“THAT MUCH-MALIGNED MONSTER – NEW MATH:” AN EXAMINATION OF TEACHER PREPAREDNESS AND TRAINING IN THE ERA OF NEW MATH, 1950 TO 1975

by

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ABSTRACT

RANDI M. HOWELL "That much-maligned monster – new math:" an examination of teacher preparedness and training in the era of new math, 1950 to 1975. (Under the direction of DR. SONYA RAMSEY)

Education reform is a continuous cycle. The cyclical nature of American mathematics education reform began in the 1950s, during the height of the Cold War. After the Soviet Union launched *Sputnik*, the American government felt education, specifically math and science, needed updating and revamping. As a result, the 1950s and 1960s witnessed a surge in federal funding for mathematics education reform. The revised mathematics, known as New Math, emphasized conceptual learning over rote memorization and computation. During the development of New Math curriculum writing groups and government backed organizations, such as the National Science Foundation (NSF), realized that American math teachers lacked adequate preparation and education. Some teachers never took a college-level mathematics course before graduating and transitioning into the classroom. As a result, New Math became difficult to implement causing organizations, like the NSF, to promote large-scale national training. The NSF developed various Institutes to train teachers across the country. Other national and local efforts emerged, specifically via televised course instruction, such as the *Continental Classroom*.

Ultimately, national and local training efforts reached more high school teachers and left elementary teachers struggling to understand strange and advanced mathematics. New Math gained the support of the federal government, schools, and the public by promising to create students capable of outpacing their Soviet counterparts. However,

New Math teacher training and support declined during the 1970s. Teacher inadequacy, low test scores, declining student computation ability, parent and teacher frustration, as well as both domestic and international crises contributed to the failure of New Math. By 1975 New Math concluded by giving way to the back-to-basics reform, the first of many subsequent mathematics reforms that continued throughout the twentieth and twenty-first century.

DEDICATION

This thesis is dedicated to my parents, Jeff and Bunny, who continue to push and support my never-ending academic endeavors, and to the rest of my immediate family who encouraged and cheered me on daily. Finally, I would like to dedicate this thesis to Lucy, my faithful and dedicated helper, who assisted with every weekend-long writing session! I could not have completed this milestone without you all. Thank you!

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LIST OF ABBREVIATIONS

AMS	American Mathematical Society
BSSC	Biological Sciences Study Committee
CEEB	College Entrance Examination Board
CMCEEB	Commission on Mathematics of the College Entrance Examination Board
CUP	Committee on the Undergraduate Program
CUMP	Committee on the Undergraduate Program in Mathematics
ESEA	Elementary and Secondary Education Act of 1965
LRI	Learning Resources Institute
MAA	Mathematical Association of America
MS-CMA	Maryland School-College Mathematics Association Inc.
NBC	National Broadcasting Company
NCTEPS	National Commission on Teacher Education and Professional Standards
NCTM	National Council of Teachers of Mathematics
NDEA	National Defense Education Act, 1958
NEA	National Education Association
NSF	National Science Foundation
NTE	National Teacher Examination
PSSC	Physical Sciences and Study Committee
SMSG	School Mathematics Study Group
UICSM	University of Illinois Committee on School Mathematics

INTRODUCTION: IF *P*, THEN *Q*[1]

"Nothing in life is certain, except 2+2 equals 4…That's the nice thing about math…It doesn't change much. Add, subtract, multiply, divide – 95 percent of math is always the same. At least that's that way it has been except for that awful time."[2] The awful time referred to in 1982 by a forty-year veteran elementary school teacher, was New Math.[3] In April 1973, Vincent J. Glennon, a professor of Education and Arithmetic Studies in the School of Education at Syracuse University in New York, published an article in the *Educational Leadership Journal*. The article, entitled "Current Status of the New Math," was a review of the late-1950s mathematics education reform that became popular from 1950 to 1975.[4] Glennon claimed that this radical change in mathematics education during the prior decades came in three thrusts. First came the push for new and improved textbooks. Developed by more than sixty different curriculum reform groups, these texts sought to introduce mathematical concepts and vocabulary previously not taught. The second thrust was "that of strengthening the mathematics backgrounds of pre-service and in-service teachers."[5] This second thrust sought to improve the standards of teaching and teachers' educational backgrounds. The final thrust described by Glennon was "improving the teacher's ability, including cognitive and non-cognitive variables."[6] This last thrust was the most complex. Glennon addressed the three most important failures of the New Math era. As he wrote this, education perspectives began to shift once more. However, his reflections on the downturn of New Math remain appropriately placed for a topic unified only in name.

This thesis focuses on the second thrust described by Glennon, the failure to adequately prepare and training teachers to execute the New Math curricula. The thesis

also explores teacher education, specifically in mathematics, from the 1950s to 1975, as well as the efforts curriculum groups made to bolster teacher training during the reform. Discussions include particular reform groups, in-service education projects, summer workshops, and the revolutionary idea of using television to teach. The new math reform era ultimately ended in the early 1970s. While there is no one reason for its dissolution, the ineffective education and training of teachers remain a significant contributing factor.[7]

In examining the history of math teacher education and various training efforts, this thesis draws primarily from journal and newspaper articles written during the period and digitized archival records from the U.S. Department of Education, the National Science Foundation, and the National Council of Teachers of Mathematics. Each chapter highlights studies and surveys completed by educators during the New Math period. These studies qualitatively illustrate aspects of this thesis' argument. New Math remains one of the most significant education reforms of the twentieth-century but ultimately ended due to a lack of adequate teacher training and preparation to sustain it. This work provides a national perspective with examples from key states, including Illinois, Maryland, and California. These states became critical in curriculum development, which promoted various forms of teacher education. While other states adopted the New Math curriculum and supported preparation for teaching staff, the large-scale national training movement remains particularly important to the understanding of modern day reform efforts.

Background

Mathematics reform became foreseeable in America during the late-1940s and early-1950s due to both international and domestic circumstances. From an international standpoint, the United States was in the middle of the Cold War and had entered the Space Race with the Soviet Union. As a result of the launch of *Sputnik*, the United States sought to increase funding to math and science education. Author, Griffith Baley Price cites three domestic causes for New Math:

> the tremendous advancements made in mathematical research in the 20th century; the automation revolution which made it theoretically possible to construct machines with enormous capabilities, and hence the need to create such machines; and the development of automatic digital computing machines making computations more quickly and efficiently than any group of humans could do -- such a computations guiding manned vehicles to the moon's surface.[8]

Based on the three technological and domestic reasons, as well as, need to compete with the Soviets, the era was ripe for education reform.

By the early 1950s, a consensus among political and educational leaders regarding math education existed. Students did not show interest in learning mathematics, with grades remaining below average in comparison to other subjects. Unfortunately, students were not the only ones with a math deficit. Adults and parents of the 1950s retained little to no mathematics beyond basic arithmetic. Many could not even perform basic operations with fractions. The inept mathematics retention and understanding of students and adults manifested itself during World War II. As a result, basic mathematics courses were developed to improve soldiers' computational skills in a time of war.[9]

The need for basic math courses during World War II sparked fear and controversy over mathematics education, and, as a result, the push for reform soon

followed. The need for change was not predicated on a failed system of education prior to World War II. The old math, referred to as traditional mathematics, was not necessarily inaccurate. Many leaders in education and mathematicians believed traditional math did not produce intellectual individuals with developed mental habits needed in a decade of war and change. In an era of accelerated technology, such as military advancements of World War II and the launching of Sputnik, American governmental officials and academics felt it necessary to provide intellectual training through mathematics. Rote learning was the primary teaching method before the 1950s reform effort. However, repetition and memorization did not promote rational reasoning, meaning a need for more conceptual learning.[10]

Although reform became foreseeable, no one quite knew what to expect. The mid-twentieth century reform movement brought with it many new ideas. For instances "by the 1950s, the subject [math] had been folded into the idea of universal education within the United States."[11] Only a minority of the population was guaranteed a formal education before the 1950s. Over the course of the 1900s, the United States became one of many democratic nations requiring ten years of formal education, which included teaching mathematics. By mandating a more prescribed course of study, educators and government officials hoped to create a sound basis for a more democratic nation. Thus, the idea of the 1950s reform unfurled from the top-down.[12]

To understand the educational reform, one must first understand New Math. The term New Math remains slightly ambiguous because a single definition was not all encompassing. The name alludes to a collection of reforms developed between 1952 and the early-1970s. The definition varies due to curriculum development by numerous and

independent groups. Thus, this thesis relies on a more collective definition taken from various curriculum writing groups. The *Oxford Living Dictionary* defined New Math as "a system of teaching mathematics to younger children, with emphasis on investigation and discovery" and on set theory, or having a "hands-on" approach.[13] An emphasis on conceptual learning over fact memorization also emerged during this period.[14]

Educators, through school districts and state education boards, taught New Math at all levels. New Math, initially cultivated at the college level, inevitably affected both primary and secondary education. Since mathematics at every level of learning is connected and dependent upon a basic understanding of numbers, it is impossible to isolate this study to only primary or secondary education. Therefore, this discussion covers teachers of various grade levels from elementary through high school and the corresponding related material. However, this thesis will also show the differences between high school and elementary school teacher opportunities. New Math existed in some form at the college level, but that aspect will not be discussed in detail. The set-up, education of instructors, and course material differ in college-level mathematics. Thus, this thesis will constrain its examination to primary and secondary education.

Traditional mathematics changed its focus from computation and memorization to conceptual learning. Teachers and mathematicians wanted students to answer the questions: "why?" and "how?." Responding to these questions promoted logical reasoning and stronger mental habits. Within this shift to conceptual learning, mathematicians introduced several new ideas including counting in base eight, sets, and symbolic logic. To develop New Math for instruction, think-tanks and curriculum writing groups formed across the country. Perhaps the two most famous of the curriculum

development organizations were the School Mathematics Study Group and the University of Illinois Committee on School Mathematics.[15]

Secondary education began utilizing New Math after a top-down push from mathematicians, educators, and politicians in the late 1950s. Starting in 1958, Congress passed the National Defense Education Act (NDEA), as a reaction to the Soviet launch of *Sputnik*. The NDEA established federal funding for higher education and targeted further research and education in science, math, and foreign language. Funding began in 1958, and gradually increased in the following years. By the mid-1950s both the Carnegie Foundation and the National Science Foundation (NSF) also helped fund New Math curriculum writing programs. The NSF and other financial backers supported numerous training program located throughout the United States. These programs were designed and studied by mathematicians who either taught or chaired mathematics departments at various universities. From the college-level professorial design, New Math developed into K-12 curricula that would eventually span a majority of the United States.[16]

The New Math reform reached almost every child in America during the late-1950s and 1960s, which meant the movement was not limited to school settings, teachers, and students. In fact, New Math breached politics and popular culture, infiltrating comics, news stories, magazines, television, and music. There are several questions regarding the education and training of teachers during the New Math period. This thesis will address the following questions. How were teachers trained and educated leading up to and during the New Math era? What opportunities did the curriculum groups provide teachers for the advancement of their education? How were workshops executed and evaluated? Were the NSF Summer Institutes and In-Service training programs effective? How were

televised courses structured, received, and utilized? Ultimately, were teachers adequately prepared to teach New Math in their classrooms? Did any of the training efforts help correct the outdated mathematics requirements for teachers during this era?

Teacher Profile[17]

This thesis is concerned with the teacher education and training during the era of the New Math reform. It is important to acknowledge who these teachers were. During the early twentieth-century, "teachers were identified as female, unionized professionals…"[18] This was an overarching view, not applicable to all portions of the country. The mathematicians of the era were primarily white, male, and middle class. Secondary and elementary teachers, specifically during the New Math era, were most likely to be women, as seen in Figure 1 below.[19] The number of male primary and secondary teachers only began increasing in the late-1940s (see Figure 1 below).[20]

Additionally, American higher education expanded in the mid-twentieth century based on the number of degrees conferred (see Figures 2 and 3). As shown by Figures 2 and 3 below, the number of degrees began increasing around 1950, with Bachelor's degrees being the most numerous. Increase of conferred degrees was due, in part, to federal funding for veterans through the GI Bill.[21] Another explanation could be due to the overall expansion of higher education during this time. Likewise, women witnessed an increase in Bachelor's and Master's degrees conferred during the 1950s and 1960s. Again, this can be attributed to the expansion of the four-year college or to the increasing number of enlisted men preparing for Vietnam.

Finally, at this time the number of degrees conferred was much higher for whites than African-Americans. According to one source,

> For blacks, the period from 1950 to 1980 was one of continued gender similarity, with both males' and females' college enrollment rates growing very slowly. The much lower rate of college completion for blacks than whites was due in part to the lack of educational resources devoted to blacks, especially in southern states, where the majority of blacks resided.[22]

African-American men who obtained a bachelor's degree continued to have lower employment rates and opportunities as compared to white men who held an equivalent degree. Even highly educated African-American men faced employment barriers proportional to their level of education. Similarly, we can infer the same for African-American women. As shown in Figure Four, African-American women worked more than white women, "because black families had lower incomes, owing in part to black men's higher unemployment rates and lower education levels than white men."[23] This remains relevant, because according to the same study: "Of the five major occupational groups, the majority of college-educated black and white women worked as teachers from the 1940s through the 1970s."[24] In contrast, black men were less likely to hold professional careers, such as doctors, dentists, lawyers, or managers, compared to their white male counterparts. As a result, black men were more likely to be teachers in the 1940s and 1950s than black women.[25] Thus, it is important to note that teaching was a prominent career for both college-educated white and black women. Unfortunately, sources lack distinguishing whether more white or more black women encountered New Math in the classroom. In addition, neither secondary sources nor published primary sources described or discussed whether either subset of women found the New Math more or less challenging.

Ultimately, the evidence shows that the teaching field employed more women than men. We can infer based on the era of desegregation that both black and white

women encountered New Math, but the specific demographic percentage of New Math teachers is undocumented. Thus, for this thesis, it is assumed that most teachers discussed were white females in urban schools who were deemed "highly qualified" in select schools or school districts. No evidence exists which shows only segregated or integrated schools administered New Math. Based on the timeframe, we can infer that many schools implementing New Math remained segregated during a portion of the reform.

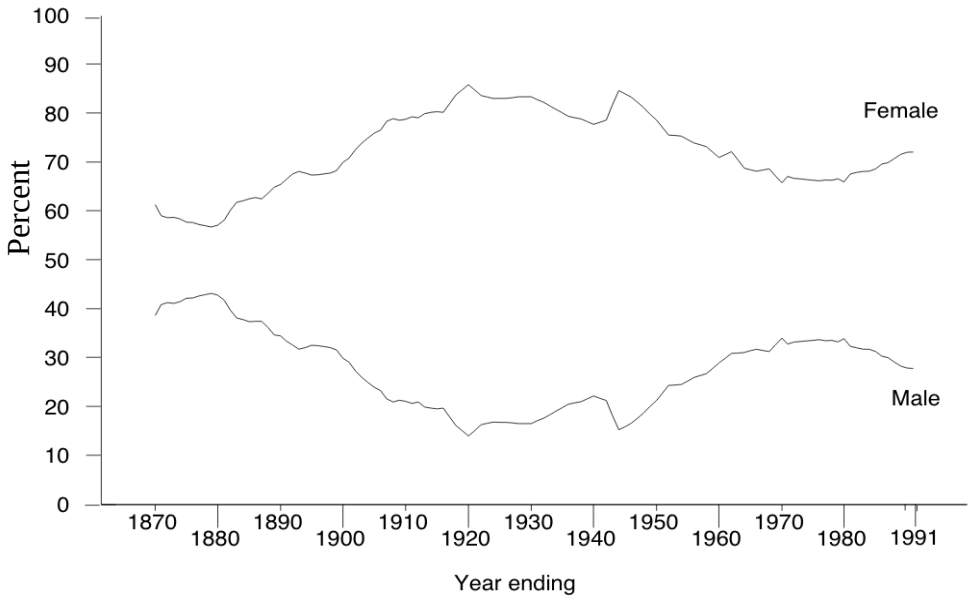

Figure 1: Percentage of Elementary and Secondary School Teachers, by sex 1869-70 to fall 1990

Source: National Center for Education Statistics and Thomas Snyder, *120 Years of American Education: A Statistical Portrait*, (n.p., 1993), 29.

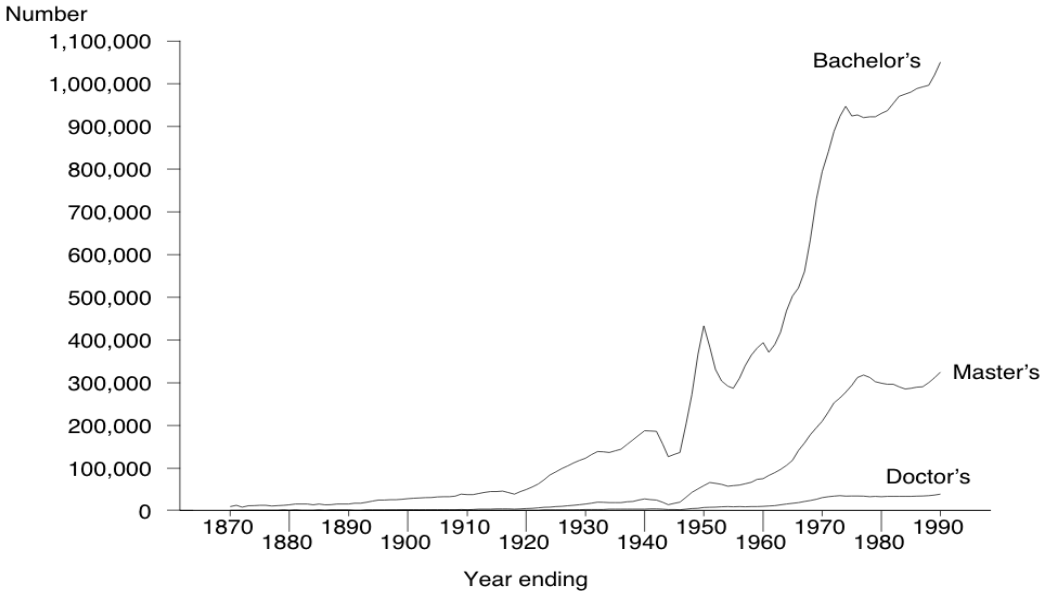

Figure 2: Bachelor's, master's, and doctor's degrees conferred by institutions of higher education: 1869-70 to 1989-90

Source: National Center for Education Statistics and Thomas Snyder, *120 Years of American Education: A Statistical Portrait,* (n.p., 1993), 67.

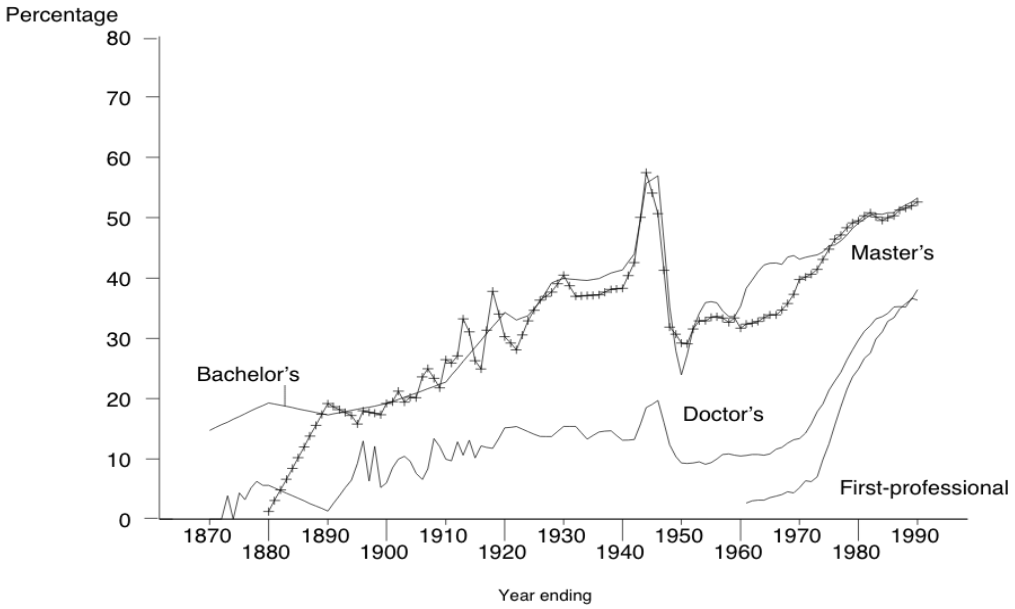

Figure 3: Percentage of Higher Education Degrees conferred to females, by level: 1869-70 to 1989-90

Source: National Center for Education Statistics and Thomas Snyder, 120 Years of American Education: A Statistical Portrait, (n.p., 1993), 68.

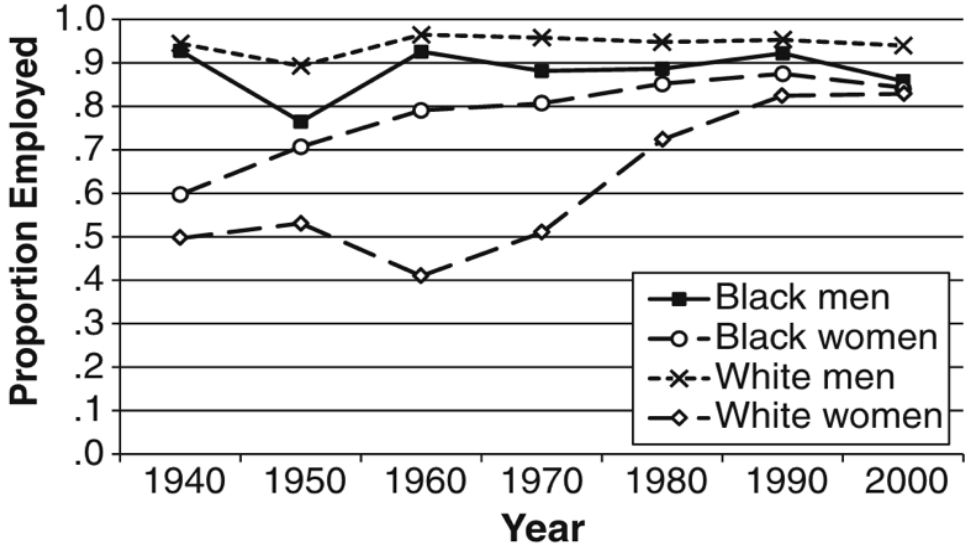

Figure 4: Proportion of 28- to 32-year-olds with a bachelor's degree that are employed, by race and gender

Source: Anne McDaniel et al., "The Black Gender Gap in Educational Attainment: Historical Trends and Racial Comparisons," Demography 48, no. 3 (June 3, 2011), 894.

Organization

While much of New Math remains open for research, this thesis chose to explore three different perspectives, which determine the structure of this project. This thesis is organized such that it examines the history of teacher education leading up to and during the New Math era. It discusses various types of service training offered to teachers in order to improve their ability to teach New Math in the classroom, with a particular focus on the use of televised instruction for teachers during this era. Finally, this project will give an overview of the reform's public image and the reaction to New Math. The first chapter investigates the educational requirements of teachers before and during the New Math era. It shows how teachers were inadequately prepared to teach complex and new

mathematical concepts, as well as how a subpar education gave way to Summer Institutes, workshops, and In-Service training.

Chapter two offers a broad national perspective on teacher training initiatives and programs. A specific emphasis is placed on televised instruction provided for educators. While many of the curriculum development groups distributed films for training, the National Broadcasting Company (NBC) created a multi-year educational television series. The series covered various subjects, including mathematics, physics, and chemistry. The series targeted college students and teachers. The mathematics segment concentrated on probability and statistics, a newer realm of mathematics not frequently offered in schools.[26] Additionally, chapter two also examines national reform training efforts, such as NSF Institutes.

Chapter three examines the public image of New Math. This portion of the thesis draws heavily on newspaper articles to illustrate the parental and teacher frustration publically exhibited during the reform process. Additionally, chapter three examines many critiques of New Math. While many articles cited teacher preparation as problematic, many parents and educators blamed the failure of New Math on the lack of computational drill. Thus, as the New Math movement came to an end in 1975 parents, educators, and administrators pushed for a return to the basics by cultivating more computational practice and less conceptualization. The New Math movement gave way to a new reform known as back-to-basics.

Finally, the conclusion addresses areas of New Math that remain uninvestigated. The conclusion also acknowledges the downturn in popularity of New Math rested heavily on the inadequate preparation of mathematics teachers during the 1950s and

1960s. Following the conclusion, an epilogue shows the continuation of math education reform by tracing subsequent restructuring efforts. Moreover, the epilogue illustrates how Common Core is the modern day New Math. Beginning with New Math, mathematics education entered a cycle of reform that continued throughout the twentieth and twenty-first century with subsequent reforms, such as Common Core. Although the historical significance of Common Core is unknown at the time of this writing, it is relevant to understand why reforms in education, and specifically in mathematics, continue to occur without fully addressing the teacher training piece. Reflections on prior reform movements carry on as Common Core dominates discussions of education. By understanding the past, this project hopes that a more positive change can be made in mathematics reform moving forward.[27]

Historiography

The assessment and investigation into the teacher preparedness and training during the New Math era builds upon the work of various historians and mathematicians. Almost all previous works neglect the teacher training aspect. This thesis' discussion draws on the works of mathematicians, historians of mathematics, historians of education, newspaper articles, and a variety of education and math journals. Reports, journal articles, and newspaper articles appeared throughout the New Math era, but many of the published books on the reform emerged after 1980. Throughout the 1980s and 1990s, several reports and articles appeared regarding the New Math reform and its decline, but none of these relevant sources were purely historical. Since the early 2000s, an increase in New Math publications, including those written from a historical standpoint emerged.

In discussing New Math, five authors standout. These New Math authors include Morris Kline, Bob Moon, Christopher Phillips, Robert Hayden, and Angela Lynn Evans Walmsley. Since this topic focuses on both education reform and social history, this thesis situates the discussion of teacher instruction and training within the existing New Math historiography, and in the wider context of education reform historiography. Many of the authors mention the lack of adequate teacher training. Unfortunately, no significant investigation into such training efforts currently exists. This thesis contributes to the existing historiography by examining the role, training, and reaction of teachers who were the crux of the reform.

Many authors traced the history of the New Math reform, including Morris Kline and Robert Hayden. Both Kline and Hayden outlined the rise and fall of New Math, including some analysis of teachers. Each author traced the roots of New Math to the pre-World War II era. They discussed the weaknesses soldiers faced when dealing with mathematics. Moreover, each author dated the onset of New Math to the early-1950s. In examining the emergence of New Math, each author highlighted the pros and cons of traditional mathematics. [28] Although Kline's writing was largely a critique of the reform movement, he acknowledged the positive aspects of traditional mathematics, in addition to the need for change. In contrast, Hayden and Angela Lynn Evans Walmsley kept the historical critique to a minimum but also placed New Math within the broader context of math education reform.[29]

Walmsley and Hayden traced math education and attempts to reform the subject of mathematics from the early 1900s. While Kline alludes to a bit of historical significance, he does not examine math reform from a broader perspective. Kline focuses

on the critique and inevitable demise of New Math. Both Walmsley and Hayden explain the impact of mathematics reform long-term. In one of Walmsley's books, she traced the evolution of mathematics education decade by decade, but only scratched the surface. She dedicated only a few paragraphs to teachers, content, and pedagogy in each chapter.[30] In contrast, Hayden spent two significant chapters of his dissertation examining math reforms, in detail, leading up to New Math. Hayden goes into more historical detail than Walmsley, as far as math education modification before New Math.[31] Walmsley is not a historian, but an educator. Much of her books, like Kline's, was an examination of pedagogy and the technicalities of teaching math. Neither Kline nor Walmsley spent a great deal of time discussing teachers or the training methods utilized during the New Math movement.

Hayden and Christopher Phillips are more interested in the actual history of New Math. However, Phillips is the only trained historian among this group of authors. Kline and Hayden were both mathematicians first, with degrees in math education or mathematics. Walmsley, a former math teacher, later earned her PhD. in curriculum and instruction. She was primarily an educator, and therefore took on an educationalist's perspective. With varying backgrounds, each author approached the idea of New Math differently. Phillips, as a historian, connected New Math to American politics, which was a different approach than any other author writing on the subject. Phillips examined the connection between democracy and mathematics education by examining the federal government's role in the reform and the government's motives behind promoting New Math.[32] Hayden and Phillips both considered the history of New Math, but not in the same ways. Phillips was a bit of an exception because he was the only historian or writer

to connect New Math with broader political and cultural context.

Although primarily concerned with education, Walmsley and Phillips overlap in their discussion of curriculum writing groups. Walmsley gave an overview of all the key curriculum writing groups within the New Math era, while Phillips specifically looks at the School Mathematics Study Group (SMSG). The time dedicated to SMSG by both authors was due, in large part, to the popularity and proliferation of the group's success. Walmsley in her discussion, gave an overview of the SMSG, whereas Phillips used the curriculum group and the propagation of their textbooks to argue about the politicization of mathematics. Phillips intertwines the SMSG throughout his book and examined it in detail from several different angles. Walmsley touched on the federal funding many curriculum groups received, but Phillips went further. Phillips discussed the leaders of the SMSG and their political influence. Phillips was the only relevant author to explore the intertwined nature of mathematics and politics within a historical context.[33]

Hayden, Walmsley, and Phillips all touched on teacher training. Again, Walmsley did not go into great detail. In her overview of curriculum groups, she highlighted some training efforts utilized but lacked an in-depth discussion of teacher education and preparation.[34] Phillips also lightly examined training efforts, but only in the context of the SMSG group. In fact, the phrase “teacher training” only appeared nine times in Phillips’ book, and often is part of a longer list. Like Walmsley, Phillips spent very little time examining the idea or ways in which teachers prepared to teach New Math. In stark contrast, Hayden devoted roughly thirty pages of his dissertation to the discussion of training elementary school teachers. As a result, Hayden’s chapter is the most closely aligned to this thesis.[35]

Hayden addressed the problems of training elementary school teachers in his chapter. In contrast to this thesis, Hayden did not explore the significance of NSF Institutes, the evaluation of NSF Institutes, or the contrasting statistics in high school and elementary school training offerings.[36] Hayden, also looked at the television show, *Continental Classroom*, much like this thesis. However, his discussion of the *Continental Classroom* was brief at best. Many times he mentioned the television show in a passing reference. Hayden did look at secondary education, but not necessarily at the inadequacies of teachers before enrolling in teacher colleges.[37]

This project expands on Hayden's chapter by giving a fuller discussion of specific training efforts. This thesis also bridges the gap in Hayden's argument regarding poor teacher education and Walmsley's scant overviews. By elaborating on how and why teachers were so ill-prepared for New Math, it is easier to understand the need for large-scale training efforts. Additionally, this thesis offers a critical analysis of New Math. Each chapter provides surveys and studies of teacher preparedness. This helps quantitatively illustrate the shortcomings of the educational system, in regards to mathematics, and the pitfalls of the New Math training efforts. This portion of the thesis builds upon Kline's criticism of New Math and its deterioration. The thesis argues that ill-prepared and poorly trained teachers contributed to the failure of New Math, much like Kline suggests.

Ultimately, this thesis does not take an international perspective. This project is geographically confined to the United States, much like the works of Hayden, Phillips, Walmsley, and Kline. Author Bob Moon discussed the development of New Math curriculum from an international perspective. His account differed because he included

personal interviews of individuals connected to the global reform. His work gave a late-1980s perspective and a broader international examination of math education reform. Moon neither classifies the New Math movement as a complete failure or a complete success. Much like Phillips, Moon spent time discussing the political influences of a top-down approach to education. In addressing the international movement as a whole, Moon did not delve into specific aspects of the American movement, such as teacher preparedness. Moon gave one of the only book-length examinations of New Math on the international scene.[38]

To recap, Kline and Hayden both argued that the New Math reform was completely unsuccessful long-term, but both examined this letdown from purely a math education perspective. Phillips also regarded New Math as an overall loss, but he examined the movement through historical and political lenses. While Phillips could not remove the educational aspect from his argument entirely, his analysis situates math reform within the context of domestic politics, rather than shifting pedagogical theories. Neither Walmsley nor Moon determined that New Math was an absolute failure. Instead, they both examined the movement from non-political perspectives, and from a more educational shift viewpoint. Hayden, Moon, and Phillips viewed the math reform as a top-down implementation, whereas Kline and Walmsley did not explicitly state whether the movement was a push from above, or a surge from below. Overall, the historiographic trends overlap in small areas. These tiny overlaps make the historiography of the overall movement more inclusive because of the varying opinions and points of view. However, the brief intersections also give future historians many opportunities to investigate further and elaborate on New Math.

Although I mostly agree with the authors that New Math ultimately failed to create long-term change, I spend more time investigating the education of teachers who were implementing the new curricula. This thesis examines the inadequate or lack of training provided to these teachers. Several authors, including Phillips and Walmsley, mentioned the problematic training teachers received, but neither spends an extensive amount of time investigating the role of teachers in the broader creation and implementation of New Math. Thus, this thesis focuses on the education and training of teachers, which remains largely unexplored in connection to the New Math movement. Therefore, a historical gap exists that requires investigation and research.

Furthermore, this thesis argues that math teachers were ill-prepared for the New Math reform, which resulted in large-scale national training efforts, primarily sponsored by the federal government. In the research of this project it was discovered that the preparation of mathematics teachers was dismal, at best, leading up to the onset of the New Math reform in the early 1950s. Research findings showed that, with little to no advanced mathematics training, teachers required supplementary instruction in order to understand New Math concepts before demonstrating it in the classroom. The additional training for New Math came in various forms including small, local trainings, to large nationally sponsored and facilitated workshops. Moreover, the increasing popularity of television technology helped to steer the national training effort. Ultimately, New Math lost both its public and financial support. As a result, parents and a wide array of educators began advocating for a new reform. In the end, New Math failed in the sense that it brought forward yet another mathematics education reform. Although New Math

gave way to a continuous cycle of future math reforms, the importance of teacher preparedness and training did not go unnoticed.

ENDNOTES

[1] If *P*, then *Q* is logic and mathematical statement. One example comes from the Northern Illinois University mathematics page: "The statement 'p implies q' means that if p is true, then q must also be true. The statement 'p implies q' is also written 'if p then q' or sometimes 'q if p.' Statement p is called the premise of the implication and q is called the conclusion." (taken from Richard Blecksmith, *Implication*, (Northern Illinois University: Richard Blecksmith, n.d.), math.niu.edu/~richard/Math101/implies.pdf.) The "if, then" statement is the start of a basic logic or mathematical proof. As such, this thesis can be viewed as a large proof. If teachers were ill-prepared to teach mathematics, then they needed additional training to understand New Math.

[2] The Associated Press, "The New Math Scare," *Kentucky New Era*, September 27, 1982.

[3] The Associated Press, "The New Math Scare."

[4] Vincent Glennon, "Balanced Progress in School Mathematics," *Editorial, Educational Leadership* 19, no. 8 (May 1962), 358; Vincent Glennon, "Current Status of the New Math," *Educational Leadership* 30, no. 7 (April 1973).

[5] Ibid, 605.

[6] Ibid, 605.

[7] Other mitigating factors point to a shifting focus on slow learners and education for all students; the growing expense of the Vietnam War and Cold War; the declining threat of the Soviet Union after the Space Race; and the fact that many viewed New Math as too complex or too difficult for both students and teachers.

[8] Vincent J. Glennon, "Three Thrusts of the New Math," by *Journal of the Association for Supervision and Curriculum Development, Educational Leadership* 30, no. 7 (April 1973): 604. Originally published in Griffith Baley Price, "Progress in Mathematics and Its Implications for the Schools," in *The Revolution in School Mathematics: A Challenge for Administrators and Teachers*, by National council of teachers of mathematics, ed. National Council of Teachers of Mathematics, Regional Orientation Conferences in Mathematics (Philadelphia: National Council of Teachers of Mathematics, 1961).

[9] Morris Kline, *Why Johnny Can't Add: The Failure of the New Math* (New York, NY, United States: New York, Vintage Books [1974, c1973], 1974),15- 16.

[10] Christopher J Phillips, *The New Math: A Political History* (Chicago, IL, United States: University of Chicago Press, 2014),1-2. Rote learning is the act of memorization and repetition. Rote learning did not promote logical reasoning or conceptual learning the academics and politicians assume the nation's students needed to be successful.

[11] Ibid, 11.

[12] Ibid, 10-12.

[13] *Oxford Dictionary* (Oxford University Press, 2016), s.v "New Maths" by Oxford, accessed October 24, 2016, en.oxforddictionaries.com/definition/new_maths.

[14] Evandro R. Valente, "Mathematics Curriculum Coaching and Elementary School Students' Mathematics Achievement in a Northeast Tennessee School System." PhD diss., East Tennessee State University, 2013, 27; Jeremy Kilpatrick, "Confronting Reform," *American Mathematical Monthly* 104, (1997), 955-957; Christopher J Phillips, "The New Math and Midcentury American Politics," *Journal of American History* 101, no. 2 (September 1, 2014): 456.

[15] Phillips, *The New Math*, 5-9, 17-18.

[16] "1941: Sputnik Spurs Passage of the National Defense Education Act -- October 4, 1957", May 29, 2014. senate.gov/artandhistory/history/minute/Sputnik_Spurs_Passage_of_National_Defense_Education_Act.html; "Strengthening High-School Teaching - NSF History Timeline | NSF - National Science Foundation." Accessed 18 October 2015. nsf.gov/news/special_reports/history-nsf/1954_teachers.jsp; "Accomplishments - Carnegie Corporation of New York." Carnegie Corporation of New York, 2015. carnegie.org/about/our-history/accomplishments/; David Klein, "A Brief History of American K-12 Mathematics Education in the 20th Century," California State University, Northridge. Last modified 2003. csun.edu/~vcmth00m/AHistory.html.

[17] In referring to "teacher" in this section, I am not including college instructors or professors.

[18] Phillips, *The New Math*, 28.

[19] Ibid, 77.

[20] National Center for Education Statistics and Thomas Snyder, *120 Years of American Education: A Statistical Portrait*, (n.p., 1993), 29.

[21] Anne McDaniel et al., "The Black Gender Gap in Educational Attainment: Historical Trends and Racial Comparisons," *Demography* 48, no. 3 (June 3, 2011), 894.

[22] Ibid, 894.

[23] Ibid, 895.

[24] Ibid, 895.

[25] Ibid, 896-897.

[26] Frederick Mosteller, "Continental Classroom's TV Course in Probability and Statistics," *The American Statistician* 16, no. 5 (December 1962), 20-25.

[27] Elizabeth Green, "Why Do Americans Stink at Math?" *The New York Times*, Last modified July 23, 2014.

[28] Kline, *Why Johnny Can't Add*,15- 16; Robert Hayden, "A History of the 'new math' Movement in the United States," (Iowa: Digital Repository at Iowa State, 1981), lib.dr.iastate.edu/rtd/7427.

[29] See Angela Lynn Evans Walmsley, A History of the New Mathematics Movement and Its Relationship with Current Mathematical Reform (United States: University Press of America, 2003); Angela Lynn Evans Walmsley, A History of Mathematics Education During the Twentieth Century (United States: University Press of America, 2007); and Hayden, "A History of the 'new math' Movement in the United States."

[30] See Walmsley, A History of Mathematics Education During the Twentieth Century.

[31] See chapters "Educational Reform Prior to the 'New Math'" and "The Second World War and Mathematics Education" in Hayden, "A History of the 'new math' Movement in the United States."

[32] See Phillips, *The New Math*.

[33] Phillips, The New Math, 14-22, 41-47, 59-96; Walmsley, A History of Mathematics Education During the Twentieth Century, 29-71.

[34] Walmsley, A History of Mathematics Education During the Twentieth Century, 29-71.

[35] See "Elementary School 'New Math'" in Hayden, "A History of the 'new math' Movement in the United States."

[36] See "Elementary School 'New Math'" in Hayden, "A History of the 'new math' Movement in the United States."

[37] Hayden, "A History of the 'new math' Movement in the United States," 115-116.

[38] See Bob Moon, *The "New Maths" Curriculum Controversy* (London: Falmer, 1986).

CHAPTER 1: THE MISCARRIAGE OF MATHEMATICS

On October 4, 1957, at roughly 7:28 pm the Soviet Union launched the world's first artificial satellite, known as *Sputnik*. The satellite, roughly the size of a beach ball, took nearly 98 minutes to orbit the Earth. Although this was a single event, the *Sputnik* launch ushered in a new era of military, political, technological, and educational change.[1] While *Sputnik* may appear rather simple compared to more modern technology, the "beeping signal from space galvanized the United States to enact reforms in science and engineering education so that the nation could regain technological ground it appeared to have lost to its Soviet rival."[2] With the launch of *Sputnik* and the fear of an inadequate education system, the United States began a nationwide overhaul of math education at all levels.

In the aftermath of *Sputnik* the United States government sought to beef up its mathematics and science curricula. Through federal and private funding, more than sixty curriculum writing groups appeared between 1952 and 1968. An estimated six hundred curriculum groups of this period fell under the umbrella term of New Math.[3] From these, many curriculum groups developed dozens of new math textbooks, filled with modern concepts and proper vocabulary. These reform groups sought to implement and disseminate their revamped material to as many schools as possible throughout the country. These texts, chock full of new and more precise language, would prove troublesome for many teachers, both seasoned and inexperienced.

Since the 1940s and 1950s, both federal and state educational standards have evolved. As a result of unstandardized education requirements and minimal prerequisites, teacher training leading up to the New Math movement varied in scope, lacked consistency, and lagged behind. The efforts of New Math curriculum groups became one of the shorter-lived reforms of the mid-twentieth century, partly because of a lack of understanding the mathematics by educators, and partly due to the lack of training provided to these same educators. This chapter examines the inadequate teacher preparation leading up to and during the New Math period. Teachers, specifically elementary educators, emerged from colleges, training schools, and normal colleges with little to no mathematical knowledge beyond arithmetic. As a result of being initially poorly educated in mathematics, teachers went into school ill-prepared for the onset of New Math and the complex concepts associated with the reform. In understanding the lack of preliminary education, it becomes clearer why training efforts became centralized and why the execution of New Math in schools ultimately failed.[4]

This chapter will first discuss the poor education students received before entering college, focusing primarily on the future elementary school educator. Next, the chapter will examine the preconditions of teacher college admissions. This portion will utilize statistics to showcase the quantity of mathematics training leading up to and during college for teachers. Finally, there will be an examination of the history of mathematics education as a whole. This discussion will begin with the early 1900s and follow the education trends through the 1960s. Ultimately, this chapter will show the trajectory of poor teacher education leading up to the 1950s and answer the question of why the new math reform needed such a large scale national training effort.

To truly understand why teachers across the nation were inadequately prepared to adopt and teach New Math curriculum, we must first understand the development of math education in the twentieth century. Thus, this section will trace the development of teacher education in regards to mathematics from 1900 to 1960. In understanding change over time, this chapter shows how mathematics teaching requirements evolved from requiring little to no formal education to necessitating a four-year degree or even a master's degree. By tracing teacher education through the 1960s, this chapters illustrates how the struggles of New Math affected academia's perception of teacher certifications, qualifications, and education within the discipline.

High School Math Requirements

Before dealing with the requirements of higher level education institutes, let us first review the mathematics required of high school students. This is relevant because admission into teaching or normal colleges did not require mathematics coursework in high school in many cases. Thus, the lack of teacher education can reach as far back as a teacher's high school education. According to H. F. Fehr, by 1950 all public school students in grades 1 through 8 were required to take a mathematics course each year.[5] However, high school math requirements continued to vary widely. For instance, according to an article by W. I. Layton, a mathematics professor and extensive math teacher certification writer,

> Twenty of the forty-eight states included in the investigation require no mathematics. Twenty-four specify one unit. One state says one and one-half units, and one calls for two units. Thus twenty six states, or 57 per cent of those which follow a four-year plan of organization in their high schools, require some mathematical training. The fact that twenty six states require mathematics is some improvement over the situation existing in 1948 according to the study by the Office of Education.[6]

Moreover, the types of math courses required by these high schools also differed. For instance, three states required a general math course or a year of algebra. Other states required just one the following math courses: general mathematics, algebra, arithmetic, or business arithmetic. While each state held different stipulations on requisite math courses, a majority of these states made suggestions for additional math classes or selective courses depending on post-secondary education decisions.[7]

Many schools during the first half of the twentieth-century promoted vocational or trade school training as opposed to a four-year college degree. For students pursuing vocational or trade training, many schools offered an alternative course in applied mathematics. In the case of applied math, this meant the course was structured in such a way to "meet the needs of pupils taking prevocational or vocational shop, business, home economics, or other approved specialized courses."[8] For instance, one state offered business arithmetic for students pursuing vocational bookkeeping and various business interests. This allowed students to take a more basic math course that appealed to their line of work.[9]

At the time of Layton's publication (1954), he felt that many states should require more math courses for high school graduation. He also asserted that the type of course offerings in high school mathematics was not appropriate and urged the National Council of Teachers of Mathematics to address these issues. Overall, the variation in required high school mathematics coursework remained widespread throughout the 1950s and thereby resulted in ill-prepared student admissions into teacher education programs. Mathematics education remains a cyclical system that breeds inadequacy, going back as far as high school and as far forward as graduating college and assuming a teacher role.[10]

Entering Teacher Colleges

It is relevant to discuss the requirements of students for entrance into teacher colleges. Layton conducted a study of 85 colleges, and their entrance requirements. He examined two, three, four, and five-year programs. The five-year program resulted in the teacher earning a master's degree. Each of these school was accredited and within the United States. Furthermore, these higher learning institutions were specifically for the education and training of teachers. Through his study of courses offered up to 1950, Layton discovered that only one-fourth of the colleges required a mathematics course for entrance to the teacher education program and university. Of these twenty colleges, entry requirements averaged only 1.2 units of high school mathematics or less than two courses.[11] Moreover, many of the colleges offered options for students to place out of any college level mathematics based on examination or approved high school course work, which meant passing the course with a C or better.[12]

Although elementary education students could opt out of college coursework in several ways, those who were required to take a mathematics course in college never surpassed the level of college algebra. Many schools required no mathematics courses during the four or five years in college. Layton stated that "of the colleges supplying sufficient data on both their undergraduate and graduate programs, 71 percent had no place in either their four-year or their five-year degree curricula for any mathematics content courses."[13] He suggested that this trend was popular for a majority of elementary education programs.[14]

According to another survey of college admission requirements for state teacher, nearly three-fourths required no mathematics. Of the colleges that did require a math

credit, the majority mandated one year of any high school mathematics. This is astonishing and frightening because the state teacher colleges accounted for nearly half of all elementary school teachers in the country.[15] Furthermore, as of 1950, roughly 35 states still did not mandate a mathematics course upon elementary teacher certification.[16] By 1960, only six states changed their requirements, leaving 29 states with no mathematics for elementary teacher certification.[17] These numbers reinforce the idea that nationwide, a majority of colleges and certification programs necessitated no math for elementary educators.

Finally, Layton further showcased the weaknesses of elementary education training. He noted that of the twenty schools that provided a fifth year of instruction (a master's degree equivalent), none of the institutions required additional, if any, math courses. It is amazing to think that an individual with a master's degree in elementary education could go through five years of college with zero math courses.[18] How does one adequately teach students the fundamentals of mathematics without the proper instruction or understanding of simple arithmetic? Until the mid-twentieth century, teacher certification requirements were slack. This further illustrated disconnect between mathematicians' research and advancement, as well as the math necessary to secondary education.[19] It becomes apparent through Layton's studies that schools and colleges before and during the 1950s created an increasingly large supply of poorly trained, mathematically illiterate elementary school teachers.

Layton concluded that the requirements for mathematics, in comparison to other subjects covered in elementary education training, remained extremely low and very concerning. For instance, the average amount of coursework for English was

approximately thirteen times that of mathematics requirements.[20] These low admissions and graduation requirements were not only shocking but appalling. While this was only a small sampling of colleges, Layton showed that elementary education college graduation requirements were no better than those for high schools. Moreover, Layton proved how ill prepared elementary teachers were who graduated before the 1950s. In his closing summation, Layton wrote:

> This seems to indicate a weak foundation for our potential teachers of mathematics in the elementary school as far as admission requirements are concerned…This inadequate preparation in mathematics for teachers in the elementary school is an alarming situation not only in view of the over-all future of our civilization, but even more especially now with the increased demands placed upon mathematics due to the present national emergency.[21]

Thus, a well-qualified teacher prior to and during the 1950s may still only have one to two semesters of mathematics not above the college algebra upon entering the classroom. Worst yet, an extremely ill-prepared elementary teacher would not have taken math since the eighth grade upon beginning their career. Therefore, it is not shocking that after the launch of *Sputnik*, only a few years later, the education reform known as New Math would attempt to build itself upon the shoulders of inadequate teachers. Ultimately, this lack of training directly correlates with the need for extensive training efforts during the implementation of New Math curricula.

An Overview of American Teacher's Education

Thus far, this chapter established the poor education students received prior to entering college, focusing primarily on the elementary school educator. It also examined the preconditions of teacher college admissions as well as some statistics regarding the quantity or mathematics training leading up to and during college. In taking a step back, this chapter now examines the history of mathematics education as a whole. This

discussion begins with the early 1900s and follow the education trends through the 1960s. From the 1900s through the 1940s, a period commonly referred to as the Progressive Era, tremendous leaps in mathematics education occurred. While these leaps are meaningful and in fact forward-looking, they illustrate the weaknesses of math education as a whole. By this point, ineffective prerequisite coursework for elementary education training in mathematics became apparent. In expanding the historical scope, math teacher training showcased the weaknesses of math education at all level leading into college. Additionally, this segment incorporates a discussion of cultural and political forces which helped shape the mathematics training for all educators.

Teachers in the first two decades of the twentieth century often taught mathematics with little formal teaching education, as illustrated. The early 1900s were full of social change as immigration increased and industrialization further developed. The consolidation of schools and school districts began in large cities such as New York and Chicago. However, centralization did not necessarily bring about better teacher education. In the early 1900s, qualifications for teachers in general varied from minimal education (often no high school diploma) to obtaining a high school diploma. Few teachers sought a two-year degree at a normal school.[22] In fact, during the first decade of the twentieth century, "a mathematics teacher probably graduated from college with only about one year's work further advanced in mathematics than the level he or she was about to teach."[23]

By the 1920s, academics began shifting focus to require a four-year degree. This meant many normal schools either made the shift to four-year universities or closed. Many teachers migrated to four-year degree programs during the 1910s, partly due to

availability and requirements, but also because normal schools had developed a reputation for focusing too much on pedagogy and not on the actual subject matter.[24] It was also during this time that secondary teachers were required to achieve higher levels of education than primary school instructors. Four-year degrees were becoming the standard but only for secondary school teachers. Elementary level instructors were still only required to obtain a two-year degree.[25] The discrepancy in degree requirements and the level of teaching was partly due to a new emphasis on formulating stronger secondary education programs. As Angela Lynn Evans Walmsley stated: "It is during this time that the mathematical competence of the elementary teacher was first questioned."[26] It was not until 1940 that the National Teacher Examination (NTE) was implemented to establish a national standard.[27]

Immediately following the onset of World War I, a dramatic exodus from teaching positions occurred. Teachers, primarily women, changed roles within the workforce. Many women left teaching to fill vacant wartime positions from previously held by deployed men. The shortage in teachers affected both rural and urban schools equally, forcing school systems to hire under-qualified individuals to fill teaching posts. Following the end of the war, public attention shifted to increasing teacher salaries.[28] Kathryn Cook, a member of the U.S. Bureau of Education from 1921 to 1927, believed there was "unusual and satisfactory progress in raising the standards of qualifications demanded of prospective teachers."[29] This was in large part due to the teacher shortage turning into a teacher surplus as women retreated from the workforce and returned to the classroom. Thus, advances in requirements "coincided with expansion of the numbers of collegiate level places for teacher training."[30]

Unfortunately, the number of math educators remained insufficient as school systems and secondary education expanded. According to Walmsley, "in 1918, a report stated the United States could not offer high levels of mathematics in schools because it lacked teachers highly trained in mathematics as well as individuals with strong mathematical backgrounds who wanted to become teachers."[31] Thus, a lack of subject-specific teachers existed at all levels. This lack of subject educator specialist continued through the 1960s as mathematicians frowned on the education of teachers. By 1920, mathematics educators became defensive of the efforts to unify and reform mathematics. Frustration and lack of a national mathematics voice gave way to the formation of the National Council of Teachers of Mathematics (NCTM) in the 1920s. In 1921, C.M. Austin, a mathematics educator and first NCTM president, stated:

> Mathematics courses have been assailed on every hand. So-called educational reformers have tinkered with the courses, and they, not knowing the subject and its values, in many cases have thrown out mathematics altogether or made it entirely elective....To help remedy the existing situation the National Council of Teachers of Mathematics was organized.[32]

Their goal was to consolidate resources and act as a voice for mathematics teachers across the country.[33] The NCTM remains an active and forceful ally to mathematics educators of all grade levels. Coincidentally, for 1920 also saw the first summer courses delivered for in-service teachers, specifically for elementary level educators. These developed courses provided a way to supplement the elementary-level educators' degree work and help improve those teachers who were under-qualified.[34]

With the development of the NCTM, teachers began cultivating alliances with higher education leaders to create more effective math curriculums in the 1920s. The

academy sought to shift the mindset of secondary education teachers away from drill-and-practice methods to deeper ideas of understanding. This meant teachers themselves needed a form of revised instructional training. As an answer to necessary revised training, higher education institutions developed three pathways to teaching mathematics: a) complete coursework in pure mathematics, b) complete coursework in applied mathematics, and c) complete coursework in pedagogy and teaching. However, teachers that previously completed their degree work did not gain training in these different approaches. Those still attending normal schools also lacked the availability of new approaches to math and teaching.[35]

While normal schools maintained an emphasis on pedagogy, they left math teachers with little background in advanced mathematics. The 1920s and 1930s witnessed an explosion in universities. More normal colleges made the transition to four-year institutions but still lacked an emphasis on subject matter training. In turn, elementary teachers continued to lack mathematics skills. The public viewed elementary level educators as generalists – not specializing in one subject, but rather slightly experienced in every subject. As a result, elementary teachers taught their students in the traditional fashion – with rote learning – just as their teachers taught them. Until the 1930s, states did not place requirements on teachers for certification. In fact, many states did not certify their teachers at all thereby creating a lack of state and national minimum qualifications for math educators.[36]

As the 1930s brought sweeping national economic depression, it also expanded teacher education. By 1930, there were nearly 150 collegiate teaching schools. A rapidly increasing high school enrollment helped with the expansion of normal schools to

collegiate teaching programs. In 1900, there were roughly 630,000 enrolled high schoolers, but by 1930, there were over 4.7 million.[37] The increased enrollment in secondary education had three effects: 1) Because more students were attending secondary schools, it now made sense to make high school completion a requirement for entrance to normal schools; 2) Normal schools were alleviated by providing primary and secondary education to incoming students; and 3) Normal schools could now focus on training high school teachers as universities pushed secondary educator certification to the level of a bachelor's degree.[38] In 1935, academia made a call for secondary teachers to again increase their knowledge of advanced mathematics and methodology. The academic community made this possible by furnishing courses at the university level.[39]

During the 1930-31 school year, fewer than three-fourths of all elementary teachers received two years of college or more.[40] In contrast, two-thirds or "60 percent of junior high teachers and 87 percent of high school teachers had at least four years of college."[41] Thus, while emphasis remained on additional and more advanced education for secondary school teachers, elementary level instructors were left with minimal training in specific subjects, including mathematics. Instead, elementary school teacher training focused more on the study of education and pedagogy. According to the U.S. Office of Education's senior specialist, Benjamin Frazier, elementary school teachers in training at that time often studied "elementary school methods, educational measurements, history of education, educational psychology, classroom management, organization and management of elementary schools, principles of education, and the elementary school curriculum."[42] While Frazier did not list specific coursework required of high school teachers, as it would vary depending on the individual teacher's specific

subject of study, he stated that by the end of the decade, 33 states required student teaching and four years of college for high school teacher certification. As standards for secondary education instructors increased and became regulated by a majority of states, it became evident that they left elementary level educators in the dust.[43]

While universities began offering more advanced math courses for some teachers, the Mathematical Association of America (MAA) and the NCTM still felt high school teachers required more adequate math knowledge for licensure. Both organizations thought secondary math educators should obtain mastery of math topics up to and through calculus. Furthermore, the MAA and NCTM felt every mathematics department should maintain a teacher whom they dubbed "highly trained."[44] By 1950 only two-thirds of states required any math training and no methods course for certification. Many institutions and organizations made strong suggestions, but formal requirements remained ambiguous.[45]

The 1940s ushered in World War II. As with World War I, the Second World War caused a scarcity of teachers.[46] In 1943, Frazier noted the dramatic increase in the number of emergency teaching certificates issued by states. According to him: "In 1940–41 the number [of emergency issued teaching permits] was 2,305; in 1941–42, 4,655; and in 1942–43, 38,285, or more than 8 times the number issued during the preceding year."[47] However, with the growing influence of World War II, that number grew to 69,423. By the end of the war, an estimated 108,932 emergency certificates had been issued, equivalent to the annual number of newly hired teachers during non-wartime periods.[48] Frazier felt that the wartime shortage was only temporary, and once the conflict ended,

pushing for higher teacher requirements and standards would resume. At this time the National Education Association (NEA) reported:

> During World War II, the quality of teaching in the public schools was allowed to deteriorate to an alarming extent. Certification and preparation standards were lowered drastically. Tax rates were not kept abreast of rising prices. Teachers' salaries lagged far behind those in defense plants and industries generally, resulting in a tragic migration of teachers to other jobs. At the conclusion of the War, the situation did not right itself, as many had supposed that it would.[49]

Thus, Frazier was only partly correct. As the NEA reported, teaching shortages did not correct themselves. In fact, the shortages and certification standards lasted throughout the 1950s and into the 1960s, as women did not flock back to the classroom, but instead gained a more concrete foundation in the American workforce.[50]

In the post-World War II years, many colleges found themselves with increasing enrollment numbers. The Second World War brought attention to the inadequate mathematics teaching in America. According to one author and mathematician, Morris Kline, the military realized how math illiterate the soldiers were and instituted special math courses to improve the overall proficiency of the troops. Furthermore, World War II highlighted the importance of mathematics and science training concerning code breaking, nuclear bomb development, aerial combat, fluid mechanics, and logistics. At the close of the war, the value of a mathematics education increased dramatically among returning soldiers. Moreover, there was a substantial increase in college enrollment following the Second World War. This was largely due to the development and implementation of the GI Bill. The combination of these factors led to growing interest and enrollment in mathematics programs overall.[51] As a result, "[college] freshmen were ready to study calculus, as the level of high school mathematics for such students had

come by 1950 to include two years of algebra, Euclidean geometry and a 'pre-calculus' course of analytic geometry and trigonometry."[52] The implications of World War II forced colleges to adopt more rigid entrance requirements for all applicants, including future teachers.

Fortunately, Frazier was correct in assuming the pursuit of high standards in teaching certification would resume after World War II. However, this was primarily due to the 1946 development of the National Commission on Teacher Education and Professional Standards (NCTEPS). This was an organization, created by the NEA to promote changes to teacher certification requirements, helped revitalize teaching standards.[53] NCTEPS became a driving force in teacher certification nationally, even accrediting colleges of education. During the Progressive Era, the gap between the education establishment and the classroom teacher grew wider. NCTEPS supported the classroom teacher by giving them a nationalized voice.[54] This rallying group pushed for significant changes in education. NCTEPS grew rapidly. Within fifteen years, affiliates occupied every state. The organization became indispensable in mandating a bachelor's degree for elementary school teacher qualifications. Furthermore, NCTEPS demanded a five-year requisite for high school educators.[55]

As a result of NCTEPS, elementary education during the 1950s became more homogenous. With the requirement of a bachelor's degree, most college elementary education programs required teachers to complete, at minimum, one math course, usually titled "teaching arithmetic." The College Entrance Examination Board (CEEB) asserted that anyone wanting to pursue elementary education at the college level was required to enter with strong math skills, and continue to pursue math coursework during their four-

year term. The CEEB also suggested that anyone pursuing a job as a high school mathematics teacher should move beyond the standard bachelor's degree and either obtain a master's degree or take four years' worth of math courses with a fifth year of teaching methods. These were the same recommendations proposed by NCTEPS. Unfortunately, these proposals remained just suggestions in many states.[56] As of 1950, only fifteen states required some form of mathematics for admission into an elementary education certification program. This meant that roughly 70 percent of states did not require any mathematics to acquire an elementary teaching certificate. Many states adopted the CEEB and NCTEPS suggested requirements, but by 1960 twenty-nine states still did not require mathematics for an elementary education teaching certificate. Additionally, by 1960 there a large number of higher learning institutions continued to admit high school graduates to elementary education program with no high school mathematics background.[57] It was not until the mid-1960s that educational agencies formally required a bachelor's or master's degree.[58]

Membership in national organizations increased over the decades. Teachers continued to build relationships across educational boundaries and levels. As a result, curriculum reform groups developed and incorporated both mathematicians and math educators. These reform efforts began at the college level but quickly moved into the realm of secondary education, which continued to dominate national focus. Though curriculum development groups promoted interdisciplinary work, they also created large discrepancies between qualified and inadequate teachers. Although national organizations and colleges sought to increase teaching requirements, broadly speaking, by 1957 it became abundantly clear that educational emphasis should shift to mathematics and

science. New math curriculum was under development as early as 1951, but the shift in focus would not occur until after *Sputnik*.

Many attributed the start of New Math to the launch of *Sputnik*; however, the Soviet satellite only propelled and accelerated the efforts of national education reform already in progress. As shown, New Math began in some forms prior to 1957. As a result of *Sputnik*, Congress passed the National Defense Education Act of 1958 which poured government funding into education and education reforms. The Soviets, with their launch, showcased their technology as compared to the United States. The fear of being technologically inferior drove the federal government to promote education change.[59] As Angela Walmsley stated: "The launching of *Sputnik* shook the nation's faith in the American school system, especially in the areas of science and mathematics… 'Sputnikshock' brought the problems of a low standard of mathematics education to the public."[60] Thus, the New Math reform accelerated and gained increased public attention in the aftermath of October 1957.[61]

In the years leading up to the 1960s, many educators, primarily at the elementary level, continued to lack the required education needed to teach New Math curriculum in their classrooms. According to some, there were doubts about whether elementary school teachers could adequately perform arithmetic.[62] Although this statement may not be accurate for every elementary level teacher during the 1960s, it did suggest that mathematicians and educators were aware of poor performing teachers. As a result, Elbert Fulkerson, a professor at Southern Illinois University - Carbondale, published a micro-study on students enlisted in the teacher education program in the late 1950s. According to Fulkerson's report, he described the Mathematics 210 course as

"'professional treatment of the subject matter of arithmetic methods and a study of trends and current literature on the teaching of arithmetic.'"[63] Thus, this was an example of what Walmsley referred to as a "teaching arithmetic" course. In his study, Fulkerson surveyed 158 students on the first day of the Math 210 the course. These students were given a test of forty basic mathematics problems, and told the test would not count against their grade. All of the participants had a four-quarter-hour course in mathematics, but with varying degrees of high school level mathematics teaching.[64]

To give some context to the types of questions given to the 158 students, this thesis selected a few example questions. The first was question number 33 on Fulkerson's test: "Find the cost of 580 gallons of fuel oil at 12.8."[65] This question was missed by 83 of Fulkerson's students. The seventh most missed question reads: "A truck loaded with coal weighs 12,550 pounds. If the empty truck weighs 5100 pounds, find the cost of the coal at $8.60 per ton."[66] This question was missed by 111 students, or more than two-thirds of Fulkerson's class. The reported overall average score was 50 percent, far below what many in the teacher teaching industry felt acceptable. Fulkerson pointed out that "the study shows that one student answered just one item correctly, and only one [student] answered as many as 39 [correctly]."[67] According to an editor's note, Fulkerson's results were accurate and equivalent to other similar studies conducted independently.[68]

With a small sample, Fulkerson illustrated how ill-prepared elementary teachers, and future teachers were in regards to mathematics. If these students could not complete basic arithmetic, how could mathematicians expect these same teachers to carry out and teach complex ideas of inequalities, set theory, and geometry associated with New Math?

As Fulkerson stated, "far too many of the 158 prospective elementary teachers studied herein have an insufficient knowledge of arithmetic to teach the subject effectively."[69]

While Fulkerson and others proved what most of the national teaching organizations knew about the poor state of math teachers, many remained unable to change requirements going into college and for certification. Before Fulkerson, the MAA formed the Committee on the Undergraduate Program (CUP) in 1953, but by 1960 the MAA renamed CUP as the Committee on the Undergraduate Program in Mathematics (CUPM).[70] While the 1953 version sought to bridge the gap between curriculum and research, the focus of the renamed 1960s organization sought to create a "broad mathematical program to improve undergraduate curriculum."[71] CUMP focused on three types of students: 1) students who sought to continue their mathematics training in graduate school, 2) students who sought to apply their mathematics knowledge to fields of science and engineering, and 3) students planning on becoming certified to teach elementary and secondary education.[72]

Regarding entrance into a four-year university, CUMP suggested that all students should have 3.5 or 4 years of mathematics. More specifically, CUMP suggested courses in geometry, intermediate algebra, elementary functions (including polynomials, rational functions, logarithmic functions, and exponential functions), and some two- and three-dimensional geometry. CUMP recognized that in the early 1960s, high schools across America did not offer many of these courses and thus colleges compensated by developing remedial mathematics courses. CUMP recommended that schools offer different quantities and difficulties of mathematics based on the level of education the teacher wished to pursue. Table 1 illustrates the types of courses required of teachers at

various levels. The table shows that CUMP recommended the fewest math courses for elementary school teachers, and the most for high school teachers. Also, Table 1 notes the level of mathematics required for teachers, specifically that elementary school teachers were not required to take courses beyond arithmetic and geometry, whereas high school teachers took more advanced courses. Many of these proposals came from mathematicians, not teachers.[73]

The desire to continue raising teacher certification and training requirements would continue throughout the 1960s. These new requirements instilled the concepts of New Math in teachers, thereby leaving them more prepared than many senior educators. Beginning in the 1960s, both mathematicians and math educators held four reasons for improving teacher certification:

> 1) the many 'new math' projects changed the standard mathematics curriculum,; 2) the promotion of discovery learning and stress on creativity among students in mathematics; 3) more emphasis on the college-bound student as more students were attending college; and 4) the introduction go newer mathematics and higher level mathematics such as probability and statistics, linear algebra, calculus, etc.[74]

These reasons carried throughout the subsequent decades as New Math material infiltrated schools and proliferated. The increased difficulty level in conjunction with the four reasons to continue improving teacher certification requirements created a divide. Many mathematics teachers in elementary and secondary education disagreed with such stringent and high-level math requirements. As a result, a split between mathematicians (college math instructors included) and those teaching secondary or elementary grades emerged. This divide would inevitably give way to the development and disagreements of New Math.

Table 1: Comparison of Required Math Courses in College for Teaching Certification

Courses	Algebra	Geometry	Calculus (3 Course Sequence)	Geometry	abstract algebra	Probability and Statistics	Analysis	Linear Algebra	Advanced Geometry	Rough total number of hours
Elementary	X	X								20
Middle Grades	X	X	X	X	X	X				28
High School*	X	X	X	X	X	X	X	X	X	33

*It should be noted that CUMP also suggested that for any high school teacher teaching advanced math courses (math courses of calculus or beyond), they should complete two-thirds of their degree work at the graduate level. A different selection of courses was not listed. Thus it is assumed that the same courses listed for high school teacher on the chart could be taken, but at a greater degree of difficulty.

Source: W. L. Duren, "A General Curriculum in Mathematics for Colleges," The American Mathematical Monthly 72, no. 8 (1965), 826; Walmsley, *A History of the New Mathematics Movement and Its Relationship with Current Mathematical Reform*, 78-80.

Nationalized Movement

It is in the 1960s that academia took note of how ill prepared a majority of teachers were. The academic academy also noted of the poor mathematics training provided to teachers and the minimal requirements needed. In fact, academics and organizations claimed that teacher education as a whole remained far too simple. Four-year programs continued to admit prospective teachers with little to no high school mathematics. This further illustrated why teachers struggled to understand and implement New Math concepts. For the first time, academia accessed teacher capabilities at all levels of education and across the country.

Education began to alter in the late 1950s, and continued throughout the 1960s. Perhaps one of the most significant dates for this project was 1958, when Congress passed the National Defense Education Act (NDEA).[75] The NDEA established federal funding for higher education and targeted further research and education in science, math, and foreign language. However, the Act did much more for education overall:

> It established the legitimacy of federal funding of higher education and made substantial funds available for low-cost student loans, boosting public and private colleges and universities. Although aimed primarily at education in science, mathematics, and foreign languages, the act also helped expand college libraries and other services for all students.[76]

Once signed into law, NDEA funding began and steadily increased over subsequent years until the passage of the Elementary and Secondary Education Act in 1965.[77] According to the Senate Historical Office, the NDEA promoted and dramatically increased college education: "in 1960 there were 3.6 million students in college, and by 1970 there were 7.5 million."[78] Thus, the NDEA

became synonymous with mid-century education reform, particularly in regards to mathematics and science due to the timing of its passage.[79]

New Math appeared in the early 1950s but lacked a single start date. Curriculum groups functioned independently of one another and developed at varying rates and times. The School Mathematics Study Group (SMSG), formed in 1958, received immense funding through the National Science Foundation and the NDEA.[80] The SMSG also became synonymous with the New Math movement and the shift in education. In discussing the changes in teacher education and requirements, 1958 was as a pivotal year because 1) the passage of NDEA allocated more funding and 2) the formation of the SMSG meant new mathematics curriculum began to emerge for teachers.

As a result of *Sputnik*, the NDEA, and the emergence of curriculum study groups, increased educational standards resurfaced in the form of New Math. More specifically, mathematicians and math educators (i.e. CUMP) supported newer and higher standards. Towards the mid-1950s, the presidents of the MAA and the American Mathematical Society (AMS) coordinated with the president of NCTM to develop SMSG. The presidents of the three associations wanted to develop a more standardized math curriculum for high school students (and eventually middle and elementary grades as well) that would better prepare them for college-level mathematics. In 1963, CUMP published a report entitled "Pre-graduate Preparation of Research Mathematicians" that mentioned the adoption of SMSG curriculum, which promoted the adoption of far more difficult concepts including axiomatic set theory.[81]

Conclusion

National organizations and mathematicians (including college level math instructors) began standardizing all levels of mathematics in the late 1950s and 1960s. While the requisites for high school graduation, college acceptance, and teacher certification developed over the course of fifty years New Math curriculum ultimately illustrated how ill-prepared teachers were with the increasingly high-level required math courses and increasingly difficult teaching concepts. Most teachers, even by 1960, were not well versed in the concepts of axioms, set theory, or even calculus. Although CUMP and the national organizations pushed to create minimum requirements, inevitably, it was left up to each state to adopt these suggestions. Furthermore, CUMP and other organizations promoted higher level mathematics in the late-1950s and 1960s but did not take into account the thousands of teachers already in the classroom who finished college with one semester or less of mathematics training.

Curriculum development groups retrained teacher as a direct result of increasing math course difficulty, the emergence of New Math curriculum requirements, and previously poor teacher certification requirements. In some cases, the curriculum groups went further and taught math teachers the concepts necessary to implement New Math in the classroom. Ultimately, this led to the development of new math courses, film training, workshops, NSF Institutes, and in-service training projects. The mobilization to train or re-teach teachers became one of the largest efforts in education history.

The era of New Math and national education change became known New Frontier after President John F. Kennedy utilized the term in his acceptance speech in the 1960 United States presidential election.[82] During this period, the federal government began

combining laws and reforms in hopes of eliminating inequality throughout the United States. Examples of this included the Civil Rights Act of 1964, the Elementary and Secondary Education Act (1965), and the Bilingual Education Act (1968). Each piece of passed legislation broke down barriers and walls once firmly cemented in the nation's education systems.[83]

ENDNOTES

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[5] Howard F. Fehr, "The Administration of Mathematics Education in the United States of America," *School Science and Mathematics* 55, no. 5 (May 1955), 55, 341.

[6] W. I. Layton, "The Mathematics Required for Graduation from High School," *The Mathematics Teacher* 47, no. 5 (May 1, 1954), 316.

[7] Layton, "The Mathematics Required for Graduation from High School," 317-318.

[8] Ibid, 318.

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[10] David Angus and Thomas B. Fordham Foundation, "Professional Preparation of Teachers for Rural Schools: Abstracts of Addresses," ed. Jeffrey Mirel, in *Professionalism and the Public Good: A Brief History of Teacher Certification* (Washington, D.C.: Thomas B. Fordham Foundation, 2001), v, 21-23; Layton, "The Mathematics Required for Graduation from High School," 316-319.

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[13] Layton, "Mathematical Training Prescribed by Teachers Colleges in the Preparation of Elementary Teachers," 555.

[14] Ibid., 554-556.

[15] F. E. Grossnickle, "The Training of Teachers of Arithmetic," in *The Teaching of Arithmetic*, ed. Nelson Henry, by National Society for the Study of Education (Chicago: University of Chicago Press, 1951), *Yearbook of the National Society for the Study of Education*, 50th, pt. 2, 208.

[16] Grossnickle, "The Training of Teachers of Arithmetic," 205.

[17] W. Wooten, *SMSG: The Making of a Curriculum* (New Haven: Yale University Press, 1965), 99.

[18] Layton, "Mathematical Training Prescribed by Teachers Colleges in the Preparation of Elementary Teachers," 554.

[19] Angus and Thomas B. Fordham Foundation, "Professional Preparation of Teachers for Rural Schools," 20-30.

[20] Layton, "Mathematical Training Prescribed by Teachers Colleges in the Preparation of Elementary Teachers," 553.

[21] Ibid, 554-555.

[22] Angela Lynn Evans Walmsley, *A History of Mathematics Education During the Twentieth Century* (University Press of America, 2007), 5, 9; Wayne J. Urban and Jennings Wagoner, *American Education: A History*, 2nd ed. (Boston: McGraw-Hill Humanities Social, 1999), 196-208.

[23] Walmsley, *A History of Mathematics Education During the Twentieth Century*, 5.

[24] Angus and Thomas B. Fordham Foundation, "Professional Preparation of Teachers for Rural Schools,"12; Walmsley, *A History of Mathematics Education During the Twentieth Century*, 9; David F. Labaree, *How to Succeed in School Without Really Learning: The Credentials Race in American Education* (New Haven: Yale University Press, 1998), 144.

[25] Walmsley, *A History of Mathematics Education During the Twentieth Century*, 8-9.

[26] Ibid, 9.

[27] Emma Spaney, "The Performance of the Mathematics Candidates in the 1940 National Teacher Examinations," *The Mathematics Teacher* 34, no. 1 (January 1941), 8-9; Heather Hill et al., "Assessing Teachers' Mathematical Knowledge: What Knowledge Matters and What Knowledge Counts," in *Second Handbook of Research on Mathematics Teaching and Learning*, ed. Frank Lester Jr (Charlotte, NC: Information Age Publishing, 2007), 115-120.

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[33] Walmsley, *A History of Mathematics Education During the Twentieth Century*, 13.

[34] Ibid, 9.

[35] Ibid, 13.

[36] Ibid, 13; Susan Light, "Impact of 'New Math' Affects Teachers Too," *The News*, May 9, 1964.

[37] Angus and Thomas B. Fordham Foundation, "Professional Preparation of Teachers for Rural Schools," 25.

[38] Ibid, 25-26.

[39] Walmsley, *A History of Mathematics Education During the Twentieth Century*, 17.

[40] Benjamin Fraizer, *Development of State Programs for the Certification of Teachers. Bulletin, 1938, No. 12*, (Washington, D.C.: Office of Education, United States Department of the Interior, 1938), Bulletin, 60-61.

[41] Angus and Thomas B. Fordham Foundation, "Professional Preparation of Teachers for Rural Schools," 18.

[42] Fraizer, *Development of State Programs for the Certification of Teachers*, 62-63.

[43] Ibid, 63-65.

[44] Walmsley, *A History of Mathematics Education During the Twentieth Century*, 21. The phrase "highly trained" is ambiguous in the text, but would seem to mean trained in math beyond the level of calculus. This phrase, "highly trained" and similar ones would also be used as tools of measurement during the New Math era. However, "highly trained" was never quantified of given a equivalent measurement on any type of teaching scale.

[45] Walmsley, *A History of Mathematics Education During the Twentieth Century*, 22.

[46] Morris Kline, *Why Johnny Can't Add: The Failure of the New Math* (New York, NY: New York, Vintage Books [1974, c1973], 1974), 15; Alan Tucker, "The History of the Undergraduate Program in Mathematics in the United States," *The American Mathematical Monthly* 120, no. 8 (2013), 7-8.

[47] Benjamin Frazier, *Relief of Teacher Shortages by State Departments of Education* (Washington D.C.: Government Printing Press, 1943), 2.

[48] Angus and Thomas B. Fordham Foundation, "Professional Preparation of Teachers for Rural Schools," 22; Frazier, *Relief of Teacher Shortages by State Departments of Education*, 1-3.

[49] NCTEPS, *The Professional Standards Movement in Teaching: Progress and Projection* (Washington, D.C.: National Education Association of the United States, 1956), 3 – 4, 12.

[50] Angus and Thomas B. Fordham Foundation, "Professional Preparation of Teachers for Rural Schools," 30-32.

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[52] Ibid, 8.

[53] Dana Cesar, "Reformation of the Teaching Profession: A Genealogy of the Oklahoma Commission for Teacher Preparation as a Regulatory Standards Board," (n.p., 2006), 50-51, 53-54.

[54] Angus and Thomas B. Fordham Foundation, "Professional Preparation of Teachers for Rural Schools," 21.

[55] Ibid, 23-24.

[56] Walmsley, *A History of Mathematics Education During the Twentieth Century*, 26-28.

[57] Walmsley, *A History of the New Mathematics Movement and Its Relationship with Current Mathematical Reform*, 78-79.

[58] Walmsley, *A History of Mathematics Education During the Twentieth Century*, 26-28.

[59] Walmsley, *A History of the New Mathematics Movement*, 1-5.

[60] Ibid, 3.

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[62] J. Stipanowich, "The Mathematical Training of Prospective Elementary Teachers," *The Arithmetic Teacher*, no. 4 (1957), 240-241.

[63] E. Fulkerson, "How Well Do 158 Prospective Elementary Teachers Know Arithmetic?", *The Arithmetic Teacher*, (1960), 141.

[64] "Editor's Note," *The Arithmetic Teacher*, (1960), 158.

[65] Fulkerson, "How Well Do 158 Prospective Elementary Teachers Know Arithmetic?", 143.

[66] Ibid, 143.

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[68] "Editor's Note," *The Arithmetic Teacher*, (1960), 158. See additional studies with similar results in Buswell, G. T., "The Content and Organization of Arithmetic," *The Arithmetic Teacher*, VI (March,1959), 77-83; John E. Bean, "Arithmetical Understandings of Elementary School Teachers," *Elementary School Journal*, LIX (May, 1959), 447-50; John L. Creswell, "An Analysis of the Relationships of Selected Factors to Mathematics and Arithmetic Competency of Prospective Elementary Teachers in Georgia" (Doctoral dissertation, University of Georgia, 1963); J. Fred Weaver, "A Critical Problem in the Preparation of Elementary School Teachers," *Elementary School Journal*, LVI (February, 1956), 255-6; Jacobs Orleans, and Edwin Wandt, "The Understandings of Arithmetic Understood by Teachers," *Elementary School Journal*, LIII (May, 1953), 501-07.

[69] Fulkerson, "How Well Do 158 Prospective Elementary Teachers Know Arithmetic?", 146.

[70] Walmsley, *A History of the New Mathematics Movement and Its Relationship with Current Mathematical Reform*, 78-79; Tucker, "The History of the Undergraduate Program in Mathematics in the United States," 9-10.

[71] Walmsley, *A History of the New Mathematics Movement*, 79.

[72] Ibid, 79.

[73] W. L. Duren, "A General Curriculum in Mathematics for Colleges," *The American Mathematical Monthly* 72, no. 8 (1965), 826.

[74] Walmsley, *A History of the New Mathematics Movement*, 76-77.

[75] For the purposes of this thesis Titles III and VII through IX of the NDEA will be most useful. These sections covered funding for science studies, teacher training workshops, teacher training via film and television, and the establishment of the National Science Foundation, who would go on to distribute millions of dollar to curriculum groups for writing, development, and teacher training. For a detailed analysis and examination of the NDEA, see: Wayne J. Urban, *More Than Science and Sputnik: The National Defense Education Act of 1958* (Tuscaloosa: The University of Alabama Press, 2010).

[76] Senate Historical Office, "1941: Sputnik Spurs Passage of the National Defense Education Act -- October 4, 1957," May 29, 2014, Accessed July 17, 2016; Urban, *More Than Science and Sputnik: The National Defense Education Act of 1958* (Tuscaloosa: The University of Alabama Press, 2010), 2-5.

[77] Wayne Urban and Jennings Wagoner, *American Education: A History*, Second ed. (U.S.: McGraw Hill, 2000), 331-333.

[78] Senate Historical Office, "1941: Sputnik Spurs Passage of the National Defense Education Act -- October 4, 1957." In regards to mathematics degrees, Tucker states that: "it is estimated that the number of math Bachelor's degrees at least doubled from the early 1950's to 1960 when there were 13,000 math degrees. In 1966, there were 20,000 math degrees. In 1970, the number had grown to 27,000 a year, over 4% of all college graduate." (See Tucker, "The History of the Undergraduate Program in Mathematics in the United States," 10-11) Thus, while the number of enrolled college students increased, it would seem the number of bachelor's degrees in mathematics grew substantially as well, at least in relation to the number of overall college attendees.

[79] Ibid.; Urban, *More Than Science and Sputnik: The National Defense Education Act of 1958* (Tuscaloosa: The University of Alabama Press, 2010), 2-5.

[80] Some sources suggested that the SMSG received nearly $10 -$12 million dollars throughout its lifespan. See: Edward Edelson, "What's Happening to New Math," *The Times*, September 26, 1974; Frank Kendig, "Does New Math Add Up?," *New York Times*, January 6, 1974.

[81] Tucker, "The History of the Undergraduate Program in Mathematics in the United States," 10-12.
[82] Urban and Wagoner, *American Education*, 311-314.
[83] Ibid, 316-319, 328-329.

CHAPTER 2: CORRECTING THE COUNT

As New Math curriculum descended upon learning institutions across America, curriculum developers and teachers quickly realized specific mathematics training was necessary. “The teachers I found are frightened. They don't understand the new math or why they are supposed to teach it.”[1] This statement made by Professor Robert Wirtz from the University of Illinois, encapsulated the emotions of elementary school teachers at more than 100 schools across the nation. In 1965, teachers remained fearful of New Math, mostly because they did not understand the material. Max Beberman, of the University of Illinois Committee on School Mathematics (UICSM), feared fast spreading of New Math left teachers ill-prepared and confused.[2] According to Beberman, “I find frightened teachers…Elementary school teachers have become so frightened by the prospect of using esoteric mathematics…they have lost all common sense.”[3] He recognized elementary level teachers could not be retrained as quickly, because they taught a variety of subjects, which differed from their high school counterparts.[4] With fearful and ill-prepared mathematics teachers inhabiting the nation’s schools mathematicians and the American government found it prudent to invest in teacher training and education to further the New Math reform.

Curriculum groups, such as SMSG, UICSM, UMMaP, and others designated large portions of their budgets towards teacher training development.[5] Numerous curriculum development groups emerged by the late-1950s, bringing with them a plethora

of training options for teachers tailored to each new curriculum. Many writing groups utilized similar training approaches. Such training included film series, workshops, summer sessions, mentor-like programs, and increased access to graduate degree work. Each type, dependent upon the focus of individual curriculum groups, offered high school, middle school, and elementary school teachers the opportunity for additional training.

While curriculum development groups promoted their training programs, a national effort to improve mathematics teaching occurred simultaneously. The National Science Foundation (NSF) emerged as a strong supporter of math teacher training programs. The NSF sponsored workshops became known as Institutes, which primarily ran during the summer months, and also as year-long programs. Institutes reached more teachers than any other training initiative of New Math, but still only reached 50 percent of secondary educators and an even smaller number of elementary teachers. The scope and reach of the training efforts would become problematic over the course of New Math implementation.[6]

Training efforts from all avenues reached only a small fraction of American educators. In 1965, *Newsweek* published an article estimating there were 135,000 high school math teachers compared to nearly 1.1 million elementary school teachers.[7] Curriculum groups only reached a small portion of elementary school teachers, compared to their ability to reach larger quantities of high school math teachers. One report showed twenty-one NSF elementary school summer institutes held in 1964, the greatest number of any year. The peak of NSF Summer Institutes for secondary teachers, offered in a single year, amounted to nearly three-hundred.[8] The minimal number of Institutes offered

to elementary level educators was not due to a lack of demand, in fact, the demand was incredibly high. According to William Mehl, a California high school teacher and frequent writer, "The applicant may be competing at any one institution with 500 to 1200 other hopefuls from whom approximately 40 to 80 teachers may be selected."[9] Although Mehl did not differentiate between levels of educators, his numbers still suggest a high demand across the board. Many estimated that NSF summer institutes for elementary educators reached a mere 1% of the nation's total elementary school teachers.[10] The importance of the numbers does not purely lie in the sheer quantity, but rather in the drastic contrast of opportunities for elementary versus high school educators.

Numbers remained just one mitigating factor in the failed efforts of teacher training. Moreover, no one ever reviewed the training efforts for their efficiency. Thus, the NSF and curriculum groups lacked quantitative data to analyze the effects of teacher training. Instead, many groups relied on ineffective opinion-based surveys.[11] Finally, training efforts cannot be entirely qualitatively analyzed. Even after attending training, data showed teachers taught the way their teachers showed them - rote method and repetition.[12] According to Morris Kline, an outspoken opponent of New Math,

> When the teachers of courses based on such texts are asked whether they are teaching modern mathematics they will usually reply affirmatively. They are under pressure from chairmen, principals and superintendents to be up-to-date and since this means modern mathematics, they profess to be teaching it. If their students do well in tests based on these courses, the impression given is that students can and do learn modern mathematics, when in fact they are being taught and tested on the traditional mathematics.[13]

There is no data source that showcases the impact on teacher training in America because no one ever collected the data. This chapter is not meant to solely demonstrate the effectiveness of teacher training but rather to illustrate the nationalized efforts made by

the NSF, televised training, and to show how high school educators were far more prepared than their elementary counterparts. This chapter will explore NSF-sponsored Institutes and NBC's nationally televised teaching program. Specifically, it focuses on the addressing the disproportionate elementary school teacher training efforts, as well as identifying, through the trainings themselves, why a division in training existed.

Lastly, a considerable portion of this chapter will explore the uses and effectiveness of film or televised training in regards to New Math. NBC promoted televised training for teachers and college students. Individuals could even complete coursework and receive college credit via televised programming. The ultimate goal of this chapter is to illustrate the broad national efforts, funded through the U.S. government, to promote and train New Math teachers, particularly at the elementary level.

The Birth of NSF Institutes

Possibly the farthest reaching and longest available access to training were the NSF Institutes. Summer Institutes for secondary education officially began in 1954 in Seattle, Washington. According to the NSF, this Institute was initially established as an experimental summer program, specifically designed for high school mathematics and science educators. However, within three years, after the launching of *Sputnik*, the government felt pressured to perform a self-appraisal, analyzing both scientific education and research. As a result of this self-appraisal, President Dwight Eisenhower called upon Congress in January 1958 to allocate federal funding through various avenues, including the NSF.[14]

In a Special Message to Congress on Education, President Eisenhower outlined a plan of action in response to national fears of Soviet technological advancement. President Eisenhower specifically described five programs in his address. The first concentrated on subject-matter knowledge of math and science teachers. Eisenhower asked Congress to approve funding for "supplementary training of science and mathematics teachers and a somewhat larger increase to support teacher fellowships" and to present "additional study opportunities to enable more science and mathematics teachers in our schools and colleges to improve their fundamental knowledge and through improved teaching techniques, stimulate the interest and imagination of more students in these important subjects."[15] In regards to mathematics, the development of additional NSF Institutes, focused on training each attendee in the New Math reform way, helped fulfill Eisenhower's request.

The next three provisions asked Congress to increase funding for course content improvement in the sciences (including mathematics), promote sciences as a career path, and increase funding for graduate fellowships. The nationwide curriculum writing groups helped improve course content. Such groups explored new textbooks, as well as new concepts, thought necessary to education. The third and fourth provisions sought to promote access to science-related education programs, as well as careers. Each of these provisions allocated funding from the U.S. government to the NSF, who later distributed the monies in the form of grants to various schools and curriculum groups.[16]

The fifth program recommended funding, through the NSF, for those seeking advanced degrees or additional training in subjects of math and science. The proposed government capital was meant "for individuals who wish to obtain additional education

so that they may become high school science and mathematics teachers."[17] Moreover, this fifth portion specifically called for "several new programs which will provide fellowship support for secondary school science teachers (during the summer months)."[18] This fifth recommendation helped generate funding for the NSF Summer Institutes that would last for more than a decade.

The federal government funded the NSF since its creation in 1950. Initially, the government appropriated roughly $225,000 for the NSF to utilize for the advancement of sciences. As the Cold War progressed and the Soviets launched *Sputnik*, the American government's self-appraisal led to fears of education inadequacies. By late 1957, it became apparent, at all levels of government and education, that something in schooling had to change. As a result, President Eisenhower's request did not go unheard. Eisenhower asked Congress to allocate money for educational training specifically through the NSF. Both Congress and President Eisenhower felt the broad reach of a national agency was the most effective avenue of science training. Effective July 1, 1958, Congress appropriated more than $134 million over the next twelve months for education reform. During this period, federal education funding more than tripled.[19]

Congressional monies resulted in the creation of Institutes, sponsored by the NSF. From the NSF emerged two additional forms of Institutes; Academic Year Institutes and In-Service Institutes. However, the pre-established Summer Institutes would also benefit greatly. Technically beginning in 1953, Summer Institutes were an experimental project. However, it was not until 1954 that the first of these Institutes geared towards secondary educators began. These Institutes lasted six to eight weeks during the summer months and provided teachers the opportunity to study material essential subject matter. These

Institutes allowed secondary teachers to become familiar with fresh findings in the mathematics (as well as other subjects) over the course of a summer.[20] Unfortunately, the NSF did not formally begin elementary teacher programs until five years, later in 1959.[21]

The Academic Year Institutes and In-Service Institutes began two years later in 1956. Academic Year Institutes allowed secondary teachers the opportunity to intensively study a sequence of courses in their field of study. For this thesis, mathematics is that field of study. Teachers enrolled in the Academic Year Institutes studied full-time for nine to twelve months. The second form of NSF Institutes beginning in 1956 was the In-Service Institutes. In contrast to Academic Year Institutes, the In-Service Institutes offered part-time instruction in the sciences, including mathematics. By allowing teachers to study part-time, it enabled teachers to continue working full time. Consequently, In-Service Institutes were held on weekends or after school hours. In many instances, these Institutes hoped to educate teachers in new or developing curricula, but many focused on bringing the teachers and schools up-to-date with changing instructional methods.[22]

Institute overseers chose teachers for their institutes from local and national pools. According to the one NSF Annual Report, Institutes were "directed toward the education of the individual teacher, without specific attention to the institutional impact of such efforts."[23] By 1961, the NSF realized their focus needed to be on local area schools and teachers, to create institutional change, rather than growing individual teachers only. Thus, the NSF encouraged universities and colleges to work with schools within proximity to create school wide and district wide education reform. Ultimately, high school teachers became far more essential to NSF Institutes.[24]

The 1965 NSF Annual Report explicitly stated that high school teachers became the primary target of the Institutes: "Over, the years the Foundation has deliberately concentrated on the training of high school teachers. It is at the high school level that science first appears in the form of specific courses taught by specialized teachers."[25] Hence, with the advent of In-Service Institutes in 1961, high school educators trained in NSF-sponsored Institutes before returning to their home school to become instructors and train elementary teachers. As a result, In-Service Institutes became the primary method of elementary teacher training.[26]

Elementary Teachers and In-Service Training

While the first formal NSF sponsored elementary teacher Institute did not begin until 1959, the Foundation recognized the need for elementary school teacher training as early as 1957. However, individualized and local efforts to train elementary teachers began much earlier. For example, Rutgers University sponsored a ten-day science "institute" beginning in 1950. The program lasted seven years through private sponsorship. In 1957 the NSF began supporting the Rutgers program due to its continued growth. Another example of early efforts to train elementary school teachers also occurred in 1957. The University of Kentucky held a conference for secondary and elementary school educators. Of the five conference sections, elementary education occupied only two sessions.[27] Early on, individual institutions identified the need in local communities and the desire to promote elementary and secondary teaching. This suggests that institutions recognized the lack of training, or the need for more training, particularly among elementary educators.

Additionally, in the pre-1959 training years, the University of Colorado and the University of Rochester each held in-service training for elementary school teachers. The University of Rochester, in 1958, organized a six-week summer program for roughly fifty elementary teachers. This program focused on the general sciences, including mathematics. However, this program was unique at the time, because of its multiplier effect, meaning that these fifty teachers agreed to devote a portion of their own time to training other teachers. Although no one labeled the program as in-service training, that was effectively what it was. In contrast, the University of Colorado program was the only one, at the time, supported by the NSF. Their in-service training program served twenty-nine local Colorado elementary teachers. In fact, the Colorado program would go on to become the basis of NSF elementary in-service training programs. Moreover, this program, at the University of Colorado, would persist throughout the 1960s. While the Colorado and Rochester programs showed promise and even gained the attention of the NSF, the Foundation neglected national training efforts for elementary school teachers until 1959.[28] Again, the efforts of universities to train local teachers through in-service training projects showed how great the need for additional mathematics and science preparation. Furthermore, although the NSF prior to 1959, in some sense, supported the University of Colorado, one could argue it was the success of the University that motivated the Foundation to assume a more national program approach.

After 1959, a flurry of in-service training projects began with the help of the Foundation. For instance, in-service training efforts began at Southeastern State College in Oklahoma, University of Washington, and Emory University. Each of these universities received one or more NSF grants over subsequent years but executed the in-

service training differently. Some in-service training occurred in a more traditional fashion where a senior educator or supervisor attended an instructional course, and then went on to train other local educators. Other in-service training utilized televised programs.[29] However, Dr. Harry Kelly wrote a memorandum to Dr. Alan Waterman in 1959, in which they outlined the need for formal elementary In-Service Institutes, as well as required funding. Both agreed that roughly $100,000 was needed to establish a 1959-1960 program. Furthermore, they agreed that with limited funding they would not publically announce the start of In-Service Institutes; rather, they first notified schools with pre-existing programs and interests. This resulted in an $80,600 sponsorship of eleven institutes and nearly 340 participants. Yet, only four of these programs focused on mathematics.[30] Programs viewed favorably by the NSF received the first option of running elementary in-service training programs, and thereby, isolated many other schools who did not have the funding prior to 1959 to begin their training efforts. Thus, in the beginning, elementary training efforts remained inaccessible to a large portion of elementary school teachers.

When the NSF-sponsored In-Service Institutes were unavailable, school districts opted to hold their own in-service training. Similar to their NSF models, instructors from an institute of higher education, school district staff, a supervisor of a local math department, a high school mathematics teacher, elementary school principals, and led district sponsored in-service training. In some instances, questionably qualified individuals via film directed training. Some of these instructors would have been extremely familiar with New Math and how to execute its principles in the classroom. Others led glorified book clubs focused on reading about New Math and new pedagogy,

but yielding no practical hands-on training. More often than not, the instruction received was not consistent across the district, state, or country. Furthermore, it was evident that elementary teachers essentially received the leftovers of training efforts. These district level workshops remained uncomparable to the national summer or year-long training more readily open to high school teachers.[31] In this trickle down form of education, how were elementary school teachers supposed to receive quality training when the delivery methods varied widely, and there was no quantitative analysis on their instructors understanding of New Math concepts? Therefore, in cases such as this, elementary school teachers received secondhand training at best.

As the 1960s progressed, the number of In-Service Institutes for elementary educators grew. Within two school years, the number of math-specific NSF programs grew 300 percent. More specifically, these In-Service Institutes sought to give teachers a more theoretical background and arithmetic structure, or in other words, the training wanted to get elementary school teachers' math capabilities up to par with New Math standards. The materials taught varied, but included curricula in development by the School Mathematics Study Group, the University of Illinois, the Madison Project, and the elementary geometry program at Stanford.[32] However, by the last reported year, 1966-1967, In-Service Institutes for elementary educators had grown substantially. In this year there were 33 mathematics focused series out of a total of 57 sponsored programs, 4,172 total participants, 55 represented institutions, and six televised training supported groups. In this last year, there were nearly 132 total proposals made with an asking budget of more than $1.3 million.[33] The large growth of In-Service Institutes lacked the reach the NSF needed to promote New Math concepts in the classroom successfully.

During the eight years of Institutes (both In-Service and Summer) for elementary teachers, the NSF sponsored 531 total elementary teacher institutes, with an attendance of 22,045. Of the 531 institutes, 326 were In-Service Institutes with 22 percent of In-Service projects focusing on mathematics (177 granted projects). These numbers did not take into account the multiplier effect that the NSF banked on. The NSF believed they only reached two percent of all elementary school teachers over these eight years. Recall that *Newsweek* published an article estimating nearly 1.1 million elementary teachers were teaching in American schools in 1965.[34] It was indisputable that the NSF failed to reach an adequate number of elementary school teachers to have a lasting educational effect, specifically in regards to New Math. Moreover, being that students build mathematical skills foundationally, the advanced high school New Math concepts would also struggle to be understood without the solid elementary groundwork.[35]

Although the NSF In-Service Institutes ended after only eight years and were unavailable in some areas, other governmental programs were in place to aid elementary teachers. For instance, under Title III of the Elementary and Secondary Education Act with the United States Office of Education, local schools and school district received funding for training. States also obtained funding for elementary teacher training through the National Defense Education Act, specifically under Title III. Additionally, the United States Office of Education reportedly supported eight training efforts for elementary math and science teachers during the 1967-1968 school year. However, this program only serviced 160 teachers. Again, a very small number compared to all the elementary teachers.[36] Unfortunately, additional programs did not help bring enough elementary

teachers up to speed on New Math principles. Perhaps the NSF could have reached more elementary teachers had the teachers had access to other NSF Institutes.

Although the NSF provided eight years of In-Service and Summer Institutes, elementary school teachers lacked access to Academic Year Institutes. According to the 1961 NSF report:

> To date only summer institutes and in-service institutes are available to elementary school teachers. Teacher training at this level presents some special problems. In fact, it is difficult to determine appropriate activities for strengthening science and mathematics in the elementary schools. A major consideration is the fact that very few of the approximately 1,100,000 elementary school teachers in the United States (kindergarten through grade 6) are trained in science and qualified to teach it.[37]

Thus, the NSF Institutes not only deliberately denied elementary school teachers the opportunity to attend more in-depth forms of training and supplemental education but acknowledged the inadequate professional training in subjects, such as mathematics. Additionally, the NSF recognized the exceedingly large number of elementary school teachers, as compared to high school teachers. Rather than developing New Math training programs focused on reaching the 1.1 million elementary teachers, the NSF decided to deny elementary educators access to yearlong training endeavors. Ultimately, this shows where the NSF focused their attention during the early 1960s. Furthermore, this demonstrates why elementary teachers were largely unsuccessful in executing and implementing New Math in their classrooms.[38]

According to a letter from two NSF members, Dr. Alan Waterman and Dr. James B. Conant, in February 1960, they felt that the NSF needed to move slowly in training elementary school teachers. The letter stated: "'All in all, it seems to me that perhaps our greatest danger lies in going too fast and too far with pre-conceived notions about

elementary science instruction before we have had the opportunity to think this over and confer with the experience of knowledgeable people.'"[39] Hence, the NSF felt the need to provide elementary teacher training but did not want to move too fast because they did not have an adequate understanding of current math and science instruction. This cautionary approach seemed reasonable; however, the NSF was not as guarded in dealing with high school teacher training. The NSF recognized the inadequate training of elementary teachers by 1961, and thereby recognized the failings of the teacher's college education.

In a discussion of the failings of elementary school teacher training efforts, it is crucial to understand how teachers perceived these trainings. Unfortunately, there is no quantitative data that shows the effectiveness of the New Math Institutes or training. More often than not, participants received questionnaires about their in-service programs with questions such as the following: "How would you rate this workshop? Will the information received be beneficial in your teaching? In your opinion, what was the most valuable part of this in-service program?"[40] These questions can be problematic. First, they only assessed how the participant *felt* after the workshop, but not how effective the workshop was when teachers replicated ideas in the classroom. Secondly, the yes-no questions often do not give great insight, leaving the complier with a two column spreadsheet, rather than a detailed explanation. From these types of questions, it is hard to tell.

Similarly, other evaluations, such as those conducted after the 1963 training by Allan W. Gurley, Randall C. Hicks, Jurelle G. Lott and M. Louise Reeves in a Georgia school district, had participants evaluate the workshop based on "four-point rating scale

from excellent to poor."[41] In this type of evaluation, none of the participants selected the rating corresponding to "poor." Instead, all participating teachers voted the training either excellent or good. As a result, the Gurley group perceived training as both positive and successful. Gurley failed to elaborate on the timing of the evaluation, or if teachers had time to implement the topics covered in training fully. Sister Mary Pascal's article "A Report on 'New Math' Workshops Conducted During the Summer of 1962 for Teachers in the Elementary Schools" is another example of New Math training evaluation. In this article, Sister Mary Pascal stated that teachers positively received the two-week workshop in regards to methodology and content. Again, there was no quantitative data to analyze; instead, the training simply seemed good.[42]

There were training leaders who sought to collect some quantitative data. Robert H. Bradford presented his findings that summer in Texas, at the University of Houston after conducting New Math training during the summer of 1965. Sponsored by a local school district, this particular workshop sought to elevate the New Math training of all the elementary teachers in the area. However, while the purpose was to train all elementary teachers, the district allowed attendance to be voluntary, which meant that only the teachers interested in additional training would attend. Bradford's evaluation differed from the preceding studies because he utilized a pretest-posttest approach. Bradford wanted to determine how much of the material the elementary teachers retained. Upon the administration of the pretest, a majority of the teachers objected to this method of evaluation, and they felt Bradford should discontinue using it. John Creswell, a professor at the University, pursued other examples of pretest-posttest evaluation in relation to New Math workshops. Unfortunately, he found not a single reference.

Creswell stated:

> The absence of pre- and posttesting as a means of evaluating workshops and in-service training programs is contradictory to the standard evaluative procedures that are used in schools and colleges. It seems that many elementary school teachers are unwilling to be judged by the same standards by which they judge their students.[43]

Thus, Creswell set out to find quantifiable data to showcase the effectiveness of New Math training efforts.

Creswell led dozens of New Math training workshops. Perhaps one of his better-known trainings occurred in Georgia, during the 1960 academic year, with roughly 313 prospective elementary teachers. Another and the more relevant one in this discussion took place in the fall of 1965 and incorporated five school districts in eastern Texas. A total of 1,075 elementary school teachers, who taught grades first through sixth participated. Creswell used a 120 question test on New Math to assess the New Math skills of the elementary teachers. Creswell administered the same test to roughly 124 sixth grade students within the same school districts. The test covered the following topics: division of rational numbers, multiplication of rational numbers, exponents, integers, and side-angel relationships of triangles. This was a proctored test, and the average teacher took two hours to complete the assessment. Most importantly, each of the 1,075 teachers previously attended one or more New Math workshops or had in-service training. Meaning, these specific teachers should be more prepared for an exam containing New Math concepts than their counterparts who had not attended training programs.[44]

The results of the 120 question test were shocking. The teacher's average

test score was roughly 56.31 percent, far less than expected. In contrast, the sixth-grade students who took the same test averaged 65.25 percent, which was roughly 8.94 percent better than the elementary teachers. Of the 1,075 teachers tested, roughly 67.53 percent received a score of 65 or worse (see chart below). It would seem Creswell was right; the elementary school teachers did not want to be judged by the same standard as their students, not because of assessment itself, but because of embarrassment.

Score	*Frequency*	*Percent*
110–120	3	0.27
100–109	29	2.70
90– 99	49	4.60
80– 89	102	9.48
70– 79	123	11.40
60– 69	121	11.20
50– 59	188	17.50
40– 49	177	16.50
30– 39	175	16.30
20– 29	76	7.10
10– 19	25	2.30
0– 9	7	0.65
Total	1,075	100.00
Mean	56.31	
Standard deviation	21.90	

Figure 5: Frequency distribution for a modern mathematics test - teachers[45]

In turn, Creswell concludes:

> the in-service training of a large number of these participants was not effective, so far as knowledge of content was concerned. It is also an accepted fact that a teacher cannot teach that which he does not know or understand. The data cited above seem to indicate that a large number of elementary school teachers are going to have great difficulty in teaching the new mathematics with any degree of understanding.[46]

According to Creswell, although the number of quantitatively evaluated training efforts and elementary school teachers was minute, his study showed that promoted workshops,

summer courses, and in-service trainings were not effective in teaching New Math concepts to elementary school teachers. While Gurley and Sister Mary Pascal's teachers may have given positive feedback, the content of the training was never accessed. Creswell's evaluation showcased the failings on New Math trainings, as far as content was concerned.

Creswell makes another conclusion. Creswell administered the same 120 question test to prospective elementary school teachers after taking two college-level courses with New Math content. The perspective teachers averaged a 93.9 percent, with only three prospective teachers scoring below the average sixth-grade test score. It seems that college courses prepared elementary school teachers far better than any supplementary training obtained. More specifically, in the area of New Math content, it became evident to Creswell that in-service training programs and other supplemental training efforts failed in comparison to college coursework. In conclusion, the inability to effectively convey New Math concepts to students in the classroom directly stemmed from the lack of college preparation, not from supplemental training effort.[47]

The In-Service Institutes for elementary school teachers yielded an incredibly low turnout. If we assume that Creswell's study applied to supplementary training programs across the nation, then his results hold true nationwide. Elementary teachers truly got the short end of the stick in regards to training opportunities and training success. With the NSF focused more intently and for a longer period on high school teachers, it is natural to assume they had more opportunities than their elementary level counterparts. However, the NSF would not be the only national effort to train teachers.

Continental Classroom

As curriculum reform efforts increased throughout the 1960s, mathematicians, curriculum groups, and educators sought to utilize all available avenues of communication. Many developed film curricula to promote and disseminate their teacher training material. Teacher film and television training efforts became prominent in various curriculum writing groups, universities, and high schools. Funding for such film series and television series varied; however, the NSF remained the primary sponsor. While numerous groups utilized television and film teaching methods, NBC also televised teaching programs and the film courses, known as the *Continental Classroom*. Later, New York used another vastly popular televised training effort, *Mathematics for Teachers*. NBC was the only network to broadcast nationally.

NBC worked with a variety of organizations and foundations to pull off the *Continental Classroom*. The show ran for several years and covered multiple subjects. For five years, NBC broadcasted the thirty minutes, five mornings a week education series. The network worked with the American Association of College for Teachers Education, the Ford Foundation, Bell Telephone Systems, and the Fund for the Advancement of Education. Therefore, showing that the NSF was not the only organization concerned with educational advancement.[48] Sparked in the aftermath of *Sputnik*, the NBC series ran from 1958 to 1963, and covered topics in physics, chemistry, mathematics, and American government.[49] The first year's series focused on physics, followed by chemistry the next season. NBC used the third year to launch a split mathematics course focused on algebra, as well as probability and statistics.[50]

During the third year, NBC sub-divided the math course. Three days a week the program targeted college students, but on a contrasting two-day a week schedule, the course aimed to reach teachers.[51] The third year was also markedly different because the first half of the math series addressed modern algebra, taught by UC Berkley's John Kelley and Julius Hlavaty.[52] The second half of the series focused on probability and statistics. Harvard's Frederick Mosteller, then chairman of the statistics department, and Montclair State College's Paul Clifford, who lectured on the applications of statistics, both taught this portion. Probability and statistics, at this point in time, was rarely taught in classrooms, making this particular portion of NBC's series exceptional and modern. By the launching of NBC's mathematics course, nearly 320 colleges and universities offered credit for the broadcasted course.[53] Many modern academics have referred to the mathematics course as the first massive open online course (MOOC).[54]

Broadcasting of the 1960-61 season resulted in the airing on estimated 175 stations. Each college or university established its own requirements for homework, course credit, and grades. The Learning Resources Institute (LRI) supplied students and schools with a pre-test, midterm, and final exam, should they desired the material. Furthermore, each school or organization used the televised course in their own way. Some institutions required weekly, bi-weekly, or monthly face-to-face meeting times. While others required no face-to-face time with a designated instructor. All of the provided material was issued free of charge by LRI and NBC.[55] Due to the vast number of schools offering course credit and the varied requirements, there is no way to assess the success of NBC's program on a national scale.

How does the NBC mathematics course relate to New Math and teacher training?[56] Bob Rippen, the producer for NBC's show, stated "the project 'opened the eyes of a lot of educators to the fact that TV could be a good instrument for teaching…'"[57] The NBC show, although not the first of its kind, showcased how wide reaching television could be, as well as how effective programs broadcast nationally could be. By the late-1950s institutions, such as the Commission on Mathematics of the College Entrance Examination Board (CMCEEB), recommended the adoption of statistics as an alternative to calculus for twelfth-grade mathematics.[58] Mosteller stated, "Instruction in probability and statistics has lagged partly because there are so few well-trained probabilists and statisticians engaged in teaching."[59] The suggestion of integrating statistics courses into high school meant there needed to be teachers available who were familiar with the subject matter. As Mosteller suggested, the quantities of teachers needed was not readily available. The role of NBC's math series became relevant.

Clifford, one of the instructors for the probability and statistics portion of NBC's series, taped sixteen sessions specifically geared toward secondary and junior high teachers. The hope was to broaden teacher ideas of basic coursework by utilizing experiments, visual aids, and alternative development. The LRI published a schedule of day-to-day topics and lessons. The LRI also distributed course material free of charge to members of the National Council of Teachers of Mathematics (NCTM). This helped promote the televised course, as well as prepare teachers who were learning statistics and preparing to teach a similar course. An estimation of more than five-thousand students enrolled in the course for college credit, and at least nine city boards approved this course for in-service training credit for teachers.[60] This was one of the largest national teacher

training efforts in modern history. Mosteller found the use of television to be helpful by yielding more one-on-one teacher-student time. However, he also recognized that mathematics could not be taught by television alone. Televised math would still need some supplementing.[61]

NBC's *Continental Classroom* was not the only televised math instruction delivered during the New Math era. Many curriculum groups filmed their own training efforts, and went into detail regarding each organization's methods and focused topics would yield an encyclopedia of material. Several film series sponsored through the NCTM and headed up by Harry D. Ruderman of Hunter College High School in New York City, gained incredible support and success during the 1960s. Ruderman was also a mathematics professor who published and contributed to various mathematical books.[62]

In the 1960s, Ruderman's primary focus was educating elementary school mathematics teachers. The series, *Mathematics for Teachers*, was filmed during the 1957-58 school year by Ruderman and consisted of 89 half-hour reels. These films promoted in-service training for teachers. Initially, the series, a state-sponsored broadcast, ran only in New York. However, Kinescope recordings allowed the series to be shown later in Albany and Rochester.[63] The show was also aired outside of New York state, in Erie, Pennsylvania. After the public state broadcasting, the films were shown at various locations for teachers to gather, watch, and discuss. The NCTM distributed the films to any requesting state or school board for $40 per half-hour reel.[64]

Ruderman targeted high school math teachers for his first series of in-service films. Ideally, he thought that his viewing audience should have a "relatively strong mathematical background."[65] We now know that was not necessarily the case. Thus, this

film was not geared for in-service training for elementary school teachers. Again, showing that in many cases, high school teachers received access to the best information first. In 1964 *Inservice Mathematics Education* report listed elementary programs, but they were not named, only briefly described. The description simply states that an elementary course existed with 36 lessons available. The lack of detail and acknowledgment continues to show how national organizations and the federal government emphasized high school teacher training over every other level of instruction.[66]

It is unfair to say Ruderman was only interested in high school in-service training. Within a few years of his *Mathematics for Teachers* series, Ruderman led a team and produced a film series known as *Mathematics for Elementary School Teachers*. This was an NCTM project, headed by Ruderman, along with Joseph Moray, a film teacher, and Reinald Werrenrath, the technical director.[67] Additionally, Julius Hlavaty, one of the NBC *Continental Classroom* instructors served as the chairman of the advisory panel. In 1962, the NCTM decided elementary school teachers need help understanding New Math. Thus, they piloted a new film series.[68] This second series, made up of ten thirty-minute color films for in-service training of elementary school teachers, began in the summer of 1963. The films examined the whole number system; covering topics such as one-to-one correspondences, counting, decimals, algorithms of adding, subtracting, multiplying, dividing, and ending with a review of all covered concepts.[69]

Ruderman's ten films, sought by teachers and school districts, gained the attention of the NCTM, who in 1967 signed a contract with General Learning Corporation, Davidson Films. The contract promised to focus on elementary school training.

Ruderman was named the director of this new project. The contract produced a twelve-episode series on elementary teacher training, as well as thirty short films for students. Both sets of new films fell under the title of *Elementary Mathematics for Teachers and Students*. The films were produced and in distribution by 1970.[70] Various groups used the series in a range of ways, from large-scale broadcasting to small scale showings. However widely distributed these videos were, the question remained: were the films productive and effective?

While there is no quantitative data available for Ruderman's first series, Joseph Moray, the film instructor published an article in 1967 and described the reaction of the ten thirty-minute films. His examination split into three parts, surveyed 147 teachers who viewed the film series. According to Moray, the teachers believed the content of the films were just right for their needs. Only a very minute portion of the surveyed teachers found the material to be too hard or too easy. Moray found that only about 78 percent of those surveyed rated the series as either good or excellent.[71] An NCTM report stated "The success of the films and text was immediate. Soon the NCTM was besieged by teachers, teachers of teachers, and school systems to carry the series forward…"[72] Additionally, the overall response was highly positive with a request for distribution and television broadcasting rights approved. The question of classroom effectiveness is not quantifiable. Rather, by the expressed desire to utilize the films, it can be assumed that the series was a success and produced positive results. [73]

Changes in Education Requirements

Even as New Math and supplemental training efforts progressed throughout the 1950s and 1960s, elementary teacher education continued to come under fire. By 1969

educators were still writing journal articles with titles such as "A Proposal for the Improvement of the Mathematics Training of Elementary School Teachers" by Herbert Spitzer. This was just one article in a forum on teacher preparation. Chapter one showed that by the 1960s, it had become abundantly clear that teachers were ill-prepared to adopt changing attitudes and approaches in the mathematics curriculum. However, this inadequate preparation persisted throughout the 1960s, particularly in regards to elementary educators. According to Spitzer's article, changes in elementary teacher preparation were not realized until these teachers encountered unfamiliar mathematical content.[74]

In 1960, the Committee on the Undergraduate Program in Mathematics (CUMP), a sub-group of the Mathematical Association of America (MAA), developed and established a panel focused on teacher training. The panel gave CUMP recommendations on minimum standards required for all teachers. In that same year, CUMP suggested two years of mathematics in preparation for college level course material.[75] More specifically in regards to elementary school teachers, the CUMP report of 1961 recommended a minimum of "twelve semester hours of mathematics, with major emphasis on arithmetic of real numbers, introductory algebra, and informal geometry" at the college level.[76] The CUMP reports understood that course material might be repeated from high school to college, but urged the "material be covered again, this time from a more sophisticated, college-level point of view."[77] In fact by 1967, Creswell published an article in which he stated that many teacher trainings required no less than "three semester hours of mathematics for certification."[78] Also, most teaching institutions adopted some part, or all of the CUMP recommended courses. As courses and materials emerged, and colleges

adopted CUMP recommendations, additional reports, and comments emerged contradicting predicted success.[79]

Over the next nine years, college courses and materials were adopted by various teaching colleges across the country. Unfortunately, these courses did not produce the expected results. In fact, Spitzer stated: "The apparent inadequacy of current college mathematics courses for elementary school is frequently mentioned by teachers of mathematics methods, by supervisors, and by the teachers who have taken the courses."[80] The minimum requirements for elementary teachers in college continued to fall short. This left teacher college graduates ill-prepared to teach advanced mathematics curriculum even at the elementary school level.

Conclusion

Although NSF Institutes, televised programming, and the changing education requirements for elementary school teachers may seem disconnected, they were in fact all interwoven. Dozens of examples exist, but the case study of Emory University in Georgia demonstrates one of the best examples of how all three aspects worked together. Emory University received a $60,000 grant during the 1960-1961 academic year for the development of an in-service television teacher training program. Emory received additional grants that kept the program funded for the following two academic years. Training took place in two segments: one where teachers watched the televised weekly programming and second took weekly trips to the University. The university visits took place at Emory and the University of Georgia, and participants received a small travel stipend. The first year yielded success, and as a result, the program continued. The following year, more than 190 teachers earned five credit hours for completing the in-

service televised training. The tremendous success also spawned a pre-fall semester workshop where more than one-thousand elementary teachers attended. The 1962-63 academic year yielded a series of workshop centers and the establishment of an elementary teacher televised training course. This is just one example of how in-service projects, television, and the promotion of additional coursework came together for the benefit of elementary school teachers.[81]

A second example is the training offered by the Maryland School-College Mathematics Association Inc. (MS-CMA). As late as the early-1970s, the need for fundamental courses aimed at elementary teachers remained. As a result, MS-CMA, initially established in 1964, developed a televised graduate-level course which elementary teachers could take for credit in 1970. In conjunction with four other colleges, the MS-CMA partnered with the Maryland Center for Public Broadcasting and the Maryland State Department of Education-Division of Instructional Television. Between 1964 and 1970, MS-CMA conducted training and surveys among elementary school teachers, which revealed a vast diversity in elementary mathematics training, as well as a great deal of fear towards teaching math. The MS-CMA also noted the teacher's desires for in-service training. Thus, the MS-CMA turned to televised instruction due to the accessibility by teachers.[82]

Upon its establishment, the MS-CMA televised training lasted for one semester and included both filmed instruction and a face-to-face component. The taped portion included twenty-eight episodes and an accompanying workbook, published by McGraw-Hill Book Company. Teachers viewed two episodes a week, and every third week attended a Saturday face-to-face session for roughly two and a half hours. These Saturday

meetings served as a networking opportunity, as well as a time to encourage elementary teachers. Of course, the meetings also promoted the chance to clarify any of the televised instruction and discussion. While the Saturday sessions greatly aided the elementary teachers, it also allowed college faculty and facilitators to identify weaknesses of elementary teaching and plan their own courses accordingly.[83]

Nearly 260 elementary teachers enrolled in the course with roughly 226 earning graduate degree credit. Teachers earned three-credit hours for completing the course, and passing a final exam. A majority found the course informative and satisfying. In an additional follow-up questionnaire, the respondents overwhelming (2:1) favored the televised course instruction over a traditional modality. Not only were the needs of the teachers met, but the course content appropriately matched the elementary educators' experience and mathematical background. As a result, the state considered a second televised course. According to the summary, "Ultimately, it is hoped that mathematically insecure and poorly-prepared elementary school teachers will gain confidence, and will be prepared for enrollment in a graduate program leading to a master's degree."[84] Unfortunately, their hopes did not come to fruition. As the UICSM director, Russell E. Zwoyer stated:

> We were unable to give teachers the amount of support that was really necessary…Our group had $12 million in federal support. About half of that was spent on teacher training but it wasn't nearly enough. Teacher training was really an astronomical problem. People did try, but they haven't really been successful.[85]

Even with continued training and the incorporation of newer technology, elementary teacher education remained a trouble spot by the late 1960s and early 1970s.

Through programs, like those in Georgia and Maryland, the combined efforts of in-service training, televised instruction, and graduate credit proved hopefully in addressing the two-decade problem of elementary teacher preparation. While local efforts seemed promising, the NSF Institutes and the *Continental Classroom* reached thousands within their short run time. By the beginning of the 1970s, a solid solution to elementary teacher preparation and training remained elusive. However, by 1975 New Math as a whole fell by the wayside. The federal government hit an economic snafu. Between the Vietnam War raging on and the OPEC gas crisis, the federal government could no longer financially support the NSF and other educational grant groups. The NSF halved SMSG's budget in 1969, and the largest curriculum writing group eventually dissipated in 1972. Finally, as budgetary restraints impacted the continuation of New Math, the mid-1970s gave way to the "back-to-basics" movement. Ultimately, national financial issues, a lack of funding, and the dismembering of curricula groups marked the end of New Math and its need for large scale-training efforts.[86]

ENDNOTES

[1] "The Trials of New Math," *Time* 85, no. 4 (January 22, 1965), 42.

[2] Ibid., 42.

[3] Harry Schwartz, "Peril to Doing Sums Seen in 'New Math,'" Special to The New York Times, *New York Times*, December 31, 1964, 22.

[4] Ibid., 22.

[5] Although mentioned previously, the acronyms stand for the following groups names, the School Mathematics Study Group (SMSG), the University of Illinois Committee on School Mathematics (UICSM), and the University of Maryland Mathematics Project (UMMaP)

[6] Robert Hayden, "A History of the 'new math' Movement in the United States," (Iowa State University, 1981), 173.

[7] "The New Math: Does It Really Add Up", *Newsweek*, 1965.

[8] Hayden, "A History of the 'new math' Movement in the United States," 190.

[9] William G Mehl, "The Summer Institute—contributor Toward Better Teaching," *The Arithmetic Teacher* 11, no. 2 (February 1964), 112.

[10] Hayden, "A History of the 'new math' Movement in the United States," 190.

[11] See Allan Gurley et al., "In-Service Education Modern Arithmetic and Good Pedagogy," *The Arithmetic Teacher* 12, no. 1 (January 1965), 63-63.

[12] Christopher J Phillips, *The New Math: A Political History* (Chicago, IL, United States: University of Chicago Press, 2014), 136-140; William Kraus, "Back to Basics: Friend or Foe?," *The Mathematics Teacher* 71, no. 3 (March 1978), 220; Susan Light, "Impact of 'New Math' Affects Teachers Too," *The News*, May 9, 1964.

[13] Morris Kline, *Why Johnny Can't Add: The Failure of the New Math* (New York, NY, United States: New York, Vintage Books [1974, c1973], 1974), 107

[14] National Science Foundation, *Fifteenth Annual Report of the National Science Foundation*, (Washington, D.C.: National Science Foundation, 1965), nsf.gov/pubs/1965/annualreports/start.htm, 17; nsf.gov/about/history/timeline70s.jsp#1970s

[15] "Dwight D. Eisenhower: Special Message to the Congress on Education," The American Presidency Project, January 27, 1958, accessed August 15, 2016, presidency.ucsb.edu/ws/?pid=11207.

[16] Ibid.

[17] Ibid.

[18] Ibid. While the address mentions school science teachers specifically, it should be noted that mathematics is often grouped as a science. Thus, while Eisenhower may have stated science, we can assume, based on the rest of the speech that mathematics is lumped in with science. Thereby making science a broad academic term not synonymous with what we perceive as biology, chemistry, etc.

[19] "Harry S. Truman: Memorandum of Disapproval of the National Science Foundation Bill," The American Presidency Project, August 6, 1947; "A Timeline of NSF History," National Science Foundation, September 29, 2008, accessed 2016, nsf.gov/about/history/overview-50.jsp.

[20] National Science Foundation, *Fifteenth Annual Report of the National Science Foundation*, 16-17.

[21] James Wailes, *History and Development of National Science Foundation Elementary Institutes, 1959 - 1967*, (Washington, D.C.: U.S. Department of Health, Education & Welfare, 1968), 2.

[22] National Science Foundation, *Fifteenth Annual Report*, 16-18.

[23] Ibid, 18.

[24] Ibid, 16-20.

[25] Ibid, 16.

[26] Ibid, 16-20.

[27] Wailes, *History and Development of National Science Foundation Elementary Institutes, 1959 - 1967*, 2-4.

[28] Ibid, 4.

[29] Ibid, 4-5.

[30] Ibid, 6-7, 16-17.

[31] John Creswell, "How Effective Are Modern Mathematics Workshops?," *The Arithmetic Teacher* 14, no. 3 (March 1967), 205-206.

[32] Wailes, *History and Development of National Science Foundation Elementary Institutes, 1959 - 1967*, 17-18.

[33] Ibid, 20-24.

[34] "The New Math: Does It Really Add Up", *Newsweek*, 1965.

[35] Wailes, *History and Development of National Science Foundation Elementary Institutes, 1959 - 1967*, 24-31.

[36] Ibid, 25.

[37] National Science Foundation, *Fifteenth Annual Report of the National Science Foundation*, 18.

[38] "The New Math: Does It Really Add Up", *Newsweek*, 1965. National Science Foundation, *Fifteenth Annual Report*, 17-20.

[39] Wailes, *History and Development of National Science Foundation Elementary Institutes, 1959 - 1967*, 3.

[40] Creswell, "How Effective Are Modern Mathematics Workshops?" 206.

[41] Allan Gurley et al., "In-Service Education Modern Arithmetic and Good Pedagogy," *The Arithmetic Teacher*12, no. 1 (January 1965), 63; Creswell, "How Effective Are Modern Mathematics Workshops?," 206.

[42] Sisters of St. Francis and Sister Mary Pascal, "A Report on 'New Math' Workshops Conducted During the Summer of 1962 for Teachers in the Elementary Schools," *School Science and Mathematics* 63, no. 7 (October 1963), 583-586.

[43] Creswell, "How Effective Are Modern Mathematics Workshops?," 206.

[44] Ibid, 206-207. Additionally, "None of the teachers had had any significant experience in teaching the new mathematics. Their teaching experience ranged from 0 to 30 years. Their college training in mathematics ranged from no semester hours to more than twelve semester hours… Very few of the participants had gone back to college to take mathematics courses in either content or method" (207).

[45] John Creswell, "How Effective Are Modern Mathematics Workshops?," *The Arithmetic Teacher* 14, no. 3 (March 1967), 207.

[46] Ibid, 207-208.

[47] Ibid, 208.

[48] NBC Television Network, *The Story of Continental Classroom on the NBC Television Network* (New York: The Company, 1958).

[49] While *Sputnik* is cited as the catalyst to NBC's project, according to Robert Carlisle, James Allan, the Commissioner of Education in New York, was planning a refresher course for all science teachers in the state already. When NBC officials heard about Allen's idea, they thought for a slightly increased budget NBC could reach teachers and students across the country. Funding was procured from numerous organizations and paid to American Association of Colleges for Teacher Education (AACTE), who in turn paid NBC, at cost, for the use of its studios and equipment. *Continental Classroom* ended officially on May 17, 1963 as a result of budget and funding cuts, including the Ford Foundation's departure from the show. (See: Robert D. B. Carlisle, *College Credit Through TV: Old Idea, New Dimensions*, 68-75.)

[50] Frederick Mosteller, "Continental Classroom's TV Course in Probability and Statistics," *The American Statistician* 16, no. 5 (December 1962), 20-21. See Mosteller's article listed three reasons why statistics and probability was chosen over other modern mathematics subject matter, such as geometry or additional modern algebra. He cites the move towards more of an applied mathematics course of study within the field, as well as advancing technology.

[51] Leon C. Fletcher, *Instructional Television Review 1959–1961*, Educational Television Research Association, (Menlo Park, California: Pacific Coast, 1961), 51.

[52] Kelley was involved in the National School Mathematics Study Group. Through the organization, he became involved in many textbook writing workshops during the New Math movement. Upon his return from the Continental Classroom filming, Kelley developed a new course for prospective elementary teachers within the math department. He also developed a New Math undergraduate major for teachers at Berkley, to prepare teachers "to teach high school math with a strong understanding of the subject; and he devised an internship program to follow their B.A. degree, enabling them to qualify for a teaching credential with a minimum of education courses that had turned off many math students." (See "In Memoriam, 2000," 2011, accessed July 27, 2016.) Thus, Kelley was very proactive in New Math and disseminating the material to as many teachers as possible.

[53] Robert D. B. Carlisle, *College Credit Through TV: Old Idea, New Dimensions* (Lincoln, NB: Great Plains National Instructional Television Library, 1974), 68-70.

[54] Rick Wicklin, "The First MOOC in Statistics," *SAS Analytics Software*, October 2, 2013, blogs.sas.com/content/iml/2013/10/02/the-first-mooc-in-statistics.html; "Enrollment in MITx MOOCs: Are We Educating Educators?," 2015, er.educause.edu/articles/2015/2/enrollment-in-mitx-moocs-are-we-educating-educator.

[55] Mosteller, "Continental Classroom's TV Course in Probability and Statistics," 20.

[56] While some historians and mathematicians may focus on particular attributes of New Math such as sets and axioms, many leave out statistics and probability in the New Math grouping. However, probability and statistics, like all of mathematics, is interconnected to other curse such as complex analysis and calculus. Like the more advanced math course, probability and statistics utilizes permutations, combinations, the binomial theorem, limit theory, sequences, and axiom theory. Thus, probability and statistics should be included in the New Math category based on the newness of the mathematics and its shared ties to other higher level math course included in New Math.

[57] Carlisle, *College Credit Through TV: Old Idea, New Dimensions*, 71.

[58] *Commission on Mathematics, Program for College Preparatory Mathematics*, College Entrance Examination Board, (New York, 1959), 44.

[59] Mosteller, "Continental Classroom's TV Course in Probability and Statistics," 20.

[60] Ibid, 21.

[61] "NBC Offers Statistics Course for Credit," *The Harvard Crimson*, February 7, 1961.

[62] See: "Tac-Tickle: A Challenging Game of Pure Strategy," The National Museum of American History, accessed October 2, 2016, americanhistory.si.edu/collections/search/object/nmah_694600. He contributed to the writing of School Mathematics Study Group, *Geometry: Teachers Commentary, Part 1*, ed. Panel on Sample Textbooks of the School Mathematics Study Group (United States: Yale University, 1960); and Harry D Ruderman and Abraham M Glicksman, *Mathematical Systems: An Introduction* (New York: New York, Benziger [1971], 1972).

[63] "Kinescopes are usually created by placing a motion picture camera in front of a television monitor and recording the image off the monitor's screen while the program is being aired." ("Kinescope," The Museum of Broadcast Communications, accessed October 2, 2016, museum.tv/eotv/kinescope.htm.)

[64] Frank Allen, "The Council's Drive to Improve School Mathematics," *The Mathematics Teacher* 56, no. 6 (October 1963), 450; V. Schult, A. Theodore, and US Department of Health, Education, and Welfare, Office of Education (ED), *Inservice Mathematics Education*, (Washington, D.C.: U.S. Office of Education and the National Council of Teachers of Mathematics, 1964), 47-48.

[65] Schult, et al., *Inservice Mathematics Education*, 47-48.

[66] Ibid, 48.

[67] "NCTM Projects and Panels," *The Mathematics Teacher* 57, no. 7 (November 1964), 490.

[68] Joseph Moray, "The NCTM Film-Text Series 'mathematics for elementary school teachers,'" *The Arithmetic Teacher* 14, no. 4 (April 1967), 297.

[69] See a full description of each film in Joseph Moray, "The NCTM Film-Text Series 'mathematics for elementary school teachers,'" *The Arithmetic Teacher* 14, no. 4 (April 1967), 297-298.

[70] National Council of Teachers of Mathematics, *Mathematics for Elementary School Teachers: The Rational Numbers*, (Washington, D.C.: National Council of Teachers of Mathematics, Inc., 1972), iii.

[71] Moray, "The NCTM Film-Text Series 'mathematics for elementary school teachers,'" 297-299.

[72] National Council of Teachers of Mathematics, *Mathematics for Elementary School Teachers*, iii.

[73] Moray, "The NCTM Film-Text Series 'mathematics for elementary school teachers,'" 297-299.

[74] Herbert Spitzer, "A Proposal for the Improvement of the Mathematics Training of Elementary School Teachers," *The Arithmetic Teacher* 16, no. 2 (February 1969), 137-138.

[75] Mathematical Association of America, "The Training of Elementary - School Mathematics Teachers: An Abridgment of the Recommendations of the Mathematical Association of America for Training of Teachers of Mathematics," *The Arithmetic Teacher* 7, no. 8 (December 1960), 421, 423.

[76] Spitzer, "A Proposal for the Improvement of the Mathematics Training of Elementary School Teachers," 137.

[77] Mathematical Association of America, "The Training of Elementary - School Mathematics Teachers," 423.

[78] Creswell, "How Effective Are Modern Mathematics Workshops?," 205.

[79] Mathematical Association of America, "The Training of Elementary - School Mathematics Teachers," 421-425.

[80] Spitzer, "A Proposal for the Improvement of the Mathematics Training of Elementary School Teachers," 137. See also: *Goals for Mathematical Education of Elementary School Teachers: A Report of the Cambridge Conference on Teacher Training*., (Newton, MA: Education Development Center, Inc., 1967); W. Robert Houston et al., *Improving Mathematics Education for Elementary School Teachers, a Report of a 1967 Conference at Michigan State*, (East Lansing, Mich.: Mich., Michigan State University, 1967); as well as the 1968 January, February, and March editions of *The Arithmetic Teacher*, which had numerous article in each detailing such inadequacies.

[81] Wailes, *History and Development of National Science Foundation Elementary Institutes, 1959*, 5-8.

[82] J. E. Lightner and John Frances Gilman, "A Televised Course for Elementary Teachers," *The American Mathematical Monthly* 78, no. 5 (May 1971), 537-542.

[83] Lightner and John Frances Gilman, "A Televised Course for Elementary Teachers," 538-540.

[84] Lightner and Gilman, "A Televised Course for Elementary Teachers," 541.

[85] Edward Edelson, "What's Happening to New Math," *The Times*, September 26, 1974.

[86] Phillips, *The New Math: A Political History*, 123-127.

CHAPTER 3: APPRAISING APPEARANCESS

Although the New Math education reform ended in 1975, public support died two to three years earlier. The 1970s brought with it various crises, which drove the focus away from Soviet competition and New Math. For instance, the federal government encountered economic and international issues with the continuation of Vietnam War and the OPEC gas crisis. As a result, federal funding for NSF-sponsored re-education and reform declined. SMSG, the largest curriculum group, dissolved by 1972 as a result of continued budget cuts from the NSF.[1] Consequently, by 1973, rumblings of another mathematics curriculum change emerged in newspapers across the country, giving way to the back-to-basics movement. Ultimately, national financial issues, decreased funding, and the dismembering of curriculum groups marked the end of New Math and its need for large-scale national training.[2]

In the late 1960s and early 1970s, parents, teachers, and academics started voicing concerns about New Math. Parents, educators, and school boards discovered students lacked basic computation abilities. Students could explain that 8 times 9 equals 9 times 8 by the commutative property of multiplication, but students could not tell teachers or their parents that 9 times 8 is 72.[3] The disconnect between computational ability and conceptual understanding caused worry and frustration to creep into New Math criticism. This chapter examines perceptions and criticisms surrounding New Math during its final years. The worry and frustration voiced by parents, teachers, academics, school boards,

and even New Math curriculum leaders encompassed the computation versus conceptualization controversy.

The Public Image[4]

A charted examination of the public image of New Math would look like a rollercoaster. Disapproval of the reform came in waves. As early as 1958, academics criticized New Math and its use of abstraction.[5] Despite early criticism, New Math gained support and attention from educators across the country throughout the early 1960s. At the same time, pop-culture shared its fears and frustrations of New Math. Thomas (Tom) Lehrer, a musician, and mathematician, created songs in the 1950s and 1960s mocking New Math and its concepts. In his satirical song "New Math," Lehrer states that the reform effort was so simple, "That only a child can do it!"[6] His song illustrated the confusion experienced by parents of New Math students only a decade later. Additionally, Charles Schulz creator of the *Peanuts* comic strip showcased national dissatisfaction of New Math through a series of cartoon publications. This series showed *Peanuts* characters' mounting frustrations with their math homework and their teacher. For example, see the below comic strip, which initially appeared in newspapers on April 22, 1964. The comic strips appeared throughout 1964 and 1965. In 1973, the CBS network adopted Schulz's New Math *Peanuts* series for an animated special titled *There's No Time for Love, Charlie Brown*.[7] By the adaptation of the animated feature, the dissatisfaction echoed by Sally, Linus, Snoopy, and Lucy reflected the sentiment of parents, educators, and students across the country.

Image 1: *Peanuts* New Math Comic Strip[8]

Written and published criticism emerged sporadically throughout the 1960s. In one article, "New Math Divides Opinion," Alexander Calandra, a physicist working at Washington University in St. Louis, spoke out against the term New Math. Calandra was quoted saying "The expression 'modern math' is often little more than a status symbol used by mathematicians to obtain grants, by educators to gain prestige, and by publishers to sell books."[9] However, historically speaking, this was not true. New Math had far greater implications than Calandra anticipated, which included national awareness of inadequate teachers and training. Calandra's criticism was not of the New Math content, but of the motivations behind New Math. A year later the Mathematical Association of America (MAA) met, and criticized the failings of New Math, building on the 1958 disapproval. According to one article, the MAA cited excessive abstraction, unnecessary terminology, and poor preparation of teachers as part of the failure of New Math.[10]

In 1963 Robert Varnum, an engineer and superintendent of a mill, spoke out about regarding the confusion and difficulty of new Math. He stated, "I have a daughter

in eighth grade and when I look at her [math] book, I can't make heads or tails of it."[11] Based on his engineering background, it can be assumed that Varnum took numerous math courses during his college training. To help ease the confusion and frustration of parents like Varnum local schools began hosting night classes for parents and guardians on New Math topics. Varnum became one of seventy guardians to attend a parent course hosted by Lincoln High School in Des Moines, Iowa on Wednesday nights. Lincoln High School was one of three schools in the district to offer parent classes to combat New Math perplexity. Unfortunately, these classes for parents did not quiet their frustration forever.[12] Varnum was an outlier in 1963. Many parents and educators were not yet speaking out publically against New Math. The major shift in criticism came in 1970 with complaints about New Math content.

Like Varnum, other parents complained about the content of New Math. At the onset of the 1970s, newspaper articles across the country, such as "New Math is Criticized" began to appear. These critiques shifted focus to the content of New Math. In the early 1970s James Shackelford became a household name after voicing his frustration about New Math. Shackelford held a PhD. in Chemistry and worked for the EPA at the time several newspapers published his story. Shackelford's frustration emerged after attempting to help his daughter with her fourth-grade homework assignment on sets. As published in the article, his daughter's homework read:

> Name the cardinal number of each set:[13]
>
> 13. W = (B, O, Y, A, N, D, G, I, R, L)
>
> 14. X = (0, 1, 2, A, B, C, 3, 4, 5)
>
> 15. Y = (The States in the U.S.A.)

16. Z = (The highest mountain in the world)

After the shock and frustration of his daughter's homework wore off, Shackelford took the problems to work the next day. He asked his EPA co-workers, all of whom held advanced degrees, to attempt the math problems listed. Although all highly educated with extensive training in mathematics, neither Shackelford nor his colleagues could answer the questions and thereby failed his fourth grader's math homework. Irate, Shackelford wrote letters to his daughter's teacher and other school officials. In the article, Shackelford stated that set theory was a postgraduate math concept not meant for elementary school students.[14] In the letter to his daughter's teacher, Shackelford wrote, "I have copies of some of the ridiculous problems and ask that you try to work them…Then after the exasperation subsides, ask the same questions of those state officials who have approved these books. And so on until you get to the idiot who wrote them."[15] In essence, Shackelford suggested that if he could not complete the homework, then neither could the teacher. As an unhappy and outspoken parent, Shackelford received much attention. Due to his outrage, Shackelford became a member of his local mathematics advisory committee.[16] His frustration showcased, for the first time, a rebellion against New Math content. Prior pushback cited textbooks or poor preparation, but as the 1970s progressed, New Math content became the target.

Shackelford was not a single fuming parent. In 1973, one mother spoke out stating that her daughter used to get all A's in mathematics before the adoption of New Math curriculum, but after the reform, her daughter received only C's in the subject.[17] Another concerned parent appeared in newspapers in 1974. Leroy Greene, a father, an engineer with substantial mathematics training, and the chairman of the California State

Assembly education committee called a hearing to examine the performance of New Math in Californian schools. In one article, Greene, referring to daughter's introductory college mathematics textbook, stated: "I was convinced…that if I knew all that was in the book I would not know a damn thing about how to solve math problems."[18] Greene cited problems with the content of New Math as shown in his daughter's textbook. More specifically, Greene's quote illustrated the emphasis on conceptual learning versus computational need. As a result, Greene called a hearing to reassess New Math and its textbooks before the states next curriculum update, which would take place in 1976. Parents, such as Shackelford and Greene, who feared the impact and did not understand New Math, helped usher in the back-to-basics math reform by calling for and helping to enact change.

Besides parents many teachers, school boards, and textbook editors also disliked the New Math. Only one article quoted a teacher describing New Math as "beautiful."[19] Unfortunately, beautiful was not the most common adjective used in describing the New Math movement. Other teachers referred to New Math and its texts as "obscene," "nauseating," and "awful."[20] Some educators went so far as to call New Math a nightmare.[21] Many thought the New Math had potential, but remained imperfect. Mrs. Maletzky, a teacher at North Potomac Middle school, said: "I think it's good, but it has its weaknesses."[22] Many educators cited the lack of computational skills as New Math's greatest weakness.[23] As teachers began turning against New Math, the movement as a whole began losing credibility. By 1973, the year of publication for each of this paragraphs quoted articles, New Math's public support waned significantly.

Perhaps the most significant blow to New Math credibility occurred when one of the movement's creators spoke out against it. According to one editorial, the 1973 University of Illinois Committee (UICSM) director, Russell E. Zwoyer, stated, "I think many of us who were involved in its inception and development now feel that the modern-math movement not only didn't solve our problems, but did some harm. It has probably made things worse at the elementary school level."[24] Jerrold Zacharias, a physicist and leader of the 1950s science reforms, said that New Math was "on the whole negative."[25] After the leaders and developers of curriculum reform publically acknowledged the pitfalls of New Math, a massive move towards a new form of math education arose. However, the public image was not the only identity that changed over the course of New Math's existence. The academic, professional, and public image shifted its perceptions in publication titles over more than a decade.

The Publication Image

As shown, this thesis relies heavily on journal and newspaper articles. As such, it seems relevant to discuss how the titles of these articles shifted over time. Francis Mueller, a mathematician, did a small study on the public image of New Math. In his article, he analyzed published titles for pieces about New Math over s ten-year period, from 1956 to 1965. He began by analyzing articles published in 1956. Although New Math existed prior to 1956, this year marked the first mass publication of articles on the topic. During this year many of the titles held a negative connotation. For instance, Mueller cites the following articles: "Why Johnny Can't Add" (1956), "Least Popular Subject" (1956), and "Digits and Dunces" (1956). These undesirable titled articles promoted feelings of fear, confusion, and anger. This correlates, with the timeline in the

previous section. However, none of the authors questioned the validity of New Math in 1956.[26]

During the middle years of the study, 1957 to 1964, the image of New Math brightened. Magazine topics shifted from a dim view of mathematics to a refreshed perspective on the subject's trajectory. The titles of the articles lightened and portrayed math as a marvelous subject-matter with new potential for future students. During these middle years, some of the article titles were "The Wonderful World of Why" (1957), "Math Made Easy" (1960), "Captivating Key to Math" (1961), and "She Turns Figures into Fun" (1961). Each of these titles portrayed a positive image of math. Headlines like "Math Made Easy" and "Math Even Parents Can Understand" (1958) helped quash the early onset parental frustration, such as Varnum. These type of titles gave the positive reinforcement for those struggling with the idea of New Math during the 1960s. Unfortunately, these parent focused articles did not quell escalating exasperation during the 1970s. Overall, the middle years' titles portrayed a highly favorable attitude towards New Math and promoted the idea of parental comprehension.[27]

Finally, in the last year of Mueller's study, he showed how the public opinion altered dramatically. While a highly favorable attitude existed for more than half a decade, the mid-1960s witnessed an abrupt change. Suddenly, the pendulum of public perception swung in the opposite direction towards reservations, concerns, and misgivings. Titles such as "Trials of New Math" (1965), "Parent education" (1966), and "New Math - Does It Really Add Up?" (1965) began to appear. In these articles, major players in the New Math reform, such as Max Beberman, began raising concerns and questions about the reform's future. Many cited the movement's shortcomings over the

achievements. Parents began expressing concern and their misunderstanding of New Math more openly and more frequently during this period.[28]

The changing publication image that Mueller illustrated through journal articles parallels the path of teacher education and preparedness. Initially, there was some apprehension about teaching New Math. However, at the height of the New Math reform, teachers attended training events in hopes of understanding new concepts. This period was viewed favorably at the time. Towards the second-half of the 1960s, the NSF began slowing its funding for national training efforts. Suddenly, voices of concerned professors and parents emerged, some of whom called into question teacher training effectiveness. This parallel trajectory showcases the rollercoaster ride that both parents and teachers felt. During the downturn in New Math popularity, one mathematician became the bluntest and most candid denouncer of the math reform.

Critiquing Kline

Morris Kline, perhaps the most outspoken critic of New Math, began writing about his discontent in 1958.[29] Kline was a mathematician, prolific writer, and professor at New York University.[30] Educators and historians hailed Kline as the chief decrier of the entire New Math movement. In *Why Johnny Can't Add* (1973), Kline outlined his critiques and suggestions for math education reform. He discussed a variety of hurdles New Math supporters and promoters faced. However, this work also encouraged a broader analysis of math education reform. As such, it is worthwhile to discuss Kline's perceptions on New Math and its eventual demise.

According to Kline, New Math's failure resided in the lack of small scale experimentation. As noted in chapter two of the thesis, very little quantitative data was collected specifically in regards to teacher comprehension. Kline stated,

> One would think that the framers of the modern mathematics curriculum would have experimented with many groups of children and teachers and thus produced some evidence in favor of their programs before urging them upon the country. The sad fact is that most of the groups undertook almost no experimental work… The superior understanding which the modern mathematics approach is supposed to provide has not been demonstrated by tests or by any other objective measures.[31]

Kline goes on to state the writing group closest to producing quantitative data was the UICSM, but this group never quantitatively proved New Math's superiority to traditional math. Large-scale testing was never indicative of New Math success. As Kline also observed, many teachers of New Math taught traditional math concepts with a sprinkling of modern mathematics. Thus, even if the government and writing groups collected testing and quantitative data, the results would not accurately reflect the success of math reform, since teachers were not strictly teaching New Math material.[32]

Kline suggested that "The bigger and more vital problem is the education of teachers."[33] By this, he meant that corrective education must begin at the top, or at the college-level. The beginning of the New Math era witnessed a shortage in college professors.[34] Due to the shortage, institutions of higher learning needed to increase the number of mathematicians and educators at the university level. Once the university level gained more and better-trained math professors, then in turn, they could better teach future math teachers. If future math teachers received stronger math training, then their prospective students could also obtain an elevated and more sophisticated mathematics training. This would perpetuate a society with more solid mathematical skills, at least in

theory.[35] The unfortunate reality was that it would be hard to fulfill Kline's dream. How would colleges and universities increase the number of math professors, if the program was already weak? The cyclical nature of education can be beneficial, but can also hamper progress when existing programs remain ineffective. Ultimately, Kline called for a shift from narrow research centered mathematicians, to math professors of broader educational insight who could help break the vicious cycle of poor mathematics training.[36]

Kline's critique did not stop at the college-level. The need to improve elementary and secondary teacher education remained a topic of interest into the 1970s. Many a student has asked: why do I need to take math? Modern day teachers cite numerous reasons – critical thinking skills, problem-solving abilities, and abstract thought process.[37] However, during the New Math years, teachers did not respond to this question effectively. Rather, teachers would respond "because it is important." Teachers during the New Math period were not versed in the applications of math because the emphasis on applied mathematics had only just developed. As Kline stated, "In particular they [teachers] know no science."[38] Thus, not only did teachers have an inadequate understanding of fundamental math, they also lacked knowledge of math's purpose in a larger cultural sense. In other words, math teachers could not explain why or how math applied to the world around students because the teachers themselves lacked an understanding of the sciences integrated with mathematics.

As CUMP released requirements for precollege and collegiate coursework, there was no mention of science prerequisites. Furthermore, in exploring the surveyed training opportunities provided to teachers, either on the national or local level, not one

mentioned training math teachers within the context of science. While educators and the NSF grouped the term mathematics under the broader title of science, they approached math separately.[39] In 2016, the idea of isolating math and science subjects seems obscure. With the proliferation of STEM, the integration of mathematics and science is necessary in modern education and society.[40]

Kline ended his book-length analysis of New Math with a praise of teachers. Kline acknowledged the pitfalls of both traditional and New Math methods. However, he also credited the survival of math education to meaningful teachers. In his closing remarks, he stated: "I think that we owe what we have accomplished to a few wise, mature, devoted teachers who by their care in choosing what to emphasize and by their personal charm and magnetism have attracted some students to mathematics. Those noble souls have saved us from disaster."[41] While this thesis argued that collectively teachers were ill-prepared for New Math and as a result required additional training, it is important to recognize that good and qualified teachers existed in America's classrooms. This small population of qualified teachers was whom Kline credited for holding the subject's education together.

Test Scores

As parents, academics, teachers, and publications expressed their concern and dismay for New Math, the education reform pendulum began to swing the other way. As these groups cited a lack of computational ability, they placed an emphasis on more drill and less conceptual understanding.[42] This push, by parents and teachers, to promote a better understanding of drill and computation resulted in the back-to-basics movement. From 1973 to 1975, many articles shunned the term New Math for a new middle-of-the-

road movement. Educators blended methods from traditional math and the New Math, taking the best qualities of both – computation and conceptualization.[43]

The push for a revised mathematics program came not just from the parents and teachers, but also from declining test scores. Opponents of the New Math reform frequently quoted test scores from three states –California, New Hampshire, and New York. According to several articles which cited the test scores, all three states saw a deterioration in computational mathematical ability. California's sixth graders experienced a nine-point drop from the 1969-70 school year when the state adopted New Math, to the 1971-72 school year. In New York, one assessment reported that nearly one-third of the state's sixth graders underperformed in mathematics. New Hampshire also experienced a sharp decline in student computational ability on state tests. [44] These state tests pointed to the deterioration of New Math.

Of the three states, California was unique because it was the only state with four consecutive years of math testing, and the only state using a universal program for grades 1-12.[45] Another study stated that "randomly selected students in grades four through eight showed not only that children could not add; they could not subtract, multiply, or divide. They also had trouble computing with fractions, decimals, and percentages."[46] Alarming test scores, combined with Greene's call for California's reconsideration of New Math curriculum resulted in a state mandate to replace all New Math textbooks by the fall of 1975. These new textbooks emphasized arithmetic and numerical computations in elementary schools. As the article stated, "the guidelines put less emphasis on the new math and more emphasis on old-fashioned arithmetic."[47] In other words, the state of California, in the fall of 1974, looked for a more middle-of-the-road compromise while

stressing a back-to-basics approach. New York and New Hampshire followed similar trajectories.[48]

Conclusion

Ultimately, 1975 marked the end of New Math and the nationwide effort of mathematicians and the NSF to change school curriculums. In viewing the movement through Kline's eyes, from the beginning, New Math was doomed. Public sentiment only vastly changed after the 1970s. In the movement's last years, 1973 to 1975, parents and educators rallied to repeal New Math by pushing for a return to drill, memorization, and computation. As a result, New Math ended and back-to-basics began. Supporters of back-to-basics did not leave behind all of New Math's ideas. Instead, educators, textbook publishers, and parents took a middle-of-the-road approach by maintaining an emphasis on conceptual learning and application, but also stressing the importance of drill and computation. With the end of New Math, critics and enthusiasts banded together to move into the next era of mathematics education reform.

ENDNOTES

[1] Fred Hechinger, "Time + Trail = Acceptance," *New York Times*, 1972.

[2] Christopher J Phillips, *The New Math: A Political History* (Chicago, IL, United States: University of Chicago Press, 2014), 123-127.

[3] "Parents, Take Heart – New Math Is Kaput," *Detroit Free Press*, November 26, 1973; Danny Walsch, "Teachers Cite Weaknesses in New Math Program," *The Daily Mail*, December 19, 1973; "New Math Just Doesn't Add Up for Some Students," *Florence Morning News*, June 4, 1973; "Now They Tell Us," *Wilmington News-Journal*, June 20, 1973.

[4] For this section, I surveyed numerous newspaper archives available to me. The news articles are taken from a variety of newspapers, academic journals, and a few magazines. I built the public perception discussed in this section and chapter based off of the variety of sources. Many articles were published in numerous newspapers, often associated with the Associate Press. Since New Math is a term with more modern meaning, specifically in reference to new math reform efforts, such as Common Core, searching only the term New Math proved difficult. Through digitized archives, I limited the search parameter years to exclude any mention of New Math prior to 1940 and after 1980. By limiting the years, I was able to weed out any non-relevant mention of New Math. Additionally, as with any search, I manipulated the keyword search terms to include 'New Math,' 'teachers,' 'training,' 'parents,' and 'reactions.' Search term criteria resulted in many of the utilized articles, as well as dozens of others. I did not utilize all the articles because many were repetitive. Additionally, there were far too many. Thus, I utilized the most relevant and useful articles for this thesis.

[5] Edward Edelson, "What's Happening to New Math," *The Times*, September 26, 1974.

[6] "Tom Lehrer - New Math," Metro Lyrics, accessed October 18, 2016, metrolyrics.com/new-math-lyrics-tom-lehrer.html; Jared Khan, "Tom Lehrer - New Math (animated)," YouTube, July 5, 2010, posted October 18, 2016, youtube.com/watch?v=UIKGV2cTgqA.

[7] *There's No Time for Love, Charlie Brown*, directed by Bill Melendez, (n.p.: Columbia Broadcasting System (CBS), 1973), Film; "Peanuts," Peanuts by Schulz, 2016, accessed November 6, 2016, peanuts.com/.

[8] "Peanuts by Schulz," Peanuts by Schulz, April 22, 1964, accessed November 6, 2016, peanuts.com/search/?keyword=new%20math&type=comic_strips#.WB-8muErKV4.

[9] G. K. Hodenfield, "New Math Divides Opinion," *The Kansas City Times*, September 10, 1965; also see Alexander Calandra, "The New Math Is A Hoax," *St. Louis Post-Dispatch*, November 9, 1969.

[10] "'New Math' Eyed," *The Daily Republic*, September 14, 1966.

[11] Jack Magarrell, "'New Math' Instructions for Parents," *The Des Moinse Register*, October 31, 1963.

[12] Ibid.

[13] Jay Matthews, "EPA Chemist Finds He Can't Work Daughter's New Math," *The Times*, November 19, 1972; Jay Matthews, "Fourth Grade Math Textbook Arouses Father's Ire," *The Times Herald*, November 23, 1972.

[14] Jay Matthews, "Fourth Grade Math Textbook Arouses Father's Ire," *The Times Herald*, November 23, 1972. Matthews recounts James Shackelford's frustration of the New Math his fourth-grade daughter was learning. Shackelford held a PhD. in Chemistry and worked for the EPA at the time the article was published. In it, he voices his concern of the New Math. Matthews shares the account of Shackelford taking his daughter's math book to work, where he asked co-workers to attempt the math problems listed. Shackelford, and all of his co-workers who also hold advanced degrees failed the fourth grade math problems. Shackelford was irate and wrote letters to his daughter's teacher (which is where the cited quote is from). Shackelford received a lot of attention. Parents, such as Shackelford, who feared and did not understand New Math, helped usher in the "back-to-basics" math reform. See also: Phillips, *The New* Math, 134-135.

[15] Matthews, "Fourth Grade Math Textbook Arouses Father's Ire."

[16] Frank Kendig, "Does New Math Add Up?," *New York Times*, January 6, 1974.

[17] Helen Carrniger, "Is New Math Backfiring?," *The Akron Beacon Journal*, March 12, 1973.

[18] Kendig, "Does New Math Add Up?,"

[19] Walsch, "Teachers Cite Weaknesses in New Math Program."

[20] The Associated Press, "The New Math Scare," *Kentucky New Era*, September 27, 1982; Carrniger, "Is New Math Backfiring?"

[21] "Newer New Math May Ease the Pressure on Parental Brainpower," *Waukesha Daily Freeman*, April 2, 1973.

[22] Walsch, "Teachers Cite Weaknesses in New Math Program."

[23] Walsch, "Teachers Cite Weaknesses in New Math Program."

[24] "Now They Tell Us"; Kendig, "Does New Math Add Up?"

[25] Fred Hechinger, "Math: Integrating The New and the Old," *New York Times*, May 4, 1975.

[26] Francis Mueller, "The Public Image of 'New Mathematics,'" *The Mathematics Teacher* 59, no. 7 (November 1966), 618-619.

[27] Mueller, "The Public Image of 'New Mathematics,'" 619-620.

[28] Ibid, 620-622.

[29] Edelson, "What's Happening to New Math."

[30] Eric Pace, "Morris Kline, 84, Math Professor and Critic of Math Teaching, Dies," *The New York Times* (The New York Times), June 11, 1992, nytimes.com/1992/06/11/nyregion/morris-kline-84-math-professor-and-critic-of-math-teaching-dies.html. Kline wrote numerous articles and books, but these are just a few: *Mathematics in Western Culture* (1953), *Mathematics: The Loss of Certainty* (Oxford University Press, 1980) and *Mathematics and the Search for Knowledge* (Oxford University Press, 1985).

[31] Kline, *Why Johnny Can't Add*, 103, 109.

[32] Ibid, 107-108

[33] Ibid, 166

[34] See chapter one

[35] I like to think of this as trickle down education.

[36] Kline, *Why Johnny Can't Add*, 167-170.

[37] Here I am citing myself. As a former developmental math instructor at a community college, these are answers I hear on a daily basis. These are also the same questions I asked during my undergraduate math studies. Of course, there is an innumerable amount of answers that could be given.

[38] Kline, *Why Johnny Can't Add*, 169

[39] Ibid, 169-170

[40] STEM stands for Science, Technology, Engineering, and Mathematics. The STEM movement is a push of the 21st century's to gain international ground.

[41] Kline, *Why Johnny Can't Add*, 170.

[42] "Parents, Take Heart – New Math Is Kaput"; Walsch, "Teachers Cite Weaknesses in New Math Program"; "New Math Just Doesn't Add Up for Some Students"; "Now They Tell Us";

[43] "New Math Yielding to Simple Arithmetic," *The Pittsburgh Press*, October 14, 1974; Locals Educators revaluate teaching techniques of new math -1973;

[44] Robert Betts, "New Math More Fun?," *Iowa City Press-Citizen*, August 14, 1974.

[45] Betts, "New Math More Fun?"

[46] Betts, "New Math More Fun?"

[47] Betts, "New Math More Fun?"

[48] Kendig, "Does New Math Add Up?"; Betts, "New Math More Fun?"; Mary Churchill, "A Drawback Found in New Math," *New York Times*, November 4, 1973.

CONCLUSION: *QUOD ERAT DEMONSTRANDUM*[1]

Although the downturn in New Math popularity and support cannot be solely blamed on teachers, the lack of preparedness and training remains a substantial factor. New Math brought to light major complications in America's math teachers, but specifically those teaching elementary school math. Mathematicians thought New Math would create little scientists and prepare students for careers in the sciences, engineering, and technology. Unfortunately, New Math created a two-and-a-half-decade descent into public confusion. From 1958 to 1972, the national average requirement for mathematics courses during pre-college years remained the same, with no significant change. The percent of students taking math courses in high school also remained unchanged throughout the 1960s. Moreover, from the evidence illustrated in this thesis, teachers remained ill-prepared despite the recognition of the need and the large-scale national training efforts. An informal survey of university teacher instructors showed their students weaker in mathematical technique than students from more than ten years prior.[2] Thus, as historian Christopher Phillips states, "the spread of new math was uneven at best."[3]

In 1969, Dr. Alexander Calandra, a then professor of physics, an advisor to the St. Louis public school and the American Council on Education, as well as a consultant to the National Science Foundation, spoke out against New Math. Calandra believed historians would view New Math and see the reform effort as a failure.[4] To a large extent, Calandra was correct, many historians and educators viewed New Math as a national disaster. However, this thesis does not assert that New Math was a horrific catastrophe. In fact, some good emerged from the failure of New Math.

As a result of New Math's failure, a spotlight showcased the tragedy of teacher education, training, and preparedness. The failure to adequately prepare teachers in mathematics resulted in an unfortunate domino effect once New Math appeared. Ill-prepared teachers, with significantly lacking mathematical ability, were given more advanced math topics to teach. As New Math progressed, these same teachers sought various avenues of training. Unfortunately, the national training efforts remained largely unattainable for elementary school educators. The skewed emphasis on high school math teacher preparation compared the elementary teachers showcased a fundamental weakness in the adoption and implementation of New Math.

Initially, New Math hoped to revamp high school courses only. However, because mathematics courses build upon one another, educators realized middle grades and elementary school mathematics also needed addressing. Inevitably, training became necessary for all levels of teaching. Unfortunately, the quantity outweighed the quality. High school teachers received more training than elementary school teachers, partially due to the significant difference in numbers. However, since the math reformers initiated efforts from the top down, high school teachers received more opportunities compared to their elementary school counterparts. In total, teachers were offered less than two decades of additional mathematics preparation as national training efforts disbanded by 1972 with declining federal funding.

The promise of New Math collapsed by 1975. As one article, published in 1974 stated, "…the new math is in retreat. The reason is simple: Parents and educators are

discovering that the children who were expected to be math whizzes often can't do the simple arithmetic needed for everyday life."[5] The results of New Math were not what mathematicians, educators, and government agencies expected. Instead, New Math left a sour taste in the mouth of the next generation. As Morris Kline stated, "What is especially grievous, then, about the teaching of mathematics, traditional or new, is not that the teachers do not know what they are teaching but that they do not know and so cannot show pupils why mathematics is vital."[6] Without the ability to explain the purpose of conceptual learning to the students, or the application of mathematics in daily life, New Math, and its teachers flopped. The excessive emphasis on conceptual learning and the lack of application or computation created an environment ripe for criticism and failure.

Additional Studies

Much about New Math remains open to further study. In the realm of curriculum reform groups, historians, thus far, have only explored the SMSG and UISMC in depth. Many other reform groups remain open for investigation and research. For instance, a further investigation of both the University of Maryland Mathematics Project (UMMaP) or the Ball State Teachers College Experimental Program could highlight the effectiveness of smaller programs. Moreover, tracing the trajectory of New Math and subsequent reforms remain open to study. Additionally, examining large program funding versus smaller program financing could potentially illustrate how size and money affected the quality of teacher training.[7] Funding is another topic of New Math that future historians should explore. The era was rich with funding entities other than the federal government. A fuller exploration of curriculum group and textbook funding would be

fascinating, and may perhaps answer many questions regarding the motivation of mathematics reform. Comparing curriculum groups funding origins and size could highlight how special interest groups and the United States pushed their curricula beliefs. Aside from curriculum groups, a study on parental involvement in New Math and subsequent reforms could highlight the effectiveness of reform efforts. Parents, as shown in chapter three, hold more sway in national education than believed. Understanding how and why parents embrace or reject education reform, specifically in math, would result in an insightful interdisciplinary study relevant to current trend. Finally, in the realm of teachers, additional in-depth studies on the effectiveness of Summer Institutes, and other curriculum reform groups would be beneficial

QED

Both current and past educational reforms harken back to the ideas of Horace Mann, an education developer, and leader, in the 1850s.[8] Mann believed in the standardization of teacher education and a national curriculum. These century old ideas came to fruition, at least in part, through New Math. It also manifested itself in more modern programs such No Child Left Behind, Head Start, and Race to the Top. In 2016, it seems impractical that modern education programs are attempting to achieve the same goals Mann envisioned more than a century ago – the standardization of education.[9] In understanding the importance of studying education reform, particularly mathematics, historians and lay people may better understand why math reform efforts continue to encounter reform. It seems that the content and method of delivery may not be the only problems in mathematics education.

In recognizing the historical significance of New Math, the hope is to understand better the impact that educational reforms can have on learning, society, and the development of the country. Hopefully understanding past reforms will shed light on the current math reform blanketing the United States. In agreeance with Kline, there is not a magical cure to undo or improve education reform, but by learning from previous attempts, it seems probable that historians and mathematicians alike can pinpoint past failures and prevent them from reoccurring. Moreover, through understanding the historical significance of New Math and its ill-prepared teachers, perhaps future reformers and educators can attempt to prepare teachers, and prevent educational discrepancies experienced during the New Math era.

Math education reform, beginning with New Math, entered an unsuccessful cycle of continuous politicization of mathematics. With numerous reform efforts, mathematics perfection and reorganization remains an unattainable dream. Although each math reform helped advanced the mathematics of today, it seems we, as mathematicians, raised a generation frightened of the subject. Instead, we should promote a learning philosophy and environment of excitement and interest, which is what academics involved with New Math set out to accomplish. Ultimately, the replacement of New Math with additional reforms created a culture of math illiteracy and fear. Only once we, as a society and as educators, end the anxiety surrounding mathematics can the next generation embrace the wonders and infinite possibilities of learning math.

ENDNOTES

[1] QED is an acronym for the Latin phrase *quod erat demonstrandum*, meaning "that which was to be demonstrated." QED is often written at the end of a mathematical proof to indicate its completion. See: "Q.E.D.," Wolfram Alpha, May 23, 2000, accessed October 22, 2016, mathworld.wolfram.com/QED.html.

[2] Morris Kline, *Why Johnny Can't Add: The Failure of the New Math* (New York, NY, United States: New York, Vintage Books [1974, c1973], 1974), 109.

[3] Christopher J Phillips, *The New Math: A Political History* (Chicago, IL, United States: University of Chicago Press, 2014), 123.

[4] Alexander Calandra, "The New Math Is A Hoax," *St. Louis Post-Dispatch*, November 9, 1969.

[5] Edward Edelson, "What's Happening to New Math," *The Times*, September 26, 1974.

[6] Kline, Why Johnny Can't Add, 152

[7] Robert Hayden, "A History of the 'new math' Movement in the United States," (Iowa: Digital Repository at Iowa State, 1981), lib.dr.iastate.edu/rtd/7427, 139 – 142.

[8] Horace Mann was a prolific writer and thinker in the realm of education during the mid- to late-1800s. He promoted the idea of a common school, teacher training, and the creation of Normal Schools (see chapter one). Also, see: Jonathan Messerli, *Horace Mann* (New York: Knopf, 1972), 263, 340; Joshua Sheats, "The Untold History of School That You Probably Don't Know (1 of 2): Interview with Brett Veinotte, Founder of the School Sucks Project," Podcast. *Radical Personal Finance*, 2014. radicalpersonalfinance.com/the-untold-history-of-school-that-you-probably-dont-know-1-of-2-interview-with-brett-veinotte-founder-of-the-school-sucks-project-rpf0089/; "Only A Teacher: Schoolhouse Pioneers," PBS Online, accessed October 18, 2016, pbs.org/onlyateacher/horace.html.

[9] Joshua Sheats, "The Untold History of School That You Probably Don't Know (1 of 2)."

EPILOGUE: THE *NEW* NEW MATH

The troublesome cycle of hastily adopting a new math curriculum, with ill-prepared teachers did not change over time. In Elizabeth Green's article, "Why do Americans Stink at Math?" she stated: "The story is the same every time: a big, excited push, followed by mass confusion and then a return to conventional practices."[1] She alludes to the cyclical nature of math education reform, both in the mid-twentieth century and in the present. In the aftermath of New Math, the back-to-basics movement took hold. One author stated, "This movement called for decontextualized and compartmentalized skills-oriented mathematics instruction and was closely connected to the minimum competency testing movement used extensively by states in the 1970s and 1980s."[2] The back-to-basics effort promoted a return to drill and memorization. Institutions supporting back-to-basics established more stringent accountability standards. Unfortunately, back-to-basics lacked fully teaching the applications of mathematics. This rebound reform stayed at the forefront of education throughout the rest of the 1970s and into the early 1980s.[3]

By 1980, the nation's school systems made a call to achieve excellence. By this time a widespread acknowledgment of declining math and science education quality emerged. According to one source, "A 1980 report by a presidential commission pointed to low enrollments in advanced mathematics and science courses and the general lowering of school expectations and college entrance requirements."[4] As a result of low test performances and a growing concern of inept mathematics students, several strands of thought on teaching the subject emerged. These new ideas focused not just on mathematical content, but also on the psychology of how students learn math. Ultimately,

these various strands of thought on learning mathematics coalesced into the release of the National Council of Teachers of Mathematics (NCTM) publication, *Curriculum and Evaluation Standards for School Mathematics* in 1989.[5] The NCTM report, known as the *Standards*, sought to redirect the mathematics teaching profession and focused on understanding how students formulated connections among different math concepts. Hence, after the back-to-basics movement, the pendulum of mathematics teaching swung back in the direction of emphasized conceptual learning.[6]

The *Standards* became highly controversial. The publication, broken down by grade level, sought to de-emphasize ideas such as rote practice, rote memorization, and finding exact answers. Many of these ideas were also popular during the New Math period. With the advent and popularity growth of the classroom calculator, the *Standards* advocated each student utilize an appropriate device for computations. The use of calculators remained a major difference between New Math and the *Standards*, but both focused on conceptual learning. Additionally, both reforms relied heavily on federal funding through the NSF.[7]

With strong funding from the NSF, the *Standards* proliferated throughout the 1990s and ultimately ignited what became known as the math wars. As one author stated:

> Mathematics education policies and programs for U.S. public schools have never been more contentious than they were during the decade of the 1990s. The immediate cause of the math wars of the 90s was the introduction and widespread distribution of new math textbooks with radically diminished content, and a dearth of basic skills. This led to organized parental rebellions and criticisms of the new math curricula by mathematicians and other professionals.[8]

Journalist, much like those of the New Math era, depicted the math wars as a nearly decade-long disagreement between computation proponents and conceptual supporters.

As one author stated, "The parents and mathematicians who criticized the NCTM aligned curricula were portrayed as proponents of basic skills, while educational administrators, professors of education, and other defenders of these programs, were portrayed as proponents of conceptual understanding."[9] These warring factions within education fought for computation or conceptualization, but neither side acknowledge the need for both. *Standards* and the math wars created a period of tension in mathematics education history. At the turn of the century, math education was once again ripe for education reform.[10]

By 2009, schools throughout the United States adopted the next and newest math reform – Common Core. The newest iteration in math reform consisted of a set of guidelines in math and reading for grades K-12, with no designated corresponding curriculum; or as Green writes, "the Common Core math standards are like earlier math reforms, only further refined and more ambitious."[11] These guidelines sketch out what a student, in each grade level, should understand and be able to demonstrate.[12] Furthermore, Common Core goals do not explicitly outline what materials teachers need to teach; the goals of Common Core hope to ensure each student leaves their respective grade with the ability to perform the same concepts across both district and state lines.[13] While states were not required to adopt these standards, many did to receive federal monies from President Obama's Race to the Top initiative.[14] As of 2014, adopting common standards was a stipulation to receiving a piece of the $4 billion Race to the Top grant fund. As a result, forty-three states adopted Common Core standards.[15]

Ultimately, New Math and Common Core both became accessible through a top-down push and influenced by massive government funding. As such, many people

equated Common Core to New Math's demise. For instance, one author, referring to Common Core and New Math, wrote: "In short, we repeated the same mistake – or a very similar one."[16] Some have gone so far to retitle Common Core as the *New* New Math.[17] However, Common Core remains viewed in present context, and not through a historical lens.[18] While the outcome of Common Core is unknown at the time of this writing, if it follows previous math reform trends, then it too will give way to another more *modern* change.

Common Core and New Math share underlying similarities. For instance, both emphasize conceptual learning. As one author states, "Like the Core, it [New Math] proposed to focus more on conceptual understanding, but to do so it needlessly complicated matters at the grade school level."[19] Before New Math and before Common Core, the "traditional math" relied on rote learning and memorization, referred to in the 1990s as "drill and kill." New Math and Common Core hoped to suspend memorization by showing students the "why" behind mathematics, specifically in arithmetic.[20]

Another similarity was that both reforms became large national programs. Both began out of fear – the fear of *Sputnik*, and the fear of failing in comparison to global competitors.[21] Additionally, they both required teacher training.[22] As one opinioned author stated, "To give the Common Core a fair shot, we need appropriate professional development for teachers…"[23] However, according to Green's article teachers spent less than four days receiving Common Core training.[24] Another article stated that while there were teachers prepared to teach Common Core, just as there were with New Math, others noted they "received scant training."[25] Jenny Aguirre's, a twelve-year veteran of first-grade teaching, told one news source, "'There's not (been) a lot of training on how to

teach (Common Core) math or on what we should expect of the children…This is just a total shift for us.'"[26] Like the teachers half a century before them, current educators received little preparation to teach the newest math reform.[27] How can teachers effectively teach students, if they lack training in the new methods or concepts? However, like the New Math teachers of the 1960s, modern day Common Core teachers can receive training. For instance, Aguirre could attend one of several district-wide small groups focused on training provided by her school district, Fresno Unified.[28]

From both eras echo the cries of teachers. For instance, "Teachers complained they didn't understand it [New Math] and that it needlessly confused their students."[29] Similarly, neither math reform emerged from the K-12 teacher perspective; rather, both reforms emerged from an outside entity. In the case of New Math, mathematicians and organizations, such as the NSF, pushed for the development of new curricula. In the case of Common Core, the outlined standards "were written by the standardized testing corporations – not working educators and experts in childhood development."[30] As another author states, "By and large, Common Core wasn't created by teachers. It was forced on us by policymakers, functionaries and corporations."[31] As a result, one study found that less than half of the teachers participating in Common Core training found it useful.[32] Without input primarily from experienced educators, both New Math and Common Core emerge as a top-down push. The curriculum changes did not arise out of teachers voicing concerns for math education, but rather from politicians and organizations who stand to gain monetarily. It would seem Dr. Alexander Calandra's perceived historical notions of New Math would more accurately apply to Common Core.[33]

Also, both Common Core and New Math received public ridicule. For instance, New Math became the focus of Tom Lehrer's satirical song "New Math.". In the song, Lehrer talks about the changed method of subtraction, as well as students working in base eight. In listening to the song, the math seems complicated and unrealistic at times, which was Lehrer's point. The lyrics stated that New Math was perceived to be so simple that only a child or student could understand it.[34] Thus, he implies how difficult New Math was for those unfamiliar with its concepts. In a similar situation, comedian Louis C.K. mocked his child's math homework during "The Late Show with David Letterman." The comedian joked, "It's like, Bill has three goldfish. He buys two more. How many dogs live in London?"[35] Again, the comedian implies a strong disconnect between the Common Core math his child is learning and his mathematical understanding. This public showcase of misunderstanding the then current math reforms helps to illustrate a strong divide between parents, the students, and the evolution of math reform thought.

These are just a few of the similarities between New Math and Common Core. The chart below illustrates a briefer comparison. While many similarities exist, there is one stark difference:

> In some ways, the Core is worse than the old New Math because of its close connection with high stakes testing. In the '60s if a child didn't understand how to add, he failed math. Today, if a child does that, he fails the standardized test and if that happens to enough students, his school loses funding, his teacher may be fired and his school may be closed. As such, the pressure today's children undergo is tremendous. They aren't just responsible for their own learning. They're responsible for the entire school community.[36]

It would seem that educational standards today put more students in jeopardy than the New Math. However, the largest connection between New Math and Common Core remains the poor mathematics education for millions of American children. In 2013, only

44 percent of high school graduates were considered prepared for college-level math courses.[37] Yet, in the fall of 2013, nearly 65.9 percent of high school graduates enrolled in college. The question becomes, how well did students ill-prepared for college math fair?[38] Sending underprepared students to take college level math courses seems to be a continuing trend.[39]

Table 2: Similarities of New Math and Common Core[40]

New Math	Common Core
Shift from memorization or rote learning to conceptual learning.[41]	Shifted from "drill and kill" method (memorization) to a more conceptual based learning approach
Utilized discovery learning	Utilize cognitively guided instruction, or as one teacher stated: "'I'm not an imparter of information…I want my children to discover.'"[42]
Provided few training opportunities for elementary teachers[43]	Elementary teachers received less than four days or "scant" training. In another instance, "elementary school teachers were expected to receive anywhere from three days to two weeks'."[44]
Parental frustration[45] - "I have copies some of the ridiculous problems and ask that you try to work them…Then after the exasperation subsides, ask the same questions of those state officials who have approved these books. And so on until you get to the idiot who wrote them."[46]	Parental frustration, with one parent stating, "I have a Bachelor of Science Degree in Electronics Engineering which included extensive study in differential equations and other higher math applications. Even I cannot explain the Common Core Mathematics approach" [47]
Training through institutes, including In-Service Institutes[48]	Training through institutes, summer workshops, and on-the-job training.[49]
Training through curriculum groups, such as SMSG, UICSM, UMMaP, etc.[50]	Training through curriculum groups, such as UCLA Mathematics Project (UCLAMP).[51]

Ultimately, the root issue of both New Math and Common Core lies in teacher training and preparation. In both cases, content is an issue, but more importantly, the accompanying pedagogy is troublesome. In both instances, a preferred pedagogy accompanied the math reforms, and in both cases, the instruction emerged flawed. The

pedagogy, being crucial to implementation remains the crux of the problem. As Kline said: "A poor teacher and a good curriculum will teach poorly whereas a good teacher will overcome the deficiencies of any curriculum."[52] Like the argument that mathematics requires computation and conceptualization, teachers require training in both pedagogy and content. One without the other is doomed.

While it seems computation and conceptualization cannot coexist, neither can education reform exist without parental support. As shown in chapter three and this epilogue, parent involvement is crucial to the survival of education reform. As parental frustration with New Math concepts increased, the reforms support declined. Parents called for a return to basics, which helped spark the back-to-basics movement. Not only did parent dissatisfaction with New Math contribute to the reform's decline, it also helped spark the next movement. Likewise, in the twenty-first century, parent and family involvement remains crucial in a child's education.

In 2010, President Obama filmed a 30-second public service announcement as part of NBC's "The More You Know" campaign. In the clip, President Obama urged parents to be proactive participants in their child's educational experience. He stated, "We all know that we can have the best schools and the most dedicated teachers in the world. But it won't be enough unless we fill our responsibilities as parents."[53] Thus, it may be safe to assume that the success of Common Core and all future education reform efforts remain dependent upon parental support. Studies, such as those discussed in the ETS "Parsing the Achievement Gap Baselines for Tracking Progress" report, suggests that "Students with parents who are involved in their school tend to have fewer behavioral problems and better academic performance, and are more likely to complete

secondary school than students whose parents are not involved in their schools."[54] As a result, these studies illustrate the importance of parental involvement for a child's success in school. Parent involvement and support does necessarily begin and end with their child's homework. Instead, parent involvement, at least in 2016, means voicing concerns, advocating for teachers and resources, attending PTA meetings and related events, and helping stock classroom supplies.

While parent involvement is better for the child's education overall, the importance of their role in math reform efforts is far greater. Typically, during math education reform tension arises between parent and teacher. Such tension was evident in chapter three when Shackelford, a father, became irate and frustrated after being unable to help with his child's math homework. In a 1997 article, "Parental Involvement in the Reform of Mathematics Education," the author outlined three causes for parent-teacher tension: classroom activities, math content, and home activities. Again, the article cited a struggle between concept and computation focused learning. After interviewing parents from more than twenty schools, the article concluded that "Parents were unsure of the consequences that reformed mathematics education would have on their children, and as a result, the tension that parents experienced in watching their children learn mathematics increased."[55] If the origins of such tensions can be addressed early on in mathematics reform, then perhaps curriculum and pedagogy change within the subject would be better received. More effort should be put into building parent-teacher communications and trust. Teacher training must first emphasize the importance of content and pedagogy, but also include interpersonal communication skills.[56]

It seems teacher training has not changed much between New Math and Common Core, but the effectiveness of subsequent training methods could be useful in altering the education path for teachers in the next reform movement. As one article reported:

> By giving concept priority over content, Common Core has failed to learn the history lesson from New Math. Students instructed according to Common Core standards will ultimately know neither the "why" nor the "how," and we will eventually consign these standards to the ever-expanding dustbin of failed educational initiatives, until the next messianic program is unveiled. And, of course, this doomed educational experiment, like its predecessors, has a high cost: our children's ability to do math.[57]

Thus, until the math education community acknowledges that teacher training is essential to reform success and until educators recognize that it is not computation or conceptualization, but a partnership of both, the cycle of mathematics reform will endure. Everyone within the realm of math education should make teacher education and training a top priority. Additionally, government and educational organization, such as the NSF, should help to fill the math training void. Without help from everyone involved in the educational field, from pre-K to doctoral program instructors, comprehensive mathematics teacher training will remain unattainable. A bottom-up or a top-down only approach to mathematics reform and teacher training will always fail. Rather, math reform and teacher training should be a bottom-up *and* a top-down approach. At the end of the day, politicians, funding, schools, administrators, or even teachers do not determine the quality of mathematics education. At the end of the day, the quality of mathematics education is the responsibility of every educator, parent, and politician regardless of affiliation. The hope and goal of this thesis remains to highlight the importance of teacher training and preparedness, but also to draw attention to the cyclical nature of mathematics reform. Ultimately, this vicious cycle of mathematics reform must

stop compromising the next generation of mathematicians, doctors, physicists, and engineers, and instead promote the idea of computation and conceptualization within the broader context of a multidisciplinary educational approach. Until society breaks the cycle of reform, mathematics education will continue to be a swinging pendulum, changing direction based not on educational need, but on more insidious motivation.

ENDNOTES

[1] Elizabeth Green, "Why Do Americans Stink at Math?," *The New York Times* (The New York Times), July 23, 2014, nytimes.com/2014/07/27/magazine/why-do-americans-stink-at-math.html?_r=0.

[2] Mark W. Ellis and Robert Q. Berry III, "The Paradigm Shift in Mathematics Education: Explanations and Implications of Reforming Conceptions of Teaching and Learning," *The Mathematics Educator* 15, no. 1 (2005), 10.

[3] Jessica Furr, "A Brief History of Mathematics Education in America," (1996), accessed November 6, 2016, jwilson.coe.uga.edu/EMAT7050/HistoryWeggener.html; David Klein, "A Brief History of American K-12 Mathematics Education in the 20th Century," November 30, 1999. Accessed November 6, 2016. csun.edu/~vcmth00m/AHistory.html.

[4] Klein, "A Brief History of American K-12 Mathematics Education in the 20th Century."

[5] Ellis and Berry, "The Paradigm Shift in Mathematics Education," 11-12.

[6] Ibid, 11-12; Klein, "A Brief History of American K-12 Mathematics Education in the 20th Century."

[7] Klein, "A Brief History of American K-12 Mathematics Education in the 20th Century."

[8] Klein, "A Brief History of American K-12 Mathematics Education in the 20th Century."

[9] Klein, "A Brief History of American K-12 Mathematics Education in the 20th Century."

[10] Klein, "A Brief History of American K-12 Mathematics Education in the 20th Century."

[11] Green, "Why Do Americans Stink at Math?,"

[12] "About the Standards," The Common Core State Standards Initiative, 2016, accessed October 9, 2016, corestandards.org/about-the-standards/.

[13] "Will Weak Teacher Training Ruin the Common Core? - the Hechinger Report," The Hechinger Report, October 1, 2014, accessed October 22, 2016, hechingerreport.org/teachers-ready-common-core/.

[14] "On February 17, 2009, President Obama signed into law the American Recovery and Reinvestment Act of 2009 (ARRA), historic legislation designed to stimulate the economy, support job creation, and invest in critical sectors, including education. The ARRA lays the foundation for education reform by supporting investments in innovative strategies that are most likely to lead to improved results for students, long-term gains in school and school system capacity, and increased productivity and effectiveness. The ARRA provides $4.35 billion for the Race to the Top Fund, a competitive grant program designed to encourage and reward States that are creating the conditions for education innovation and reform; achieving significant improvement in student outcomes, including making substantial gains in student achievement, closing achievement gaps, improving high school graduation rates, and ensuring student preparation for success in college and careers; and implementing ambitious plans in four core education reform areas…" Taken from U.S. Department of Education, *Race to the Top: Executive Summary and Key Policy Details -- November 2009,* (Washington, D.C.: U.S. Department of Education, 2009), www2.ed.gov/programs/racetothetop/executive-summary.pdf. See also, "Race to the Top Fund," U.S. Department of Education-Programs, May 17, 2016, accessed October 9, 2016, www2.ed.gov/programs/racetothetop/index.html.

[15] Green, "Why Do Americans Stink at Math?,"

[16] "Common Core's New New Math Has the Same Problem as the Old New Math," Common Dreams, August 28, 2016, accessed October 9, 2016, commondreams.org/views/2016/08/28/common-cores-new-new-math-has-same-problem-old-new-math.

[17] There are numerous publications which refer to Common Core as *New* New Math. See: "Common Core's New New Math Has the Same Problem as the Old New Math"

[18] It is prudent to note that further discussion of New Math's comparison to Common Core draws primarily upon public opinions, as Common Core cannot yet be viewed through an entirely historical lens because it is still in practice.

[19] "Common Core's New New Math Has the Same Problem as the Old New Math"

[20] "Common Core's New New Math Has the Same Problem as the Old New Math"

[21] According to the 2012 Program for International Student Assessment (PISA), which evaluates and ranks math and science skills among 15-year-olds, the U.S. placed 35th out of 64 countries surveyed in math. See: "Is the U.S. Losing the Tech Race?," Los Angeles Times, April 20, 2014, accessed October 22, 2016, latimes.com/opinion/op-ed/la-oe-teitelbaum-stem-fears-20140420-story.html; Sean Coughlan, "US 'in denial' over Poor Maths Standards," *BBC Business* (BBC News), May 21, 2014, bbc.com/news/business-27442541; "U.S. Students Improving – Slowly – in Math and Science, but Still

Lagging Internationally," Pew Research Center, February 2, 2015, accessed October 22, 2016, pewresearch.org/fact-tank/2015/02/02/u-s-students-improving-slowly-in-math-and-science-but-still-lagging-internationally/.

[22] See the chart on page 112.

[23] "The Common Core Is Today's New Math – Which Is Actually a Good Thing," Phsy.org, 2015, accessed October 9, 2016, phys.org/news/2015-09-opinion-common-core-today-math.html.

[24] Green, "Why Do Americans Stink at Math?"

[25] "Common Core Standards Bring Dramatic Changes to Elementary School Math," Ed Source, January 20, 2014, accessed October 18, 2016, edsource.org/2014/common-core-standards-bring-dramatic-changes-to-elementary-school-math-2/63665.

[26] "Common Core Standards Bring Dramatic Changes to Elementary School Math,"

[27] Green, "Why Do Americans Stink at Math?"

[28] "The Fresno Unified School District is the 4th largest school district in California, serving more than 73,000 students." See "About Us," Fresno Unified District, 2016, accessed October 18, 2016, fresnounified.org/Pages/about-us.aspx or fresnounified.org/.

[29] "Common Core's New New Math Has the Same Problem as the Old New Math,"

[30] "Common Core's New New Math Has the Same Problem as the Old New Math,"

[31] "Stockholm Syndrome – the Only Reason Any Teachers Still Support Common Core," Gad Fly on the Wall Blog, November 6, 2015, accessed October 9, 2016, gadflyonthewallblog.wordpress.com/2015/11/06/stockholm-syndrome-the-only-reason-some-teachers-still-support-common-core/.

[32] "Will Weak Teacher Training Ruin the Common Core? - the Hechinger Report"

[33] Alexander Calandra, "The New Math Is a Hoax," *St. Louis Post-Dispatch*, November 9, 1969. See chapter three and the conclusion for more discussion on Dr. Calandra.

[34] "Tom Lehrer - New Math," Metro Lyrics, accessed October 18, 2016, metrolyrics.com/new-math-lyrics-tom-lehrer.html; Jared Khan, "Tom Lehrer - New Math (animated)," YouTube, July 5, 2010, posted October 18, 2016, youtube.com/watch?v=UIKGV2cTgqA.

[35] Green, "Why Do Americans Stink at Math?"

[36] "Common Core's New New Math Has the Same Problem as the Old New Math,"

[37] "STEM Education Statistics," National Math and Science Initiative, 2016, accessed October 22, 2016, nms.org/AboutNMSI/TheSTEMCrisis/STEMEducationStatistics.aspx.

[38] Floyd Norris, "Fewer U.S. Graduates Opt for College After High School," *Business Day* (The New York Times), January 9, 2015, nytimes.com/2014/04/26/business/fewer-us-high-school-graduates-opt-for-college.html.

[39] See chapter one where I discuss the lack of mathematics courses and preparedness that students had going into college in the decades before the 1970s.

[40] This chart was built by myself. Each point of comparison has its own reference. Many of the New Math observations pull from discussions in the preceding chapters. However, each of the Common Core similarities pulls from web-based articles or blogs and will have their own footnote for particular reference or a list of numerous supporting reports.

[41] "The Trials of New Math," *Time* 85, no. 4 (January 22, 1965).

[42] "Common Core Standards Bring Dramatic Changes to Elementary School Math." See also: "Effective Teacher Training Critical to Success in Common Core Math," The Hechinger Report, March 7, 2014, accessed October 22, 2016, hechingerreport.org/content/effective-teacher-training-critical-success-common-core-math_15027/.

[43] See analysis and data presented in chapters one and two.

[44] "Effective Teacher Training Critical to Success in Common Core Math"

[45] Howard Mehlinger, "New Civics Stresses Practical Politics," *Archives* (The New York Times), January 8, 1973, nytimes.com/1973/01/08/archives/new-civics-stresses-practical-politics.html?_r=0; G. BYRNE, "Overhaul Urged for Math Teaching," *Science* 243, no. 4891 (February 3, 1989), 597.

[46] Jay Matthews, "Fourth Grade Math Textbook Arourses Father's Ire," *The Times Herald*, November 23, 1972. Matthews recounts James Shackelford's frustration of the New Math his fourth-grade daughter was learning. Shackelford held a PhD. in Chemistry and worked for the EPA at the time the article was published. In it, he voices his concern of the New Math. Matthews shares the account of Shackelford taking his daughter's math book to work, where he asked co-workers to attempt the math problems listed. Shackelford, and all of his co-workers who also hold advanced degrees failed the fourth grade math

problems. Shackelford was irate and wrote letters to his daughter's teacher (which is where the cited quote is from). Shackelford received a lot of attention. Parent's, such as Shackelford, who feared and did not understand New Math, helped usher in the "back-to-basics" math reform. See also: Christopher J Phillips, *The New Math: A Political History* (Chicago, IL, United States: University of Chicago Press, 2014), 134-135.

[47] See the letter from a Common Core student father, taken from: "Dad's Rant about Common Core Goes Viral," *Time Magazine*, March 26, 2014, accessed October 21, 2016, time.com/38816/dads-rant-about-common-core-math-problem-goes-viral/. "Dear Jack, Don't feel bad. I have a Bachelor of Science Degree in Electronics Engineering which included extensive study in differential equations and other higher math applications. Even I cannot explain the Common Core Mathematics approach, nor get the answer correct. In the real world, simplification is valued over complication. Therefore: 427 – 316 = 111. The answer is solved in under 5 seconds: 111. The process used is ridiculous and would result in termination if used. Sincerely, Frustrated Parent." See also: Alia Wong, "The Common Core Is Baffling Parents so Much That It's Forcing Them to Hit the Books," *The Atlantic* (The Atlantic), August 6, 2015, theatlantic.com/education/archive/2015/08/common-core-schools-parents/400559/; "Uncommon Frustration: Parents Puzzled by Common Core Math," Journal Sentinel, June 5, 2014, accessed October 21, 2016, archive.jsonline.com/news/education/uncommon-frustration-parents-puzzled-by-common-core-math-b99281204z1-261921571.html; "Math Teachers Seek Solution to an Age-Old Frustration Study Nights, Hot Lines May Help Parents with Homework," The Baltimore Sun, October 14, 1996, accessed October 21, 2016, articles.baltimoresun.com/1996-10-14/news/1996288016_1_children-math-new-math-math-teachers; "Common Core Ignites Math War in North Carolina," The News & Observer, November 28, 2015, accessed October 22, 2016, newsobserver.com/news/local/education/article46840650.html.

[48] See Chapter two for more on NSF In-Service Institutes and Summer Institutes.

[49] "Will Weak Teacher Training Ruin the Common Core? - the Hechinger Report,"; "Effective Teacher Training Critical to Success in Common Core Math."

[50] See introduction and chapter two.

[51] "Mathematics Project — UCLA Center X," UCLA Center X, 2016, accessed October 22, 2016, centerx.gseis.ucla.edu/math-project.

[52] Kline, *Why Johnny Can't Add*, 170.

[53] "President Obama Stars in 'the more you know' PSA," The Hill, February 3, 2016, accessed November 26, 2016, thehill.com/capital-living/in-the-know/121169-president-obama-stars-in-the-more-you-know-psa.

[54] Educational Testing Service and Paul E. Barton, *Parsing the Achievement Gap: Baselines for Tracking Progress*, (NJ, 2003), ets.org/Media/Research/pdf/PICPARSING.pdf, 20; "Parental Involvement in Schools," Child Trends, 2013, accessed November 27, 2016, childtrends.org/indicators/parental-involvement-in-schools/.

[55] Dominic Peressini, "Parental Involvement in the Reform of Mathematics Education," *The Mathematics Teacher*, 90, no. 6 (1997). See also:

[56] See Shelley Billig et al., *Studies Of Education Reform: Parent And Community Involvement In Education*, (n.p.: U.S. Department of Education, Office of Educational Research and Improvement, 1995); Jean Johnson, "Can Parents Save American Education?," *Huffington Post* (The Huffington Post), May 22, 2013, huffingtonpost.com/jean-johnson/can-parents-save-american_b_3314522.html; "Parents Want to Be Involved in Children's Education yet Don't Understand Key Factors Affecting Public Education Quality," Public Agenda, October 24, 2012, accessed November 26, 2016, publicagenda.org/pages/index.php?qid=187.

[57] "Common Core's Newer Math," National Review, January 23, 2014, accessed October 22, 2016, nationalreview.com/article/368595/common-cores-newer-math-david-g-bonagura-jr; Educational Testing Service and Paul E. Barton, *Parsing the Achievement Gap: Baselines for Tracking Progress*, (NJ, 2003), ets.org/Media/Research/pdf/PICPARSING.pdf.

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