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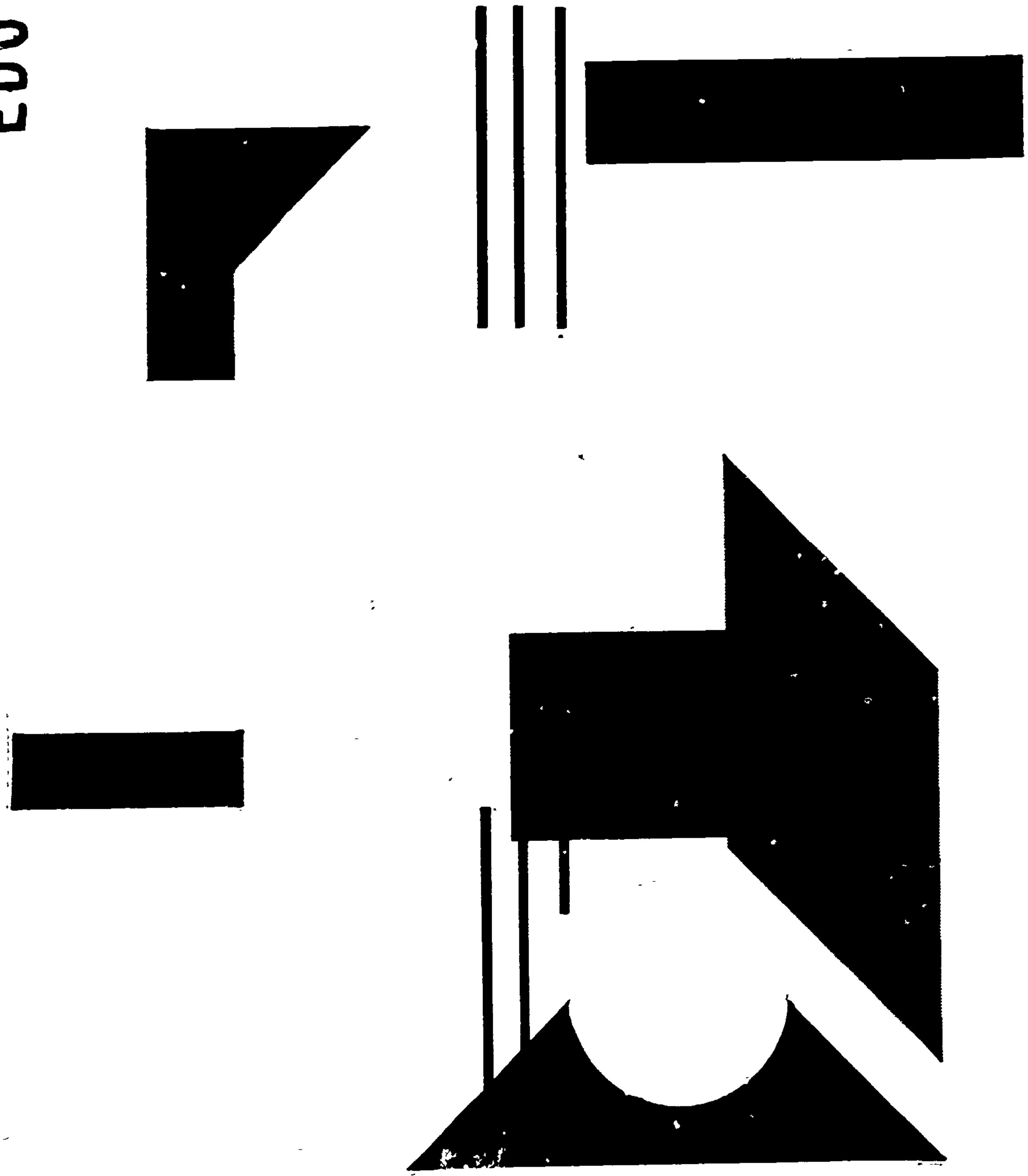
ABSTRACT

This booklet is one of a series devoted to changes in major curricular areas in the school systems of Kentucky. Included are twenty-one articles written by administrative and teaching personnel who are involved in mathematics programs of an experimental or innovative nature. The articles describe programs dealing with modern mathematics, computer assisted instruction, teaching techniques, general mathematics, computer programming, calculus, and merit evaluation. Brief program descriptions for a number of national curriculum projects in mathematics are included. (RS)



NEW DIMENSIONS

Mathematics in Kentucky

Requests for additional copies of this publication should be directed to:

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WENDELL P. BUTLER
SUPERINTENDENT OF PUBLIC INSTRUCTION

Dear Educator:

This publication is the third in a series devoted to changes in major curricular areas. The purpose of the series is two-fold: to provide a medium for the exchange of ideas; and to provide a means of recognizing outstanding work of local school systems and individual teachers in Kentucky. The superintendents and instructional supervisors in each district in the State of Kentucky have been asked to recommend, as contributors to the series, administrative and teaching personnel who are involved in programs of an experimental or innovative nature. These persons were then asked by the Office of Curriculum Development to submit articles describing their programs.

The response from the districts to the two previous issues has been gratifying. We are deeply grateful for the cooperation of the contributors. It is our sincere hope that you will find this publication useful in planning your own programs.

Very truly yours,

Wendell P. Butler
Superintendent of Public Instruction

New Directions: New Dimensions
Mathematics in Kentucky

Office of Curriculum Development
Bureau of Instruction
Kentucky Department of Education
1969

INTRODUCTION

As we move around to the various Kentucky school districts, we are increasingly aware of the commitment of so many of our people to excellence in education. The incorporation of new knowledge into the programs of the various disciplines, the implementation of new methods in accord with recent theories of learning and instruction, and the use of a broad spectrum of materials and media—all of these give evidence that Kentucky educators are making every effort to keep pace with accelerating educational change. The articles in this publication describe such efforts and should serve to challenge all of us to examine our own programs thoughtfully and objectively, that children in Kentucky may have the best possible opportunities for learning.

Each teacher of mathematics recommended by a superintendent or supervisor was asked to submit an article describing his or her program. No limitations were placed upon the writers as to the mention of specific teaching materials. However, references in this publication to materials or special programs should not be construed as value judgments or recommendations regarding materials or programs on the part of State Department of Education personnel.

Don C. Bale, Assistant
Superintendent for Instruction
Kentucky Department of Education

ACKNOWLEDGMENTS

This publication would not have been possible without the interest and cooperation of many people. We are deeply grateful to the curriculum directors, teachers, supervisors, principals, and superintendents from local districts who have contributed recommendations or actual articles for this volume. The support of high-level administrative personnel of the Department of Education has provided encouragement for the initiation and continuance of the series. Staff members of the Division of Information and Publication, Kentucky Department of Education, have given invaluable assistance. We are particularly indebted to Mrs. Mary Marshall, director of that division, and to Mrs. Natalie Oliver, staff artist, who created and executed the graphic design.

We are grateful to the following for graciously granting us permission to reprint portions of materials which have been previously published: Association for Supervision and Curriculum Development; National Association of Secondary School Principals; National Council of Teachers of Mathematics; Kansas Association of Teachers of Mathematics; F. A. Owen Publishing Company.

Our greatest indebtedness, however, we owe to Russell Boyd, mathematics consultant, Department of Education, who sought out important programs, made contacts soliciting articles describing them, and contributed himself the outstanding lead article on "The Continuing Revolution in Mathematics" as well as the concluding article which sums up current curriculum projects across the nation. Without Mr. Boyd's interest and enthusiasm, this publication could not have been.

Martha Ellison, Coordinator
Curriculum Development
Kentucky Department of Education

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TOWARD A BROAD PERSPECTIVE

THE CONTINUING REVOLUTION IN MATHEMATICS

RUSSELL BOYD
Mathematics Consultant
State Department of Education

Perhaps never before in the history of education has so much furor been created over change in a single subject area as has been created in the past ten years with regard to the teaching of mathematics. Perhaps never before in the history of education has so much change occurred in so short a time span as in the field of mathematics. This change is by no means over. What started as a gentle breeze in the fifties is gaining momentum. During the next ten years this revolution promises to reach hurricane dimensions.

In February, 1963, Mary Folson said, "It is said that one-half of the mathematics we have today has been created by men who are still alive."[1] Just four years later in February, 1967, Robert B. Kane said, "About 95% of all mathematicians that ever lived are alive today."[2] Advances in science and technology in the last fifty years have resulted in a chain reaction in which mathematics has fed the flames of science and technology which in return have stimulated further research in mathematics. While there are still classrooms that remain relatively untouched by this revolution—classrooms that resist any innovation—educators could no more revert to the mathematics of ten years ago than America could go back to the horse and buggy days.

There are several reasons for this emphasis on change in the teaching of mathematics in the elementary and secondary schools. One is found in the rapid advance of knowledge and technology that to a great extent depends on mathematics for a base. Do you ever take the time to consider the mathematics involved in putting a satellite in orbit around the earth or moon, in putting a man in space, in putting a man on the moon and bringing him back to earth? True, computers do the calculations, but the computer is just a tool of man, a machine that does what it is directed to do. It is the mind of man that directs the computer.

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[1] Mary Folson, "National Problems and Trends in the Mathematical Training of Elementary School Teachers." CUPM Report No. 7, February, 1963, Mathematical Association of America.

[2] Robert B. Kane, "School Mathematics", *The Arithmetic Teacher*, XIV: 2 (February 1967), p. 126.

A second reason for change is a need for a more effective sequence from one grade to the next and from the elementary to the secondary school. The child needs a broader base for future mathematics than he has been getting from arithmetic alone. As a result, geometry and algebra, among other subjects, are introduced in the grades. These topics, not new to the student when he enters the secondary school, provide a smoother transition to the secondary school.

Another reason for change is the recognition that the regular elementary arithmetic program was limited mainly to emphasis on the four fundamental processes—addition, subtraction, multiplication, and division. The emphasis was on drill and speed. Drill has its place, but understanding should come first.

The need for a better understanding of the structure of mathematics as essential to a satisfactory and permanent grasp of the subject matter is a fourth reason for change. The child needs to know about the structure of the number system and the *Why's* of the processes as related to computational procedures. It is as important for the child to know the *Why* as it is to be able to do the calculation.

A need for an improved mathematics' program for children of different abilties constitutes a fifth reason for change. Mathematics must be more challenging for the brighter pupils while promoting better understanding among the slower pupils. The new mathematics program will not make a class a more homogeneous group. It should produce a more heterogeneous group. The broader the base of mathematics, the wider the horizon, the more opportunities there are for challenging the individual. If homogeneity is the goal, it can be approached by spending time on drill and the lock-step curriculum as has been done in the past.

Industry is demanding people with a better understanding of mathematics and higher levels of training in mathematics, which means that many concepts once reserved for the secondary schools and colleges must now be introduced much earlier.

The revolution in the mathematics curriculum in the elementary and secondary schools has been and is being consummated through a two-pronged approach.

In 1951 Max Beberman founded the University of Illinois Committee on School Mathematics (UICSM), the purpose of which was to re-examine the traditional mathematics subject matter and the method of presenting it at the secondary school level. The first ten years were directed toward developing a sequential curriculum for grades 9 through 12, primarily for college capable students. UICSM introduced the "Non-Verbal Awareness Method," a discovery method approach to mathematics. Students are taught by leading them to make their own discoveries about mathematical concepts but are not forced to verbalize the concepts they have formed.

Mathematicians and educators were soon made aware of the fact that if much innovation was to materialize at the secondary level, the elementary school mathematics curriculum and methods of teaching must be revolutionized. As a result of this awareness, about ten years ago a series of projects were initiated by college professors, elementary and secondary teachers and, in some cases, representatives from industry to make a critical study of the elementary school mathematics curriculum.

The School Mathematics Study Group (SMSG), founded in 1958 at Yale University and moved to Stanford University in 1961, was directed by E. G. Begel and financed by the National Science Foundation. This group recommended that a critical study be made of the elementary school mathematics curriculum. Among the aspects of the program recommended for study were: (1) grade placement of topics, (2) development of concepts and mathematical principles, (3) the possible introduction of new topics, particularly from geometry, (4) topics for the able learner, (5) training of teachers, (6) relation of elementary school mathematics to future study of the subject, (7) methods and materials for effective classroom instruction, and (8) the application of findings in concept-formation from psychology and child development to learning of mathematics. This group developed a grade sequence of materials and a teacher's handbook to be used in in-service programs, workshops and undergraduate classes in mathematics for elementary teachers.

The University of Illinois Arithmetic Project, under the direction of Professor David Page, has prepared materials designed to increase the child's interest and understanding of mathematics through insight and discovery. The project's main concern was the development of materials for grades K-6. These materials were prepared with two purposes in mind: (1) to assist teachers in acquiring an understanding of mathematics necessary for successful teaching, and (2) to develop exercises and activities in mathematics which appear appropriate for elementary children.

The Madison Project, founded in 1957, under the direction of Professor Robert B. Davis, Syracuse University and Webster College in Missouri, was at first concerned with the development of materials to explore particular mathematical ideas primarily with elementary school children but has been expanded to include materials for the secondary school. This project is concerned with supplemental or enrichment materials that "give life" to mathematics. Three major purposes of the project are to promote interest in mathematics, to stimulate children to think, and to provide a sound background for future mathematics.

The Stanford Project, under the direction of Professor Patrick Suppes, has developed three programs for elementary school children: Sets and Numbers, Geometry for Primary Grades and Mathematical Logic for Gifted Fifth and Sixth Graders. Since 1963, Professor Suppes has developed a Programmed Computor-Assisted Instruction program. This program is used primarily in the Stanford area but has been connected by teletype to schools in Kentucky and Mississippi. The Kentucky project is centered in the area served by Morehead State University. This project is treated in an article in this publication by Drs. Morris Norfleet and Leonard Burkett.

The Greater Cleveland Mathematics Program (GCMP) is the result of a cooperative effort of school districts and local business and industry in the Greater Cleveland area. A major purpose of the project is to develop the best possible curricula, kindergarten through grade 12, and to implement them in the schools of Greater Cleveland. Texts have been developed for grades K-6 and are being revised for use in the schools in September, 1968. GCMP is currently developing materials for the slow learner at the secondary level and is planning a program whereby algebra and geometry will be taught simultaneously

These are just a few of the many projects that have been developed and are being developed in this country, the primary purpose of which is to discover what mathematics can be learned, what should be taught, the grade level at which it should be taught and the best methods for presentation. New or modern mathematics textbooks are based on one or more of these studies.

The tremendous problem of training and retraining of teachers, if these changes are to materialize in the classroom, represents the second phase of the two-pronged approach. All of these projects and studies emphasize the importance of in-service training of teachers. Handbooks and materials are directed toward teacher training in the new mathematics concepts.

In 1964, Title III of the National Defense Education Act (NDEA) was amended to provide funds, on a matching basis, for NDEA in-service mathematics workshops. Since that time there have been in Kentucky 190 of these mathematics workshops that have retrained more than 6,000 teachers, most of whom are elementary teachers.

The National Science Foundation, the U. S. Office of Education, and private foundations have funded Summer and Academic Year Institutes, In-Service Institutes and Cooperative College-School Science Programs that have retrained thousands of mathematics teachers. The emphasis here has been at the secondary level (grades 7-12); however, some elementary teachers have received training through one or more of these programs.

Additional thousands of teachers have been retrained, through on-campus and off-campus classes and workshops, by the colleges and universities. Through many of these classes and workshops, teachers have been able to earn credit at the undergraduate or graduate level.

As a result of the increased emphasis on mathematics, the Committee on Undergraduate Programs in Mathematics held a series of meetings, one of which was in Louisville, to make a study of teacher preparation in mathematics as a part of certification requirements. The recommendations of this committee, together with the recommendations of the Berea Conference on the Mathematics Program for the Preparation of Elementary School Teachers, led to the present requirement of six semester hours in mathematics for elementary teachers for certification in Kentucky. This requirement is in addition to the methods course.

Perhaps the emphasis on training and re-training of elementary teachers will have a more lasting impact on the continuing revolution in mathematics than the textbook materials used. It is the teacher who makes the difference, not the materials per se. This is essentially what Don K. Richards was speaking of when he said, "It is important for local leaders to notice the emphasis on teachers being adequately prepared. Curriculum is really a 'people' problem. It is not possible to change the curriculum without changing teachers. They must be acquainted with various mathematics curricula before they can develop their own specific program."[3]

On the basis of results obtained from a questionnaire recently sent to all superintendents in Kentucky, more than two-thirds of whom have responded, 64% of Kentucky's elementary teachers have been trained in new mathematics concepts. A breakdown of the type of training follows:

[3]Don K. Richards, "Local Curriculum Development," *Bulletin of the National Association of Secondary School Principals*, LII; 327 (April 1968), 47.

College training as part of certification requirements	18%
Graduate and undergraduate campus and off-campus classes and workshops	41%
NDEA Title III Mathematics workshops	27%
Others	12%

That Kentucky's elementary teachers have had more than one type of training is evident from these totals and from the comments made by the respondents.

The revolution in mathematics is continuing. The next ten years may produce more change than has been produced in the ten year period now ending. The projects that initiated change are continuing to function; many more have been and are being organized; and materials and methods are being field tested. There are no final answers, only more questions. These questions, among others, are concerned with what can be learned, what should be studied, grade placement of materials, methods and materials for reaching the slow learner, individualized instruction, providing for the needs of the fast learner, computer assisted instruction, and in-service training of teachers.

Topics such as sets, number bases other than base 10, modular arithmetic and numeration systems other than Hindu-Arabic have been introduced to the school curriculum to help children understand their own numeration system. Caution should be taken that these topics are studied for this purpose and not for their own sake.

Grade placement of materials is receiving increased emphasis from kindergarten through the twelfth grade. Geometry and algebra, once reserved for the secondary school, are now being introduced in the elementary school. By using the spiral approach, concepts introduced early in the school curriculum are expanded upon until by the time the child begins a formal study of the topics, he already has a good background of understanding.

Many junior high schools are offering what is considered high school algebra to the higher ability eighth grade students. This accelerated program provides the opportunity for these students to study what was traditionally thought of as college level courses in the junior and senior year of high school. One needs only to consult a college catalog to realize the extent of the emphasis placed on an accelerated mathematics program in the secondary school.

The slow learner, once bypassed by the revolution in mathematics, is now receiving increased attention. In March and December, 1967, New York held two statewide conferences on Low Achievers in Mathematics. The primary purposes of these conferences were to develop a philosophy, set up objectives, and develop instructional techniques. On March 25-27, 1964, the U. S. Office of Education and the National Council of Teachers of Mathematics jointly sponsored a conference on the Low Achievers in Mathematics. Two school systems doing experimental work in the areas of materials and techniques in working with low achievers are Des Moines, Iowa, and Jefferson County, Colorado.

The Comprehensive School Mathematics Program, Southern Illinois University, and the Individually Prescribed Mathematics Instruction Project at the University of Pittsburgh are directed toward developing modules or packets of work designed to permit the child to progress at his own rate. These materials are being tested in the vicinities of Carbondale, Illinois, and Pittsburgh, Pennsylvania. In-service teacher training is an important part of these projects.

The Association of State Supervisors of Mathematics and the University of Denver sponsored a five-day conference on Computing and Mathematics Instruction December 8-12, 1967. The purposes were to view current uses and effects of computers in mathematics education and to explore possible effective future uses. This conference was funded by the National Science Foundation. During the summer of 1968 the University of Denver was host to a National Science Foundation Institute, the purpose of which was to train teams of three key educators—two senior high school mathematics teachers and one college or university instructor—from each of about fifteen states in the utilization of computers in mathematics instruction. The three educators were to form a nucleus to conduct similar Institutes in their respective states during the summer of 1969. Other colleges and universities are hosts to Academic Year, In-service and Summer Institutes in computer science and computer mathematics that are funded by the National Science Foundation.

Returns from questionnaires sent to all states and territories during November, 1967, show that 37 elementary schools involving 1,740 pupils and 452 secondary schools involving 40,521 pupils were using computers as an instructional device. Thirty-five states and territories, including Kentucky, reported some use of computers in the classrooms. This is minute compared to the total number of pupils in our elementary and secondary schools, but if one considers the cost involved and the length of time high speed computers have been in use, this represents quite an achievement.

The emphasis on in-service training for elementary teachers of mathematics is not abating. During the school year 1968-1969, the system of Wisconsin State Universities and Wisconsin Department of Public Instruction launched a statewide in-service program in mathematics for elementary teachers involving nine television stations, nine FM radio stations, and eight state universities. Pennsylvania State University has developed a programmed computer-assisted instruction program utilizing a mobile computer unit and teletype machines designed to train teachers in the new mathematics concepts. This program was field tested in the Williamsport, Pennsylvania, area during the 1967-1968 school year. Plans are underway to expand the program to other areas of Pennsylvania during the school year 1968-1969 and eventually to surrounding states. A conference was held March 7, 1968, on the campus of Pennsylvania State University, to which representatives from Pennsylvania, West Virginia, Kentucky, and Tennessee were invited. The purpose of the meeting was to acquaint these state representatives with developments and to formulate plans for the future.

Supported by funds from the Commonwealth of Pennsylvania and the U. S. Office of Education, the Pennsylvania Department of Public Instruction initiated the Pennsylvania Retrieval of Information for Mathematics Education Systems (PRIMES) in 1965. The purpose of this project is to make readily available to every district in the Commonwealth information concerning pupil objectives and mathematics concepts and to relate them to the age or grade level of the child. More than 300 content items, classified under seven general mathematics topics, and approximately 2,000 pupil objectives, stated in behavioral terms, have been identified. Each lesson is classified according to the mathematics concept presented, the expected pupil behavior, type of problem, vocabulary and symbolism used, grade level intended and pre-text and post-text activities. These lessons are indexed by key-punched data processing cards. Questions may be addressed to the system by letter, telephone, or personal visit.

The California State Department of Education recently published Part 2 of Mathematics Program K-8 (1967-1968 Strands Report by a Statewide Mathematics Advisory Committee) in which the mathematics curriculum is divided into nine strands as follows: (1) Numbers and Operations, (2) Geometry, (3) Measurement, (4) Application of Mathematics, (5) Statistics and Probability, (6) Sets, (7) Functions and Graphs, (8) Logical Thinking and (9) Problem Solving. While it was not the intention of the committee to be prescriptive to authors, publishers, and teachers, they attempted to set forth a "strong and clear statement of the many subtle and crucial issues in curriculum planning, together with our recommendations and commitments on these issues." Algebra, according to the report, is not listed as a "strand" because the central ideas of a modern algebra course can easily be identified as an extension of the framework of the strands described here. The committee believes that the next five years will see more and more students ready for a first course in algebra at the beginning of grade eight.

These projects and curricula are representative of the continuing revolution in mathematics. All are directed toward meeting the mathematical needs of the child in a rapidly changing environment. Whether the child is a slow learner or gifted, he is going to need more mathematics and a better understanding of mathematics. He needs to learn how to learn mathematics.

The increase in membership in the National Council of Teachers of Mathematics during the past ten years further emphasizes the extent of interest in mathematics. Organized in 1920, the membership of this organization had reached only 13,000 by 1958. By 1967 the membership had passed 49,000. Last year ten regional meetings sponsored by NCTM were attended by more than 20,000 mathematics teachers. The attendance at the annual meeting in Philadelphia in mid-April, 1968, was expected to reach 8,000.

Irvine H. Brune, writing in The Mathematics Teacher, said, "Curricular changes in mathematics, particularly during the past ten years, have aggravated some of the problems of preparing teachers. Chief among those problems stands the need for growth on the job. The teacher's subject grows rapidly, his courses of study change at least occasionally, and his knowledge of how pupils learn had better grow. The teacher needs to learn more mathematics, more details of curricular changes in mathematics, and more methods of teaching mathematics. He can never conclude that now he is fully prepared."[4]

The teacher of mathematics, as never before, realizes that he must keep abreast with new trends in his field of specialty and that he should be ever on the alert for better ways of reaching the individual child.

[4]Irvine H. Brune, "Points and Viewpoints," *The Mathematics Teacher*, LX: 6, (October 1967), p. 653.

TEACHING MATHEMATICS

A more difficult task than learning mathematics is learning how to teach it. The teaching involves not only mathematics, methods, and materials but also complex human beings—our students—who differ from one another in their intellectual, emotional, and physical reactions. The successful teacher understands the learning process as well as the goals of instruction.

As classroom teachers, we have to make many difficult decisions every day. We must decide what to teach, how to teach it, and how much to emphasize certain ideas and skills. We must select activities and materials that will be appropriate for pupils with widely varied interests and abilities. We must be able, finally, to evaluate the effectiveness of our instruction.

To teach mathematics successfully, we must know the subject matter; but we must also be able to communicate our knowledge to the pupils. We need to search for appropriate examples and vivid illustrations. We need to formulate challenging questions. We need to encourage pupils to participate in exploring mathematical ideas. If we can instill into our pupils our own curiosity about mathematics, they will come to share our enthusiasm for the subject.

Donovan A. Johnson, "Teacher Preparation: We Must Broaden Our Concern and Involvement," *Newsletter, The National Council of Teachers of Mathematics* (December, 1967).

CURRICULUM CHANGE IN MATHEMATICS

THOMAS J. DUNN
Administrative Assistant for Instructional Services
Fayette County Schools

Providing for the formulation of curriculum objectives and for the determination of curriculum content and organization are specific and major responsibilities of the Division of Instructional Services of the Fayette County School System of Lexington, Kentucky.

The merger of the Lexington Independent Schools with the Fayette County Schools created an immediate need for the revised formulation of curriculum objectives and for the redetermination of the curriculum content and organization which would be best suited to the merged school system. In addition, changing times had made the present curriculum guidelines in both systems out-dated.

Seeking the best thinking to begin the approach to curriculum revision, an advisory committee was appointed to initiate the important task which would ultimately affect the school community of some 35,000 students and 1,800 teachers and administrators. This advisory committee was composed of central office administrators representing the superintendent, coordinators in the Division of Instructional Services, school principals, the director of guidance, and the coordinator of curriculum development from the State Department of Education.

Purposes and uses of written curriculum guides were clarified in the advisory committee's initial meeting. Curriculum guides may be used in various ways and have specific purposes in serving the child in school, the teacher, the counselor, the principal, the central administrative staff, the Board of Education, the parent and the general public.

For the child in our schools:

The curriculum guide provides for a sequential, logically developed instructional program from Grades 1 through 12, better assuring that there will not be needless repetitions or omissions in the continuous learning program for each child.

In a system where there is a great deal of intra-system mobility of school population, and where district lines are often changed, the curriculum guide provides a means for a continuous educational program for the child who may spend a level of his school life in two or more schools.

For the teacher and counselor in our schools:

The curriculum guide—

provides a valuable reference for a total overview of the instructional program of pupils.

provides a valuable aid and resources for long-range and daily planning.

is a help to the teacher and counselor in providing instruction more nearly at the level of learning for the individual child.

provides a valuable tool for the teacher, as well as the counselor, in interpreting the instructional program to pupils, parents, and administrators.

For the principal in our schools:

The curriculum guide—

provides a valuable reference for a total overview of the instructional program he is responsible for administering and supervising.

provides the basis for the orientation of new staff members to their teaching responsibilities.

provides a valuable aid to the principal in supervising the work of individual teachers and the teacher's instructional program.

provides necessary information to the principal in developing the total organization of the instructional program in his school.

serves as an aid to the principal in selecting textbooks, supplementary materials, equipment, supplies and various resources for improving the instructional program in the school.

provides information to the principal for interpreting the school program to pupils, teachers, the superintendent and staff, the public, and the Board of Education.

For the Superintendent and the Administrative Staff:

The curriculum guide—

provides a reference for an overview of the total instructional program in the school system.

provides valuable information for interpreting the instructional program of the school system to both the professional staff and the public.

provides information for determining expenditures for instructional needs.

provides direction in determining and developing in-service programs for teachers and administrators.

provides information needed for annual reports to the Kentucky State Department of Education, and for accreditation reports to the Southern Association of Colleges and Schools.

For the Board of Education:

The curriculum guide provides the Board of Education a resume of the total school program for which the Board has a responsibility to the parents and to the general public of Fayette County.

The curriculum guides, upon adoption by the Board of Education, provide a Board of Education policy for the curriculum of the Fayette County Schools.

Following the clarification of purposes, the advisory committee moved to establish a plan of work for curriculum development and for writing the guides. Believing that classroom teachers, as professional educators, play an instrumental part in curriculum development, and believing that all teachers in all schools should have a voice in what is being taught in the school, an organizational system was developed which permitted representation of each school in the work to be done. The elementary schools were divided into three geographical areas with each school having a representative to an area. The secondary schools comprised a fourth area with similar representation. From the four areas, a central committee of ten teachers was selected to work with consultants and coordinators to direct and to coordinate the total effort of the system in a specific area of curriculum development. The Central Committee, along with the coordinators and consultants, was charged with the final responsibility of producing the finished curriculum guide.

Because of many changes which had developed in the teaching of mathematics over the past years, the advisory committee decided that revision of the mathematics curriculum should receive top priority in curriculum revision work.

To initiate the work of the mathematics curriculum revision, a listing of outstanding mathematics consultants was compiled, and from this list a nationally known math consultant was invited to spend the day working with members of the central committee and the central instructional staff. The day was culminated with the consultant addressing all principals and the math representatives from all schools in the system.

Released time was provided at Board expenses for the ten members of the central committee to complete much of its work, and a consultant from the University of Kentucky was employed with ESEA Title III funds. In the ten days of released time which the central committee used periodically during the school year, the committee directed the necessary communications to and from each individual school to gain the best ideas and the representative thinking of all teachers. During this time, the central committee also studied professional literature and a wide variety of math programs, viewed films pertaining to the development of behavioral objectives, discussed together and with the consultant many points of view related to the development of the mathematics curriculum.

By the end of the school year, the central committee had gathered what it felt was sufficient information and data to write a mathematics curriculum guide for Grades 1 through 12 for the Fayette County Schools.

With the assistance of ESEA Title III funds, three weeks of time during the early summer enabled the members of the central committee to complete the new curriculum guide in mathematics, one which will bring innovations to the math program of the system and one which hopefully will provide directions for an improved mathematics instructional program for each student in the school system. Final editing and publishing of the guide was scheduled for completion during the summer of 1968.

During the summer the new mathematics curriculum guide was presented to the Board of Education for adoption as the official mathematics curriculum for Fayette County Schools.

After Board approval, and during the summer, all principals were instructed in the changes which have been made in the mathematics curriculum in an attempt to help each understand the significance of the changes. In the pre-service days immediately before school begins, all principals, in turn, instructed their mathematic teachers in the use and application of the new guide.

The coordinator of mathematics for the Fayette County Schools will make plans to do in-service work with teacher groups and faculties during the next school year to further clarify the mathematics curriculum as presented in the new guide.

It is the plan of the Division of Instructional Services that continuous revisions to the mathematics curriculum will be made as needs arise to keep the math guide current and to provide better the sort of mathematics program that our youth need.

With the cooperative effort and thoughts of our teachers, principals, coordinators, consultants and Kentucky State Department of Education personnel, it is our hope and belief that we will have developed curriculum objectives, content and organization in our mathematics curriculum guide which will improve our instructional program in mathematics.

Your Own Philosophy

If you were asked to describe, in a hundred words or less, your general philosophy for teaching mathematics, what would you say?

The J. P. Math Philosophy

Teach mathematics, lots of it. Show that mathematics has to do with the children's world, in school and out of school. Sneak up on a major topic so that by the time you are ready to teach it pointedly, the children already know most of it. Get the children actively involved in each lesson. Make sense to them.

Dr. Jo Phillips, "Teaching New Math," *The Instructor* (February, 1968), p. 40.

ELEMENTARY PROGRAMS

THE ORIGIN AND DEVELOPMENT OF MODERN MATHEMATICS AT HIGHLAND SCHOOL

MRS. VIRGINIA ATKINSON
Principal
Highland Elementary School
Hopkinsville, Kentucky

At a time when pupils' interest, achievement scores, and Sputnik were calling for a change, modern mathematics was introduced to the pupils of Highland Elementary School. This program is based on the following beliefs:

> Mathematics is a system of related ideas. These ideas are not acquired through the repetition of the words of someone else nor are they acquired through meaningless drill. They are acquired as the result of inquiry; of the kind of thinking that is done when the ideas that have been acquired are used as a means of discovering new ideas.
>
> A child should be provided with many enriching experiences. Through these experiences a child will get a background of attitudes, appreciation, facts, and skills that will enable him to do the mathematics of later years and be able to meet independently any situation in which a need for mathematics arises.
>
> Mathematical experiences should be on the child's level so that he will be able to understand new ideas and in general to achieve. This achievement helps the child to have a positive attitude toward mathematics.

A summer institute afforded the principal the needed background to launch the program on a limited basis in September, 1961. Using a guide prepared in the institute, Highland teachers participated in a workshop after school. Later, they were in NDEA sponsored workshops for primary and for intermediate levels, where a modern mathematics booklet was prepared for parent education.

Spontaneous enthusiasm compelled the teachers—and the principal—to begin immediate use of the new concepts with all pupils, grades 1-6. Since state textbooks were not yet available, *A Guide for Teaching Primary Children* was written by the principal and enrichment materials were added.

To implement the mathematics program further, a small selected group needing a challenge in mathematics was taught from an enrichment workbook for a thirty-minute period once a week. Interest mounted rapidly as their mathematical understanding increased. This group continued to be outstanding in mathematics as it progressed to junior high and thereafter. Recently, one of these pupils who is now a junior in high school has taken the college entrance examination and made a perfect score in mathematics.

We have learned that this program, like any good instruction, necessitates a great deal of planning by the teachers, supervisors, and administrators. The faculty envisioned team teaching as the means for strengthening the mathematics and language arts programs.

Team teaching, organized two years ago, has enabled the teachers to assess each child's ability and teach him on his level. Some beginning pupils are able to move from the concrete to the abstract more rapidly than others. Grouping within the classroom for mathematics instruction enables the teacher to challenge without frustrating the pupils. The day when all pupils in a class are assigned "X" number of probems for drill has passed. Drill is an important mathematical tool, but it must be used with discretion. For example, once a child understands place value as it relates to the fundamental operations in expanded notation, there is no reason to continue drill using expanded notation. Grouping for mathematics instruction has proven as advantageous as grouping for language arts.

More and more material is becoming available.

Some of the most useful aids, in addition to textbooks, include counters of many kinds, abacus, flannel board objects, duplicating masters, liquid measures, both plane and space geometric shapes or objects, various charts (showing properties, equivalence, etc.) demonstration clocks, board and pupil compass and protractors. As additional material becomes available the interest and the enthusiasm abounds and achievement scores continue to substantiate the success of the program.

This approach to mathematics inspires and encourages the individual to think and discourages rote memorization. This better prepares him to enter the field of unified mathematics as it is presented on the secondary level. Eventually, pursuit of his chosen profession is greatly facilitated since a pattern of positive thinking has already been formed.

THE SCHOOLS AND THEIR PURPOSE

This, above all: education is not a game. The present writer—and, most likely, the present reader—have livings to earn and families to support. Jobs in education may make this possible. Yet the schools do not in fact exist for our benefit; they serve a purpose as serious as the purpose of hospitals (and with no schools, or bad enough ones, there can be no hospitals, or only very bad ones); they serve a purpose as serious as armies and nuclear missiles (to be sure, this hardly seems to be recognized, but it is absolutely sure that man cannot fail to recognize it for many more years); they serve a purpose as serious as legislatures and courts (in this case the famous remark of Thomas Jefferson remains accurate today and will continue to be accurate in the future); they serve a purpose at least as serious as whiskey, cosmetics, tobacco, detergents, floor wax, and automobiles.

We cannot apologize for a relentless impatience to improve education. We can never settle for "business as usual." We cannot merely write learned papers for the edification of our colleagues and the enhancement of our own professional image, or for the enlargement of our income. Our schools are not as good as they might be; they are not as good as they need to be; and it is our job to make them better. The verdict of our colleagues on us will count as nothing compared to the verdict of history on our civilization.

Robert B. Davis, *The Changing Curriculum: Mathematics* (Washington: Association for Supervision and Curriculum Development, 1967), pp. 73-74. Reprinted by permission.

MATH AT McNEILL

CLARENCE N. WOLFE*
Learning Program Director
McNeill School
Bowling Green, Kentucky

The McNeill Learning Center is the site of an ambitious attempt at individualizing instruction. This is a school consisting of children who represent a cross-section of abilities and backgrounds in traditional grades 1-8, with no selection of students or staff. The program was begun in 1966 through a grant from Title III, ESEA, to establish an innovative program for Region II, Kentucky.

Since we are striving for individualization of learning, there is practically no large group instruction, no attempt to teach a group of thirty children the same thing at the same time at the same rate. The teachers are called learning coordinators, as this is their task—to coordinate the learning of children. There are two divisions within the school: Plaza A containing grades 1-4, and Plaza B containing grades 5-8. There is some interplaza movement but mostly the children move within their own plaza.

We have attempted to completely individualize the mathematics program, allowing each child to be successful in math and to proceed as rapidly and as far as he possibly can according to his ability, background, and interest. We felt that as long as we were in the traditional self-contained classroom and kept the children in a lockstep situation we could never have an adequate mathematics program. Too little emphasis is placed on math, especially in the primary grades, in the self-contained classroom where a teacher is supposed to be an expert in everything. It is an impossible situation to even suppose that teachers will do an equally good job of teaching all subjects. Many times math is the subject that suffers. Many elementary teachers are poorly trained in math and dislike math, and this is transmitted to the student.

We began by taking two teachers in each plaza who volunteered to take full responsibility for math as their primary task. These were not people especially trained in math but good elementary teachers who liked math and did a good job of teaching it. All students move to these four people sometime during the day for mathe-

*Since writing this article, Mr. Wolfe has joined the staff of Project MUST, Bowling Green.

matics. Since they are concerned primarily with mathematics they can devote their time to planning, organization, study, and preparation for a better mathematics program.

Since we no longer have a central library, each mathematics area serves as a learning center, an area where there are people, places, and things pertaining to mathematics. This would include one or two learning coordinators (teachers), a part-time aide, a mathematics library consisting of reference books and a wide assortment of textbooks of all levels, multi-media such as manipulative devices, games, flim loops, film-strips, and tapes, and, in Plaza B, individual study carrels.

Plaza A math consists of two learning centers to which children move for mathematics, directed by Mrs. Patricia Shanahan and Mrs. Rachel Walker. Learning packets prepared by the staff for each child include directions, materials, multi-media, and evaluations. We use a multitude of materials in preparing these packets which are found in the math learning center. Individual children are directed to packets according to their past and present performance, ability, and interest. The learning coordinator works with the children individually and in small groups, allowing each child to proceed as rapidly as possible. There is great variance in the number of packets which individual children will complete in one year, but the next year each begins at his point of completion from the preceding year.

Due to the state of flux of mathematics instruction in Kentucky, and to our changeover in the past few years from "traditional" to "modern" math, we have children in each plaza with a wide variety of backgrounds in math. We are attempting to have a strong sequential modern math program and at the same time concentrate on the weaknesses of individual children in concepts and computation due to past experiences in mathematics. We use many types of materials—audio-visuals, games, laboratories, multi-level commercial materials—any material which we feel fits the individual child's needs.

In Plaza B we have a large learning center directed by Miss Ruby Warden and Mrs. Ruby Daniels. This room was formerly two classrooms but with the removal of a wall became a large area in which we can house all types of materials pertaining to mathematics, including a math library and student study carrels. These children are individually scheduled on twenty minute modules according to their need in mathematics. There is no mass movement of children as a child moves on his own individual schedule. Each child works in a mathematics packet according to his needs. The learning coordinator works with individuals and small groups in giving instructions, aid, and evaluation. Within the packet are self-evaluations, and each student is given a written and/or oral evaluation at the end of the packet. From these evaluations, both by the student and coordinator, the student is directed to his next learning pack. There is no basic text and no assigned homework (although many children request to take material home, which we encourage by allowing them to take tapes, recorders, filmstrips, etc., in addition to books). There is no repetition of a pack; but if the evaluation indicates lack of sufficient comprehension, the student is directed to additional material on the same concept. If he demonstrates sufficient comprehension on the evaluation, he goes to another pack in the mathematics curriculum.

We began the program by determining from achievement tests and learning coordinators' opinions the placement of children in the mathematics sequence. We plotted for each plaza a possible sequential development of mathematics where individual concepts would be emphasized, but at the same time allowing for flexibility for the individual student. The student in Plaza A or Plaza B begins at the appropriate place in the curriculum and covers as much mathematics as possible each year. To have time for team planning, the staff stays each afternoon for one and one-half hours after the students are dismissed. We also were able to have a four weeks planning session in August, 1967.

Although we have not been in the program long enough to have a critical evaluation of students, many achievements of the program are apparent. Students are more independent and accept much responsibility for their own learning. They are much happier, due to their not being frustrated or bored by being kept with a group. Some children will complete what would be traditionally two or more years of work in one school year, allowing them to have greater scope and depth in mathematics than would ordinarily be possible. Slower children are learning mathematics but are working at a level where they too can be successful. There is no failure; the child completes as much as he can and continues from there the following year.

I am extremely pleased with the program thus far. There has been much more accomplished than I had dreamed possible in this short period of time. Since McNeill is serving as a Title III center for Region II, there have been hundreds of visitors from the state, nation, and foreign countries. Many of the things we are doing are being adopted successfully by other schools. We hope that we have in some small way contributed to the improvement of education in Kentucky.

COMPUTER ASSISTED INSTRUCTION IN EASTERN KENTUCKY

DR. MORRIS L. NORFLEET
Vice President, Research and Development
Morehead State University
Morehead, Kentucky
and
DR. LEONARD BURKETT
School of Education
Morehead State University
Morehead, Kentucky

In recent years, much emphasis has been placed upon methods and techniques of teaching arithmetic. Teachers with large classes have been hard pressed to find the time to adequately teach all the needed concepts and follow-up by furnishing the needed drill and practice necessary to firmly establish the competencies and to indicate areas of weaknesses which might need further development.

A single teletype console offering a drill and practice program in arithmetic via computer was moved into a remote school in Eastern Kentucky for a six weeks period ending May 17, 1967. This was a cooperative effort involving Central Midwestern Regional Educational Laboratory of St. Louis, Stanford University of Palo Alto, California and Morehead State University in Kentucky. The impact of this computerized program in mathematics on these rural isolated youth, as shown by statistical data and teacher observation, was phenomenal. The mean gain in computational skills for twenty-nine students for a six weeks period was 7.7 months.

The Eastern Kentucky Educational Development Corporation is presently administering a project which utilizes twenty-eight of these teletype terminals in ten different schools in Eastern Kentucky. The project was organized in cooperation with Morehead State University, Morehead, Kentucky. The Institute for Mathematical Studies in the Social Sciences, located at Stanford University in Palo Alto, California, provides computer time and instructional materials. Technical services have been sub-contracted to the Central Midwestern Regional Educational Laboratory, Inc. (CEMREL), of St. Louis, Missouri. The program is financed with funds made available through the Elementary and Secondary Education Act (PL89-10) of 1965 (Title III) and through state and local sources.

HOW IT WORKS

As the name implies, computer assisted instruction in mathematics is to *assist* in the task of instruction and is not designed to take over the instructional program. It might rightly be designated as a highly sophisticated teaching aid.

After the teacher has developed a concept in arithmetic, the student is furnished drill and practice by the computer. The student activates the teletype terminal by pushing the start button. Immediately, the machine types "Please type your number and name." The student types in a four digit number and first name. His last name is typed by the computer, thus starting his drill and practice lesson.

The first lesson on each concept consists of a pretest on the particular concept. According to his score on the pretest, he is branched into one of five levels of difficulty in the concept for his first lesson. Thereafter, his score on each lesson determines whether he stays on the same level, moves to a higher level, or moves to a lower level until he has completed a series of five lessons on the concept. The program attempts to keep the success level of each student between 60% and 85% by moving the student up or down in the levels of difficulty. The last, or seventh, lesson on each concept consists of a post test of the same level of difficulty as the pretest.

ADVANTAGES OF THE PROGRAM

Several benefits are derived from this drill and practice program that could not possibly accrue from other types of drill and practice.

Individualization

The computer individualizes the lesson for each child as the teacher could never do because of the time factor involved. The branching system keeps each student at a level where he can enjoy a certain amount of success and yet keeps him on a high enough level to furnish a challenge.

Feedback

The feedback from the computer tells the child immediately whether he has made a right or wrong response. If he continually makes a wrong response, he is finally given the correct response and allowed to type this in so that the last answer he sees is the correct one. When his lesson is completed, he is presented a printout of the number of problems in the lesson, the percent correct and the time taken. The printout might look like this:

20 JUNE 1968
16 PROBLEMS WITH 94 PERCENT CORRECT IN 171 SECONDS
GOOD-BYE, BOBBY. PLEASE TEAR OFF ON THE DOTTED LINE

. . . .

The teacher is given a printout each day of class performance. This encourages the diagnostic approach to teaching, using these evaluative results.

Motivation

Students enjoy the computer type of program and have shown a high degree of motivation. When a student is working on the teletype machine, he is so absorbed in his lesson that discussion among observers of the program does not seem to penetrate and bother him. Many reports have come in from teachers concerning children who had been attendance problems and have shown marked improvement because of their reluctance to miss their "turn" at the computer. This new method of instruction arouses interest in parents who have never before indicated interest in the child's school program. Something about the computer printouts elicits interest from parents where other school papers have failed.

OUTLOOK FOR THE FUTURE

With the reduction of transmission costs modern programmed material can be made available to the most isolated educational situations. Many possibilities are now being investigated for cutting operating costs. One such possibility is the sending of computer signals via the micro-wave networks used by educational television stations. Advances are being made in the technology involved in computerization of different type materials and in the adaptation of programs to computer instruction. The near future should see the best of programmed material, teaching techniques and evaluation approaches become available to schools heretofore outside the main stream of education technological advances being made elsewhere.

THE NUMBER LINE

MRS. VERA L. MATTHEWS
Morgan Elementary School
Paducah, Kentucky

Two years ago the mathematics program in the elementary schools of Paducah was revised. Instead of stressing the traditional mastery of skills, teachers were encouraged to emphasize the more modern approach of stressing the understanding of mathematical concepts.

As an intermediate teacher of Mathematics I have found that many of these concepts can be developed in a meaningful way by the use of a number line. By the time children reach the fifth grade they have already acquired an understanding of certain number relationships and numerous number patterns and are ready to proceed into more advanced concepts. The concepts can be developed with much interest and enthusiasm when children are encouraged to seek out and discover ideas for themselves, to explore various patterns and relationships, and to arrive at their own generalizations.

Basic operations and equations

By displaying a number line on the chalk board and allowing each child to manipulate one of his own at the same time, children are led into making many discoveries which result in a keen and lasting understanding of many addition, subtraction, multiplication and division facts. Even though the children have had previous experience with these operations and how they relate to the number line, the purpose here is to help them extend their knowledge through other discoveries. For example they show the combination $3 + 4$ by beginning at point 0 on the line and jumping to 3 followed by 4 jumps to the right. Then they show the combination $7 - 3$ by beginning at point 0 and jumping to 7 followed by a jump of 3 units to the left of 7. With these basic ideas the children are able to relate the following equations:

$$3 + 4 = 7$$
$$7 - 3 = 4$$

This type of practice leads children not only to discover that subtraction is the inverse of addition, but they can also discover, by manipulating other jumps on the line, that $3 + 4 = 4 + 3$ which clarifies the commutative principle of addition.

This same method is used to explore multiplication and division concepts. For example, the children are told to begin at point 0 and to make 4 jumps of 3 units each. The landing point will be 12. Now they are able to relate the following equations:

$$3 + 3 + 3 + 3 = 12$$
and
$$4 \times 3 = 12$$

Using the same number line the children are now instructed to begin at point 12 and make 4 jumps of 3 units each to the left. From this they're able to see that $12 - 3 - 3 - 3 - 3 = 0$, and $12 \div 3 = 4$. Not only can they see from this that division is simply repeated subtraction, but many other concepts of the basic principles and operations begin to unfold in a rather meaningful way.

Rational Numbers

Up to this point we have used the number line primarily as a physical device for developing mastery of whole number concepts. The children should now be led to discover the relationship between the physical representation used to describe a line and the actual geometric concept which is abstract. Once they are able to think of a line as being a certain set of points, they can quickly visualize the fact that they have been working with points corresponding to whole numbers. Yet there are points between these whole numbers that have not yet been named. With this understanding we are ready now to explore the set of rational numbers. To begin this lesson the children measure the distance half way between 0 and 1. It's easy to see that since this point is exactly half way between the two points, the notation $\frac{1}{2}$ would name the point. Since this notation has two parts we stop here and examine each part. They can see that the 2 shows the division of the segment and the 1 shows how much of the segment is being considered. Here the terms numerator and denominator are introduced. The children proceed now to name each whole number point and each point half way between any pair of whole numbers. In this way they mark all the points which name the set of halves. For example, $\frac{0}{2}$ $\frac{1}{2}$ $\frac{2}{2}$ $\frac{3}{2}$ etc.

This helps them to discover that for any point on the line there are many names, and for each point they are able to build a set of equivalent fractions. The concepts of lower and higher terms are made visible and the algorithm for addition and subtraction with like as well as unlike denominators is easy to grasp. The meaning of improper fractions and mixed numbers is also clearly understood.

Graphing

Here again the number line is used in a most effective way to understand the idea of graphing. Now that the children are able to locate points for whole numbers and label them, graphing is a simple but exciting experience. Once they understand that graphing a point on a number line is merely marking a dot for that point they are able to review many other concepts which they have previously learned. For example, graphing becomes an exciting experience by employing the following exercises at the chalk board:

1. Graph the set of whole numbers between 0 and 10.
2. Graph the set of whole numbers < 10.
3. Graph the set of odd numbers < 10.
4. Graph the set of even numbers < 10.
5. Graph the set of prime numbers less than 10.
6. Graph the set of whole numbers > 2 but < 10.
7. Graph the set of rational numbers $\geqq 0$ and ≤ 5.

The children are led here to the discovery that since each point on the number line represents a rational number they may show a graph by simply marking a solid line.

With this knowledge, it is now easy for the children to graph ordered pairs of numbers by using two number lines: one extending horizontally; the other extending vertically and intersecting at point 0. We call the horizontal line the input line and the vertical one the output line. With their knowledge of functions they can easily locate the point for (4, 2) by first locating the 4 on the input line and matching it with the 2 on the output line. They can see that for each ordered pair there is exactly one point. This helps them to be able to locate a point for any pair of rational numbers also.

Integers

This lesson always creates a high level of interest, but children are introduced to the set of integers primarily to broaden their understanding of our number system. Here again the number line is utilized very accurately. The children have been working with number lines showing 0 as the beginning point and extending to the right infinitely. This lesson helps them to see that a number line may extend to the left of 0 infinitely, as well as to the right, and that for every positive integer there is a negative one that can be matched with it. With this knowledge, and the knowledge that they have already acquired by number line practice, it's easy and exciting for the children to make many other discoveries and to perform simple operations upon integers.

Working with children in this manner has been a rewarding experience for me, for no longer do they think of mathematics as being a dull and uninteresting subject but rather as an exciting and fascinating part of their total school program.

Some projects (e.g., the Madison Project) and many schools are building "math labs." The rationale is something like this:

a. Following Piaget, it is assumed that actual perception and actual active manipulation of physical materials contribute to concept formation, for some students if not all students;

b. The evidence seems to indicate (rather strongly) student preference for this method of learning;

c. Watching a child manipulate physical materials often gives the teacher deeper insight into how the child is thinking about a task than can be obtained by purely verbal methods;

d. Traditional verbal methods seemed to create a superficial rote learning that did not seem to help the child when—as in shop or lab—he was confronted with tasks involving real objects;

e. Using actual physical objects necessarily challenges the "one right answer" syndrome that afflicts many children and teachers;

f. "Math labs" create a desirable classroom social setting for individualizing instruction.

Robert B. Davis, *The Changing Curriculum: Mathematics* (Washington: Association for Supervision and Curriculum Development, 1967), pp. 41-42. Reprinted by permission. Copyright (c) 196. by the Association for Supervision and Curriculum Development, NEA.

HELPING TEACHERS AND PUPILS WITH NEW MATH

MISS ATTIA M. BOWMER
I. N. Bloom School
Louisville Independent Schools

With the advent of "new" math, a revised set of goals for the elementary school mathematics program has emerged. Today our sights are higher as we seek for each child

To develop an interest in mathematics
To gain some understanding of the structure of our number system
To gain greater understanding of algorisms
To develop proficiency in the skills of mathematics
To grow in ability to think rationally
To improve in the ability of learning how to learn mathematics.

There is no law that decrees that "new" math will be better taught than the "old" arithmetic was taught. Aware of this, the Bloom School staff has endeavored to improve the quality of instruction as well as the content of the mathematical program.

It was the teachers, in 1961, who first felt that our program in arithmetic should be strengthened. That year we read and discussed current literature on the modern approaches to math, viewed filmstrips, and collected materials from various experimental programs. Two secondary teachers with modern math backgrounds were invited to speak. Teachers began trying out some of the new ideas gleaned from their reading. Number lines and "frame" mathematical sentences began to appear on chalkboards.

The following summer I enrolled in a university modern math workshop and two years later attended a National Science Foundation institute in mathematics at the University of Colorado.

For two years the majority of our in-service faculty meetings were devoted to the study of modern mathematics. Teachers extended their backgrounds individually through meetings and workshops, TV in-service lessons, university classes, and reading. During the first year of the current textbook adoption, we reviewed the concepts presented in the teacher's edition of the series.

Our professional library began to grow. Today the teachers' reference shelf in the school library contains some twenty-five volumes on various phases of elementary math instruction, a pamphlet collection, and an information file of mathematical activities and teaching suggestions. The school subscribes to *The Arithmetic Teacher* and other periodicals that present current articles on mathematics. There are, also, a few paperbacks with explanations of modern mathematics for parents.

In the belief that a child will be better able to deal with abstract ideas if he has had much experience with concrete and semi-concrete phenomena, we have sought to provide a variety of "things" that can be used to stimulate quantitative thinking throughout the grades. Many of these, such as a collection of units of measure, can be easily obtained at little or no cost. Some aids must be bought in sufficient quantity that each child in an instructional group may have the experience of manipulating the device. Materials that are to be shared by a number of classes need to be housed in a central location.

Let me hasten to point out that it is not the quantity of teaching aids but the careful selection and use of these aids that enhance or restrict learning. A few children may learn independently, but it is more likely that more children will learn more, and learn more efficiently, if the teacher has an awareness and understanding of underlying principles that enable him to ask the right question at the right time, so that a child's awareness is focused and sharpened. In one fourth grade class the teacher and pupils talk much about volume and area as they wrap packages or paint surfaces, although these may not be, strictly speaking, mathematical activities.

In kindergarten and in the first three grades we use Cuisenaire rods as a supplementary aid. This past year I had the pleasure of introducing these rods to three of our first grade classes. Each lesson was preceded by a period of free play. In the first lessons we played games designed to teach the child to discriminate lengths through the sense of touch. Later, pupils learned the relative values by color and expressed their ideas in terms of equalities and inequalities. Finally, they were introduced to number values and continued their discoveries of basic concepts. These sessions were a delightful experience. The teachers and I learned much in our observation of the children in free play. Their sense of balance and symmetry was amazing and their enthusiasm for learning tremendous. Occasionally the participating teachers and I found time to analyze the learning situation. This pooling of observations, ideas, and suggestions was, I believe, profitable to all of us.

Young children need many sensory motor experiences in the area of mathematics as well as in other areas. Our primary grade children act out their number stories. They walk on number lines; play number games; manipulate counters and counting frames; draw and cut sets; make patterns of pegs in pegboards; and speak their number sentences. Even the kindergarten child begins to gain the concept of conservation of quantity as he pours water from one container into several smaller containers of varying shapes and then reverses the process.

Experimentation has not been limited to the primary grades. In an effort to help children develop ability to think rationally, to learn more about how to learn, and to stimulate their interest in the subject, I have, in alternate years, conducted an enrichment class, known as Special Math, for fifth and sixth graders. Pupils who, in the opinion of their teachers, have above average mathematical aptitude are invited to participate. Frequently other pupils request membership, or the request may come from parents. Since I feel that interest at this age is at least as important as aptitude, and indeed may lead to it, these children are also included. If the class becomes too large, it is split by grade levels.

The class, which meets for forty-five minutes twice a week, is conducted informally without the pressures of grades or material "to be covered." A discovery approach is used and every trick of the trade is employed to encourage independent thinking. Ideas for problems, class activities, and projects are culled from many sources. I usually begin with some of the ideas from the Madison Project materials and then proceed as needs and interests of the group dictate. This is rather an ideal kind of class, since the children learn for the pleasure of learning and I teach it for the joy of teaching. Many of these pupils continue their interest into junior and senior high school.

Thus far I have described some of our experimentation in our regular program and in our enrichment class. Our attempts to date to provide special programs for low achievers have been limited. Within each classroom most of the teachers group for math instruction by achievement level. This past year, however, to meet the needs of these particular children, we divided the entire sixth grade into three groups on the basis of achievement level for math instruction only.

For additional remedial help for individuals, teachers employ the pupil team approach, in which a child of greater ability assists a child having difficulty, or two pupils with similar problems help each other. Intermediate grade pupils are also trained to tutor first and second graders. The tutor then works with the pupil for ten to fifteen minutes three days a week. We find that both children profit from this experience.

We have no adequate evaluative tools for all our pupils' learnings. We cannot even be sure that we are providing the most worthwhile mathematical experiences at each grade level. It goes without saying, come old math or new math, we still have pupils who have not mastered the basic number facts despite our efforts. More of our children today, however, find math challenging and more list it as their favorite subject. The teachers find that children daily demonstrate a better understanding of quantitative ideas and have more confidence in tackling new problems.

In describing our school program, I want to make it clear that I certainly do not advocate that any elementary school principal become a math teacher on the side, but I do strongly recommend that school districts provide the services of a mathematics specialist and trained resource teachers who can offer assistance and support to the classroom teacher and impetus to the math program at the elementary as well as at the secondary school level. In-service workshops under highly skilled leadership need to be financed on a continuing basis if practice in the classroom is to keep pace with knowledge in the field. The experienced teacher deserves new information and stimulation as well as the neophyte.

MATH GROUPING: THIRD GRADE

MRS. TOMMYE CAGLE
MRS. MARY LOU COOPER
Third Grade Teachers
Caverna Elementary School
Horse Cave, Kentucky

Working in a self-contained classroom of a small town school offers challenges, since teachers and students often are church, social, and business friends and associates. While it is advantageous to know and understand the background and environment of one's students, such circumstances can also pose problems.

One such problem is that of stimulating interest and motivation since the same people in the same school house with the same routine could become boring.

In our six grade, eleven-teacher, elementary school, we have a Reading Improvement Teacher and a part-time Librarian. Our school is one of three schools in Caverna Independent District. We are unique in that our small system of three schools, with a certified personnel of forty-seven people, is located in two counties—Hart and Barren. Our students come from the Horse Cave-Cave City area.

Obviously, we are limited in some ways, but we have many things in our favor. We have an interesting teaching staff, community resources, a low rate of pupil "turn over," and a relatively small number in our classes. Our administrators have encouraged freedom of experimentation.

With increased talk of modern math, we third grade teachers began to feel the need for enriching our math program. In addition to our text, we had been using other books and aids, but had been doing practically nothing in so-called modern math.

To stimulate interest in math, to possibly reach more individuals, and to try to inject some modern math, we launched our program.

Both sections of third grade went to one room for math class at a specified time each day. As one teacher prepared for instruction, the other assisted in preparing students for work. One main objective was to keep children constantly involved by having one teacher free to plan while the other was working with them. Thus more time was made available for individual help.

It was explained to the students that this was an experiment. We were hoping to make arithmetic more interesting. With student help, we listed on the board skills and areas in which we needed to improve —things a third grader might hope to accomplish. A child was asked to record the list and make a chart for display.

The text and other books were used only for reference. Textbook activities, however, were used as "seatwork" at other times during the day. For about two weeks, we prepared study sheets involving various skills. Individual scores were kept. Our lesson for the day would be built around the sheet.

Children in about the top one-third of the class were "drawn out" and placed in an advanced math class. A student teacher was given the top group, and the regular teachers worked with the other children. A small remedial class was placed at a table in the room with the advanced group. Children in the advanced group, in addition to their other work, assisted the remedial students. It was made clear that grouping was flexible and shifting would be done as the need seemed to arise.

For the sake of time, students usually checked their own work. However, on Friday, for the purpose of individual analysis, a test covering skills of the week was given.

How about modern math? The teachers discovered that this term must mean an approach by which many available techniques and methods are used to arrive at mathematical conclusions. Unknowingly we had been using for years many of the so-called modern math techniques.

Being practically unschooled in modern math, though, we ordered ready-made liquid duplicator books which were in sequence and had an accompanying teacher's guide. This gave us a base from which to work.

Parents began to question the strange-looking sheets that were going home. They felt inadequate in assisting their child. A few after school conferences developed and a night session was planned. Several parents, children, teachers, and principal, had a "Math Night." It was "great" seeing Mother and Johnny working modern math sheets together.

With this situation, some motivation and interest was inevitable. Several students went on to the advanced group but none were demoted.

Some materials and techniques used were

1. Showing flash cards by rows.
2. Calling number combinations orally while children wrote answers.
3. Some working at board while others worked at seat.
4. Two students competing at board with others keeping score.
5. Listening to problems on tape recorder and putting answers on paper or reciting orally.
6. Using toothpicks to illustrate problems.
7. Using a number line at the board or at their seats.
8. Spelling bee of math words.
9. Playing store to learn how to make change.
10. Visiting a grocery store to study measurements and read labels.
11. Having an art lesson using geometric forms.
12. Listening to a talk on coins by a coin collector.
13. Studying liquid measure by using various size milk cartons.
14. Using the multiplication records. (These have a tricky rhythm and the children like to pantomine dancing.)
15. Using related film strips. Much time was spent in doing simple equations with unknowns. They made math statements and questions; the how and why in all processes were emphasized.

Even though we still had some low achievers, we really felt that math did become more important to them. There was a challenge and increased motivation. We felt that we were sending on children who had a broader concept and better understanding of mathematics. Standard tests were not given, but results on teacher prepared tests and student performance convinced us that the experiment was successful.

It is suggested that this type grouping might not always work. Teachers involved must work congenially; parents, students, and administrators must be receptive; class enrollment should not be extra large; a fairly normal curve of abilities would be desirable; and physical facilities must be adequate. The help of student teachers was a big contributing factor.

NEW MATH IN CARTER COUNTY

MRS. N. B. CLARK
Teacher, Soldier School
Soldier, Kentucky

Five years ago "new math" came to Carter County. Now it is an accepted and vital part of the elementary school program. Its aim is to help the student develop skills in mathematics and enjoy learning those skills.

Mathematics has traditionally been considered a rote discipline which only the talented few could claim to enjoy. The new system, designed to give greater understanding of the elements of mathematics, is given in such a manner that more students than ever before can truly enjoy math.

The "new math" relies more on a student's reasoning out the solutions to problems than in his memorizing the answers. It emphasizes more of "how and why" and less of "this is the way it is." The student is shown the way but allowed to use his own natural reasoning abilities—abilities he often does not realize he has.

Each child is worked with at his grade level and at his learning level. He is allowed to progress as fast as he can, but not pressed to go further than he is able to at one time. The child is not just told that he must learn mathematics, as if it were a dose of bad medicine, but he is shown why it is important for him to understand mathematics.

In Carter County all eight elementary schools have moved into the "new math" program. It begins in the first grade and continues through the sixth or eighth, as the case may be. In at least one of the schools, computers are being used to supplement classroom instruction (in the Upper Tygart Elementary School, grades one through six). High school mathematics courses in the four county high schools are now adjusted to the "new math" methods, also.

The Carter County schools initiated the program by first retraining its mathematics teachers and all elementary teachers who give instruction in mathematics. They attended special night sessions at Grayson and Olive Hill high schools and received special additional training at nearby Morehead State University. All new teachers must be prepared to teach the "new math" system.

How successful is it?

Here is a typical comment from one of our teachers who teaches seventh and eighth grade students at Soldier Elementary School: "The children just love it—they take to it so much easier than they did to the old-style arithmetic. They just eat it up." She adds, "Students understand what they are doing better than they ever did before—I think that is the key."

The children are not only learning "new math" but a new language along with it. And one of the big problems has been to convince parents that "base two" and other such new terms are as basic and are as practical for their children in learning math as "two plus two." Parents have been invited to visit the schools periodically and to observe the new methods. They have been shown, wherever they showed an interest, just how "new math" works.

We see a great future for our children's abilities in mathematics under the new system. It seems to be the first real breakthrough in a general understanding of the often perplexing problems of mathematics to the ordinary citizen.

WHAT IS A TEACHER?

On this old earth God saw the need of special people; so he gave us teachers.

A good teacher is a combination of: Faith, Hope and Charity.

She has Faith that the little boy with a frog in his pocket will grow up to be an outstanding statesman; the little girl with the runny nose will someday be a fine and understanding woman.

She has Hope that just a small fraction of what she tries so hard each day to pour into those sometimes obstinate minds will take root and grow.

She has Charity to forgive the parent who is indifferent to her best efforts, and to try all the harder to help that child.

Yes, the good teacher has Faith, Hope and Charity, all three.

UP-TO-DATE WITH MODERN MATH IN FLOYD COUNTY

CLEM MARTIN
Director of Instruction
Floyd County Board of Education
Prestonsburg, Kentucky

Four years ago, Floyd County Educators, convinced that the Sputnik-inspired curriculum reform had launched a modern mathematics program here to stay, assessed their local situation with regard to finance and pupil-teacher preparation, considered the possibilities available through federal assistance, then reached their decision to initiate a program of modern mathematics in Floyd County Schools.

Response from the teachers, upon whose classroom performance successful implementation of the program depended, was encouraging. In-service centers, made possible by the State Department of Education through the use of NDEA funds, were established, whereby teachers who lacked the necessary preparation for teaching modern mathematics were offered eight three-hour sessions of orientation to the program. In addition, courses at both the graduate and the undergraduate level were offered by various colleges for those interested in gaining credit or in auditing the courses.

Recognition of individual differences among teachers as well as pupils was a factor taken into consideration by both teaching and administrative personnel. Accordingly, teachers who had completed in-service training or college courses but still felt inadequate to deal with the subject were encouraged to seek advice from the Department of Supervision. A frequent outcome in such cases was a form of team teaching, or an exchange of services within the school system which enabled those more adept in the field of mathematics to assume responsibility for teaching the subject. In some instances, high school teachers took over the teaching of algebra in the seventh and eighth grades—a subject previously taught at the secondary level only but now required in the elementary grades.

Supplementing the effort of workshop, college, and supervisory personnel toward initiation and implementation of the modern mathematics program were representatives from various textbook and educational supplies companies who made known to teachers and demonstrated the use of various materials available for effective teaching of modern mathematics. Purchase of a selective quantity of these materials was then made possible through funds supplied at the local level, and which, if the teacher so desired, were matched by funds made available through NDEA.

The transition from traditional to modern mathematics was not without its period of chaos and frustration. Particularly was this true at the upper elementary and secondary levels, where pupils with no previous training in modern math were introduced to the subject in advanced form. The ideal approach of beginning at the first grade and advancing year by year to more difficult levels simply would not apply. Modern technology had applied pressure to higher education. Higher education had stiffened its requirements, and the college-bound student found some instruction in modern math a *MUST* for survival there. A period of pupil-parent-teacher-administrator anxiety had to be dealt with at every level in the elementary and secondary field.

With three years of modern math instruction behind it, Floyd County is now beginning an evaluation of this program. Standardized tests are being given and compared with scores obtained prior to initiation of the program. The results, thus far, have been encouraging to those who were fearful of a very sharp decline in achievement during this transitional period. We expect and hope for more significant gains in this area as greater familiarity with the subject increases the proficiency of both teacher and pupil.

An appraisal of the current situation with respect to teacher preparation for the teaching of modern math is an encouraging one. Approximately 277 teachers will be teaching mathematics in Floyd County Schools next year. Of these more than ninety percent have had training in the teaching of modern math. We expect to increase this percentage through additional in-service training and to facilitate the services of all our math teachers with the addition of a mathematics consultant to our supervisory staff.

Needless to say, we will not be satisfied with our program in Floyd County Schools until an evaluation of pupil performance with very positive results can be obtained. It is toward this goal that the combined effort of all those concerned with the mathematics program is directed.

We believe in the program and are hopeful that repetition and revision, combined with additional training, will result in a solid foundation of mathematical training for the pupil preparing to meet the increased demands of an ever-changing society.

USES OF A TEACHER'S AIDE IN THE MATHEMATICS AND SCIENCE PROGRAM

MRS. ODESSA HARMON
Caverna Elementary School
Cave City, Kentucky

Before the days of the teacher's aide I would say to others and to myself, "If I had a secretary or a helper to assist while I am in the classroom, especially when I have a combination group, I feel that I could do a much better job of teaching." To my surprise, there came a day when I got the news that most teachers would be getting an aide at least a part of the day.

This particular year my students were forty fourth graders. The class was composed of the most capable students because they were grouped according to ability. These children were "eager beavers" and ready to go at all times. I was fortunate to have one aide assigned to my room for one half day each day during the second semester. She assisted us with experiments. Materials were brought mostly by the students, set up, and performed by them while the aide stood ready to help in anyway she was needed with the items used. I selected films and filmstrips. She assembled them for use. Bulletin boards were planned by the children and me and displayed by the aide. Often I made work sheets for the students to work out by using their books or for completion while an experiment was being demonstrated. The aide typed the material. Our textbook served only as a tool of guidance. When it came to field trips the aide was a grand person to have around. Forty fourth graders certainly need another "you" on these occasions.

During the school year of 1966-1967 and 1967-1968, I taught intermediate combination classes, necessary within our system because of overcrowded classes. During these school terms I felt that we needed the help of the aide more in our mathematics program. The answers to problems were often put on the board by the aide and the children checked their own work to evaluate themselves. During this time I moved about the room to discover what had been done and to help those who needed extra instructions. In mathematics the aide was a "right hand" with audio-visuals. She set up the record player while I was busy motivating the class to listen and later to repeat the multiplication facts. She presented flash cards to groups. Some days the papers, consisting of the previous assignment, were collected by her, checked, and passed on to me for determination for extra drill and individual instructions. This was done often while I worked with the other grade.

True and false tests, or any tests with specific answer keys, were checked by the aide but never returned to the individuals until I had gone over them to determine the knowledge and abilities performed.

The children soon learned to love the aide next to their teacher and looked forward to the time that she would be with them. They wanted and needed more attention within the science and mathematics program, because much of the time they were doing individual work. With their short attention spans, eagerness to show, and things to tell or to ask someone, it was to the student's advantage to have the second person around.

The aide is not expected to take the position of a teacher. She has not been trained to this point. However, the assistance of an aide, managed properly, gives the teacher and pupils much more of their valuable time for shared experience and individual instructions.

A further benefit was that at the end of the day I didn't find myself in such a panic nor threatened by the thought of having left out so much because of the lack of time.

"The Art of Teaching Mathematics"

1. Cultivate a sense of humor.
2. Ask interesting and exciting questions.
3. Let students know that you believe math is important.
4. Keep in touch with students' interest and fads.
5. Teach with enthusiasm.
6. Make provision for student discovery.
7. Be flexible.
8. Students must participate and enjoy in order to learn to love math.
9. The art of teaching begins with enjoyment.
10. "A teacher must know and like his stuff; he must know and like the pupils he's going to stuff; and, above all else, he must stuff them artistically."

Dr. Max Sobel, Professor of Mathematics, Montclair State University, speaking to the National Council of Teachers of Mathematics Annual Convention.

UP-GRADING ACHIEVEMENT IN MATH

MARY M. McALISTER
Teacher, Cochran School
Louisville Independent Schools

The current Cochran School mathematics program has been in operation for four years. For several years preceding the experiment, approximately seventy-five percent of the children tested in grades four, five, and six were working below grade levels according to the Metropolitan Standardized Tests. Spurred by this realization, a group of teachers met for a discussion of "What can be done to up-grade this school's program in math?"

Following the discussion, each teacher spent some time reading and searching for suggestions for improvement in the teaching of mathematical skills and concepts to exceptional children. It was found that many articles on teaching in disadvantaged areas and the central city schools were being written, but specific suggestions and practical helps were not given. Realizing that there was no best plan guaranteed to produce results, the group decided to try a program based on grouping the children in grades four, five, and six for instruction in math, and providing an enrichment program geared to the pupils' abilities.

Before students could be assigned to groups for instruction, an evaluation of each child's accomplishments in content areas took place. First, each pupil was given a standardized test in math. The scores were evaluated in terms of the child's ability. Strengths and weaknesses were noted. Second, anecdotal records kept by former teachers were reviewed. Social behavior patterns were noted and used as an aid in placing each child.

Groups were formed on the following bases:

- Group A—Pupils from grades 5 and 6 whose math achievement scores ranged from six months below grade level to above grade level
- Group B—Students from grades 4, 5, and 6 whose scores ranged from one-half year to a year and a half below grade level
- Group C—Children from all three grades needing help in all arithmetical skills and concepts; all students far below grade level

Some general aims and goals were formulated for the three groups: to try to instill in each pupil a desire to improve his math achievement; to make the study of mathematics more challenging by using audio-visual materials, games, and concrete teaching aids, both commercial and teacher-made; and to improve the students' achievement so that their stanine scores would be average or above in comparison to those of the city at large.

In addition to the general aims, the teacher of the top group decided to work on two others: to develop an understanding of the fundamental mathematical principles; and to strive to give pupils an enrichment program that would stimulate and challenge them to do some creative thinking.

Enrichment Program for Top Group

Since the math periods were fifty minutes in length, it was felt that two fifteen minute periods per week could be devoted to "Challenges for Thinking." This period was for the entire class and was, whenever possible, coordinated with the math concepts being taught during that particular week.

During September, learnings from previous grades were reviewed. The short periods were devoted to the history of counting, so that pupils could begin to get an understanding of what numbers are and to catch a bit of the fun and fascination of them.

One October day the children came in and found this question on the board, "How would you like to be able to multiply without learning the multiplication facts?" Their enthusiasm had been sparked. Multiplication was worked with renewed interest.

In November and December, time was devoted to enrichment and creative learning. Much pupil and teacher planning took place during these weeks. For incentive we used such devices as the treasure chest. Small cards, containing a challenge or a mathematical question to be solved, were placed in the chest. One card was drawn and answered by a team member. A correct response gave the team a point. An example of a treasure chest card is "Who Am I?":

When you multiply by me,
  I really am quite tame.
No matter what the factor is,
  The product stays the same.
    (Zero)

The short periods in the last two weeks of November were spent in planning activities to be presented to the entire class during the first week in December. Even though these children were considered good workers, they were as a class divided into three groups for math instruction. They did their planning within these groups.

Group A selected three books to be reviewed and reported on in an original manner. They dramatized "Early Men and Mathematics" from *New Ways In Math;* displayed all of the measuring devices found in their homes to illustrate *Things That Measure;* and taught the class how to multiply on their fingers as a demonstration from *Numbers Old and New.*

Group B made charts to show:

(1) Even numbers in nature, such as 2 (the hands of a child), 4 (legs of some animals), 6 (the legs of an insect) etc.;

(2) Triangular numbers 1, 3, 6, 10, 15; and

(3) Clock arithmetic.

Group C was taught how to play the games of Nim[1] and Kalah[2] during the planning period, and they in turn taught the games to the class during the reporting period.

In January and February, we used class texts as a basis for studying geometry. Students constructed and displayed geometric figures.

The fifteen minute periods from March through May were used for various kinds of enrichment such as transparencies, filmstrips, and meaningful practices.

As we attempt to evaluate results, we see three distinct benefits from our math program: Children have learned much in the content area, interest in the subject has improved, and achievement has been raised. Even though standardized tests are designed to test speed in computation and rote skills and not originality, cleverness of pupils, and the changes in behavior, the children's scores were much higher. The students in the middle and top groups ranked average and above with those of other city schools. Teachers involved in this type of planning, grouping, and teaching are so confident of the value of this work that they plan to use the idea for the school year 1968-1969. There will be a few additions and some deletions before the year begins.

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[1]Irvin Adler, *Magic House of Numbers* (New York: The John Day and Company, 1957), pp. 100-103.

[2]John B. Haggerty, "Kalah—An Ancient Game of Mathematical Skill," *The Arithmetic Teacher,* II (May, 1964), pp. 326-330.

Out of the ninety-eight children in the program at the end of the year, only one pupil expressed strong feelings against math.

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Sets

"Birds of a feather, flock together
So do geese and swine."
When objects do it, mathematicians pursue it,
And another name consign.
Many words may describe a group or a tribe,
A bunch, a school, or a herd.
New Math, you will learn has a different term—
A tool summed up in a word.
Take a ball and a tree, and some A, B, C's,
A duck, a car, or a Jet.
Put them in brackets, so you can match it,
Then you must call it a SET.

Anne E. Smith, *Bulletin of the Kansas Association of Teachers of Mathematics,* 42:1 (October, 1967), p. 7.

SECONDARY PROGRAMS

EDUCATION OF THE EXCEPTIONAL CHILD IN MATHEMATICS AT CONNER JUNIOR HIGH SCHOOL

PHILLIP RHEA ROLLINS and
JAMES N. STONE, Teachers
Conner Junior High School
Hebron, Kentucky

Conner Junior High School has a combined enrollment of 715 in grades seven to nine. Of the 197 freshmen, 85 take a General Mathematics Course, 90 are enrolled in Modern Algebra I, and 22 take Modern Algebra II. These 22 are products of the program we of the Mathematics Department hope to define.

This program began three years ago at an In-Service Day at Boone County High School. With the encouragement and support of the Boone County High School Mathematics Department, a program was begun to help meet the needs of the exceptional child in mathematics.

There are many reasons why an advanced program for the exceptional child is necessary.

As educators we must anticipate and provide for the needs of both the individual and society. With the technological and scientific explosion, we are compelled to take a more objective look at our programs in mathematics.

We felt a need for revision and improvement of our program to provide an opportunity for the exceptional child in mathematics to excel beyond the challenge that previously had confronted him.

It appears that these mathematically talented and eager children had lost the sense of challenge, competitiveness, and the desire to excel. They previously had been grouped according to age rather than achievement. Many teachers had tried to challenge them with extra work but it became too exhausting for the teacher, who had to consider also the other students in the classroom. It was soon evident that many mathematically talented children were not being challenged. They became discouraged because the pace was slow, tedious, and boring. We felt that if our program could not be revised to meet their needs, we had failed them and failed ourselves.

We have always heard, "An exceptional child can learn in spite of the teacher." We would like to suggest, "An exceptional child can fail because of the teacher and his program."

Because of the conditions already discussed we felt a need for and did organize an advanced program for the mathematically talented child.

Nature of the Program

The program involves using a modern albegra I text. The pace is the same as our regular Algebra I classes because those participating in the program, top eighth graders, are placed in the existing Algebra I classes. Every Algebra I class has at least one top eighth grader. We have found this type of grouping stimulates competition between the eighth graders and freshmen, thus helping both the eighth and ninth graders to improve their achievement.

Criteria used in selecting Students

First, we feel the most important factor is a good teacher recommendation. The seventh grade teacher can evaluate the student's enthusiasm, desire, and effort toward a high mathematical achievement.

Second, their arithmetic computation, concepts, and applications are checked. They must have at least an average of 9.0+ in these three areas. Many have much higher averages. We place more emphasis on arithmetic concepts and arithmetic applications than on computation.

Third, the students' intelligence quotients are checked. This particular factor has always been 120 or higher.

Explaining the Program

After compiling a list of 18 to 30 students who meet these basic requirements, we explain our program to the students and parents. For instance, we might say, "Mrs. Newberry, your son Charlie was recommended to take Algebra I as an eighth grader. We would like to explain our program to you. Charlie will receive no high school credit for this course and must take two additional courses after he completes this one. However, this will enable him to take all five courses offered in mathematics without taking two courses in any one year. He may wish to complete only the two required courses, but even this enables him to take one extra course that he would not have been able to take otherwise." If both parent and child agree with the program, he is accepted.

When these eighth graders complete Algebra I, they are grouped homogeneously in an Algebra II class. In fact, they are the only Algebra II groups we have.

They are challenged even more in Algebra II, where they are required to prove several theorems, conic material, ranging from groups to fields to exponential and logarithmic functions to conic sections. In addition to this they explore new avenues of mathematics by reporting on books related to mathematics.

The last three weeks of school are spent studying the many uses of the slide rule. We feel this is a very important part of the program because many of these excellent students will use this knowledge in other fields of science.

Planning the Program

Planning the program is very easy. The time involved in qualifying students is the big factor: looking for intelligence quotients, achievement scores, and talking with teachers about prospective candidates.

Of course the school itself must provide an Algebra II course for those who complete the first year of the program. However, this presents no problem because there is no change in the total number of pupils taking mathematics. They are just given an opportunity to take more advanced and more challenging courses earlier.

Each year we select students for the program for the coming year. In fact, we have about 25 who participate this year.

The remainder of the program is taken care of by the high school, which provides the students in the program with a challenge. The students are homogeneously grouped throughout the rest of the program.

Success of the Program

We are enthusiastic about the program and confident it has met and will continue to meet the needs of exceptional students in mathematics.

Approximately 95% of the eighth graders taking Algebra I take Algebra II as freshmen. The remainder take Algebra again as freshmen. Those 5% who take Algebra I a second time have always made the top grades in the class. Even if a certain percent take Algebra I again, we feel they have not lost any time.

The high school has reported that approximately 85% of our students in the program continue to be the top students. They say that homogeneous grouping allows them to be further challenged, to explore new ideas, and to allow students to reach the ultimate in achievement.

Starting such a program involves a little extra time for the department but compared to the high level of achievement these students acquire, the time involved becomes insignificant.

We feel this type of program helps less talented students also. With the top eighth graders promoted to an Algebra I course, the remaining eighth grade classes are more homogeneously grouped than before. The teachers of these remaining eighth grade classes are better able to meet the individual needs because they conform more nearly to the same level of achievement.

Will this program work for others? We are sure if the criteria mentioned are used—teacher recommendation, mathematical achievement score, and intelligence quotient—that a very successful program of meeting the challenge of the exceptional child in mathematics can be attained.

> We cannot afford to have, as we now do, such a large proportion of our citizenry feeling confused or threatened by everything scientific or mathematical. We must develop programs in mathematics and general science which will carry the great majority of students to a reasonable level of competence and will provide a suitable basis for more specialized work beginning in high school or for college-level programs in general science.

Andrew Gleason, "The Interface of Science and Mathematics," *The Bulletin of the National Association of Secondary School Principals*, 52:327 (April, 1968), p. 119.

MATHEMATICS COMES TO LIFE VIA SPACE FIGURES

THEODORE MARTIN
Mathematics Teacher
duPont Manual Junior High School
Louisville, Kentucky

After recess one day, one of my pupils asked me, "What is your favorite space figure?" Children as well as adults raise many questions about mathematics. It has been my idea to answer these questions and at the same time to reveal a bit of the modern mathematical horizon via such questioning, so I answered good-naturedly, "My favorite space figure is the small stellated dodecahedron." The blank expressions and then the laughing glances among friends were all the indication needed to know that interest had been aroused, and the question now needed only to be directed and developed.

After pondering over what I had said, someone asked, "What is that?" At first I thought that the unfolding of this subject (the set of space figure—polyhedra) would be one of considerable difficulty for the Classes of Twenty. As pointed out by Mr. Belcher,[1] this is a small class (not to exceed twenty pupils in size) established under the Title I Area for improving the educational opportunity for selected pupils who cannot qualify for educable mentally retarded (EMR) classes and who are greatly retarded in achievement in mathematics and other courses. Nevertheless, the children were so fascinated by the thought of having the opportunity to make these space figures and to see what they *really* look like that eager questions tumbled out one on top of the other. In the analysis of the class response, I have come to the generalization: The human mind of the underachiever can accept completely abstract ideas if they are derived from or illustrated by concrete examples; hence, tangible objects are essential in bringing that necessary contact with reality into the symbolic world of mathematics.

Since children like to plan, draw, cut out, construct, and talk about whatever they are making, it was decided that we would reserve our Fridays for such an activity, which is in keeping with the ob-

[1]Eddie W. Belcher, "Project Section IX," *Expanding and Enriching the Curriculum for Educationally Deprived Elementary and Secondary School Pupils of Louisville, Kentucky* (1966), p. 1.

jectives and special educational needs which the Classes of Twenty has been designed to meet.[2]

Each Friday, it was apparent that the children were fascinated and were beginning to have an awareness and an appreciation of all the work involved in the making of three-dimensional figures. There is no doubt that the minds of the young ones remembered much more easily and appreciated a lot more the first-hand experiences of this activity which involved their imaginations than the passive activity of observing figures in the textbooks.

In clarifying the need for this extra class activity (i. e., paper folding of three-space figures), I can say specifically, after observing the effects that it has had on the attitudes and work habits of the pupils who were achieving far below their grade level expectancy, that this class activity can help any mathematics teacher to obtain the following primary aims:[3]

1. Recognition of certain basic figures;
2. Development of such basic skills and techniques as the construction of geometric figures and the proper use of a drawing compass and protractor;
3. Acquisition of basic vocabulary and certain facts, such as the sum of the angles of a triangle;
4. Development of an appreciation of the beauty of geometric form; and
5. Elementary training in space perception.

Three-space figures have always been a source of wonder. They serve a useful purpose in promoting understanding of concepts and principles, in concentrating interest and attention, and in securing the active participation of the student in the learning activity. For a class to set out to make the full set of three-space figures is an activity which demands patience, teaches skill, satisfies instinct, arouses interest, stimulates enthusiasm, ensures pupil involvement, and brings much pleasure. In fact, the main use of a model is the pleasure derived from making it. Cundy and Rollett refer to this as being the creative value of a model.[4] When it is made it can be used to demonstrate the fact which it illustrates. This will appeal more to the pupil if he actually made it, moreover, he will remember much

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[2]*Ibid.*, 11-12.

[3]Bruce E. Meserve and Max A. Sobel, *Mathematics for Secondary School Teachers*, (Englewoods, N. J.: Prentice-Hall Inc., 1962), p. 177.

[4]H. Martyn Cundy and A. P. Rollett, *Mathematical Models*, (London: Oxford University Press, 1961), p. 14.

more easily its parts. Crudeness of construction is no drawback to the usefulness of a model and may even be an advantage in stimulating someone else to do better.

To exercise a great fascination over the minds of the young ones, I can think of no better activity than paper folding of space figures. Excellent models[5] can be constructed out of construction paper, which works very well in projects of this sort. Even parents became involved in our growing awareness of 3-dimensional figures. Reports from the home indicated that children enjoyed asking startled adults, "Do you know what a rhombicuboctahedron looks like?

Reporting on first hand observations of geometric figures we see every day provided rich and varied conversational materials, language arts experiences, intensely interesting concepts, and the discovery of concrete examples of regular space figures.

The emphasis on our class activity has been on an experimental, informal, investigative approach, with the laboratory method of teaching as the predominant procedure. It is around this method of teaching that the best evaluation can be made; namely, teacher observation.

From our classroom experiences we found the list of materials, advices, and instructions suggested by Cundy and Rollett to be very appropriate for students.[6]

The unfolding of our classroom activities for underachievers was given with the hope and distinct understanding that this pleasant experience will be as much the reader's as our own. As in all subjects, the student learns more when his interest is stimulated.

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[5] *Ibid.*, p. 79-81.
[6] *Ibid.*, p. 15-18.

SEEKING A GOOD GENERAL MATHEMATICS PROGRAM

ROYCE A. SPECK, Teacher
Elizabethtown High School

In 1966, we here at Elizabethtown High School, under the direction of our Principal, Mr. Paul E. Kerrick, undertook a study to improve our general mathematics program.

Our first step was to put together a class of ninth and tenth grade boys who had signed up for General Math 9. The idea of one class of general math consisting only of boys was for motivating reasons, but this was not really necessary as we found out during the next school year with a class of both boys and girls.

The first six weeks were spent on general mathematics with emphasis on fundamental principles and the application of these principles to problems that the student will meet in his future. One such problem dealt with was the calculation of the true rate of interest from automobile advertisements in the newspapers. The class also went to the gym and worked problems dealing with perimeter, area, and computation of the seating capacity.

At the beginning of the second grading period, we decided to challenge and motivate the students in a different way. The class was of average ability in general mathematics. We felt that if we were going to really teach these students something, we needed a new direction. The class understood they would soon be seeking employment. They also knew that the following three factors entered into their gaining employment: a recommendation, their high school record, and a score on an employment test. We concluded that the best way to raise their score on an employment test would be a working knowledge of basic algebra. This was a class of students of average general mathematics ability.

We started at the first chapter of an Algebra I text and followed it until the end of school. We did not rush, nor did we concern ourselves with the more difficult problems in each section. We wanted a working knowledge of the basic algebra. Starting this late, we did not finish the book, and none of the students received Algebra I credit. During the next school year, some of the students took a regular Algebra I course, and one member of this group led his class with an "A."

The second year of this program was started differently. Instead of selecting a group, students were taken as they came to sign up for General Mathematics 9; and the class started on the very first day, with proper explanation, in Algebra I and continued until the end of the year. Several of the students received Algebra I credit and planned to take geometry as their next mathematics course.

Some few students were much below the others in general mathematics ability. We believed that they needed more work in arithmetic than in algebra. They were given programmed or diagnostic type work which showed their areas of weakness. Then they were alternately given work and tests until each area was improved.

I see three conclusions from these two years of this program. First, most of our students would profit from taking algebra. It is something new for the pupil to learn, and it reviews all the principles of basic mathematics as well. Second, it is possible to find some gifted students who for some reason were guided into the general mathematics program. I can think of two with I. Q.'s of 130 and 120 who did outstanding work in algebra. These would not have reached their potential in a general math class. Third, students of lower than average mathematics ability should be in a class of basic arithmetic of the diagnostic type.

We believe that there should be a similar course in geometry for those students who do not receive algebra credit to take as their second math course. It should lean more to the practical or problem side than to the theoretical side.

The basic philosophy of our school system, as stated by our Superintendent. Mr. T. K. Stone, is "For every child—all he is capable of becoming." For our general math program, I believe algebra best accomplishes this for students of average and higher general math ability.

AN EXPERIMENTAL APPROACH IN GENERAL MATHEMATICS II AT TODD COUNTY CENTRAL HIGH SCHOOL

MRS. VIRGINIA THOMPSON
Todd County Central High School
Elkton, Kentucky

The second course of general mathematics had always created a problem at Todd County Central High School. This course had been a catch-all for people needing the second credit in math and had students coming into it with a course in a very simple basic math, a more advanced basic math, or elementary algebra. This year these classes were composed of students with IQ's ranging from 52 to 129 and math achievements ranging over several grade levels.

Until this year this course had been taught in a traditional classroom situation, using the textbooks of fundamental arithmetic, practical application in measure, and everyday problems. The members of the math department decided that this was not meeting the *needs* of the students. After much study and research, we decided to experiment with programmed material for this class.

Programmed material changed the whole climate of the classroom; everything was centered around the individual child. All instruction was individualized, with each child working at his own speed and on his own level during class time. Since the role of the teacher was so greatly changed, adjustment was for a time difficult. No longer was the teacher the leader, "pulling and pushing the students," but instead a supervisor aiding only as the need arose and administering checks at certain intervals.

A wide variety of programmed material was selected from Encyclopedia Britannica Press, Behavioral Research Laboratories and Addison-Wesley. The variety provided suitable material for each student. Since the program was experimental, all of the students were started in a basic mathematics series of five books. This proved to be a mistake. Next year a test will be given to determine individual needs and placement will be made accordingly. At the beginning of the year an inventory survey was given. When a series of five books were completed, a second inventory was given. Ninety-eight percent of the students showed improvement, with increases ranging from 50% to over 100% in some instances.

At times during the year the students became bored with the routine of constant work. To overcome this, units of different subject matter were used. However, this method of having students work on programmed material part of the week and something else the rest was not too successful. It seemed to confuse the students to change their line of thought too frequently, so these extra units were subsequently taught without any intervals of programmed material. Some students, also, tended not to work as they should. To correct this to some degree, a certain percentage of their final grade was based on their participation during class. At the same time they were helped to understand that they were competing with their own past performance rather than with each other.

One of the greatest advantages of this program was the aid it gave the absentee. Absences had always been a problem with many of these students. Instead of having to come in during study hall to get help with the material that was missed, the student now knew where to begin and he could continue on his own. With several students who began school as much as a month late because of farm work, this was very advantageous.

Programmed material did not mean mass promotion, for some students did not work up to their potential. Some students were on such an extremely low ability level that they were not able to handle any of these materials, even with much teacher help and encouragement. In some cases, the SRA Computational Skills Kit and Addison Wesley ASMD Programmed Texts were used successfully. In two instances none of the material could be mastered. However, other material, McGraw Hill Programmed Math for Adults, has now been obtained and should be of aid to these students in the future.

After completing the basic mathematics series, the students selected the branch of mathematics they wanted to pursue further. In the classes, students could be found working programmed material in Algebra I and II, Consumer Math, a modern approach to mathematics, and Plane Geometry. Many of the students accomplished much in these fields, even more than the teacher had expected.

In these classes programmed material seemed to accomplish its purpose as well as, if not better than, any other method used. This proved to be a good approach in meeting the individual needs of the students enrolled in General Mathematics II at Todd County Central High School.

JEFFERSON COUNTY ADDS TWO NEW DIMENSIONS TO THE MATH PROGRAM

LEO COLYER
Supervisor of Mathematics
Jefferson County Public Schools

During the summer of 1968 the Jefferson County Board of Education conducted two in-service workshops devoted to computer programming. Thirty-eight teachers participated in these workshops in which the Olivetti Underwood Programma 101 desk computer was used. The objective of the workshop was to acquaint teachers with the computer to the degree that they can use the machine in a computer-assisted mathematics program.

A program of this kind was introduced at Fairdale High School during the 1968-1969 school year. It is believed that the computer will be invaluable in speeding up the solution of many problems that normally take much time which could be used profitably in working with additional, and perhaps more advanced, mathematical concepts.

Students will learn the principles of digital computers and appreciation of the computer's role in our world of expanding knowledge and scientific accomplishments. They will learn the basic steps of computer programming and will actually write programs for problem solving. Emphasis will be placed on student involvement at all times, and students and teachers will utilize the computer as much as possible when discussing daily assignments. In addition, research projects and extra-class computer activities will be encouraged.

Moreover, the program will be evaluated continually during the year to determine the possible uses of the computer in the junior high and elementary mathematics programs.

Advanced Placement Classes Added

The Jefferson County Board of Education has rewritten its mathematics curriculum for its Advance Program to provide for the completion by the end of the eleventh grade of the prerequisites for the Advanced Placement Program in Mathematics. There are two distinct course descriptions for twelfth grade Advanced Placement Mathematics denoted Calculus AB and Calculus BC.

Calculus AB can be offered as an Advanced Placement course in the senior year by any school that is able to organize a curriculum for mathematically talented students in which all of the prerequisites for a combined year's course in elementary functions and calculus are completed prior to grade 12. If students are to be adequately prepared for the Calculus AB examination, well over half of that year's course must be devoted to topics in differential and integral calculus.

Calculus BC can be offered by schools that are able to complete, prior to grade 12, a substantial introduction to elementary functions in addition to the prerequisites for Calculus AB. Calculus BC is an intensive full year course in calculus which places due emphasis on theoretical aspects of the calculus of functions of a single variable and which includes topics in infinite series and differential equations.

Beginning this year and continuing for perhaps two more years the Jefferson County Schools will offer Calculus AB, a less rigorous Advanced Placement course, in the twelfth grade. It is believed that by the end of this two or three year period, articulation in the mathematics curriculum of the Advance Program will have taken place and that Calculus BC can then be offered in the twelfth grade.

In seeking to prepare personnel to teach effectively Advanced Placement Mathematics, Jefferson County sent three teachers this past summer to the National Science Foundation Institute for teachers of Advanced Placement Mathematics at Michigan State University.

INNOVATIONS IN SECONDARY MATHEMATICS FOR NON-COLLEGE-CAPABLE

MRS. ANNABELLE BRASHER
Mathematics Supervisor
Hopkinsville Public Schools
Hopkinsville, Kentucky

For the past few years, the secondary students in the Hopkinsville Public Schools have been grouped homogeneously for mathematics and textbooks have been chosen especially for the various groups. However, the mathematics teachers have been concerned because the materials being used for the non-college-capable students were not really suitable and our goals were not being met. Even after grouping, these students continued to have no interest in mathematics and no desire to improve. Therefore, the mathematics supervisor contacted many schools throughout the country to find out what others were doing and to get ideas that might be helpful. The mathematics teachers met with the mathematics supervisor frequently throughout last year to study the materials received and to decide upon a completely new program for these students.

This year in grades 7, 8, and 9, the textbooks have been supplemented by more suitable materials prepared during the summer by a committee of teachers working with the mathematics supervisor. Title III funds made this phase of the work possible. First it was decided that a sequential program should be planned for the three grades rather than each being a repetition of the same topics. Each of the three years was to start with a new and different topic instead of with review. For the seventh grade we chose flow charting, a topic which could be built upon throughout the year and in future years. The eighth grade topic selected was clock arithmetic, which proved to be very popular with the students and also let us get in some review of basic facts in disguise. Probability in the ninth grade gave the students a chance to experiment with something interesting and helped to get the year off to a good start. Next, materials to fit the remainder of the course of study that was chosen for each grade were selected and prepared. These included practical applications such as ordering from a catalog, games and ideas that could be used for fun and drill, and exercises to supplement those in the textbook, generally easier and giving better explanations. A great deal of variety was planned for each grade. Then the mathematics supervisor prepared charts for each grade, listing where all material on each topic could be found and a guide giving suggestions for the order in which they should be used throughout the year.

In grade twelve, Title I funds have made it possible for us to equip a mathematics classroom as a laboratory. Desk calculators (one for every two students) constitute a major part of the equipment and are used to take the tediousness out of the calculations. They allow the emphasis to be placed on setting up the problem rather than on doing the computation. A cash register, a full-keyboard adding machine, and a forms register are used when we simulate the operation of a retail store. Individualized and small group instruction is made possible by the use of a tape recorder and listening stations, and a tachistoscope is helpful for remedial work for large or small groups. Other special items include probability supplies, surveying equipment, a small pool table for teaching geometry, and a camera with which the students prepare series of slides for teaching purposes. An incidental benefit from the business machines is the learning of skills which may be useful when the students get jobs.

No textbook is used for the twelfth grade course. The local businessmen have supplied us with examples of ways they use mathematics frequently and with related problems on their company letterheads. These problems are the heart of the course because they show the student his need for mathematical skills in a much more meaningful way than any textbook can. Receiving a copy of the problem right on the business letterhead makes these quite realistic to the students and gives them the incentive to acquire the necessary skills to solve the problems.

Here is an example which was contributed by the Hopkinsville Monument Company:

Granite weighs 180 pounds per cubic foot. Freight charges are $1.80 per cwt. Calculate the freight charges on the following monument:

Die 6′ long x 1′ thick x 3′ tall
Base 8′ long x 2′ thick x 10″ tall

In order to work this problem the students must be familiar with several concepts of measurement-abbreviations, changing from one unit of measure to another, volume, etc. Thus the teacher is given an opportunity to teach these topics as the student sees the need for them. He is much more willing to learn because he knows the problem is a real life one.

Other problems which we have received cover such topics as determining moving costs, finding how much paint to purchase to give the walls of a room two coats, figuring the cost of re-shingling a house and of adding a patio, computing the cost of a set of tires when a chain discount is given, finding the cost of buying a refrigerator on time, and deciding whether to accept a bid of so much per cubic foot of space in a house or so much per square foot.

Many different activities are being carried out in this course in practical mathematics. Businessmen have frequently been guest speakers, and field trips have been taken to several businesses. One project involved the selection and purchase of a share of stock during a visit to a stockbroker's office in September, followed by its sale in May. Other topics covered include payroll, income tax, buying and operating a car, buying a house, insurance, surveying, probability, planning a vacation, and many others that the students will need to know as consumers and as members of the working world.

The following are typical problems furnished by local business men.

From Southern Printing, Incorporated:

How much will 5,150,000 Flour Coupons cost per thousand? The coupon is printed on the front and back. Coupon runs 32 on sheet, 17¼" x 24"

The paper 17¼" x 24", weighs 22 pounds per 500 sheets, cost 22¢ per pound.

It takes 1 pound of ink (@ $4.00 per pound) per 7,152 impressions (an impression being each time sheet goes through press).

The press will average 4,000 impressions per hour @ $10.50 per hour.

It will take ¼ hour per 500 sheets to cut the coupons into individual coupons. Cutting @ $4.60 per hour.

To bank 24,000 coupons and wrap 24,000 coupons into packages and labeling outside of package will require 10 minutes each package. Rate — $4.75 per hour. Any left over part counts as whole package.

The artwork, negatives and offset plates cost $350.00

From the Kirkpatrick Concrete Supply Co., Inc.:

In answer to your letter requesting sample problems concerning everyday business, I am listing a few below with the answers. These are sample problems that we figure several times a day in our business. I would like to point out that concrete is sold by the cubic yard and we have to convert any figures given to us into cubic yards and our break down is on the quarter of a cubic yard. As there are 27 cubic feet in a cubic yard, some of our answers fall between these quarters of a yard and that is the reason we go to the next yard.

Our customers will call in and tell us they have a garage floor to pour that is 20 feet wide 24 feet long and 4 inches deep. How many cubic yards will it take to pour this floor?

The next person to call in will say he has a house footing to pour. The house is 60 feet long, 40 feet wide. The footing will be 20 inches wide and 8 inches deep.

If the price of the concrete is $14.90 cubic yard, how much would each of the above jobs cost?

From The Sherwin-Williams Co.:

Determining square footage area for purpose of estimating amount of paint to be used.

Item: Water Tower
Hgt.: 130 Ft.
Dia.: 71 Ft.

Water tower to receive two coats of primer and two coats of finish enamel.

Primer covers 375 square feet per gallon. Finish enamel covers 425 square feet per gallon.

How much paint will it take to paint this water tower?

From D. B. Bostick & Son, Inc., Plumbing and Heating Contractors:

Figure the amount of heat required to heat a building 20′ x 40′ and 10′ tall using the following factors per sq. ft. of surface exposed to the outside. Windows take up 600 sq. ft. of the outside walls. The crack around the glass is 400 lineal feet.

Roof—11 BTU per sq. foot
Walls—26 BTU per sq. foot
Glass—85 BTU per sq. foot
Crack—85 BTU per foot

BTU per sq. ft. are per hour and we want the heat loss for the entire building per hour.

Sq. ft. of glass	X Factor =
Sq. ft. of outside wall	X Factor =
Sq. ft. of roof	X Factor =
Lineal ft. of crack	X Factor =
	Total

In the junior high classes and in the twelfth grade course, all activities are carried on during the class period, with very little outside work expected of the students. Most activities are planned so that each phase of them can be completed in one period. At all levels. the emphasis has been on making the students enjoy mathematics. Thus recreational activities play a vital part in each course, since a great deal of mathematics is learned "painlessly" in this way, and hence attitudes towards mathematics are improved and achievement is increased. Some of these activities include solving cross number puzzles. cracking codes. graphing pictures, working with magic squares, doing calendar arithmetic, and playing commercial games such as Euclid. Hi-Q, and Hex. Many puzzles and games from books such as *MATHEMATICAL FUN, GAMES AND PUZZLES,* by Jack Frohlichstein have been quite helpful.

The program for non-college-capable has been successful so far. More students are applying themselves and more are interested in learning than we have had in the past. Interest in the twelfth grade course has resulted in the enrollment for next year being double that of this year's, and several college-capable students have been attracted to it. Also we have decided to extend the course by offering a two-year program beginning in the eleventh grade next year. The response to this has been good.

We believe the results have been worth the effort and plan to continue to improve the course offerings for the non-college-capable students in the future.

PROGRAMMING ON A SHOESTRING

MR. W. T. WILLIAMS,
Fourth Form Head
Sayre School
Lexington, Kentucky

The two areas of computers and educational TV are probably the fastest growing fields in education today, and if we are to believe even a part of what McLuhan and others have to say on the subjects, we are behind before we start. In math a great deal of attention is being given to CAI (Computer Assisted Instruction) and other computer orientations. It is important to distinguish between CAI and what could be called COM (Computer Oriented Mathematics). It is not difficult to distinguish between the two in terms of money. CAI is an expensive venture requiring close cooperation on the part of programmers, mathematicians, psychologists, and teachers, while COM is something which can be done by the interested classroom teacher on a shoestring budget. Our experience here at Sayre proves this, and the students feel they have really benefitted from the program.

Four years ago Sayre was asked to participate in a pilot program sponsored by the School Mathematics Study Group (SMSG). The purpose of the program was to teach and act as critic for a new text in computer programming. The idea behind the SMSG approach was to introduce formally into the secondary school curriculum an introductory course in programming as a separate course offering.

Two texts were used. One (Algorithms, Computation, and Mathematics) describes in considerable detail the scientific approach to the construction of algorithms via the use of flow chart language. The second book, a supplement to the main text, describes one of the technical languages for direct access to the computer. These supplements are available in FORTRAN, ALGOL, or COBOL. We used FORTRAN. There is no great initial advantage in the choice of language; however, many of the newer languages (BASIC, QUICKTRAN, CAL) are much simpler and may be better.

SMSG made computer time available on the IBM 7040 at the University of Kentucky and we were able to continue the arrangements when we no longer served as a pilot school. The University now has the IBM 360 system which is considerably faster than the 7040 and, as a result, cheaper.

The approach used in teaching the course was double-barrelled. First, the algorithm we needed for a certain problem was developed by the techniques suggested in the flow chart text. We then wrote a program in FORTRAN with the aid of the FORTRAN text and put it into the machine. Actually, each student programmed the problem in his own way. As a consequence, several solutions were available which differed only in language. Each student submitted his problem to the machine and received his own results. The machine allows for some flexibility in programs, but, generally speaking, will not accept an error in logic. The machine has a number of prerecorded error messages, and if the program has an error, it will print out a message indicating the error as closely as possible. Since each student communicates directly with the machine, a great deal of interest is generated, and the competition between students and machine becomes quite keen.

After one problem was completed, we went back to the flow chart text to pick up another. This bouncing back and forth was continued throughout most of the text, or, as in our case, until we had worked eight problems.

The texts were written for the average tenth grade student, but we used them with accelerated eleventh and twelfth grade students in our regular courses. The program as conceived by the SMSG group is probably a little ambitious for the average tenth grader.

There is no question of the value of the program. Although the course was called computer programming, one really must know his elementary mathematics or he will not be able to communicate effectively with the machine concerning problems other than very simple ones. You may recall the old cliche that one does not learn his algebra well until he tries to work some problems in calculus. The same is true for computer mathematics.

The most important benefit is that the student is presented with a very immediate need for knowing his mathematics. Furthermore, the rapidity of the machine offers such an attraction that few youngsters can resist the urge to use it.

Since our experience with the SMSG program, we have made several adjustments which we feel have preserved the mystique of the machine, have been successful in introducing the youngster to a very useful tool, and, most importantly perhaps, have preserved our present math curriculum.

Obviously, the easy way to offer the course is simply to set aside a semester for it and begin. However, the high school mathematics curriculum has absorbed a great deal of college mathematics during the past ten years, and it is difficult to see how part of those eight semesters can be given up to another program.

An approach which has done everything we feel should be done in this area is to enroll the youngsters in the regular mathematics courses for the twelfth grade (Analytics and Calculus or Finite Math). The first six weeks period is devoted to a study of the construction of algorithms with the use of flow charts. Starting with simple summations we work up through sorting, the Euclidean algorithm, the Fibonacci series, and games.

A couple of lectures on how the computer works are capped off with a tour of the computing center. The youngster is instructed in how to use the key punch machine and given eight problems. It is up to him to work all the problems with the aid of the FORTRAN text. Naturally, a few minutes of class from the regular course should be taken to answer pertinent questions, but, generally speaking, students do very well in working out their own salvation. If all problems are worked to the instructor's satisfaction, one-half credit is given in computer programming.

No test as such is given except during the introduction to flow chart language.

One set of possible problems is given below. Variations are necessary, of course, since the students' mathematical knowledge must be considered. Certainly it is an impossible list for tenth grade students and a difficult one for seniors. However, the problems must be challenging from a logical standpoint since the machine is to do the laborious part—the pick and shovel work.

1. Read a card containing five numbers. Find the sum and arithmetic mean. Print out the sum, mean, and the five numbers.
2. Read a card containing ten numbers. Find the square root of the sum and the square root of the average. Print out the sum, average, and their respective square roots.
3. Read 10 cards, each containing one ordered number pair. Determine the position of the point represented by this pair on the XY-plane and print out appropriate hollerith statements.
4. Determine the one-hundred cumulative sums of the first one-hundred integers. Print out the number of addends and their sum (one hundred answers).
5. Input two linear equations and determine the intersection, if any.
6. Read a 50 element linear array (A^k) and construct a new one-dimensional array (Bi) using the formula Bi = A(k+1)–A(k).
7. Find a real root of a cubic equation.
8. Perform a sorting problem using DO statements.

Three hours of machine time is sufficient for fifty people. Fees vary, but $130.00 an hour is reasonable. Various input media can be used, but cards are probably best. Punched tape, magnetic tape, and the teletypewriter all present problems the student cannot readily handle himself. Utopia would be to have a key punch machine in the school so that youngsters could prepare their cards without the worry of transportation problems. Too, the business department could utilize the key punch machine in their office equipment course. The rental on these is about $85.00 per month.

No pretense is made at calling this a sophisticated approach. But it is one which allows the student to get some excellent introductory work at very little cost. Using this approach we found that youngsters interested in mathematics, either applied or pure, had their appetites whetted and their knowledge and understanding of elementary mathematics broadened considerably.

Ed. Note—Mr. William T. Williams is now Headmaster of Ballingbrook Day School, Petersburg, Virginia.

THE CALCULUS PROGRAM AT OWENSBORO HIGH SCHOOL

SHELDON REYNOLDS
Assistant Principal
Owensboro High School
Owensboro, Kentucky

The calculus and analytic geometry program at the Owensboro High School is an outgrowth of a program initiated in the junior high schools in the late fifties. At this time, the junior high school began to offer first year algebra in the eighth grade to a group of advanced or superior students, making it possible for these students to have five years of mathematics above arithmetic at completion of high school.

In the late fifties the Owensboro High School offered a course called "Senior Mathematics" or "Advanced Mathematics." This program was continued by different names until the school year 1963-1964. When I came to the high school to teach these advanced mathematic classes, the course was called "Analytic Geometry." The text in use included sections on solid geometry, plane trigonometry, analytic geometry, a few pages on calculus, statistics, and advanced algebra.

The calculus program we have now at the high school came about more as an experiment or more as a request from a few students than as a planned program. I started teaching the book mentioned above to two classes. One class, of nineteen pupils, was content to stay in this text, but in the other group thirteen students were not happy with the material. They claimed they were repeating too much and would like more advanced mathematics. I asked them if they would like to purchase text books and really study calculus. They expressed a desire to do this. In searching for a text the only reasonably priced book was an old traditional text. We ordered thirteen of these and started the study of calculus. Students had already had a good section on analytic geometry in the first text.

The following fall these thirteen students went to various schools throughout the United States and we were very much pleased with their grades. One pupil went to Yale and made an "A." We had pupils at Washington University in St. Louis, Georgia Tech, and Vanderbilt. Several went to the University of Kentucky and received "A's" in their first course in calculus. We have had such good results with the grades our pupils have made after taking this course that we have continued in about the same pattern. We teach twelve weeks of analytic geometry and follow this by twelve weeks of differential calculus and twelve weeks of integral calculus.

The principal of the high school, Mr. Joe O. Brown, and the head of the Mathematics Department, Miss Geneva Foust, have encouraged the work we have done in these classes. In the next few years, we will probably adopt a text that will combine and unify analytic geometry, differential and integral calculus. It will devote more time to theory than applied problems.

There have been people who object to calculus' being taught in the high school. Their two main objections are that the pupils become over-confident and run into trouble later. The other objection is that high school teachers are not qualified to teach calculus. We will agree that these points are well taken, but we would like to point out that in recent years the National Science Foundation has made it possible for teachers to pursue advanced work in graduate mathematics so that at the present time many of the high school mathematic teachers have as many college credits in mathematics as some college teachers had a few years ago.

I understand that there are only four high schools in the state that offer a course similar to ours and that we have the largest number of pupils taking calculus. If our course has been a success, I believe it has been due to our two main objectives: to teach as much calculus as possible but at the same time to teach a love for the subject. The meaning and significance of the definition of limits and continuity are not easily grasped. Complete understanding generally comes after a period of time and use of these definitions. It would be very easy to make this course so difficult that pupils would hesitate to sign up for it. No material is given on a test unless the pupils have had an ample opportunity to learn this material. My advice to any school system thinking of putting calculus into its program would be to select an instructor interested in pupils and not one who takes pride in failing as many as possible.

We have also changed our math program in the tenth and eleventh grades. Up until three years ago, we taught plane geometry in the tenth grade, plane trigonometry and solid geometry in the eleventh grades. The last three years, we have unified geometry in the tenth grade and trigonometry and analysis in the eleventh grade.

One other thing is worth mentioning: we try to keep up with our students after they leave our school. Many of them send me copies of their test and examination papers. This is a great help to me in planning my class work. Each year during Christmas vacation, we have a class reunion for the ones who graduated the previous spring. It is very interesting to hear them discussing their courses and teachers after their first few months in college.

By statistics I do not mean a collection of numerical facts, but the science of organizing data and making decisions or predictions through the analysis of data. One might say that statistics is the quantitative science of learning by experience. The mathematics underlying this science is known as probability theory.

All of us make statistical decisions every day. Suppose we put the cat out before dinner because we are afraid he may jump on the table in the middle of the meal. Probably the cat hasn't always jumped on the table when he was allowed in at dinner, but it has happened often enough (especially when we are having fish) to convince us that we had better put him out. To put the cat out is a statistical decision based on our estimates of his probable behavior and the inconvenience it might cause, balanced against whatever inconvenience there may be in finding the cat and the pangs of conscience we may feel about banishing him to the cold.

In this situation the data were considered only informally because they were clear and (probably) overwhelmingly strong in support of our decision. Statistics has a serious role to play when the data are either weak or obscure. If we sample a dozen voters in a municipal election and find that seven prefer candidate A to candidate B, the data are clear enough but the small sample size makes them very weak. We can hardly be convinced by these data that A is a shoo-in. Statistics will help us decide what credence we should put in the results of the poll.

Andrew Gleason, "The Interface of Science and Mathematics," *The Bulletin of the National Association of Secondary School Principals*, 52:327 (April, 1968), pp. 124-125.

A MERIT RATING IN MATHEMATICS

ELIZABETH B. JAYNE
Chairman, Mathematics Department
Paul G. Blazer High School
Ashland, Kentucky

In the spring of 1965, the State Department of Education instituted the merit rating system to recognize schools which had superior programs in certain areas. This system meant that along with accrediting, the State Board of Education would also give a school extra commendation for maintaining an exceptional program in a particular subject area. Dr. Harry Sparks, Superintendent of Public Instruction at that time, advocated such a system, saying that it would be one way to ensure that districts strived for quality education.

The teachers in the mathematics department at Paul G. Blazer High School, feeling that they had a fairly strong mathematics department, wished to investigate the possibilities of a merit rating. The department found the criteria for application to be fairly subjective.

The mathematics department conformed to the guidelines which were set up by the State Department of Education as a basis for application in the following ways:

1. Each teacher in the mathematics department possesses a bachelor's degree and is teaching in his major field. All of the teachers have had recent courses in modern mathematics.
2. The teachers wrote a "working" philosophy for the department. This philosophy is being continually revised. This continual revision helps the faculty to be constantly aware of changes in pupils' attitudes toward mathematics and aids the department in improving its teaching methods.
3. The courses offered in the mathematics department are more than the minimum requirements for graduation. At the present time the department offers in grades ten through twelve the following courses—Modern Algebra I, II, and III, Modern Geometry, General Mathematics II, Trigonometry, and Advanced Mathematics (this is a college preparatory course, not just advanced high school arithmetic). At any time there exists sufficient demand by the students for a new course to be added to

the curriculum, the proposed course is thoroughly studied and, if deemed worthwhile, is added to the curriculum.

4. Each pupil enrolled in a mathematics class is leveled according to his ability. There are three levels for Modern Geometry and Modern Algebra II. Since the higher ability students take Algebra I in grade nine, there are only two levels, II and III, for Modern Algebra I. At the present time there is only one Advanced Mathematics class. The Algebra III and Trigonometry course has two levels, I and II. The lower the number the more accelerated the course.

The mathematics department maintains a confidential information card for each pupil enrolled in mathematics. These cards are first filled out in grade nine. Each card contains the pupil's I. Q. scores, scores on achievement tests in both reading and mathematics, and grades received in mathematics courses beginning in grade eight. A space is provided for the pupil's teacher to make any recommendations concerning successive mathematics courses.

These cards are kept by the teachers for the pupils they have in class. They are helpful in checking past performance and in determining if a pupil is working up to his ability. At the end of each school year the teacher completes the card for each student for the year and makes his recommendation for course and level for the next year.

A student may be permitted to move to a higher level if he feels that he can do the work and if he has his teacher's recommendation. He may be permitted to move to a lower level if he is having difficulty, also upon recommendation of his teacher. The teacher may suggest that a pupil change levels if he feels that this would be to the pupil's advantage.

The difference in levels is based upon how thoroughly a topic is covered and the number and difficulty of problems assigned. At the present time, the same textbooks are used in all levels. The lower level classes need more detailed explanation and are not required to solve (though they are encouraged to try) some of the more difficult problems. The higher level classes require less detailed explanations and are expected to do some individual investigation as well as many of the more difficult problems.

5. The mathematics department has acquired, under the Federal Government Title III Program, a wealth of audio-visual equipment. This apparatus includes such items as transits, plane tables, hypsometers, angle mirrors, demonstration slide rules,

alidades and various other materials for demonstrating mathematical principles. Several of the mathematics classrooms are equipped with overhead projectors. Many prepared transparencies for overhead projectors are also available. The teachers have access to equipment for making transparencies tailored to their particular teaching. Several filmstrips are available to the department and beneficial films can be readily secured. When not in use, audio-visual material is stored in an instructional supply room. This equipment can be used by any teacher in the department on short notice. There is no lengthy checking-out procedure or previous notice needed to use this equipment.

6. The teachers meet about once each month (or whenever necessary) to correlate the courses and discuss any new ideas, textbooks, or questions which may arise.

7. The library has available to the students and teachers in the mathematics department many of the books recommended by the National Council of Teachers of Mathematics for high school libraries. These books were ordered upon recommendation of the mathematics teachers.

8. Upon completion of application for a merit rating the mathematics department was visited by a team from the State Department of Education. This team observed each teacher's teaching and student reaction. The team talked individually with the teachers and questioned each one about his work. Many of these questions pertained to the number of failures to determine if individual needs of the pupils were being met.

The mathematics department is continually striving to maintain and improve the department. The teachers are presently studying the possibility of offering an elementary course in computer programming in the fall of 1969. The teachers are trying to find better ways of leveling classes. Any new audio-visual equipment and materials for replacements are requested to be ordered. The teachers are constantly aware of new publications in mathematics and make recommendations to the library for those which would best benefit the students.

The attainment and maintenance of the merit rating by the mathematics department of Paul G. Blazer High School requires the department be subject to continual review and constructive criticism for constant improvement. This criticism is appreciated whether given by fellow teachers, the administration, the public, or by other school systems. We try to make improvement a habit.

π

MRS. VERA CUMMINS, Teacher
Pendleton County High School
Falmouth, Kentucky

"What are those numbers?" "What's that supposed to be?" "Is that all one number?" Those were comments heard from my homeroom the morning after the hanging of . π . by some of my advanced mathematics and calculus students. Earlier in the week I had shown my advanced mathematics class a copy of Computation of . π ., RS-7 of the School Mathematics Study Group Report Series which had just arrived. In this booklet a computer number evaluation correct to 2,000 places is given. After finishing a test, some of my students asked if they could display the number. Knowing that it would take up too much room on the chalk board we decided to hang it around the wall. The students wanted it displayed completely horizontal so that the effect of length would not be obscured. They obtained two rolls of wide adding machine tape, magic markers and masking tape and went to work. It took several days of working during their study periods to finish the number. We mounted it high on the walls above the chalk boards, and it encompassed the room two and one-half times. As the students viewed the number around and around, their expressions became full of wonder and amazement. One boy said, "Its unbelieveable, and just think, that's not the end. It just keeps going on and on."

I had planned to take it down in a week or so, but the students guarded this number as if it were their own discovery. They brought other students into the room before school to see it, and each time the tape began to loosen from the wall they repaired it.

The awe inspired by this accuracy in the evaluation of . π . had its roots earlier in plane geometry. This was the students' first introduction to trigonometry and was used in finding the area of a triangle when two sides and the included angle are known. In our text there is that magical page entitled, "Four Place Table of Trigonometric Function." After explaining the procedure the following dialogue ensued:

Teacher: Do you understand the definition of the function?
Class: Yes.

Teacher:	Do you understand how to read the table?
Class:	Yes.
Teacher:	Do you understand how to use this table in solving the problems?
Class:	Yes.
Teacher:	Do you believe these values are correct?
Class:	Yes.
Teacher:	Why?
Class:	Silence
Teacher:	Well?
Student:	They are in the book.
Teacher:	If all the tables were destroyed could you work the problems?
Class:	No.
Teacher:	How did we get the tables to begin with?
Class:	Someone had to make them.

Thereupon we started to derive our own tables and spent a week of class work on this project. Every student had to derive his own sine, cosine and tangent tables correct to three decimal places, and we used multiples of 5° from 0° to 90°. The only tools that were allowed were the straight edge, compass, and graph paper, agreeing that if necessary one could have made his own graph paper with straight edge and compass. This requires a great deal of working space especially in obtaining the tangent values. The students were constantly reminded that the accuracy depended on the tools they were using and their own exactness in using them.

Soon, we came to the section on the circle. As we all know, . π . is defined as the ratio of the circumference of a circle to its diameter, or C=. π . D, and is given correct to four decimal places as 3.1416. This time I did not have to ask the questions as the students wanted to know if they could determine . π . using the trig tables we had devised. We used the limiting process of inscribed and circumscribed regular polygons and after another week of class we obtained our value. It took the construction of 60-sided regular polygons to obtain an accuracy correct to two decimal places.

There were times during these procedures when I questioned the value of these unplanned projects. It would have been much simpler to have said to the class, "Here it is, accept it."

I believe that these projects were valuable to the students. Probably, some of the students gained only the right to say to their children someday; "If you think geometry is rough now, why I had to evaluate . π . when I was your age." However, I know that most of the students learned to question the "how" and the "why." The amazement that inspired them to hang . π . was not the computer evaluation itself. Rather they had discovered what could be done with a keen mind, perseverance, and simple tools, and now they have a glimpse of what man is capable of accomplishing using sophisticated tools.

If mathematics was completely changed *internally*, this amounts to nothing compared to the changes in the ***applications*** of mathematics to science and technology. The advent of high speed electronic digital computers constitutes an industrial revolution second to no other. Even the question of *who uses mathematics* has a different answer nowadays. In 1900, one could answer: physicists, astronomers, chemists, actuaries, and engineers. In the 1960's, the answer can be inferred from such facts as the observation of colleges *where the computer laboratory is located in the school of education.* Nowadays one would have to answer: biologists, economists, psychologists, physicians, geologists, metallurgists, meteorologists, military decision makers, business decision makers, educators, historians, linguistics experts, sociologists, epidemiologists, lawyers—and, as before, all of those who work within mathematics itself, or in any part of the physical sciences and technology.

Robert B. Davis, *The Changing Curriculum: Mathematics* (Washington: Association for Supervision and Curriculum Development, 1967), p. 48. Reprinted by permission.

CURRENT CURRICULUM PROJECTS

CURRENT CURRICULUM PROJECTS IN MATHEMATICS

The listing that follows has been categorized to fulfill the arbitrary standards of this publication. First, those projects under the aegis of ESEA Title III U. S. Office of Education about which detailed information is available are summarized. Second, projects sponsored by the National Science Foundation are presented in resume. Third, other projects sponsored by the U. S. Office of Education and National Science Foundation are listed. Finally, those projects sponsored by private foundations and colleges and universities are summarized.

These listings were taken from the *Sixth Report of the International Clearinghouse on Science and Mathematics Curricular Developments 1968,* edited and published under the direction of J. David Lockard. University of Maryland. Given here are the names of the projects, the directors, the institutions with which they are connected, and a resume of purposes and objectives.

Many of these project centers publish valuable news letters and periodic reports which contain valuable information and ideas. Teachers and administrators who wish to keep abreast of innovative studies will find these projects worthy of investigation.

Projects Under The Aegis Of The Title III ESEA, U. S. Office Of Education

Advanced General Mathematics Curriculum Materials Proposal (Math III) J. Ben Cox, Director of Federal Projects, Richland County School District Number One, 1616 Richland St., Columbia, South Carolina. 29201

The purpose of this program is to develop effective materials for a third and fourth year program for students who, immediately after high school, will seek employment in business and industry or will seek additional vocational or technical training. Materials prepared for Math III are non-textbook oriented, utilize inductive learning, and stress daily student participation in concept development. This project proposes to ultimately develop a four-year General Mathematics program commensurate with student needs and abilities rather than simply improving the traditional two-year program. Topics for Math III were determined by results of a survey of business and industry.

Calculators in a General Math Laboratory. Gene Catterton, P. O. Box 69, Wynne, Arkansas 72396

Grade and Age Levels: General Math, 9th grade.

Central Iowa Low-Achiever Mathematics Project (CILAMP). Dr. Frank W. Broadbent, 1164 26th Street, Des Moines, Iowa 50311

This program proposes to develop materials for use in grades 7-9 with low achievers in mathematics; to provide teachers with an appreciation of the complex problem of low achievement; to develop and implement non-conventional teaching methods; to involve local businesses and industries in a concern for the problem; to investigate the specific causes of deficiencies in different types of low achievers; to evaluate the effects of the new programs, materials and techniques on the teachers and students involved.

Central Midwestern Regional Educational Laboratory—Comprehensive School Mathematics Program (CEMREL-CSMP). Burt A. Kaufman, CEMREL-CSMP, 103 South Washington St., Carbondale, Illinois 62901

The purpose of this program is to develop a totally individualized mathematics curriculum based on the spirit of the Cambridge Conference report, "Goals for School Mathematics," which will utilize modern technology to its fullest potential. It is also expected that this program will create, design, and build a model school of the future in which such a curriculum would operate. To this end, a systems approach will be taken. The chief difference between this and other projects is that the substantive aspects of education, the subject matter, is stressed. For this reason, professional mathematics will play a major and indispensable role.

1965-66 General Mathematics I & II Writing Project. Mr. George Hudson, Albuquerque Public Schools, P. O. Box 1927, Albuquerque, New Mexico 87103

The specific objective of this program was the preparation of mathematically sound, updated content of a difficulty level appropriate for use with less able high school pupils. Units were written by instructors who had been teaching the general mathematics pupils with whom the content was to be used in 1965-66 and 1966-67.

High School for One. Dr. Chester Hausken, Northwest Regional Educational Laboratory, 710 S.W. 2nd Avenue, Portland, Oregon 97204

This program is aimed at improving the quality and quantity of education for youth in rural, isolated high schools in the Northwest region by developing, field testing, evaluating and demonstrating, in cooperation with agencies and organizations self-instructional, multi-media systems of instruction in several subject matter fields.

Mathematics Computer Center. Dr. Virginia T. Gilbert, 321 So. 9th St., Apt. 15, Las Vegas, Nevada 89101

This center aims at expanding and enriching the entire mathematics curriculum including: increasing interest and holding power in math; deepening student's mathematical understanding; and extending the mathematical content as well as including practical application from science, engineering, business, and the community. Further aims are to help students develop organized thought processes; to show them the necessity of a precise mathematical formulation in problem solving through utilizing the computer as a tool and learning computer techniques; and to improve attitudes and values concerning the place of computers in our modern technological society.

Patterns in Arithmetic (PIA). Dr. H. Van Engen, Research and Development Center for Cognitive Learning, 1404 Regent Street, Madison, Wisconsin 53706

This project aims to provide a complete course in arithmetic for the elementary school as a means to re-orient the mathematics program and to provide in-service work for teachers.

A Program for Mathematically Underdeveloped Pupils. Dr. Jack L. Foley, Building S-503, Sixth Street North, West Palm Beach, Florida 33401

Purposes of this project are enumerated as follows: to develop appropriate materials that make a truly effective learning situation for non-college preparatory students; to develop techniques for measuring teacher and student changes in attitudes resulting from this curriculum innovation; to determine whether success in the program has an influence on the dropout rate in mathematics and from school; to evaluate results by testing, comparing effectiveness of techniques, counselor-student interviews, parent questionnaires and reactions of people not connected with the program; to give these students an appreciation for and a knowledge of mathematics; to develop criteria to identify students achieving below their indicated potential as opposed to students who normally learn at a slow rate; to diagnose the mathematical deficiencies of individual pupils to the end that specific causes for the deficiencies might be revealed and corrective teaching may be instituted.

The project has attempted, and succeeded to a considerable extent, to add prestige to a part of the mathematics curriculum that previously was totally without prestige. By inserting topics which were previously restricted to the college preparatory program, structuring to a considerable degree, and inserting high interest topics, the project is well on its way to establishing a mathematics program that is appropriate for a large part of the secondary school population. The project staff believes that, with high interest topics and prestige associated with the basic mathematics program, students and teachers will exert a greater effort in their mathematical endeavors.

Secondary School Mathematics Curriculum Improvement Study (SSMCIS). Professor Howard F. Fehr, Box 120, Teachers College, Columbia University, New York, New York 10027

The Secondary School Mathematics Curriculum Improvement Study (SSMCIS) has two main objectives: (1) to formulate and test a unified secondary school mathematics program (7-12) that will take capable students well into current collegiate mathematics; and (2) to determine the education required by teachers who will implement such a program.

Stanford-Brenton Computer Assisted Instruction Laboratory. Professor Patrick Suppes and Professor Richard C. Atkinson, Institute for Mathematical Studies in the Social Sciences, Ventura Hall, Stanford University, Stanford, California 94305

A full tutorial program in primary-school mathematics and reading is to be developed.

Teaching Mathematics Through the Use of a Time-Shared Computer (CAM). Jesse O. Richardson, Director of Computer Research, Research and Development Center, Massachusetts Department of Education, Olympia Avenue, Woburn, Massachusetts 01801

A major problem in the field of mathematics education is the development of new teaching tools. This proposed study has as its basic goal the development of a mathematical laboratory based on a time-shared digital computer. In working towards this goal the staff will focus on solving the following problems: (1) how can a time-shared computer be programmed to act as a useful tool for teaching mathematics; (2) how can classroom teachers be taught the necessary techniques to enable them to use this new teaching tool successfully; and (3) how can such multiple-user computer facilities be developed in line with economic constraints?

In addition to demonstrating the economic feasibility of this new approach, the staff plans to test the hypotheses that: a terminal teletypewriter connected to a large computer operated in the time-shared mode will give the mathematics student the feeling of working his own computer; having the computer on an "always ready" basis will encourage students to engage extensively in voluntary extracurricular use of the computer terminals; the presence of a continuously available real-time computer in the classroom will lead students to acquire a more thorough grasp of mathematics.

Projects Under The Aegis Of National Science Foundation

Boston College Mathematics Institute (BCMI). Stanley J. Bezuszka, S. J., BCMI, Boston College, Chestnut Hill, Massachusetts 02167

The major objective of the institute program is to offer courses and prepare instructional materials for teachers of mathematics. A distinguishing characteristic of the philosophy of this program is the emphasis on the structural approach to mathematics in combination with stress on the historical aspects of the subject.

Cambridge Conference on School Mathematics (CCSM). Mr. Hugh P. Bradley, Education Development Center. 55 Chapel Street. Newton, Massachusetts 02160

The program grew out of a conference in 1963 which explored curriculum reform needs in mathematics. The report of the conference, "Goals for School Mathematics," outlined exploratory thinking on mathematics curriculum. While it was recognized that the CCSM is not primarily engaged in the preparation of materials for classroom use, it was felt that it was necessary to develop and try out some materials to demonstrate the feasibility of the goals. Thus, a continuing part of the program has been work, with a limited number of schools, in developing and trying out units. Copies of the working papers are available upon request. In recent years the attention of the program has been turned towards the problem of teacher education and the integration of mathematics and science education in the lower schools.

Demonstration and Experimentation in Computer Training and Use in Secondary Schools. Professor Thomas E. Kurtz, Kiewit Computation Center, Dartmouth College. Hanover, New Hampshire 03755

The purpose of this project is to demonstrate the large-scale use of the computer as a broad aid to secondary education without requiring major curriculum changes or extensive teacher re-training. Through materials to be developed cooperatively with the participating schools, the staff expects to show the value of computing as an aid to course teaching in many subjects and as a significant mechanism for extra-curricular education of students. It is expected that these materials, appropriately reviewed and modified during the course of the project, will provide important guidelines for the development of the potential of computers in secondary education on a broad front.

Grand Rapids Mathematics Laboratory Project. Lauren G. Woodby, Mathematics Department, Michigan State University, East Lansing, Michigan 48823

The aim of this project is to train teachers in the use of a laboratory-discovery approach to learning mathematics.

The Madison Project of Syracuse University and Webster College. Professor Robert B. Davis, Mathematics Department, Smith Hall, Syracuse University, Syracuse, New York 13210

To develop, disseminate and implement a supplementary program in mathematics for nursery school through grade 12 is the goal of the Madison project. Special attention is given to the kind of creative learning experience which children can have in school and outside of school. This involves extensive consideration of the social organization of the classroom and of similar matters. In general, the "point of intervention" for the Madison Project is at the point of instructional planning on the part of the teachers. It is not at the point of designing textbooks or producing textbooks. Because of the emphasis on actual classroom experiences, the project makes a very large number of video tapes and films that show actual classroom lessons. At the present time, these films, or excerpts from them, are available in many different forms for study by teachers or by prospective teachers. In addition, the project for the last two years has put special emphasis upon "mathematics laboratories" and the use of physical materials; in doing this, it has often joined forces with the Elementary School Science (ESS) Project of ESI, and with the Nuffield Mathematics Project in England. The project has put particular emphasis upon operating workshops for teacher education, particularly in the cities of San Diego, Los Angeles, Chicago, New York, Philadelphia, St. Louis, and Washington, D.C.

School Mathematics Study Group (SMSG). Dr. E. G. Begle, SMSG—Cedar Hall, Stanford University, Stanford, California 94305

The primary purpose of the SMSG is to foster research and development in the teaching of school mathematics. The work of SMSG consists primarily in the development of courses, teaching materials and teaching methods. It is a part of SMSG's task, in cooperation with other mathematical organizations, to encourage exploration of the hypotheses underlying mathematics education.

Survey of Recent East European Literature in School and College Mathematics. Professor Alfred L. Putnam, Department of Mathematics, Eckhart Hall 411, The University of Chicago, Chicago, Illinois 60637; Professor Izaak Wirszup, Department of Mathematics, Eckhart Hall 413, The University of Chicago, Chicago, Illinois 60637

Principle aims of the survey are to develop an extensive information program on current Soviet and other East European mathematics at the school and college level; and to make available from these sources mathematical materials for teachers and students in American schools and colleges.

Projects Under The Aegis Of U. S. Office Of Education And National Science Foundation

Computer-Based Mathematics Instruction at the Stanford-Based Laboratory for Learning and Teaching. Professor Patrick Suppes, Institute for Mathematical Studies in the Social Sciences, Ventura Hall, Stanford University, Stanford, California 94305

Four major aims of CBMI are to develop an operational drill-and-practice program in elementary school mathematics, grades 1-6; to develop remedial work in basic mathematics for secondary school students at the drill-and-practice level; to develop a tutorial program in mathematical logic and algebra; and to develop a drill-and-practice program in spelling. The objective of both laboratories is then to test and evaluate these programs in as quantitative and in as scientific a way as is possible with methods of quantitative data analysis and behavioral and psychological theory.

Minnesota Mathematics and Science Teaching Project (MINNEMAST). James H. Wernta, Jr., 720 Washington Avenue S.E., Minneapolis, Minnesota 55414

Coordinated mathematics and science curriculum for grades K-6, and materials for in-service education of teachers are produced by MINNEMAST.

University of Illinois Arithmetic Project (At Education Development Center). David A. Page, University of Illinois Arithmetic Project, 372 Main Street, Watertown, Massachusetts 02172

The central theme of the project is that the study of mathematics should be an adventure, requiring and deserving hard work. Children who grasp some of the inherent fascination of real mathematics while they are in elementary school are well on the way to success in further study of mathematics and science. Students who are not to continue a formal study of mathematics deserve a taste of the subject that is at least as appealing. The project is not attempting to develop a systematic curriculum for any grade level, in the view that determining an adequate curriculum is not possible until more alternatives exist to choose among. What is needed are frameworks that provide day-to-day, "here-is-something-to-try" ideas for the classroom. The emphasis is on things that the teacher can begin working with soon. The term "new mathematics" is avoided by the project. More properly, the project seeks novel ways of doing old mathematics —new structures or schemes within which can be found large numbers of interrelated problems revealing significant mathematical ideas. Teachers participating in an institute work on sequences of such problems each week to become acquainted with the mathematics, and then begin to make up and try out their own sequences. Throughout its work, the project has found that improved computational skills usually follow work with its materials. Children will do impressive amounts of computation in order to solve problems that interest them.

University of Illinois Committee on School Mathematics (UICSM). Professor Max Beberman, 1210 W. Springfield, Urbana, Illinois 61820

Until 1962 the UICSM devoted its efforts to producing a highly self-consistent and inter-related series of texts for college bound students in grades 9-12. These texts are unusual in that they embody "discovery method" pedagogy; they were the first to introduce a strong deductive thread to the teaching of elementary algebra; and they introduce and use principles of logic and a level of precision in language which is not common to high school texts. Since 1962, the major curriculum development effort has been the development of unusual approaches to topics in junior high school mathematics appropriate for culturally disadvantaged students in large urban school systems.

University of Maryland Mathematics Project (UMMaP). Henry H. Walbesser, Director of Maryland Mathematics Project, College of Education, University of Maryland, College Park, Maryland 20740

The principal purpose of the project is to contribute to the improvement of the teaching of mathematics. The project has produced experimental textbooks for mathematics in junior high school and experimental textbooks for courses in mathematics for elementary teachers. In addition, the project has conducted research studies in the learning of mathematics. Presently the main efforts of the project are directed toward the development of an in-service course for elementary teachers of mathematics which incorporates behavioral objectives and specific evaluation, and the research into mathematics instruction with the use of behavioral hierarchies.

Significant Projects Of Professional Groups And Universities

California Mathematics Improvement Programs (MIP). Mrs. Bryne Bessie Frank, Bureau of Elementary and Secondary Education, 721 Capital Mall, Sacramento, California 95814

The California State Legislature passed legislation to implement a project to assist the public schools of California to improve mathematics education. There are four programs:

1. Test Development: a new test to be developed to measure the degree to which California's revised mathematics program is being met (rather than to assess individual pupil achievement). Forms will be developed for grades 3, 6, and 8.

2. Three Pilot Research Programs are to be set up to investigate the use of specialists in mathematics at the elementary grades; programs are to run three years, in grades 2 and 5 the first year of 1968-69 and picking up grades 3 and 6 the next two years.

Descriptive information and guidelines for each of the four programs are available from the California Department of Education.

College Curriculum Development Project; Curriculum Resources Group (CRG). Mr. Conrad Snowden, Institute for Services to Education, 55 Chapel Street, Newton, Massachusetts 02160

This is a research and development project, initiated in the summer of 1967, to determine if a new curriculum in the first and second year can overcome more successfully than the present conventional program the major educational deficiencies of the student population in 13 predominantly Negro colleges. The Curriculum Resources Group is working closely with 100 teachers from the participating colleges in the preparation and trial of new materials and new pedagogical approaches in English, mathematics, social sciences and natural sciences. An evaluation study is an intrinsic part of the program. Curriculum materials are not yet available.

A Computer-Assisted Instruction Laboratory in Mathematics and Science. Mr. Fred O'Neal. A Computer-Assisted Instruction Laboratory in Mathematics and Science. Bingham Junior High, 7618 Wyandotte, Kansas City, Missouri 64114

This project will investigate the uses, techniques and procedures of computer-assisted instruction in mathematics and science at the eighth grade level. The staff will prepare supplementary and enrichment materials and will conduct in-service teacher training activities in conjunction with the University of Missouri at Kansas City. The materials and facilities will be prepared in 1968 with pilot operation scheduled for 1969. An evaluation procedure will be established as the project progresses.

Frederick County Quality Improvement Program for Mathematics. Miss Louise Weagley, Frederick County Quality Improvement Program for Mathematics, Frederick County Board of Education, 115 East Church Street, Frederick, Maryland 21701

The purpose of this project is to behaviorally describe and sequence a portion of the mathematics curriculum in order to provide a model for possible future curriculum development. The writing of grade five mathematics, the testing, and the model was to have been completed by May 1968.

The Greater Cleveland Mathematics Program of the Educational Research Council of America (GCMP). Mr. John F. Mehegan, Educational Research Council of America, Rockefeller Building, 614 Superior NW, Cleveland, Ohio 44113

GCMP set out to develop a comprehensive, sequential mathematics program for all children in grades kindergarten through twelve, a program which is both mathematically correct and pedagogically sound.

Individually Prescribed Mathematics Instruction (IPI Math). Henry Cohen, Learning Research & Development Center, 160 N. Craig St., University of Pittsburgh, Pittsburgh, Pennsylvania 15213

New Hampshire Mathematics I and Mathematics II. Fernard J. Prevost, New Hampshire Mathematics I and Mathematics II, Consultant, Math; State Department of Education, State House Annex, Concord, New Hampshire 03301

This project provides a two course mathematics sequence in grades nine and ten for non-college bound students. The course materials provide experiences in arithmetic and geometry concurrently with the development of a basic Algebra I background.

New York State Education Department. Gordon E. Van Hooft, New York State Education Department, Albany, New York 12224

In addition to booklets listed in previous Clearinghouse Reports, the following have been produced:

1. Mathematics 7-8 (Syllabus 1967)
2. Science 7-8-9, Block G, Living in the Space Age 1967.
3. Science 7-8-9, Block H, Weather and Climate 1967.
4. Science 7-8-9, Block I, Forces at Work 1966.
5. Science 7-8-9, Block K, Energy at Work 1967.
6. Experimental Biology Syllabus, 1967 edition.
7. Physics Syllabus, 1966.
8. Tips and Techniques for Elementary Science, 1966.
9. Air Pollution, 1966.
10. Water Pollution, 1967.

An Earth and Space Syllabus revision is in preparation for publication in the fall of 1968.

Pennsylvania Retrieval of Information in Mathematics Education System (PRIMES). Emanuel Berger, Bureau of Research Administration and Coordination; Doris E. Creswell, Bureau of General and Academic Education, Department of Public Instruction, Box 911, Harrisburg, Pennsylvania 17126

Ponce Curriculum—Production and Translation of Science and Mathematics Materials. Mrs. Josefina S. Oliver, Box 1125, Ponce, Puerto Rico 00732

Program for Pre-College Centers, Curriculum Resources Group (CRG). Mrs. Emily Morrison, Institute for Services to Education, 55 Chapel Street, Newton, Massachusetts 02160

Wisconsin Mathematics Curriculum Publications. George L. Henderson, Wisconsin Mathematics Curriculum Publications, Department of Public Instruction, 126 Langdon Street, Madison, Wisconsin 53702

Curriculum bulletins for Wisconsin schools are provided for grades K to twelve. The K-6 guide is complete and is being tested. The others will follow in 1969 (7-8) and 1970 (9-12). Each bulletin is organized in terms of specific behavioral objectives. The synopses represent complete projects or projects in the preliminary stages of development in various localities throughout the United States or projects which do not involve curriculum development but which will be of interest to persons concerned with curriculum.