (SMSG) had written many of their textual materials as the 1960s began. The national leadership of SMSG was established, its materials widely circulated and its institutes were well attended. The creative leadership, exhibited by UICSM and SMSG through its inservice education, workshops and institutes, benefited the mathematics community as a whole as well as directly assisting the student and teachers.

Much of the research in the early 1960s centered around evaluation of the work in progress, criticism of the efforts and dissemination of an ever widening amount of the information developed through the efforts to reform mathematics education. The United States Office of Education provided opportunities to research the programs in progress and to disseminate its findings.

At a conference held in March of 1960, sponsored by the U.S. Department of Health, Education and Welfare (HEW) and the National Council of Teachers of Mathematics, the inservice education provided for high school mathematics teachers was investigated. The Conference on Inservice Education stressed the expansion of the new curriculum, citing the specific recommendations of UICSM, SMSG, CEEB and the Secondary School Committee of NCTM. The conference commended the inclusion of set and function theory, the logical deduction of geometry with expansion of analytic geometry, and the stress on language, understanding and structure. These changes demanded well qualified and skilled teachers. Therefore, the conference praised the benefits achieved through inservice and institutes.[1]

Dr. W.L. Duren, a member of the inservice conference, addressed the issue that high schools were not staffed by adequately prepared teachers. He recommended that salaries be raised, qualifications expanded, teacher training greatly modified, and summer institutes and inservice education broadened. To keep pace with the twentieth century's technological demands calculus must be introduced to more high school students. However, this required a high school teacher capable of teaching what was previously a college program.[2]

Dr. Henry W. Syer, another member, surveyed colleges and found that 64 percent had sponsored an institute funded by National Science Foundation (NSF). Others were sponsored by private funds such as the Ford Foundation. Some universities excused themselves from direct involvement when outside funding was not provided. Others required high school teachers to pay their own expenses. Some provided consulting assistance to the local high school program.[3]

The state departments of education also fostered and provided study groups. Some demanded little background preparation while others required considerable mathematical knowledge. At the state levels, various techniques, such as formal classes, conferences, lectures and curriculum planning sessions were attempted. Some provided unusual assistance, conducted by distinguished leaders, while others achieved little.

One of the beneficial results was a cooperative program established by neighboring colleges, using a college liaison to encourage the local school system. The lines of communication gave assurance and support to the secondary teacher's efforts to change mathematic programs within his or her building.[4]

An Illinois Plan for Improvement of Instruction was cited as broad and effective. Begun in April 1958 with NDEA Title III funds, consultants were appointed statewide to assist elementary school mathematics teachers. This assistance for elementary teachers was provided since NSF institutes had existed only for high school teachers. Illinois requested SMSG materials and used them with the consultants. Telecasts were conducted for inservice training by Channel 11 in Chicago which offered several courses. The state legislature considered the establishment of TV connections to classrooms at a cost of $11.5 million. Gussie Phillips, a mathematics consultant for the Illinois Office of the Superintendent of Instruction, prepared an extensive report on Illinois' work in teacher preparation and inservice education for the Inservice Conference. Illinois had established a well-prepared program that could serve as a model for other states.[5]

Under NDEA, counseling had received major support. Conant in the <u>American High School</u> had, along with Rickover, advocated a strong counseling program to direct students to study mathematics and science and to choose careers beneficial to the national interest. A well-designed guidance program should assist students in selecting courses, colleges and careers.[6]

The report on guidance training provided by the U.S. Department of HEW revealed that America's high schools attempted to educate children with IQ scores ranging from 85 to 165. Since World War II, a greater interest was directed to the high level student, the college capable. The conference report stated, "It is the student with college-level ability that NDEA legislation is designed to help."[7] However, guidance must be available so that services were available to all students, the gifted, the average, the retarded, and the socially maladjusted.

A regional conference of NCTM, chaired by G. Bailey Price, of the Department of Mathematics at University of Kansas, claimed that the progress in mathematics had been so extensive that it should be called a revolution. Both the tremendous advance in mathematics and in automation influenced mathematics education. The theoretical and analytical procedures demanded mathematical understanding to organize data in the quest for knowledge.

In this 1961 meeting, several questions remained to be addressed: Was America's mathematics education adequate for the technological era? Did teachers know mathematics well enough to enthusiastically encourage the talented students to explore, the average students to achieve, and the struggling student to grow?

Price said that it was critical to retain present mathematics teachers, to assist them to improve teaching techniques, and to prepare the new teachers sufficiently. In addition Price wanted smaller high schools consolidated so that a larger student body would experience a more diversified curriculum.

Attending this meeting was Kenneth G. Brown, a specialist in mathematics for U.S. Department of HEW, who stated the need for improvement in school mathematics was recognized by the Carnegie Foundation which gave $500,000 and the NSF which gave $4 million to SMSG to develop sample textbooks. Brown reported that SMSG's work was the product of the combined effort of 100 mathematicians and 100 high school teachers in producing mathematically sound and teachable materials. Brown also noted the work of Beberman at UICSM which, by 1960, had influenced 25 states, some 200 teachers, and over 10,000 students who used UICSM materials.[8]

Brown mentioned the University of Maryland projects for seventh and eighth graders, directed by John Mayor, which attempted to bridge the gap between arithmetic and high school mathematics. Maryland's work helped to provide background and research for the SMSG project.

Brown also mentioned the Boston College Mathematics Institute, conducted by Rev. Stanley J. Bezuska, S.J., which stressed the development of students' imagination and creativity in grades eight through twelve. The Ball State Teachers College project stressed logical development of the presentation of material within texts. This project was directed by Charles Brumfiel, who later continued his work at the University of Michigan. Another project for ninth and tenth grades was conducted at Southern Illinois University by Morton K. Kenner and Dwain E. Small. The Southern Illinois Project had a small audience, but its work emphasizing sets and axioms, was well done.[9]

To actualize the recommendations of CEEB and the NCTM and to expand the findings, research, and materials of the many mathematics projects, the report of the regional conference of NCTM stated that all must unite to implement the new mathematics in secondary schools. To do this, the appropriate educational authorities must see the need. The students needed to be selected and placed so that they could effectively achieve mathematical skill and knowledge. The parents needed to be informed of the goals and aims of the programs and how the programs will assist their children. The teachers should be better prepared and provided with opportunities to continuously expand their knowledge of content and pedagogy.[10]

Brown and the federal analysts still wanted the reforms to continue and information to be diffused. Reform produced change in secondary schools throughout America in contrast to earlier local efforts. Not all in America had faced the need for changes. Others realized that some changes in mathematics education already needed to be readjusted and revised.

Francis Keppel, dean of the graduate school of education at Harvard University, believed that real changes in education occurred through its personnel. The schools in 1961 were faced with three primary forces. Keppel stated, "The first is the demand of the domestic economy that the high school become an extension of the primary school."[11] The high school was a screening device where the student explored a variety of possibilities. Without a high school diploma, unemployment was a probable consequence for one's economic future. A second force, "makes the American of the 1960s think of education as a battlefield, in which victory will go to the nation with the best trained and most determined population."[12] Keppel's second force made education an instrument of foreign policy. Keppel considered the third force to be "locality: the impact on the curriculum of the climate of thought in the area."[13] Here attitude, background and environment brought much to the school setting. As Keppel said:

> If my line of reasoning is correct, if for the reasons of national defense we wish both to assure equality of opportunity and the greatest development of scientific talent, our fiscal policies should put far more support behind the schools in the slums than in the suburbs.[14]

Keppel's suggestions reflected an attitude which would be soon adopted through the efforts of Johnson's Great Society. His recommendations had been too long neglected in national mathematics reform efforts.

Keppel claimed that the federal government spent $119 million on agricultural research but gave only a few million to the U.S. Office of Education for the Cooperative Research Program under Title VII of NDEA. Americans, Keppel believed, were not pleased with antiquated methods and desired a real curriculum for all students to achieve their fullest potential. Educational improvements demanded ever increasing funds as inflation, which tripled the cost of education in the 1950s, was projected to again double by the end of 1960s. America's dissatisfaction with old educational methods created a willingness to accept new ideas. A mood filled with innovation sparked a creative air. Critical problems within education needed to be continuously addressed.[15]

Norton Levy, a high school teacher from Massachusetts, suggested that mathematics reform efforts were not adequate. The objectives of SMSG wanted the citizen to better understand the role of mathematics in the modern world. Levy believed this broad goal was too much to ask the newly fashioned courses or freshly prepared teachers to achieve. The best way, suggested by Levy, was to incorporate the abstract mathematics with the concrete by utilizing the community at large and by gaining from this a community of consultants.

Levy sent out 335 questionnaires in his local Massachusetts community of 12,000 people seeking assistance.

some twelve people became guest speakers for his classes. Thirteen community members arranged student visits to their places of employment while others joined planning sessions, tutored students and discussed careers with students. The community consultants suggested applications of mathematics to history, to games and to encourage girls to study mathematics. After the study, Levy realized that a four-year college education should not be recommended to all students since a two-year technological education may be better for some.

Levy's research of the reforms of mathematics education cautioned the educational community not to assume that all problems could be solved through the approach taken by the reform committees and conferences. Many adjustments needed to be made at a local level to use its potential available and to create an expanded program beneficial to the student.[16]

In December 1961, the First Inter-American Conference on Mathematics Education was held in Bogotá, Columbia. The response to the welcoming address was given by Marshall H. Stone, a mathematics educator from the University of Chicago. He stated that United States wanted to improve mathematics education for the twentieth century by developing mathematics with imagination and skill. College professors were critically needed. Some American secondary school training institutes had weaknesses while others made tremendous contributions. Stone cited Edward G. Begle, a member of the conference, as the "leader of principal organization carrying on this important work in the United States, Professor E.G. Begle, director of SMSG, now at Stanford University."[17]

Stone later presented his paper, "Some Characteristic Tendencies in Modern Mathematics," which examined the explosive proliferation of mathematics and its applications. While the new mathematics stressed the importance of algebra, Modern Algebra was not being developed at the university level. However, its fundamental concepts and techniques were essential to lead one to levels of abstractions and a study of algebraic systems, sets, groups, rings and fields.

Stone stated that the child should be confronted very early with the function concept. Even a superficial exposure established a familiarity to a common underlying principle of mathematics. The expertise of a good teacher, aware of psychological problems involved in educating, was vital. From concrete thinking about real situations arose the meaningful mathematics problem. From the problem, the student received a key to its solution and was led to the abstract concept.

Stone told his audience that symbols represent ideas of the mind and that memory and recall allowed the mind to compare symbols. Dissecting and combining symbols, the mind would effect inference and abstract thinking. All these procedures must be comprehended and mastered by the mathematics teacher wishing to draw the student into the logic which is necessary in algebra and mathematics development.[18]

Stone made another critical observation. He said,

> From a pedagogical point of view, there is an antithesis between the manipulative aspects of mathematics--that is to say--the correct, and at the bottom mechanical calculation with mathematical symbols and the intuitive search for the patterns or structural feature latent in particular mathematics systems.[19]

The modern approach to mathematics was often falsely judged to stress understanding and logical development while down playing memory activities. This was not the intention of developers of mathematics reform for they realized that teaching memory alone extinguished interest and imagination. However, they knew that structural insights often aided manipulative skills. Essentially both were needed to be developed in modern mathematics, creating a true unity.

Another member of this Americas Conference was Edward G. Begle who presented a paper, "The Reform of Mathematics Education in the United States of America." In 1961, he stated that reform had been necessary to satisfy the demands of both mathematics and science teachers who claimed that so much of mathematics was obsolete. Society was more dependent on mathematics and science.

Begle outlined a progression of developments which contributed to the present status of mathematics education.

In the late 1940s, the University of Chicago investigated eleventh and twelfth grade mathematics. The UICSM, begun in 1951, wanted students to be more involved in generating concepts. Begle credited the University of Maryland with helping advance his work with concepts and structures for seventh and eighth graders. The Commission on Mathematics of CEEB had national importance with its recommendations on revising mathematics curriculum but only produced one product, an excellent book on probability for high school use.[20]

Then in 1958 with the blessing of the Mathematical Association of America, the American Mathematical Society and the National Council of Teachers of Mathematics, the SMSG was formed. Begle told this conference the three primary aims of SMSG were curriculum revision, encouragement of students, and improvement of teacher training and inservice. He applauded the equal authority given members of the SMSG panels whether from high schools or universities. These members, Begle stated, were

> . . . chosen because of their known ability in mathematics and mathematics education and their ability to work successfully in a group . . . not selected because of their own ability, but because of the importance of the positions they occupied . . . almost invariably this turned out to be a grave mistake.[21]

Many who made the greatest contributions were not themselves in influential positions. From their talents and enthusiasm, SMSG received great benefits. Begle felt, "Some progress is being made, but much remains to be done and most of the programs which I have described will undoubtedly continue into the indefinite future."[22]

Howard F. Fehr's paper on "Reform of Instruction in Geometry" cited the essential change in geometry as dropping self-evident proofs to accept the concept of an axiom, a truth accepted without proof. He praised the work of Birkhoff and Moise, who under NSF, prepared an experimental textbook, SMSG Geometry, which included a treatment of space with vectors, an arithmetization of geometry, and mathematical structure.[23]

In representing the United States at this conference of the countries of the Americas, Fehr, Stone and Begle informed representatives from other countries about the efforts of the past decade to reform mathematics education in the United States. Stone warned that stressing manipulation without intuitive search would create a faulty curriculum. Begle praised the results of the experimental development of SMSG, but realized much still must be done. Fehr praised the advances of SMSG Geometry, but knew that its adoption would take time.

Over the years, the U.S. Department of HEW Office of Education had printed a series of bulletins which analyzed research in the teaching of mathematics. Published in 1963, the Analysis of Research in the Teaching of Mathematics was based on 247 responses from questionnaires sent to 454 colleges. Of those schools, forty-six were doing research in teaching mathematics. Abstracts of forty doctoral dissertations, forty-nine master theses and sixteen non-degree research projects were included in the bulletin. This type of bulletin provided mathematics teachers with current findings in their field.[24]

Such items as problem solving, grouping of students, enrichment programs, teaching aids and work effectiveness study were included. In the high school research, there appeared much interest in the higher ability student. However, no significant evaluation appeared comparing SMSG methods with traditional approach.

What appeared ahead for 1960s was the need to identify the critical areas still to be explored such as improved pedagogical techniques, teaching deprived children, and applications. More researchers in mathematics education were needed to expand and to develop the reforms. Another area that needed improvement was the methods of reporting and communicating the results of experimentation and research to the educational community, parents, and the public.[25]

Others researched education and wrote on the merits of inservice education. The need for a continuous education of working teachers was essential. To keep current with new knowledge and technology in mathematics and science, schools needed well informed teachers. Thus, inservice as a working function of the educational system needed to adjust to the changing curriculum, to the modifications of teacher demands, and to the application of research ideas to the classroom. The new teacher would profit from institutes and inservice by sharing ideas and discussing techniques with others.[26]

James B. Conant's The Education of the American Teacher, a study funded by the Carnegie Corporation which began in 1961, was published in 1963. He noted the quarrels that existed among educators at the turn of the century, the changes that occurred during World War II, and the failure to challenge the academically talented. After Sputnik, Conant saw the layman entering the academic debates.

For Conant, one major error was a lack of cooperation between the academic professors and the secondary schools. For the public, there was too much criticism on both sides and not a unified effort to improve America's education. Conant wanted professional organizations, universities and states to work together to establish new accreditations for teachers. He cited the School Problems Commission of Illinois which worked in this area.

According to Conant, "A greater knowledge of the subject matter is a need of many teachers today and the need will continue for many years."[27] He believed that teachers could expand their knowledge through classwork, institutes, and inservice education. However, Conant's sample of teachers revealed that only 20 percent had attended at least one summer institute. Sample testing of courses was insufficient to establish the merits of a class or a program. Conant stated, "I believe that the ultimate test should be how the teacher actually performs in a classroom, as judged by experienced teachers."[28] This anticipated the significant expansion and development of classroom supervision.

Conant made some critical suggestions for improving the quality of American teachers. They should possess a baccalaureate degree, have student teaching experience, and have an endorsed teaching certificate. He saw no difference between the Bachelor of Science holder and the Bachelor of Arts holder who taught mathematics. With some sixty hours in a liberal arts or a general education, thirty to thirty-six in the specialty field, mathematics, and the remaining hours in professional classes, the mathematics teacher would be prepared effectively to instruct the students. He also believed that inservice education, such as that in progress under NSF, was vital to support, to expand and to encourage the working teacher. The teacher who attends classes and inservice training should be rewarded, but the teacher's self education, which was also vital, was difficult to encourage.[29]

Teacher networking continued to expand through professional organizations, publications, conferences and institutes. Critical to this expansion was the communications of the Office of Education and National Council of

Teachers of Mathematics. In 1964, the NCTM published An Analysis of New Mathematics Programs which contained eight commissions' reports and projects on curriculum programs, including UICSM and SMSG. The programs were examined for their structure, methods, vocabulary, concepts versus skills, use of proof, placement of topics, applications and evaluations.

For the classroom teacher, who often felt isolated from her peers, let alone the research community that was formulating the reform, such bulletins provided insight into what assistance was available. The bulletin allowed the teacher to select a project which appeared suited for the teacher's situation. The experimental projects offered alternatives to the traditional approach to mathematics instruction. Through the NCTM's Mathematics Teachers, teachers were notified of the location, content and application forms for various institutes. With special federal funding which provided stipends for participation, many teachers were encouraged to attend.[30]

A conference, held in March 1963 under the joint auspices of NCTM and the U.S. Office of Education, studied the problem of planning inservice education for mathematics teachers. State supervisors of mathematics and the NCTM Committee on Inservice Education met to discuss existing programs, to find financial support for local and state inservice programs, and to develop pilot programs in states not conducting inservice education.

Lewin A. Wheat, supervisor of high schools for Baltimore, Maryland, saw Maryland's mathematics inservice as a far reaching program offering continuous education to teachers, supervisors and principals in twenty-four local school systems. Although a state wide activity, regional operations were encouraged to implement local needs. The state's leadership in mathematics inservice was enhanced by the National Defense Education Act as well as the curriculum prospects.

Gussie Phillips discussed the Illinois Plan for Improvement of Instruction in Mathematics, a series of workshops for elementary teachers. These workshops arose after a three year study published in 1958 by the Mathematics Study Group of the Planning Committee for the Allerton House Conference on Education in Illinois. With the NDEA funding, consultants were appointed in July 1959 to develop the inservice program. By 1961, nineteen workshops were held throughout the state and the leaders were requested to evaluate each. Only two were held in 1960, by spring of 1963 some twenty-eight were held. Over this three year period, a total of 138 state sponsored workshops were held in Illinois with another fifty-four locally sponsored workshops. Some discussed the materials of UICSM and other high school groups used SMSG materials. The wide use of workshop and inservice education in Illinois permitted both urban and rural counties to share in the mathematics reform.[31]

There were about 30,000 teachers of mathematics who, by 1963, had attended one or more NSF institutes. These teachers formed a base for new leadership and for planning future workshops. Over a nine year period some $90 million was spent by the federal government. Through Title III of NDEA, matching funds were given state departments of education. In addition, direct grants to colleges were provided by NSF to conduct research and inservice projects. Corporations like Carnegie, Shell Oil, General Electric and the Ford Foundation assisted research and development.

Professional organizations such as NCTM, the Mathematical Association of America (MAA) and the American Mathematical Society (AMS) assisted inservice education through direct support, participation, and providing lecturers. The United States Office of Education had given grants for inservice training and workshops while providing matching funds to the states. There were specialists in mathematics at the Office of Education, such as Kenneth Brown, whose responsibility was "to assist the national effort to improve the quality of instruction in school mathematics."[32] Individual states with matching NDEA Title III funds, assisted mathematics education by learning of recent curriculum developments, by encouraging universities to establish inservice programs, by studying the growing need of the disadvantaged, and by preparing publications to communicate the reforms. The experimental materials of Maryland's Project, UICSM, SMSG and others were given to the parents to gain their support.[33]

The efforts of the National Science Foundation throughout the 1950s and early 1960s to support research assisted the reform of mathematics education. Passed in 1958, the National Defense Education Act had established, with the Office of Education, avenues to put federal funds to work to assist education. Under Title III, improvement of instruction was encouraged. The Office of Education's operating fund for "fiscal 1962 was $499 billion, an increase of 130 percent from 1954."[34] Student loans had been arranged in over 1,000 colleges through NDEA. A wide diversity of programs were made possible through NDEA.

In 1961, Congress extended NDEA for two years at a cost of $500 million. In 1963, after the death of President Kennedy, Lyndon Johnson signed two education measures, one for construction of college facilities and another extension of NDEA, with amendments extending assistance to more students at a cost of $1.5 billion. Now NDEA was to expire on June 30, 1965. So far NDEA "had assisted 7,000 graduate and 490,000 undergraduate students with their schooling. The total expended under Title III for upgrading instruction was $181 million by 1963."[35] Over a six year period of the NDEA a total of 8,500 NDEA fellows, 600,000 undergraduates received federal loans for schooling.

The passage of the Civil Rights Act of 1964 outlawed discrimination in any program receiving federal funds. Many changes were seen in NDEA. "No longer would students applying for loans have to be in the critical 'defense' fields of science, language, mathematics or engineering to receive preference."[36] Other technical schools or business schools could be attended by students receiving federal grants. The "forgiveness" feature for those entering teaching was extended from public to private schools, including college teaching.

Federal funding moved support from mathematics institutes to other directions. Many felt that the critical work of reforming mathematics education had been accomplished, and federal funds could best be directed to other areas of education.[37]

Lyndon Johnson who believed in extending educational opportunities to all people saw the crisis in education from a new view. As a former teacher, who had borrowed money to attend college, Johnson sought to provide federal support to deprived children.

It was reported in 1965 that one-third of the students enrolled in fifth grade would not graduate from high school. Over eight million American adults had not completed fifth grade while fifty-four million had not graduated from high school. Further, of the many college students assisted by NDEA only about one-third came from low income levels.

The Equal Opportunity Act of 1964 began the important war against poverty. Headstart, the Job Corps, and aid to qualified students from low economic backgrounds were enacted to help America's most needy. Congress enacted the Elementary and Secondary Education Act (ESEA) of 1965 through which federal funds were directed to educational service centers, promotional programs for the deprived, and programs for the handicapped, the retarded, the non-English speaking, the pre-school child, the dropout, and the gifted.[38]

The ESEA, an outstanding piece of legislation, which addressed the establishment of human and social equality within the schools was passed with Johnson's direct help by the Eighty-ninth Congress. President Johnson described this Congress "as the greatest in American history . . . from your committees and both houses have come the greatest outpouring of creative legislation."[39]

In 1966, Course and Curriculum Improvement Projects described educational research and curriculum projects in progress. The projects were described as attempting to incorporate contemporary knowledge within the school system. In this 1966 review, SMSG was characterized as a group project in which "text materials were designed to illustrate the kind of curriculum which the members of the group feel is demanded by the increase use of science, technology and mathematics in our society."[40] However, SMSG's membership reflected a narrow group of mathematics educators and mathematicians who did not embrace other educators, psychologists and sociologists who would have added depth and humanism to the problem of reform.

A very important evaluation project was established by SMSG in its National Longitudinal Study of Mathematics Ability. Students originally in grades four, seven and ten were followed to see their performance. The guide listed the achievements of SMSG as including texts for elementary, junior high and senior high students, SMSG supplemental materials, teacher commentaries, new mathematics library, study guides and film courses were also praised.

The guide to improvement projects also included a historical development of the UICSM project. Later UICSM included extensive work for the underachievers in mathematics and, with particular care, for the culturally deprived. All materials were tested in Champaign-Urbana for this newest test group, the deprived. All the experimental material developed from 1951-1962 were obtainable in 1966 from D.C. Heath and Company.

The ideas of UICSM and SMSG were continued through the work of the Cambridge Conference in the summer of 1963 where long range goals of mathematics education were discussed. Later meetings at Cambridge were held to stimulate revisions and further evaluation. In March 1965, a three day conference, at Cambridge, was attended by representatives of major groups involved in reforms of mathematics education. Seeking better communication, a small workshop was planned for the summer of 1965 on these topics, areas of geometry, applications and circular functions. After 1965 the Massachusetts Institute of Technology's Cambridge Project centered on teacher education.[41]

As the funding was redirected and as the public saw a new crisis in education centering on improving life for all our people, the general enthusiasm and support for mathematics education reform lessened. The primary goals of leading projects like UICSM and SMSG were viewed as attained. Many commercial publishers were distributing textbooks which used the innovative ideas of these reform projects such as: Dolciani's _Algebra I_, Merserve's _Mathematics For Secondary School_ and Thomas' _Elements of Calculus_.

America's contributions within reform projects needed to be circulated to other countries. Therefore, in 1966 a Second Inter-American Conference in Lima, Peru, was supported by the Ford Foundation, NSF, SMSG, Organization of American States (OAS) and United Nations Educational, Scientific and Cultural Organization (UNESCO). Its purpose was to indicate to twenty-three countries that a reformed mathematics education was needed for the economic and social growth of their countries.

Howard Fehr presented a paper and maintained that the new curriculum was not that different from the traditional approach of twenty years ago. What was still needed was a reconstructed curriculum which recognized the psychology of learning mathematics while stressing the concepts and theories of a strong mathematical structure.[42]

In reporting the work done in the United States, the primary contributors to reform of mathematics education were listed as the UICSM project, the Commission on Mathematics of CEEB, the Committee for Undergraduate Programs in Mathematics of MAA (CUPM), Secondary School Curriculum Committee of NCTM and materials of SMSG at Stanford University. America had improved mathematics teacher preparation requiring some thirty hours in this academic field and supplying inservice education for the working teacher. The reform had been supported by individual universities, private foundations and the government through NSF and NDEA. The United States was proud of the accomplishments that began in 1950 with the passage of NSF.[43]

Marshall H. Stone, of the University of Chicago, wrote in 1965 a critique of the Cambridge Conference. The purpose of the Cambridge Conference was to formulate views upon the shape and content of pre-college mathematics. However, he did not feel that the conference formulated an "optimum curricula" although its participants were leading mathematicians and mathematics educators, including the director of SMSG, Edward G. Begle.

Stone said, "I am reluctant to believe that the Cambridge Report represents the best thinking of which we in the United States are collectively capable in the field of mathematics education."[44] He found nothing beneficial in a curriculum which consolidated twelve years of mathematics and three years of college work into a secondary program. The merit of the Cambridge Conference was:

> in its willingness to challenge the extent of our current achievements in the field of mathematical education and to demand a thorough and uncompromising revision of the entire school mathematics curriculum from grade K through grade twelve.[45]

The Conference made only indirect references to the accomplishments of prior projects like UICSM, SMSG and CUPM. The international achievements in this area, such as the Inter-American Conference, were not included. It would have been beneficial and "extremely useful to start from one of the existing new treatments of elementary school mathematics, as a first approximation [for example, the SMSG program] and to describe modifications needed to convert it."[46] The Cambridge Conference did not profit from the research and experimentation of other projects. The proposals of the Commission of Mathematics had accelerated a movement pioneered by UICSM which led to SMSG. However, Stone believed that many challenges facing mathematics education would be resolved by 1990, but with suggestions other than those of the Cambridge Conference.

In 1965 the Office of Education published the sixth in a series Analysis of Research in the Teaching of Mathematics. Information was collected by eighty-three colleges. This included one hundred eleven for doctor's degrees, forty-one for master's degrees and twenty-two independent studies. Eighty-one of these were devoted to secondary education, forty-eight to elementary and forty-five to higher education. Such reports gave the mathematics community a consensus of the extensive research in progress during the early 1960s.

A summary of research on SMSG materials verified that students using them did as well as students taught with traditional methods. The SMSG student also learned new and exciting concepts. From a study of ninety-two classes using SMSG in grades seven through twelve, we learned that they did as well as others on standardized tests. This was done by Charles H. Kraft in 1962 at Minnesota National Laboratory. The research indicated that secondary students can now learn concepts which were earlier reserved for college programs.[47]

Kenneth A. Smith developed a comparison of several first year algebra books in 1961. He found that ninth graders using UICSM who were in the upper third on general intelligence tests showed significant gains in understanding basic mathematical concepts. The original aim of UICSM under Max Beberman was to develop an understanding of mathematical concepts. Smith felt that UICSM's First Course in

Algebra used the discovery method with a non-traditional approach. Smith characterized SMSG's Mathematics for High School - First Course in Algebra as having difficult concepts which need a slower pace. He also reviewed Mallory, Skeen and Merserve's First Course in Algebra as traditional in approach but lacking a coordinated attack on the basic concepts of algebra.[48]

The analysis included extensive work on teacher education and inservice training. For the details of 174 studies one must read the work prepared by Kenneth E. Brown, a mathematics specialist for the Office of Education. He provided the mathematics teacher, the administrator and the researcher with ideas and evidence of the work achieved in mathematics education.

In 1967 Frank G. Jenning, a writer for Saturday Review, took an investigative approach to the educational developments since World War II. Our schools were in crisis, but as his article stated, "It Didn't Start With Sputnik." Sputnik made the public realize that "schools were not doing their job."[49]

Jenning stated "very little was said about the dangers of federal aid to education"[50] when almost $13 billion was spent for 7.8 million GIs who advanced their education through the Veterans Readjustment Act. The advances in science and technology along with modern communication and mobility made the United States, a national society. However, the school curriculum had changed very little in post-war America.

The aim of democracy to educate all of America's children required the teaching of practical courses. The Rockefeller Panel Reports of 1958 assessed America's schools and recommended that they provide a greater academic challenge for students. The struggles over the church-state issue, separate but equal charade and the population explosion continued. In such a vast nation, educating many varied students, America's educational system required constant assessment. Through reform conferences and projects, the United States assessed its mathematics education. The reform efforts were a sincere attempt to remove obsolete material and to produce a secondary mathematics program which would better prepare its students.[51]

In retrospect, Edward G. Begle, wrote about SMSG a decade after it began at Yale University in 1958. Begle quoted from the SMSG Newsletter (March 1959) which contained the following objectives: to improve curriculum through the understanding of mathematical concepts, to motivate more students to study mathematics, and to assist the mathematics teachers' development. SMSG fostered research, expanded teaching methods and content. SMSG publicized its work, making it available to anyone who wished to use it. From panels of mathematicians and mathematics teachers, basic discussion generated ideas which were included in SMSG materials. In 1962 both the needs of below average students and extraordinarily gifted students were studied by special SMSG programs.

Monographs, supplementary publications, teacher commentaries, film courses, programmed learning, evaluation in longitudinal studies, and program effectiveness were some of the special areas developed by SMSG. These were activities directed to fulfill the general aims of SMSG. Although much research, and experimentation were involved in the SMSG project to the reform of mathematics education, Begle stated, "It is equally apparent that together these come nowhere near a complete fulfillment of these goals and purpose. There is much left to be done."[52]

One of the major accomplishments of SMSG was the unification of the mathematicians and the classroom mathematics teacher in a common effort to produce a national project. SMSG sold over four million textbooks used by unknown numbers of students. Other commercial books were inspired by SMSG research. The financial support of NSF and participation of many teachers encouraged SMSG's efforts. Begle said, "As long as that support continues, SMSG will continue to work towards its goals."[53]

An extensive report on mathematics education was begun in 1966 by the National Society for the Study of Education (NSSE). It would take four years before its publication. This report clarified the extent of the mathematics revolution which began two decades earlier with the evolving of new mathematics. Edward Begle's introduction noted that new mathematics differed very little from the traditional approach. However, very relevant to the new learning theories were recent developments in psychology of instruction. Jean Piaget, in his The Child's Conception of Numbers, was intrigued by problems of cognitive growth and by knowledge learned through errors. He believed that one's environment might serve to generate a period of disequilibrium from which an expansion of ideas would flow. Piaget's concept of environmental stimulus was in keeping with Pestalozzi's object lesson and Dewey's laboratory techniques. All of these sought to aid the intellectual growth and learning skills of a child.[54]

Although new mathematics contained many of the concepts traditionally taught, the approach, which emphasized understanding concepts, utilized the interrelationship of the concepts and formulated the structure of mathematics through logic and deduction, was revolutionary. The new mathematics presented the school administrator with new problems to address within the financial limits and physical structure of the school. Modifications of the school program were dictated by the expansion of mathematics curriculum. Topics included in the contemporary curriculum, such as calculus and computer classes, were not a part of the secondary program in the 1950s.[55]

Within the <u>Sixty-Ninth Year Book</u> of the National Society for the Study of Education - <u>Mathematics Education</u>, Begle with James W. Wilson, Mathematics Department Chairman, University of Georgia, wrote chapter X, "Evaluation of Mathematics Programs." They evaluated the quality of mathematics, materials used, and pupil outcomes from leading mathematics projects. Wilson and Begle also analyzed the projects' effect on schools.

If the project was in progress then a formative evaluation occurred. If another project had been completed then a summative evaluation was done. The different programs were also compared. However, essential to any evaluation was a measure of student proficiency. Begle and Wilson used a model developed by the National Longitudinal Study of Mathematics Abilities of SMSG. The model included the interdependence of the Number System, Geometry and Algebra as content elements with activities of behavior including computation, comprehension, application and analysis.[56]

Accountability and effectiveness of the reformed mathematics were major areas of concentration for mathematics educators as the 1960s drew to an end. At a symposium, The Twenty-Third State Conference on Educational Research in 1971 in San Diego, California, such items as mathematics laboratories, computer hardware, films, transparencies, audio tapes and games were investigated. Pedagogical aids such as team teaching, sharing university facilities, and establishing an advisory committee from community of scientists and general public were researched.

The studies indicated that the mathematics laboratory as a complex learning environment made new demands on the teacher which were unique from the lecture approach.[57] In addition to Viggo P. Hansen, professor of education at San Fernando Valley State College, Edward G. Begle participated in the discussion of accountability. "Goals and objectives can be specified and tested . . . more sophisticatedly now then ten years ago," said Begle.[58] One needed to evaluate growth relative to specified goals and objectives. Begle considered many tests to be out of date since they evaluated the individual student. What was needed was an evaluation tool which was designed to concentrate on the program, the teacher, and the school.

Begle suggested the SMSG matrix which assessed content and cognitive levels which specified the objective for each. Here is the format of Begle's matrix.

	Arithmetic	Algebra	Geometry	Function
Knowledge				
Computation				
Understanding				
Application				
Analysis				

[59]

Using Begle's matrix, an entire curriculum guide for a course such as Algebra I could be written. A topic under Knowledge would be chosen such as algebraic exponents. There would be sub-topics included as follows: the definition of exponents, its symbolic representation as well as the extent of the development of exponents at this course level. The finer the subdivisions were then the more exacting were the objectives.

Under Computation would be listed the various laws for the basic operations of exponents. The objective within Understanding must include the abstractions and the generalization that the student must comprehend which would continue into higher level courses. For Application, the student would be given science examples such as, writing numbers in scientific notation and learning particular scientific formulas. These would extend beyond measurement by exponents to exponential computational skills within physical formulas. The objective specified in analysis would consist of content and means of testing each subdivision on the determined goals which would indicate success.

In each box, appropriate objectives were identified as well as the instrument of measure. Begle stated that one must effectively create "sensible goals and . . . appropriate measuring instruments."[60] Begle felt that mathematics education had done a good job in this area. However, more sophisticated instruments were needed to measure teacher effectiveness which was not a stable trait easily measured.

When looking beyond such obvious leaders in mathematics education as Begle, we find educators like Charles E.

Silberman who wrote that it was a myth to consider the reforms of mathematics education as a response to Sputnik. The reforms had begun before Sputnik in 1951 with UICSM. What Sputnik achieved was the generation of public support which increased federal funding and accelerated the reforms. However, Sputnik really proved only that the Russian's German scientists were ahead of America's German scientists.

The remaking of American education and its curriculum began outside the schools which had demonstrated an intellectual softness generated by the extremes of Progressive Education. Life Adjustment in many ways was anti-Dewey and anti-democratic when it maintained that only 20 percent of America's population could benefit from an intellectually oriented education. Jerome Bruner, of Harvard University, when asked about the merits of curriculum changes, suggested that all new material be judged by assessing its value to an adult. Would it make the child a better person or give that child a better adulthood?[61]

In A History of Mathematic Education in the United States and Canada, Lucien B. Kenney, a critic of the reforms in mathematics education, maintained that the projects disregarded the basic purpose of secondary education, the education of future citizens. The projects neglected the different needs of the American pupil. With emphasis on content, other outcomes were often neglected.[62]

Evan Clinchy, a writer for NCTM, also criticized the projects which arose from learned scholars who chose the content and attempted to modernize the curriculum. With federal financial support and national distribution, they introduced a new, at times radical approach, to teaching mathematics with materials which fostered inductive reasoning. Too often teacher training concentrated on preparing teachers to use certain project material rather than a general increase of mathematical knowledge and teaching techniques.[63]

As earlier stated, Marshall Stone, of the University of Chicago, strongly supported efforts to reform mathematics education. However, he warned of its narrowness in not including recent worldwide developments in mathematics education. He also believed not enough was done for the less academically talented student nor for improving teacher preparation.

In 1973, Morris Kline's book, Why Johnny Can't Add, was printed. Kline questioned the extending of the new curriculum since its merits were questioned by mathematicians and teachers. Kline wanted the new mathematics effectiveness better assessed. Although they were not identical, Kline believed it was fair to overlook the differences that existed among the various projects.

The traditional approach contained too much memorization, but the new approach reinforced understanding through logic. The deductive approach encountered many obstacles and had questionable pedagogical merit, as Kline viewed it. Kline showed that historically most concepts first had intuitive meaning, some application and then abstraction occurred. The deductive method long used in secondary geometry had not motivated students nor inspired them to do further work in mathematics. Thus, Kline believed that the stress of logical deduction in modern mathematics could not stimulate students as the projects had hoped.[64]

Kline warned of the increased rigor within modern mathematics. He believed, "The rigorous development of a branch of mathematics is often so artificial that it is meaningless."[65] Kline saw the growth of mathematics as similar to that of a tree. With an excessive development of rigor, "the students will constantly be burrowing further down to the roots and will never get to see the tree proper."[66] Kline stated:

> Certainly much of the rigor in modern texts was inserted by limited men who sought to conceal their own shallowness by a facade of profundity and by pendants who masked their pedantry under the guise of rigor. You can rightly accuse them of pseudosophistication. If mathematical education of the traditional type has suffered from the martinets who impose rote learning, the newer education will suffer more horribly from the rigor-mongers.[67]

Edward G. Begle reviewed Kline's book for the National Elementary Principal in 1974. He called Kline an "amateur historian of mathematics" who produced sweeping statements in Why Johnny Can't Add.[68] Begle used SMSG as the representative curriculum program since it was national in scope. Begle agreed with Kline's correct assertion that modern mathematics valued structure. However, structure did not affect the students' ability to utilize mathematics. Begle stated that "after being exposed to SMSG, Johnny could add well enough to take first prize in the problem-solving contest."[69] Begle developed throughout this article his rebuttal to Kline's criticism which included: an inordinate emphasis on symbolism, the too early introduction of set theory, making mathematics as a servant of science, and an over-emphasis on structure. Begle criticized Kline for insufficient scholarship on the mathematical content of the reforms and for distracting society from future reforms.

Begle stated: "During the sixties a host of new curriculum materials were produced. But we still do not know how to adapt them effectively to the needs of inner city and minority children."[70] Through the reform projects materials, procedures and methodologies were developed to assist in instructing, monitoring, and evaluating. These must not be put aside but utilized to solve problems in mathematics education while responding to society's demands.[71]

A senior research associate, Oliver Selfridge, from Massachusetts Institute of Technology, also responded to Kline. Selfridge said, "I think that, by and large, Kline is right in his criticisms of the new math."[72] He pointed to the fact that parents were disgusted with it. He saw intuition down played and abstraction considered a blessing.

The extremely well organized and financed projects had a wide distribution of their findings. Kline did not make specific recommendations about what needed to be changed or how the changes could be made. Selfridge also felt Kline was unfair in his charges against the teachers of mathematics that they only followed orders within the new programs. Although there was less controversy about mathematics education as Kline wrote in his book, his criticism stimulated parents and educators to investigate the still unfinished mathematics reforms.[73]

Well into the 1970s, Begle continued to write about SMSG and respond to criticism of the program. With such a massive amount of material to investigate, some critics did not take time to investigate the aims, methods and content of SMSG, but criticized its failure to solve the existing problems in mathematics education in the American school system. Begle said, "We make mathematics education an object of study in the hope that if we know more about it we can discover how to improve it."[74]

In his March 1973 article for The Mathematics Teacher, Begle divided the mathematics educational process into interrelated variables: objectives, teacher, curriculum, instructional process, student, and the environment. Education takes place over a long period and prior mathematics achievement directly predicts present performance. Begle was careful to note that computational skills do not predict achievement in understanding, application, and analysis of mathematics. However, he felt that the educators had a much better understanding of mathematics education. Begle said, "We have better tools to work with. We know much more about construction curricula, and about testing and research methods, than we did at the beginning of the sixties."[75]

After Begle's death on March 2, 1978, Critical Variables in Mathematics Education was published. The final manuscript was completed only a few weeks prior to his death. Judged by many as a curriculum developer, Begle was best remembered as a mathematics educator. The bulk of his labors always centered on the improvement of education. Through his labors as mathematician, educator, director, and author, a large body of vital research was developed during a critical period of need in American education. With teacher inservices, articles, films and extensive evaluation, he offered the mathematics community a lifetime of effort and care. He had assisted in the revision of teaching so as to research and to lay open the problems therein. Begle realized that SMSG lacked theoretical structure but hoped to find an empirical base for the future.[76]

The noteworthy additions in his last work were Begle's consideration of the elements outside of content. He addressed student variables and hoped that psychologists would discover more data on learning and understanding so that mathematics education would profit. The bulk of the work of SMSG, effectively completed by the mid-sixties, did not investigate topics that Begle included in his final work. Most noteworthy was the chapter on "Environment" in which ability grouping, acceleration, class climate, class size and school organization were considered. Such ideas as ethnic and family background were researched to find if there was a relation to mathematics achievement. He could find no research which contributed to improvement of mathematics education.[77] He hoped for more tangible evidence which he did not find, but Begle knew that nature of mathematics precipitated change and that change would continue to demand reform and modification of mathematics education.

During 1980, the Center for Science and Mathematics Education analyzed research in mathematics education. Inluded in Investigations in Mathematics Education by Begle were six working papers which dealt with a diversity of topics and their relationship to learning. Through this window, provided by Begle, potential variables were identified. Hopefully, the initial work of SMSG and other mathematics projects established the structure and format which united many individuals to explore the improvement of mathematics. With this wealth of past knowledge and the new glimmers from on-going research, the problems ahead in mathematics education will be confronted, explored and researched by the mathematics community.[78]

The major accomplishments of the mathematics education reform were completed by the mid-sixties. With the federal funding attempting to structure a "New Society," the improvement of content, approach and techniques within mathematics education were set aside. The forces, which maintained that our world position demanded quality as the key product within education, lost their control. Adjustment to America's technology era had begun. The threat of Russian superiority had lessened. The shortage of scientists and teachers was addressed, so America reassessed the crisis of education from the humanitarian position. The excellence which was possible within the design of perfected curriculum under the well qualified teacher must now be open to all our students. Therefore, mathematics educators knew in the mid-sixties that extensive work must be done to adjust and to modify the reform efforts, to address the needs of the culturally deprived, the slow student and the drop out.

The scope of the accomplishments of America's mathematics projects were significant. The unified efforts of many mathematicians and mathematics teachers formulated a national approach toward teaching mathematics. The impact of the developments in mathematics reforms formulated policy changes in American mathematics education. From both the supporters and critics, this chapter investigated the accomplishments and weaknesses of the developments within mathematics education.

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CHAPTER VII

SUMMARY AND CONCLUSIONS

This chapter will summarize the important developments and suggest some general conclusions. Throughout this dissertation on the development of mathematics education 1950-1965, historical evidence was provided which revealed an organized increase of support for the improvement and innovations from various sections of American life. The main growth in mathematics education occurred during a fifteen year period after World War II. The efforts of mathematicians and mathematics teachers, supported by private funds, universities and the federal government, created a policy for mathematics education which was national in scope. The individual school district always retained the freedom to accept or to reject the reformed mathematics curriculum prepared during this period. However, the individual district, school or mathematics teacher was no longer isolated since the dissemination process was nationwide. The developments in mathematics education established a support effort, research materials, advances in texts and materials and teacher inservice to assist, to advance, to change, to modify and to expand mathematics education for the student, teacher and the school.

The development of mathematics education in America's secondary schools from 1950-1965 was a formative process which began with the innovative concepts of mathematicians, like Cantor, who introduced set theory, and the ideals and methodology of the Progressive Movement at the turn of the century. Progressives such as Rice, Dewey and Parker realized that the American educational system was not fulfilling the needs of society. The Progressives wanted memory work eliminated from student lessons and new laboratory techniques using discovery method included in the curriculum. Such critical thinking, using the discovery method to arrive at student comprehension, was a vital element in the structure of mathematics education at mid-century.

The imperative to reform mathematics education was heightened as the scientific advances of the twentieth century demanded a better prepared secondary student. The national effort during World War II had united the academics, business interests, military and government. The effort had dramatically shown that America's united forces could meet tremendous challenges in defense of the nation. Now scientific necessity united educational and political forces. America realized the new challenge was to reconstruct the school system to prepare the students to meet the task before them.

Private Foundations were also influential in funding the scientific and educational research needed to reform mathematics education. Through their financial support, projects were developed to improve the teaching of mathematics. The University of Illinois Committee on School Mathematics (UICSM) was such a project. Initially formed and funded by the University of Illinois, the project became a model for later mathematics projects.

Professional research, encouraged by the National Council of Teachers of Mathematics (NCTM), contributed to the revisions of secondary school mathematics during the 1950s. The widely published results of the Commission on Mathematics of the College Entrance Examination Board (CEEB) encouraged immediate curriculum changes in mathematics. No longer was there any doubt that critical changes in mathematics education were an established necessity.

Long before the Sputnik crisis of 1957, falsely attributed as the start of mathematics reform, leading commentators on education stated that technical and scientific needs required a modification of mathematics education. To continue the advances made by universities, private and military research as well as the Atomic Energy Commission, Congress established the National Science Foundation (NSF) to support and to encourage continued research. The GI Bill was another effort by the federal government to assist the returning soldier and to encourage higher education for many veterans. The manpower shortage was a reality America faced, especially in mathematics, science and education. America searched for ways of promoting and stimulating students to enter these fields.

The federal government had directly assisted education through the passage of legislation such as: the Northwest Ordinance of 1785, Morrill Act of 1862, Smith Hughes Act of 1917, GI Bill of 1944, and the Fulbright Act of 1946. However, the NSF established a specific organization to support research, to collect data and to monitor current work. In 1953 the NSF was expanded to include direct funding for teachers' inservice education, workshops and year long institutes. With the National Defense Education Act (NDEA) Law of 1958, the federal government provided grants and loans to states and individuals to advance mathematics education. Through NDEA funds laboratories were equipped, publications were supported, and materials purchased for individual school districts.

Supported by universities, private foundations and federal programs, America's mathematics community addressed the necessity of immediate reforms. When the crisis in education was made public knowledge through efforts of Bestor, Smith, Conant and Rickover and dramatically heralded by the Russian success with Sputnik, American educational policy was altered. The mathematics projects represented an important effort to improve American education.

A new policy was formulated to attack the crisis in mathematics education. Using the recommendations from NCTM and CEEB and the working model of UICSM as well as other mathematics committees and programs, a new harmony developed between mathematics teachers and mathematicians. This unique fellowship brought to the reform question a multitude of talents to attack this educational challenge. These reform efforts grew into a program of national scope, namely, School Mathematics Study Group (SMSG).

The traditional mathematics program, based on three-hundred-year-old concepts, no longer provided American students with a sufficient educational foundation. American educational policy reacted to the critical needs of society, to the recreation of an academic educational atmosphere, and to preparing students for the future. The national impact of mathematics programs like UICSM and SMSG was a united effort. The individual district nor teacher was no longer isolated. Support and assistance were now available in the form of curriculum materials, laboratory equipment, new programmed courses, inservice education and filmed materials.

Never believing that one particular curriculum or approach was perfect for all students, SMSG created a program with national visibility and importance. The materials developed and produced by SMSG through federal support of NSF were dispersed into local school districts. The National Defense Education Act of 1958 provided funds so that individual districts were able to replace obsolete mathematics programs and to supplement the inadequacies of others through the purchase of new materials.

The evidence revealed that the power of federal support developed a new mathematics program and unified a large cross section of American secondary education. The improvement of mathematics education was approached through curriculum reform and pedagogical modifications, generating student interest, and teacher education. Through inservice programs, workshops, and institutes financed by federal and state funding, mathematics education experienced an intensive investigation. The combined efforts of each participant in the programs, conferences and commissions contributed to generating the data and preparing the recommendations that sparked mathematics education.

Although critics argued over the merits of various changes in mathematics education, few questioned that change was crucial. The development and change of mathematics education directly produced reform in sequencing classes; actual classroom presentations such as, use of the discovery method or of programmed learning; innovative curriculum ideas; accelerated programs like Advanced Placement Program; revisions of undergraduate programs; mandating of student teaching and the extension of teacher inservice education.

Secondary mathematics courses were introduced into junior high so that seventh or eighth graders were starting accelerated programs. Such variations in sequencing as completing two years of secondary Algebra before beginning Geometry offered alternatives. The college entrance testing now included more advances and content specified by both the CEEB and CUP. Therefore, the college-capable were given adequate preparation in secondary mathematics. Teacher education included student teaching, now a requirement for most state certificates. Universities like Northwestern University expanded their education programs for liberal art students by introducing the Masters in Teaching Program (MTA).

During the 1960s, evaluations of the effectiveness of mathematics programs were conducted. For example, the Longitudinal Study of SMSG attempted to scientifically investigate the merits of the new SMSG and compare it with traditional approaches. Extensive research revealed that SMSG students could do computational skills as well as the traditional student but the SMSG students achieved better on tests in logical and critical thinking. Through later efforts of both UICSM and SMSG, the addition of mathematics application within the secondary program was achieved. The modest efforts to address the needs of the low mathematics achiever was developed by SMSG which researched psychological and cultural factors of the mathematics student. Assistance to the culturally deprived student was a later development in mathematics education. In the SMSG Studies in Mathematics, the leaders of mathematics education investigated the special needs of both the rural and urban child deprived of financial security, family support or cultural enrichment. The evidence of these contributions within mathematics education, 1950-1965, are provided throughout this dissertation.

Unfortunately, an important element, the humanistic concern, was significantly absent from the mathematics education reforms from 1950-1965. For too long, the students with their individual talents, family background and environmental stresses were viewed as the recipient of mathematics instruction rather than as a formative element in the program's development. Possibly the developers of the program were so focused on their purpose in perfecting mathematics education that they neglected the humanistic dimension. Essentially, the membership of committees and commissions consisted of mathematicians and mathematics teachers who held influential academic positions. They were talented researchers and established authors in mathematics and mathematics education. This community almost single-mindedly was concerned with mathematics improvement. They were so focused on reform that they did not envision the complexity of the social and human setting for the reforms suggested for mathematics education. If this serves as an admonition which might help current reform efforts, then even the omissions of the past truly can benefit the future development of mathematics education.

What needed to be included was an understanding of the psychological and human struggles of America's students. These students, diverse in talents and personal backgrounds, could not approach mathematics in some academic vacuum. When educators and mathematicians dealt with secondary education an understanding of adolescent individuality was vital. American educational policy has sought to provide a rich, meaningful educational setting so that an individual can achieve according to his talents and efforts. Therefore, any mathematics reform must address this diverse student body, providing the maximum help possible for all secondary students. The deprived, disadvantaged, bilingual, special education, handicapped and low achieving students are not exceptions to the educational program but essential participants in American education.

The mathematics reformers, however, did not examine the social pressures nor the effect on education of the Vietnam War, the Peace Movement, Student Rights and Segregation Problems existing at the time. Mathematics educators attempted to bring about change on a national scale. The mathematics reform efforts received little publicity outside of the educational community to assist in the actualization and extension of these reforms to all American students. Often parents were not properly informed of the purpose nor benefits their children would derive. Even the school administrators, superintendents and school boards were not directly involved in supporting the reform of mathematics education. As public funding and political support was directed to the humanitarian reforms of Johnson's Great Society and the War on Poverty, the view that mathematics reform had been accomplished by the mid-sixties was publicly accepted.

The instructional methodology used in the reform efforts still relied too heavily on the lecture method. Although the mathematical laboratory, the discovery method, and programmed learning were encouraged, many classroom teachers were not sufficiently prepared to implement these suggestions. Too often, the materials produced, except for UICSM, were not experimentally prepared nor tested to validate their authors' conclusions. Were they the best ideas or concepts? Were they only the consensus of a committee which arbitrated an agreeable conclusion? Evaluation of any academic project is extremely difficult if specific identifiable goals are not stipulated at the start. As Begle attested the abstract purposes of improving deductive reasoning, critical thinking and fundamental comprehension were difficult to test especially since existing evaluation tools did not measure such improvements.

The development of teacher programs such as inservice education, workshops and summer institutes were outstanding efforts to revitalize American mathematics and science teaching. Many American teachers attended the projects, but still they represented a small number of the mathematics teachers. Too often, inservice education was slanted towards a particular project. Therefore, the teacher was basically trained to present a special approach to mathematics education without really expanding his knowledge of the subject nor his ability to delineate between alternative approaches to teaching mathematics.

The reform projects and curriculum committees by the mid-sixties were viewed as having fulfilled their duties of preparing materials and suggesting curriculum modifications. At this time, materials were being commercially produced by leading publishers in America. People lost interest in attending the conferences which suggested that new and creative leadership was lacking. Many no longer received the stipends formerly available through NSF. Now most of the efforts concentrated on comparing and testing new programs like SMSG and the traditional approach. Such comparisons revealed that SMSG was superior to the traditional approach in preparing students to think critically while they appeared equal in developing computational skills. With the Johnson administration's emphasis on the Great Society, the impetus and funding for reform of content areas, such as mathematics, were neglected or abandoned. Research funds were redirected to investigate social issues, special education, and equity in American education.

The American mathematics reforms from 1950-1965 contributed many new educational ideas and approaches. From the reform efforts, dialogues were established with secondary teachers, college professors and professional mathematicians. Their united efforts stimulated indepth discussions, research, reform and a broad reconstruction of mathematics education. An essential contribution was the realization that change was possible. During this short fifteen year period, the change became a reality. From this reality, there was no doubt that the mathematics community would, in the future, be willing to accept the possibility of change.

From the general purpose of wanting students to logically reason, to critically deduce, and to analyze and to assimilate, a wealth of new concepts, class sequencing, methodology and pedagogical reforms were generated. The reformers developed special materials, laboratory structure, programmed learning, films and teacher inservice programs. Each one, although not perfect, was a constructive attempt to reform mathematics education so that it better prepared America's students for a more scientific and mathematically oriented society.

No one program was ever intended to be the absolute curriculum reform. Rather, the reformers made a genuine effort to eliminate obsolete concepts and to improve traditional approaches to secondary mathematics. The contributions of this reform were many. The general logical structure, emphasis on language and logic as well as the deductive discovery method are present in the materials produced for secondary education. Inservice education, no longer a specialized program, is now included in local school districts and viewed as an essential and formative way of supervising and enriching teachers. Teachers' preparation in undergraduate education as well as state requirements support the view that a liberally-trained person, if provided with professional methodology and student teacher experience, will become a better teacher. The efforts of reform in mathematics education can be credited with enriching American education.

The critics, too often with hindsight, judged the mathematics reforms of this period as not being child centered nor structured with Bloom's taxonomy or Maslow's Hierarchy of Needs. More consideration might have been given to general changes in school administration that the mathematics modification required. If more parents had been included in the reform efforts, then the human issues might have been addressed. More numerous participants would have extended and expanded the mathematics programs.

From the positive developments in mathematics education that resulted from the reforms, we have learned much. They remain a guide for future change. From unexplored areas such as the special education, the non-college bound and the slower student, a vista for further research existed, but funding was critically absent. The model for continuing efforts in mathematics education still remains the developmental work of 1950-1965.

As American mathematics educators, learning from the past, address current needs, they must not be isolated in their immersion to improve mathematics education. They must recognize the academic needs of a diverse student population and not only heed the specialized demands of the scientific community, the military, or the future technical necessities of any special interest group. The architects of the Great Society envisioned education as a force to eliminate the economic condition of the thirty million poor of America. Through improving educational opportunities and providing for their special educational needs, each student's growth would increase America's human capital, better society, and improve his or her own life. From both the merits and deletions of the extensive mathematics developments of 1950-1965, American educators can learn. They must profit from the lessons of the past so as to continue change and to improve education for all American children.

This dissertation has presented a history of human effort and achievement to produce change in mathematics education. From the initial theories and ideals of Rice, Parker and Dewey to the actual practical achievements of mathematics projects such as UICSM directed by Beberman and SMSG directed by Begle, the American educators recognized the needs of students, assessed merits of change, created new programs and educational methods. They produced not only a national awareness and support, but also specific results. The supporters of the new approach to mathematics which stressed language, logic and understanding, wanted students to think and reason and not to recite and memorize. To fulfill the academic growth wanted by Rickover, Conant, Smith and Bestor, was a tremendous task undertaken by mathematics education. The new mathematics education was to provide a rich learning experience filled with the excitement of discovery and creativity while comprehension was achieved.

The critics of the mathematics reform efforts such as Kline, Stone, and Selfridge enumerated the shortcomings of the reforms, their narrow purpose, and the concentration on curriculum improvement rather than student achievement. However, the perfectibility of any human effort is an ideal impossible to achieve. The critics can not become so overpowering that they detract or diminish the extensive developments in mathematics education. What was produced from 1950-1965 was a wealth of data, which in historical perspective, provides information from which future change can spring. The developments established a tradition as well as a model in which the united effort of mathematicians, mathematics teachers and educators produced awesome results. This growth foundation is solid and never to be set aside, but flexible to support future investigations by providing assistance, information and confidence to again modify mathematics education to suit America's students, people and nation.

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LETTERS/INTERVIEWS

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The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the dissertation is now given final approval by the Committee with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

March 26, 1990
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