DOCUMENT RESUME

ED 432 468 SE 062 707

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TITLE Mathematics Education Goes to War: Challenges and Opportunities during the Second World War.
PUB DATE 1999-04-21
NOTE 20p.; Paper presented at the Annual Meeting of the National Council of Teachers of Mathematics (77th, San Francisco, CA, April 22-24, 1999).
PUB TYPE Reports - Descriptive (141) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Educational History; Elementary Secondary Education; *Mathematics Curriculum; *Mathematics Education; *World War II

ABSTRACT

The years immediately preceding World War II were difficult ones for American mathematics educators. Ironically, the most significant challenge they faced was due in large part to the unprecedented success of public schools in attracting and retaining students, especially at the secondary level. Studying mathematics had long been an integral part of the American school experience, an expression of national identity through the curriculum. This paper discusses mathematics education and mathematics curriculum during the second world war. (Contains 40 references.) (ASK)

Mathematics Education Goes to War:

Challenges and Opportunities During the Second World War

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National Council of Teachers of Mathematics
77th Annual Meeting
Research Presession
April 21, 1999

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The years immediately preceding World War II were difficult ones for American mathematics educators. Ironically, the most significant challenge they faced was due in large part to the unprecedented success of public schools in attracting and retaining students, especially at the secondary level. Studying mathematics long had been an integral part of the American school experience, an expression of national identity through the curriculum.[1] School mathematics constituted an explicit and accepted portion of what all students in the United States studied. Clearly, the position of mathematics in the curriculum also had been bolstered by the tenets of mental discipline, a theory that collapsed under the weight of experimental evidence presented in the late 19th and early 20th centuries.[2] The legitimating strength of curriculum as an expression of national identity was insufficient to sustain school mathematics with the failure of mental discipline and, especially, with the growth in student enrollment and the changing characteristics and aspirations of the students who attended school during the first half of the 20th century.

Urbanization and prosperity afforded an increasing number of young people during the early years of the 20th century the opportunity to attend school for longer periods of time. By the 1930s, economic depression eliminated employment opportunities for many students who almost by default chose to remain in school and continue their educations. Enrollments grew ever more rapidly as alternatives to school disappeared.[3] A significant number of the students who remained in school were unlike previous generations of students. They possessed few or no ambitions for further education and their immediate post high school employment prospects were bleak. In previous years, they would have been working and probably would not even have considered seriously attending or completing high school. For educators, these students presented a vexing problem as well as an opportunity. Clearly, they could not be turned away during an era of diminished resources, for they represented much needed funding for the schools.

Unfortunately, these students often demonstrated little interest in the traditional curriculum and commonly were viewed by educators as having little chance for success with it. For mathematics educators, the question of what to do with these "new" students presented two alternatives, either the mathematics curriculum had to be changed or school mathematics reduced or eliminated. Both courses of action were followed.

The percentage of students enrolled in the traditional sequential mathematics courses, algebra, geometry, and trigonometry, declined during the years from 1890 to 1948. A new course, general mathematics, was added to the curricula of many schools. Offered as a practical alternative to the sequential mathematics courses, general mathematics was intended to insure that most students possessed at least some degree of mathematical competence. Unfortunately, the perception of general mathematics as "ill-defined and often poorly, or at least unwillingly taught" appears to have had a firm basis in reality in many cases.[4]

Advocates of general mathematics courses regularly asserted the practical, as opposed to formal, nature of such general courses. For most students, traditional school mathematics failed the test of social efficiency, for they were unlikely to apply often or directly most of the mathematics they learned. During these years of efficiency and specialized curricula in the larger schools, this perceived lack of immediate, practical utility for most students contributed to the decline of school mathematics, and especially the sequential courses, in the curriculum.[5] Also during the interwar years, some child centered progressive educators, such as William Heard Kilpatrick, questioned the need for formal mathematics study at all.[6]

Fortunately, by the close of the 1930s, concern over the breadth and quality of mathematics education reached such a level that thoughtful educators began seeking ways to improve significantly the teaching and learning of mathematics in schools. These efforts resulted in two major reports released in 1940, the Progressive Education Association's *Mathematics in General Education* and *The Place of Mathematics in Secondary Education* prepared by the Joint Commission to Study the Place of Mathematics in Secondary Schools of the National Council of

Teachers of Mathematics and the Mathematics Association of America. Both reports reached startlingly similar conclusions. First, all students should learn mathematics. Second, for many students, this had been a neglected curriculum area. Third, a revitalized mathematics curriculum that addressed mathematics as an essential form of understanding related to virtually all human endeavors should be developed.[7] The seeming consensus between progressive educators, mathematics educators, and mathematicians concerning the place and importance of mathematics in the curriculum for all students might have proven to be a firm beginning for robust reform. Unfortunately, World War II intervened and diverted attention from these reports. Other imperatives for school mathematics loomed too large and familiar legitimations proved too alluring.

As Americans prepared for inevitable involvement in the Second World War, mathematics educators foresaw a renewed emphasis on school mathematics as the subject came to be understood as a prerequisite for success in modern, technological warfare. This attention, however, tended to reinforce the perception that the importance of learning mathematics lay in the ways in which it could be applied directly to solve immediate, practical problems. In other words, mathematics was a useful tool and nothing more. Casting aside the spirit and conclusions of *Mathematics in General Education* and *The Place of Mathematics in Secondary Education*, mathematics educators returned to the comfortable legitimations offered by social efficiency arguments. As the nation prepared for and engaged in war, more people undoubtedly would be required to apply more mathematics than ever before. The war thus offered a compelling if ultimately short-lived rationale for requiring more students to study more mathematics.

The argument that mathematics was a practical wartime tool received prominent attention in Marston Morse and William L. Hart's article, "Mathematics in the Defense Program," published in the May 1941 issues of both the *Mathematics Teacher* and the *American Mathematical Monthly*. Morse and Hart provided a detailed list of the mathematical "needs" of both officers and enlisted personnel in the various military branches as well as of industrial

workers. They also emphasized the critical role of effective guidance in helping students to design appropriate mathematics programs of study. Such guidance was important, since, for the most part, Morse and Hart proposed reliance on traditional, sequential mathematics courses. However, they also recognized that many of the students who would be called upon first to support the war effort through either military service or industrial work lacked adequate mathematical backgrounds as well as the time to complete the sequential courses. Thus, they proposed "*abbreviated*" courses, to be taught regularly, that addressed logarithms, plane trigonometry, intuitional solid geometry, and introductory solid geometry. Such "refresher" or, probably more accurately, "pre-induction" courses were destined to offer a much discussed solution to the perceived inadequacies of prewar mathematics education. Morse and Hart concluded their article with a direct appeal to the social efficiency argument:

> *Mathematical content with military uses* is the most socialized variety of mathematics to which they [high school students, especially males] can be exposed at present.[8]

Advocates of improved mathematics education regularly sought to enhance the status and role of school mathematics in the curriculum using arguments based on widely anticipated wartime manpower needs.

Harl R. Douglass presented the common viewpoint that the war presented an unprecedented

> opportunity not only to recover lost ground, but to establish the importance of our field in a realistic way that cannot be denied, thus relieving us of the constant necessity of apologizing for our failure to educate for the mathematical needs of the great mass of American men and women.[9]

Invoking a military metaphor, one North Carolina high school mathematics teacher observed, "Today, perhaps as never before, mathematics is demanding a place in the front lines of high-school teaching."[10] Such military allusions offered an important and publicly popular

legitimation for school mathematics as well as provided a potentially significant means of improving student motivation in mathematics classrooms. The expected relationship between school mathematics and ultimate military success was made clear early and prominently by the man who soon would become the nation's foremost naval officer.

Admiral Chester W. Nimitz, then Chief of the United States Navy's Bureau of Navigation, spoke at the University of Michigan during October of 1941. At the request of an individual in attendance at that presentation, Nimitz briefly summarized his remarks in what became known as the "Nimitz letter" that appeared both in the *Mathematics Teacher* and the *American Mathematical Monthly*. Nimitz bluntly recounted failure rates exceeding 60 percent on the mathematics tests required for entry into the Naval Reserve Officer Training Corps. He also noted that 3000 out of 8000 college graduates who applied for other Naval officer commissioning programs failed due to insufficient mathematical knowledge and that 75 percent of the failures in navigation courses resulted from similar mathematical deficiencies.[11] His vivid portrayal highlighted the importance of mathematics education to a nation at war in the twentieth century. No doubt, Admiral Nimitz's rapid rise to public prominence as the nation's most visible Naval officer extended additional credibility to his message. Nimitz, in a letter of about 500 words, accomplished what mathematics educators over the previous four decades had been unable to do. He articulated reasons that would assure near universal acceptance for the widespread study of mathematics in some depth by most high school students, thereby elevating the subject to a position of prominence in the curriculum for the foreseeable immediate future. Although transitory, this legitimation provided the basis for those who advocated revising school mathematics to meet wartime demands of the military, industrial workers, and the home front.

The nation's most visible educator, John W. Studebaker, the United States Commissioner of Education, called for a "curricular conversion" to maximize the schools' contribution to the war effort. Among his suggestions was the incorporation of "military illustrations and applications" in mathematics courses.[12] Although the wartime rhetoric contains many suggestions

for possible military applications suitable for attention in mathematics classrooms, a small sample of these advocacies provides a sense of their extent. One University of Illinois professor, for example, urged mathematics curriculum change "so as to lay much greater stress upon aeromechanics, aeronautics, auto mechanics, navigation, gunnery, and other aspects of modern warfare."[13] His generalizations failed to offer teachers any practical advice about or examples of the actual teaching of such topics. Providing such advocacies of the generalized "what" that bypassed the more mundane but detailed suggestions of "how" became something of a cottage industry during the World War II years.

Fortunately for the busy wartime mathematics teacher who desired to implement suggestions such as Studebaker's, a number of authors addressed the "how" question by offering examples of specific material deemed suitable for classroom use. Typical of these works was a *Mathematics Teacher* article by H. M. Bacon of Stanford University. Bacon not only suggested that mathematical problems associated with artillery fire could be addressed in high school classrooms but also included five examples with detailed solutions as well as four additional examples with only final answers provided.[14] The extent to which such problems with a military basis ever entered actual classrooms remains unknown. Nonetheless, wartime teachers who were professionally active had access to a variety of military topics for classroom use. Still, many students who graduated or otherwise left school during World War II did not enter military service.

An immense number of people was needed for industrial work to keep soldiers, sailors, and airmen equipped with an unprecedented array of armaments and other supplies. Preparation for industrial work, sometimes viewed as less glamorous or significant than military service, called for mathematics problems perceived as less likely to motivate students than problems with explicit military references. Industrial work did not prompt a significant number of suggestions for wartime curriculum change. In fact, individuals concerned about the preparation of students for industrial work tended to focus on rather low-level mathematics outcomes for students, not

those likely to raise the subject's status in the postwar curriculum. The results of a survey conducted by Olin Roberts of Pasadena, Texas, for example, revealed that industrial workers seldom engaged in computations with whole numbers greater than 10,000, with decimals beyond three places, or with fractions with denominators other than two, four, eight, sixteen, thirty-two, or sixty-four.[15] Such competence in basic arithmetic, although necessary, was far less than the "substantial secondary mathematics" including trigonometry for industrial workers suggested immediately prior to the war by Morse and Hart.[16] Experience appears to support Roberts's contention. Near the war's end, a training instructor for Raytheon Manufacturing Company suggested that fundamental arithmetic "which must be mastered" was the schools' concern. Other necessary mathematical principles could be taught better on the job.[17]

Interestingly, although differing in depth, these suggestions were not dissimilar to those offered by some military officers. They recognized that curriculum change and new wartime topics were less important than helping students to learn mathematics well. For example, Colonel B. W. Venable, on the War Department's General Staff, wrote that while "fanfare and military glamour" might attract some students to take more mathematics courses and to learn more in them,

> the normal processes . . . of education need little or no adjustment to become valuable to our National effort. It is not so much the increase in number and variety of subjects available to the student as it is placing the proper emphasis on those courses already established that have practical value, and teaching them in a practical way.[18]

Venable apparently preferred that educators tinker with the existing curriculum and somehow improve their instruction in hopes that more students would be able to apply to real situations the mathematics they studied in schools rather than undertake wholesale curriculum revision based on wartime topics and themes. Yet, a traditional curriculum modified marginally, if at all, seemed

woefully inappropriate to many mathematics educators during those years while the nation struggled for what many understood to be its very existence.

Brehon B. Somervell, the commanding general of the Army's Services Supply Department, claimed, "Every classroom is a citadel." He warned educators,

> Surely you will make certain now that no American soldier is ever killed or injured because you failed to do your part to provide adequate training.[19]

Such rhetoric that tended to "draft" students as well as teachers into national service with vital roles to fulfill, whether intended to be taken literally or offered primarily for its motivational and morale effects, served to spur teachers, including mathematics educators, to seek relationships between their subjects and the war effort. Thus, the general suggestion that the prewar mathematics curriculum, if taught and learned well, would suffice tended to have less appeal to many wartime mathematics educators than the suggestion that the curriculum be centered more directly on contemporary war-related issues and themes. After all, many of them sensed that they were engaged in their own protracted "war," one whose outcome would determine the future prospects for their subject in the curriculum. Relevance and utility were their tactics, and no potential opportunity could be ignored.

The "home front" offered one such opportunity. Most if not all wartime students already were participants to one degree or another in a variety of symbolic and practical patriotic activities. War savings, conservation, and salvage offered opportunities through which even the youngest school children could contribute to the war effort. *Mathematics Teacher* editor William David Reeve pointed out

> it would be a mistake to overlook the importance of the home front, which will obviously be so necessary in the days of peace that lie ahead. Social and economic arithmetic, or the mathematics of the consumer, should not be overlooked.[20]

Reeve's suggestion foreshadowed for his readers the evolution of prewar social efficiency into advocacy of postwar Life Adjustment Education. What he failed to do in this editorial was to articulate any reason for the study of mathematics beyond the simple computations required of most Americans in their daily lives. Despite the surface attention accorded school mathematics during the Second World War, the foundations necessary for significant postwar improvement and growth largely were ignored and unattended.

Attention to topics such as "point rationing, ceiling prices, food supply, inflationary spirals, salvage, subsidies, agricultural parity, hidden inflation, victory gardens, [and] victory models," although timely, was unlikely to provide an appealing rationale for a substantive study of mathematics by a large number of students for extended periods of time.[21] For example, "Salvaging License Plates" suggested a variety of mundane and largely nonsensical calculations that were contrived for a mathematics class in a Philadelphia school engaged in a license plate recycling project.[22]

Clearly, one major goal of such curriculum suggestions was to enable students to sense that they had a personal and direct role in the home front war effort. Under the auspices of the Education Section of the War Finance Division of the United States Treasury Department, Walter W. Hart, Veryl Schult, and Violet Coldren prepared for the *Mathematics Teacher* a comprehensive unit of study entitled "The Teacher of Mathematics and the War Savings Program." In this twenty-one page guide, the authors did not offer suggestions intended to improve students' mathematical competence. Rather, the authors' goal was stated plainly:

> It is hoped that the introduction of such [wartime financial] problems will increase pupil understanding of the current savings program. From increased pupil understanding will come greater cooperation on the part of students and their parents in the voluntary savings program of the country.[23]

Such a use of mathematics classes to address important wartime concerns, although symbolically important, offered little help or encouragement for restoration of mathematics to a place of prominence in the postwar curriculum.

The perceived need for more students to learn more mathematics rapidly, whether for use in the military, in industry, or on the home front, was complicated by the fact that many students were inadequately prepared mathematically to begin intensive study. For example, many students who might soon find the need to apply trigonometry were in no position to enroll in a traditional trigonometry course. Special "pre-induction" mathematics courses such as that proposed in 1941 by Morse and Hart became widely discussed possible solutions to this problem.

A committee appointed by the United States Office of Education and the president of the National Council of Teachers of Mathematics prepared a widely circulated report entitled "Pre-Induction Courses in Mathematics." Based on a survey of the technical manuals used in military training, the committee recommended in 1943 that schools establish one-year and one-semester "refresher" mathematics courses as well as make changes in their sequential courses. The one-year course was to address arithmetic, informal geometry, and algebra. Detailed outlines delineated the specific content suggested for such courses. The content for a one-semester course depended entirely on whether or not it was a "refresher" course. For those students who had studied mathematics previously, the focus was on geometry and algebra, while, for the mathematically weakest students, the emphasis was to be placed on "arithmetic plus certain essential topics from general mathematics such as scale drawing, including elements of blueprint reading, numerical trigonometry, informal geometry, and simple formulas and equations." Facts and practical applications were to receive primary attention in the sequential courses. Questions about whether or not students with weak or nonexistent formal mathematical backgrounds, presumably those for whom pre-induction and refresher mathematics courses were designed, could complete successfully and profit from such a diverse array of topics addressed in so little

time appear not to have been addressed. Undoubtedly, many students would have found such curriculum schemes challenging.[24]

Another report, issued in the same year as "Pre-Induction Courses in Mathematics," succinctly offered what was to be the guiding precept of many wartime mathematics educators:

> The mathematics now taught in high school should be practical to the extent that it has immediate application or that it is needed for other essential mathematics or that it pertains directly to the war effort.[25]

The idea that students could be given a one-semester or one-year "dose" of mathematics to remediate years of neglect proved alluring, if ultimately unrealistic. In any case, engaging students in whatever mathematics courses they took remained a persistent concern. Means of making school mathematics appealing to students, many of whom had shunned the subject previously, seemed worthy of pursuit.

Some mathematics educators believed that clothing the problems assigned to students in wartime rhetoric would motivate them to solve more problems, thus enhancing interest and improving learning. Aviation was a popular topic for obvious reasons. As literary scholar Paul Fussell observed:

> If the illustrations [in popular magazines' display advertising from 1942 to 1945] are to be believed, all young men are in the Air Corps, where they are officers almost by definition (or, in 1942, cadets destined soon to be officers).[26]

New York City mathematics teacher Lillian Moore described her use of the aviation theme to improve mathematics teaching and learning.[27] *Mathematics Teacher* editor William David Reeve, the Texas Department of Education, and the popular press such as *Newsweek* were among the individuals and institutions that viewed the "air conditioning" of school mathematics as a wartime innovation that presented definite postwar opportunities.[28] Changing the problems that students solved in mathematics classes would be facilitated by new textbooks, and some publishers attempted to avail themselves of the opportunity the war presented.

Despite widespread advertising in the professional journals, most mathematics textbooks changed little in substantive ways during World War II. That any attention and resources were devoted to the revision, production, and promotion of textbooks for schools in a nation fighting a world war, perhaps for its survival, is noteworthy. Problems with military themes dealt almost exclusively with aviation, although some problem sets included occasional naval references. The ground war remained virtually invisible in textbooks. Problems that addressed military issues did so mainly in nonviolent ways; they portrayed a war with neither enemies nor bloodshed.[29] One wartime observer of purported textbook revisions noted the lack of thought and creativity expended by most authors:

> It didn't take much trouble either – the old problems still appear. Ship becomes plane, plane becomes ship, elevation becomes depression, or train becomes plane, box becomes airplane gas tank.[30]

Although of dubious practical significance, wartime changes in school mathematics served a perhaps more important symbolic function, providing every student an opportunity to engage in the war effort through preparation for ultimately more direct contributions.

Eventually, however, the war would end. Many mathematics educators appear to have been blinded by the sudden positive attention paid to their subject after years of neglect, if not outright hostility. They failed to develop a compelling case for their subject that would remain convincing after the war, largely relying instead on the convenient rationale provided by wartime conditions and concerns. As early as 1942, the weakness of depending solely on the war as a legitimation for school mathematics was pointed out. Joseph Seidlin of Alfred University warned, "*Mathematics for defense is but a temporary objective.*"[31] Another educator observed:

> Teachers of mathematics, especially at the high-school level, will need to rally all their resources of influence and persuasion if the war is to result in any permanent improvement of the sadly neglected mathematical education of the general public.[32]

By 1944, the National Council of Teachers of Mathematics took action intended to sustain and improve mathematics education in a postwar environment.

The National Council of Teachers of Mathematics authorized formation of the Commission on Post-War Plans on February 25, 1944. Between 1944 and 1947, the commission issued three reports on its work. "The First Report of the Commission on Post-War Plans" offered five "tentative proposals" for secondary school mathematics:

1. The school should insure mathematical literacy to all who can possibly achieve it.
2. We should differentiate on the basis of needs, without stigmatizing any group, and we should provide new and better courses for a high fraction of the schools' population whose mathematical needs are not well met in the traditional sequential courses.
3. We need a completely new approach to the problem of the so called slow learning student.
4. The teaching of arithmetic can be and should be improved.
5. The sequential courses should be greatly improved.

Crucial to the Commission's second proposal was a suggested three-track curriculum composed of "sequential mathematics, related mathematics, and social mathematics."[33] Sequential mathematics, the traditional curriculum of algebra, geometry, and trigonometry, was to be reserved for the highest "technically trained men and women," whereas related mathematics was intended for "a middle group of trained workers and thinkers at a somewhat lower level." Social mathematics, designed for the "many people who may not go into the type of jobs which require special knowledge and skills in mathematics" was to "be limited to the things required for them to live a rich, well-rounded life."[34]

Although "The Second Report of the Commission on Post-War Plans: Improvement of Mathematics in Grades 1 to 14" offered increased details about desired reforms in mathematics

education, the commission's first report, coupled with its final "Guidance Report of the Commission on Post-War Plans," essentially set the tone for immediate postwar school mathematics.[35] The curricular path a student followed would be determined by his or her intended roles in later life. In essence, mathematics educators employed the rhetoric of what emerged as Life Adjustment Education, the 1940s progeny of social efficiency.[36]

Advocates of Life Adjustment Education contended that the conventional school curriculum served well only those few students of highest abilities who would continue their formal educations at the postsecondary level. Viewed by advocates as a means of providing more appropriate, although critics would contend not better, educational opportunities for all students, Life Adjustment Education relied heavily on the basic tenet of social efficiency, "that the principal function of schooling should be the adjustment (preferably the happy adjustment) of individuals to the social world in which they find themselves."[37] Despite the democratic rhetoric commonly associated with Life Adjustment Education, the scheme's roots in the often mundane trivialities of "daily life" proved largely uninspiring, especially after four years of world war. While the degree to which Life Adjustment Education rhetoric actually influenced school practice remains problematic, the power of that rhetoric over public perception does not. It tended not to advocate academic excellence and paved the way for yet another round of severe criticism of public schooling in general and mathematics education in particular.

Mathematics education emerged from the World War II years better positioned than it had entered them. The usefulness and necessity of mathematical understanding and problem solving ability became clear, and criticism of the subject temporarily diminished. Unfortunately, despite wartime prominence and the work of the Committee on Post-War Plans, school mathematics again soon fell victim to curricular neglect. Shackled by the rhetoric of social efficiency and Life Adjustment Education, mathematics in the schools slipped back into relative obscurity. Most people, in their "well-adjusted" lives, perceived little need for learning mathematics beyond the rudiments of arithmetic. Although some mathematicians began to

complain in print about the quality of precollegiate mathematics education as early as 1948, school mathematics languished until the next perceived crisis arose in 1957 with the launching of Sputnik.[38]

During the war years themselves, mathematicians played relatively minor roles in the improvement of mathematics education. While some served on the varied committees that suggested curriculum revisions based on perceived wartime exigencies, they refrained from advocating substantive curricular or pedagogical change. Wartime mathematics teachers found a variety of other, more lucrative career options, and a significant number of them left the schools for other, often war-related, work.[39] Mathematicians found an even greater number of demands for their expertise, including military and industrial projects as well as post-secondary military training initiatives and even the preparation of replacement mathematics teachers. Only after educational critics such as Arthur Bestor began to advocate that substantive school reform must originate outside the schools themselves and with experts in the various curricular areas did a significant number of mathematicians begin to turn their attention to school mathematics.[40]

The Second World War focused attention on school mathematics at least temporarily. Following decades of criticism, neglect, and decline, there remained during the war years little question of the importance of students learning mathematics. Unfortunately, mathematics educators by and large failed to pursue the ideas offered in *Mathematics in General Education* and *The Place of Mathematics in Secondary Education* and did not develop a compelling and robust case for school mathematics that would last beyond the immediate needs of war. Limited by the tradition of the sequential curriculum for "the best students" and the apparent belief that not all students could succeed in rigorous mathematics courses, mathematics educators sought to develop specific curricula for specific groups of students based on their theorized future uses of mathematics. Whether or not wartime mathematics educators could have pursued other arguments that would have resulted in the widespread expectation of significant mathematics study by all students remains an unanswerable question.

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Author(s):

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Publication Date: April 21, 1999

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