This volume provides recommendations for teaching mathematics and science to intermediate students who have been taught using the MINNEMAST materials during the primary grades. After reviewing briefly the goals and content of the primary curriculum, the authors discuss the transitions from the integrated program to distinct curricula in mathematics and science. For each field, several criteria for the intermediate curriculum are defined and alternate models are offered. Text and supplementary materials are suggested for each of these models. Brief descriptions of the recommended texts are provided. (SD)
The Minnesota Mathematics and Science Teaching Project
produced this booklet under a grant from the National Science Foundation.

1970, University of Minnesota. All rights reserved.

MINNEMAST
Recommendations for Science and Math in the Intermediate Grades for Science and Math Recommendations
Mathematicians, scientists and educators combined their talents to produce the 29 sequential units that make up the MINNEMAST Curriculum. They have coordinated the teaching of mathematics with the teaching of science in kindergarten and the primary grades. This coordinated curriculum provides a firm foundation on which the children can build as they follow other mathematics and science non-coordinated curricula in fourth grade and later.

We place special emphasis on the actual handling of materials by the students, which leads to a true understanding of concepts, as opposed to rote learning. Through actual experience, children see how math and science serve each other and how closely interrelated they are. We think that mathematics and science taught as totally unrelated subjects cannot provide as good a preparation as with this approach.

If your school or your district is not presently employing the MINNEMAST Curriculum, we heartily invite and encourage you to examine it and to try it out and encourage your fellow teachers to do so. Our Overview, which provides an illustrated description of the contents of each unit and our auxiliary books, is available upon request. A pamphlet, Questions and Answers about MINNEMAST, and a price list will be sent free upon request. Our Overview will be sent free upon request. Our Overview will be sent free upon request.

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The 29 coordinated units and several other publications are available from MINNEMAST on order.

OTHER MINNEMAST PUBLICATIONS

MINNEMAST RECOMMENDATIONS FOR SCIENCE AND MATH IN THE INTERMEDIATE GRADES

(Description of content of each publication)

OVERVIEW

QUESTIONS AND ANSWERS ABOUT MINNEMAST

ADVENTURES IN SCIENCE AND MATH

LIVING THINGS IN FIELD AND CLASSROOM

MINNEMAST HANDBOOK FOR ALL GRADES

Printed TEACHING AIDS FOR KINDERGARTEN AND GRADES 1, 2 and 3

STUDENT MANUAls FOR Grades 1, 2, 3, 4, 5 and 6

LIVING THINGS IN FIELD AND CLASSROOM

ADVENTURES IN SCIENCE AND MATH

MINNEMAST RECOMMENDATIONS FOR SCIENCE AND MATH IN THE INTERMEDIATE GRADES

ORIOn MINNEMAST PUBLICATIONS

MINNEMAST Director
MINNEMAST CENTER
720 Washington Ave. E.
Minneapolis, Minnesota 55414

For additional information, a price list and orders, write to:

MINNEMAST Director
MINNEMAST CENTER
720 Washington Ave. E.
Minneapolis, Minnesota 55414
Many thousands of children are studying or have studied science and math via the MINNEMAST Coordinate K-3 Curriculum. Many more will be entering our program in the future. We have had numerous requests from educators interested in our intermediate grades curriculum. Many more will be studying science and math via the MINNEMAST Coordinate K-3 Curriculum. We should also like to see the positive attitudes toward science and math that children acquire in our program continue to grow. We should also like to see the special concepts and skills that children develop by the end of Grade 3 put to advantageous use in the next grades. We believe that the intermediate grades offer great opportunities for the application of children's skills. The MINNEMAST staff, too, is much concerned with the kind of science and math education that children will receive in Grades 4, 5, and 6. We should like to see the positive attitudes towards science and math that children acquire in our program continue to grow. We should also like to see the special concepts and skills that children develop by the end of Grade 3 put to advantageous use in the next grades. We believe that the intermediate grades offer great opportunities for the application of children's skills. The MINNEMAST staff, too, is much concerned with the kind of science and math education that children will receive in Grades 4, 5, and 6.
In this booklet the authors suggest a number of alternatives for the continuing education of MINNEMAST children. Our suggestions are intended to be helpful rather than dogmatic. Curricula not mentioned by us may prove to be more suitable for certain local conditions, and educators are encouraged to survey other materials for themselves to see if this may be so. Also, our failure to mention any particular curriculum is by no means to be interpreted as a criticism of it. We hope our comments on materials that seem to be adequate successors to our curriculum, recommendations of materials that seem to be adequate successors to our curriculum, are merely presenting here for your consideration, and are in no way an attempt to be helpful rather than dogmatic. Curricula not mentioned by us may prove to be more suitable for certain local conditions, and educators are encouraged to survey other materials for them. Alternatives for the continuing education of MINNEMAST children. Our suggestions are intended for the continuing education of MINNEMAST children.
6 of the first grade. Because of the greater maturity of first graders, the kindergarten lessons are quickly mastered.) We have also published two auxiliary books: (1) Living Things in Field and Classroom is useful at all elementary levels; and (2) Adventures in Science and Math can be used by both, teacher and student at different levels to provide experiences that involve the student and science. In fact, the science that we make and science, In fact, the science that we make.

There are many natural bridges between math-

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**Why coordinate mathematics and science?**

---

Feasible between mathematics and science wherever there are many natural bridges between math-

exploring, discovering, and clarifying the relationships of math-

to provide settings that enable the children to solve interesting problems,

to provide experiences that involve the stu-

to develop competency in both mathematics and science,

The principles of the MINNEMAST Project are:

- To provide motivation and enrichment.
- To develop competency in both mathematics and science.
- To coordinate mathematics and science.
- To provide experiences that involve the student and science.
- To provide settings that enable the children to solve interesting problems.
- To provide experiences that involve the student and science.

---

Advantages in Science and Math can be used by both teacher and student at different levels to master math quickly. We have also published two auxiliary books: (1) Living Things in Field and Classroom is useful at all elementary levels; and (2) Adventures in Science and Math can be used by both teacher and student at different levels to master math quickly. We have also published two auxiliary books: (1) Living Things in Field and Classroom is useful at all elementary levels; and (2) Adventures in Science and Math can be used by both teacher and student at different levels to master math quickly.
pendent of science. However, the many discoveries and demands for quantification in the various sciences provide a great impetus to the advancement of mathematics. Because of these valid relationships between the two disciplines, project planners and writers believe that an early coordinated approach helps children see the interrelationships and develop a stronger and deeper understanding of both fields of study. We also believe that this coordination leads to an earlier appreciation of the principles on which the world operates. Either planning and writers believe that an early coordinated approach helps children see the interrelationships between the two disciplines, provide a great impetus to the advancement of mathematics.
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Because MINNEMAST coordinated the teaching of mathematics with the teaching of science, many of the objectives and methods used in the teaching of various suburban schools were described in the preceding section of the document. However, educators who specialize in mathematics will be more interested in this section of the document because of the similarity of our MINNEMAST learning/teaching model for both subjects. Mathematics transition statements for students are more often than not, reiterating here some facts particularly as they pertain to mathematics.
The power and utility of this tool is established early in the program. Thus there evolves one of the most important relationships ever established early in the program. This, therefore, is the world.

Webster defines arithmetic as a 'branch of mathematics that deals with real numbers and computations with them.'

As a result, our students tend to view mathematics as a set of rules to be memorized and applied under appropriate stimuli. This view is in contrast to the frequently held student view of mathematics as a kind of 'game' whose pieces behave in a very predictable manner—adhering to rules which they have been instrumental in developing. This method emphasizes early development of mathematical materials and their application in the development of the MINNEMAST program. Projects chosen for MINNEMAST children in the intermediate grades will have inherent in it much of the former emphasis and little, if any, of the latter. The result of this has been played on small part in the development and implementation of the MINNEMAST project. Project members hope that the mathematics program chosen for MINNEMAST children in the intermediate grades will have inherent in it much of the former emphasis and little, if any, of the latter.

The power and utility of this tool is established early in the program. Thus there evolves one of the most important relationships ever established early in the program. This is, therefore, the world.
Our project staff believes that the primary grades are the time for the implantation and preliminary development of appropriate major mathematical ideas, a time for the child to experience mathematical concepts, a time to observe, to wonder, to explore avenues of interest and appeal, a time to be involved in the rudiments of inductive thinking derived from experience with routine thinking derived from drill. As a result of this philosophy, MINNEMAST students have been exposed to elements of number theory, set theory, Euclidean geometry, and projective geometry, as well as transformational geometry and the intuitive idea of a mathematical function. Furthermore, MINNEMAST students have been exposed to elements of number theory, set theory, Euclidean geometry, and projective geometry, as well as transformational geometry and the intuitive idea of a mathematical function. The importance of computational facility is recognized, but it is felt that the development of these skills prior to the provision for multiple student opportunities to experience the concepts in concrete form is unwise from both a mathematical and pedagogical viewpoint. According to our staff, the primary grades are the time for the implantation and preliminary development of appropriate major mathematical ideas.
In searching for a reasonable successor to its primary mathematics program we have placed a high priority on:

1. The suitability of included topics relative to continuation and expansion of fundamental concepts that MINNEMAST has begun to develop.
2. The degree to which student involvement is encouraged.
3. The degree to which student involvement is developed and deepened.
4. The degree to which these topics are introduced and developed.
5. The degree of variation of mathematical ideas.
6. The extent to which students are encouraged to discover and develop mathematical ideas for themselves.
7. Realizing its obligation to provide specific suggestions for the intermediate grades that can be used to continue to develop the mathematical ideas it has begun to develop, the MINNEMAST Project has conducted a careful examination of the more popular mathematics commercial text series. The criteria stated above have formed the basis from which these textbooks are chosen.

Mathematics curricula than the vast majority of programs available. In search of a reasonable list of available programs, the MINNEMAST Project recognizes the importance of student involvement in learning activities. Commensurate with this recognition is our belief that children have become accustomed to learning activities. The criteria stated above have formed the basis from which these textbooks are chosen.

TRANSITION CRITERIA
should have the opportunity to develop ideas traditionally transmitted by rote.

...Probably no program has been successful in developing a totally discovery-oriented program, but MINNEMAST students do have many opportunities to formulate important ideas for themselves. "Development of insight through discovery," "conceptual approach emphasizing discovery," and "problem-solving as discovery" are typical program descriptions found in the introductory pages of commercial text series. Our investigations have indicated that pupils are not involved in true discovery activities to the extent that such statements suggest. Discovery is a laudable aim that is often minimized. Editorial pressures, standardized achievement tests, as well as concern for administrative and community anxiety, are factors that tend to limit severely the production of a truly process-oriented commercial program. In attempting to select materials that offer continuing problem-solving challenges with discovery as an integral part of the instructional process, MINNEMAST suggests three models for your consideration. These models are recommended for use in Grades 4 through 6 by children who have used MINNEMAST materials through Grade 3. You will notice that each model includes supplementary material from the Madison Project. Although supplementary, this material is considered as integral to the Madison Project.

...development of insight through discovery?...
series are described. The three models we are suggesting are listed here in alphabetical order:

Model 1

1. SRA Elementary Mathematics Program
   Science Research Associates, Inc.
   Singer Company (1968, 1969)
   Madison Project (Supplemental)

Model 2

1. Sets and Numbers
   Addison Wesley Company (1968, 1969)
   Madison Project (Supplemental)

Model 3

1. SRA Elementary Mathematics Program
   Science Research Associates, Inc.
   Madison Project (Supplemental)

We do not intend that commercial series not mentioned above should be conspicuous by their absence. It is entirely possible that commercial material other than those named will be more appropriate for use than those listed. We would encourage local curriculum committees to examine and keep in mind local objectives. We would encourage local curriculum committees to examine additional materials to determine whether or not they are consistent with the philosophy, aims, and the teaching-learning mode of the MINNEMAST program. We do not intend that commercial series not mentioned above should be conspicuous by their absence.
Minnemast's mathematical skills and concepts are listed, unit by unit, on pages 28 through 32. This list can be used not only for assistance in determining which math program to select for the intermediate grades, but also for selecting individual Minnemast units to teach at other levels where it is felt there are certain gaps in the students' mathematical education.

The list can be helpful in choosing units to include for study in math education courses, too.

The Minnemast Project was unable to locate a commercial text series that fully reflects the philosophy of mathematical learning to which it subscribes. Therefore, the desirability of supplementary materials has been discovered to allow schools to make certain modifications in their mathematics programs at the elementary level. The objectives of the Madison Project were found to be largely consistent with the Minnemast philosophy from both a content and pedagogical viewpoint. The Madison Project materials have been designed to allow schools to make certain modifications in their existing mathematics programs at the intermediate grade level. The objectives of the Madison Project materials were realized that its materials are designed to provide a foundation for developing a 4-8 program away from rote learning and toward learning by processes.

The Minnemast Project materials are designed to allow schools to make certain modifications in their mathematics programs at the elementary level. The project was found to be largely consistent with the Minnemast philosophy from both a content and pedagogical viewpoint.

The project materials have been designed to allow schools to make certain modifications in their existing mathematics programs at the intermediate grade level. The objectives of the project materials were realized that its materials are designed to provide a foundation for developing a 4-8 program away from rote learning and toward learning by processes.

The project materials can be used not only for assistance in determining which math program to select for the intermediate grades, but also for selecting individual Minnemast units to teach at other levels where it is felt there are certain gaps in the students' mathematical education.

The list can be helpful in choosing units to include for study in math education courses, too.
to move toward a greater use of physical materials and multi-sensory experiences in mathematics classes to create greater opportunities for small-group work and individualized instruction to use a specific teaching strategy based on the children's work and individualized instruction to create greater opportunities for small-group math classes to move toward a greater use of physical materials and in-service materials provide detailed suggestions for teachers new to Multi-Math. The Madison Project has realized the necessity that the MINNEMAST Project has initiated. Also, the Madison Project has made available a non-graded program—"to make available the simplest possible program for students who are not experiencing success in mathematics—"to make available the simplest possible program—"to open the door to a reconsideration of the grade-level placement of many topics—"to open the door to a reconsideration of the grade-level placement of many topics (but correct responses are made by students who are not experiencing success in mathematics, especially when unexpected student initiatives are made by students during an exploration period). The discussion of activities the children have done—"to use a specific teaching strategy based on work and individualized instruction to create greater opportunities for small-group math classes—

Besides the similarity in teaching methods in the MINNEMAST and Madison Projects, the specific topics developed in the Madison Project are a natural extension of many threads that the MINNEMAST Project has initiated. Also, the Madison Project has realized the necessity in many instances of providing specific instructional suggestions for teachers not familiar with these materials.
The Madison Project greatly simplifies the problem of in-service teacher training by providing the basic components of a complete instructional package for both teacher and students. In particular, the Madison Project's Curriculum (Beta) is recommended. This curriculum is made up of a combination of lessons developed by the Madison Project, the Elementary Science Study (ESS) and the Nuffield Project of Great Britain and by individuals such as Marion Walter, Lauren Woodby, Leonard Sealey, Z.P. Dienes, Edith Biggs and Geoffrey Matthews.

Curriculum Beta combines elements of carpentry, social studies, art and communication skills with mathematics and science. It is intended to reach a great diversity of children and to develop skills with mathematics and science. It is in particular for those schools wishing an intermediate level mathematics program that is a logical successor to the MINNEMAST materials. The Madison Project is felt to be an essential element in any transitional model. As is hoped that school personnel responsible for this type of curriculum can serve to stimulate the interest of children and to promote the development of mathematical and scientific concepts.

Certain parts of Curriculum Beta can serve quite different purposes because of the variety of its content. Certain parts of Curriculum Beta can serve to develop skills in mathematics and science, while other parts are designed to promote the development of communication skills and social studies.

For both teacher and students, Curriculum Beta is a complete instructional package in-service teacher training by providing the basic material that can be most effectively taught. The Madison Project greatly simplifies the problem of in-service teacher training by providing the basic material that can be most effectively taught.
decision will seriously attempt to integrate these materials with whatever Commercial program is ultimately adopted. A much more complete description of the Madison Project is provided in Volumes I and II of its Final Report, "Modern Mathematics Program as it Pertains to the Interrelationship of Mathematics, Teaching Methods and Classroom Atmosphere." Here we shall content ourselves with adding only that Curriculum Beta is a non-text program using materials from a wide variety of sources. A partial list of the Madison Project materials follows. Selections of supplementary materials should be made and ordered well in advance of the dates they will be needed. For additional information, write to the addresses provided in this list.

The Classroom Divided into Small Groups
The Concepts of Volume and Area
A Fifth-Grade Lesson on Place-Value of Numbers
An Introduction to Geometry via Manipulatives
Using Geoboards with Second Graders
Cluing and Shimping
Geometry Via Concrete Objects

can be seen in the following films:
Actual classroom lessons of Curriculum Beta

(Selections of supplementary materials should be made and ordered well in advance of the dates they will be needed. For additional information, write to the addresses provided in this list.)
In-Service Course for Teachers (combines films and printed material)

Second Lesson

A Lesson with Second Graders

Outdoor Mathematics

Motion Geometry

Signe Number, Rational Approximations and Small-Group Instruction

Counting, Volume and Rational Approximations
Lauren Woodby's Outdoor Mathematics, which emphasizes measurement, ratio and proportion, is a part of Curriculum Beta. Uses for Dienes', MAB blocks, other than those already mentioned, are included.

Beryl Cochran's development of place-value numerals by the use of beans, tongue depressors, and so on, is a part of the curriculum. Included is the sine-generating machine developed by the Cambridge Conference on School Mathematics during the summer of 1967. The simple rough study of periodic functions, such as temperature at various hours of the day, was suggested by Professor Andrew Gleason of Harvard University.

Publications

Inquiry in Mathematics via the Geo-Board, by Donald Cohen. (Available from Walker Co., 720 Fifth Avenue, New York, N.Y., 10019.)

Discovery in Mathematics: A Text for Teachers

Discovery in Mathematics: Student Discourse

Explorations in Mathematics: A Text for Teachers

Explorations in Mathematics: Student Discourse

(All by Robert B. Davis. Available from Addison-Wesley Publishing Company, South Street, Reading, Massachusetts 01667.)
I Do and I Understand
Mathematics Begins
Pictorial Representation
Beginnings
Computation and Structure

Shape and Size

Environmental Geometry
Probability and Statistics
Graphs Leading to Algebra
Problems: Green Set and Red Set
(All of the above are products of the Nuffield Project of Great Britain. Available in the United States from John Wiley and Sons Pub.)

I Do and I Understand (Available from Radim. Films, 211 East 43rd Street, New York, N. Y. 10017.)

Other Films

Three films not produced by the Madison Project are also highly recommended for expressing mathematical concepts very clearly and for relating mathematical ideas to other areas of study. They are:

I Do and I Understand (Available from Radim. Films, 211 East 43rd Street, New York, N. Y. 10017.)

Maths Alive (Available from National Audiovisual Library, 9 Paxton Place, Gypsy Road, Lomond, S. E. 27, England.)

Classrooms in Transition (Available from Mary Lela Sherburne, Education Development Center, Inc., 55 Chapel Street, Newton, Mass.)
effective mathematical learning.

exploratory activities we feel are so essential to
can provide the additional amount of the kind of
that approach. The Madison Project materials
rather varied in activities and a sound mathematics-
gram. The Addison-Wesley Program provides both
interchangeable with suggestions for the use of manip-
complete middle school mathematics course.

Multiple interpretations of mathematical concepts,
large approach to rational numbers geometry, number theory, coordinate
and the-dimensionality of geometric forms, estimation
ary-appropriate include the geometry of the circle.
jouth grade materials that are felt to be pattern-
aries that of the MINNEMAST Project.

Multiple interpretations of mathematical concepts,
multiple interpretations of each topic of the circle,
thetic approach to rational numbers
large approach to rational numbers
ary-appropriate include the geometry of the circle.
activities for lesson presentation. Topics in the
supplementary books as well as detailed supplements
ction of each chapter, a short list of appropriate
leaves for each lesson, suggestions for the use of
supplementary materials for each chapter, reference
signed for the teachers, use a suggested list of
arious from the students texts, this series contains
acceptable successor to its primary materials.
MINNEMAST Project has examined and found to be an
Intermediate Mathematics Program that the MIN-
ary materials represent perhaps the most complete

Unusually well illustrated, the Addison Wes-

Authors: Eich, O'Daffer
Addison Wesley Company (1968)
Text Series: Elementary School Mathematics

RECOMMENDED COMMERCIAL TEXT SERIES

29
The Singer Company Series, Sets and Numbers, provides a Mathematical program that can be successfully adopted to succeed the MINNEMAST K-3 mathematics curricula. The authors of Sets and Numbers recognize the need for active student participation in the learning process and have designed many experiences accordingly.

An attempt has been made to shift the responsibility for learning from the teacher to the student. Problem situations are sometimes designed so that learning takes place from the concrete to the abstract. Two-dimensional models are extensively used to provide the concrete framework from which mathematical ideas can ultimately be abstracted. Multiple embodiments are suggested for many of the concepts considered. It is hoped that students will be encouraged to play a central role in the development of the mathematical ideas.

The MINNEMAST K-3 mathematics program has been concerned with many of the topics treated in the 1-3 materials of the Singer series. MINNEMAST students will therefore possess many of the skills and concepts required for such programs. The MINNEMAST K-3 mathematics curriculum provides a mathematical program that can be successfully adopted to succeed the MINNEMAST K-3 mathematics curriculum.
Successful involvement in the fourth grade book of the Sets and Numbers series. The list of mathematical concepts and skills that have been developed by the MINNEMAST Project (pages 28 through 32) should be examined carefully so that discrepancies between these and the Singer Company Series generally presented a single mathematical idea in a number of different contexts. Realizing the importance of the role that visual and manipulative materials play in the effective learning of mathematics, the authors have developed Multimathematics Manuals to correlate with each text. These manuals, the authors also report, the extent to which supplementary activities might be required, could be used to advantage. Tests would also reveal areas where additional activities can be discovered. Tests would be helpful in diagnosing these and the Singer Company Series should be examined carefully so that discrepancies between these and the Singer Company Series have been developed. The Sets and Numbers Series, The list of mathematical concepts and skills that have been developed in the fourth grade book of the SRA Elementary Mathematics Program Series: Science Research Associates, Inc. (1968, 1969) Text Series: SRA Elementary Mathematics Program
Although the materials suggested do not represent a complete picture of the breadth of materials to which the MINNEMAST Project would subscribe, these teachers, as indicated above, offer useful suggestions for sensory activities in the mathematics program at three levels of ability (remedial, average, enrichment). The teachers' editions are quite thorough from a pedagogical standpoint. They offer detailed suggestions for appropriate methods of presenting lessons for the students. Beyond those suggested for the students, the teachers do not develop mathematical ideas for the teacher. The topics considered are conventional in nature but are presented in a mathematically acceptable manner. As indicated above, the topics considered are conventional procedures. The topics are often given multiple embodiments of ideas, and students are often encouraged to develop their own rules and procedures.

The Madison Project materials, we feel, are beyond those suggested for the students. The SRA Series can provide a sound mathematical program for children in the intermediate grades. Although the Madison Project materials are certainly a step in the right direction, we do not feel that they are adequate to the breadth of the Madison Project's goals.
UNIT I, WATCHING AND WONDERING

No specific math skills

UNIT 2, CURVES AND SHAPES

- Recognition of: curves
- Open
- Closed
- Non-simple
- Simple

UNIT 3, DESCRIBING AND CLASSIFYING

- Includes circle, triangle, square, rectangle
- Regions and boundaries
  - Open
  - Closed

UNIT 4, USING OUR SENSES

- No specific math skills

UNIT 5, INTRODUCING MEASUREMENT

- Length: comparing lengths, ordering
- Area: comparing areas, superposition, ordering, reference object
- Volume: comparing volumes, ordering
- Time: comparing durations of events

Kindergarten mathematics skills and concepts
Unit 6, Numeration
Ordering sets
Equivalent sets
Counting 1 to 10
Introducing 0
Numerals 0 - 10

Unit 7, Introducing Symmetry
Recognition of: rotational symmetry; repeating patterns, bilateral symmetry

Unit 8, Observing Properties
Intersection of sets

Unit 9, Numbers and Counting
One to one correspondence (more, fewer)
Numerals from 0 to 20 (counting)
Ordering with symbols: <, >, =

Unit 10, Describing Locations
Introducing point, line, segment, locations
Naming of each of the above
Intersections of lines
Using a grid, betweenness, simple maps

Unit 11, Introducing Addition and Subtraction
Addition (1 digit by 1 digit), union of sets, arrays
Number line, introducing simple fractions
Numeration, 0 - 100

Unit 12, Measurement with Reference Units
Comparing lengths, ordering
Measuring length with standard units such as inches and centimeters
Imprecision of measurements
Perimeters
Grade 2

Unit 12, Continued

Comparing areas, superposition, reference objects

Unit 13, Interpretations of Addition and Subtraction

Comparing volumes, displacement, standard units

Comparing, ordering and measuring durations

Unit N/A

Exploring Symmetrical Patterns

Rotational, translational and bilateral symmetries

Unit 15, Investigating Systems

No specific math skills

Unit 16, Numbers and Measuring

Ordering numbers, objects

Approximate nature of measurements

Circumferences, diameters

Fractional units

Unit 17, Introducing Multiplication and Division

Measuring weight

Base 4 numeration, Roman numerals

The abacus, numerals through 999

Adding 2-digit numerals on slide rule

T-notation, place value

Circumferences, diameters

Fractional units

Approximate nature of measurements

Ordering numbers, objects

Measuring weight

Unit 18, Scaling and Representation

Math-related measurement, maps

Scalings and representation by means of simple fractions

Multiplying 1 digit by 1 digit

Multiplying on the number line, on parallel number lines

Multiplication as repeated addition

Introducing Multiplication and Division

Measuring weight

Base 4 numeration, Roman numerals

The abacus, numerals through 999

Adding 2-digit numerals on slide rule

T-notation, place value

Circumferences, diameters

Fractional units

Approximate nature of measurements

Ordering numbers, objects

Measuring weight

Unit 19, Extended Numbers and Measuring

Ordering numbers, objects

Approximate nature of measurements

Circumferences, diameters

Fractional units

Unit 20, Exploring Symmetrical Patterns

Rotational, translational and bilateral symmetries

Unit 21, Investigating Systems

No specific math skills

Unit 22, Numbers and Measuring

Ordering numbers, objects

Approximate nature of measurements

Circumferences, diameters

Fractional units

Unit 23, Introducing Multiplication and Division

Measuring weight

Base 4 numeration, Roman numerals

The abacus, numerals through 999

Adding 2-digit numerals on slide rule

T-notation, place value

Circumferences, diameters

Fractional units

Approximate nature of measurements

Ordering numbers, objects

Measuring weight

Unit 24, Scaling and Representation
Unit 19, Comparing Changes
- Time - duration and clock reading
- Plotting ordered pairs and weight/volume data

Unit 20, Using Larger Numbers
- Place value to 999
- All addition and subtraction facts
- Introducing addition and subtraction algorithms
- Estimation

Unit 21, Angles and Space
- Points, line segments, rays, angles
- Angle measurement with clock protractor
- Polygons: classification by properties such as number of sides, sides, angles, angles, angle measurement with clock protractor
- Points, lines, the segments
- Similar triangles, congruence
- Polyhedra (transition to 3-dimensional shapes)
- Tessellations (distinguishing patterns)
- Convexity or concavity, regularity or irregularity
- Introducing addition and subtraction algorithms
- Place value to 999

Unit 22, Parts and Pieces
- Distinguishing between counting and amount measures
- Parts and pieces
- Fractions greater than 1, mixed fractions
- Adding and subtracting fractions on the number line
- Fractional parts of objects and sets
- Distinguishing between counting and amount measures

Unit 23, Conditions Affecting Life
- Bar graphs, coordinate graphs
- Interpreting graphs

Unit 24, Change and Calculation
- Complete addition and subtraction algorithms
- Place value without limit (T notation)
- Graphing ordered pairs (time/distance relations)

Unit 25, Multiplication and Motion
- Graphing ordered pairs (time/distance relations)

Grade 3
Unit 25, Continued

Interpreting graphs

Review of multiplication as repeated addition, as arrays, as Cartesian products

Multiplication using a graph with lines of certain slope

Understanding motion as the relation between time and distance (evident in the slope of a graph)

Multiplication using a graph with lines of certain slope

Review of multiplication as repeated addition, as arrays, as Cartesian products

Interpreting graphs

Unit 26, What Are Things Made Of?

Graphing volume/weight relations

Model building of regular polygons for angle measurement

Transition from clock protractor to standard protractor

Interpreting graphs

Unit 27, Numbers and their Properties

Developing standard multiplication algorithms for multiplying 1- and 2-digit numbers in column form

Practice with basic multiplication facts

Unit 28, Mapping the Globe

Measurement of area, angles, length

Model building

Unit 29, Natural Systems

Recognizing patterns and symmetries

Model building of transformations

What are things made of?
It has been stated that the aim of the MINEMAST Project is to exploit the interrelated nature of mathematics and science in a way that helps children understand the quantitative nature of observed phenomena. We believe that through this approach youngsters will learn about their environment and will also learn to recognize patterns, regularities and uniformities in the environment.

This is important because understandings based on his own observations and data can help the child make valid predictions. The MINEMAST Program presents the study of science as both knowledge of the environment and skills in eliciting answers from it. The children investigate a series of carefully planned science problems, gain understanding of each problem and learn procedures for problem solving. We believe that this method of teaching science is consistent with much of the contemporary research related to learning. It goes beyond the acquisition of facts toward the development of useful, lifelong attitudes about the endeavor of science that is called "active scientific investigation." This approach will help the child make valid predictions, test hypotheses based on his own observations and data, and learn about the environment and will also learn to recognize patterns of observed phenomena. We believe that though help children understand the quantitative nature of mathematics and science in a way that
GENERAL SUGGESTIONS

We would hope that a curriculum selected to follow the MINNEMAST Program would be complementary to the teaching-learning mode already established. We would hope that the program would provide continuing opportunities for youngsters to investigate and discover. We would hope that the selected program would present topics as open-ended, investigative and quantitatively designed.

The MINNEMAST K-3 materials provide an adequate background of information and skills so that the following transition illustrations should present few, if any, science transition problems. The suggested programs are representative of a wide range from which schools can make selections. There is no program existing today, other than MINNEMAST, that provides a coordinated approach to mathematics and science. We believe that within a few years such programs will be developed and published. Until that time, the teacher must look to programs that offer strong possibilities for investigation and quantification.

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Consider the widely used text series, Concepts in Science, as an example of commercial materials that might be used. The books can be read and end-of-chapter questions can be answered by the children; or the books can serve as the nucleus for an active, investigative science program. The several skills expected of youngsters (instrument reading, graph interpretation, young readers, problem solving, equipment manipulation, and some under-}

...
Implicit in each of these programs is a development scheme that reduces the extent of the survey and uses a smaller number of selected topics to develop a depth of knowledge through active participation in investigative activities by students. Programs that follow this pattern include SCIS (Science Curriculum Improvement Study), ESS (Elementary Science Study), SAPA (Science A Process Approach, developed by the American Association for the Advancement of Science), and a collection of mathematics-oriented materials called Measure and Find Out (Scott, Foresman and Co.).

In assessing science programs for continuity of the principles used in MINNEMAST and evidence of a teaching-learning mode in which students have developed competencies, these factors were the prime considerations: open-endedness, desirable lessons are those that set the stage for the children to find their own answers, and the printed version of other people's lessons does not support these facets with illustrations that consistently present facts and do little more than support facts with illustrations. This is in contrast to lessons that set the stage for the children to find their own answers.

In assessing the extent of the survey, it is important to assess the meaning, as much of the survey presents facts and does little more than support these facts with illustrations. This is in contrast to lessons that set the stage for the children to find their own answers. Research evidence substantiates the need for children to be involved in doing operations. The ability to ask useful questions, to think of ways to answer these questions, to design and conduct experiments and to collect data and evidence of a teaching-learning mode in which students have developed competencies, these factors were the prime considerations: open-endedness, desirable lessons are those that set the stage for the children to find their own answers, and the printed version of other people's lessons does not support these facets with illustrations.

Research evidence substantiates the need for children to be involved in doing operations. The ability to ask useful questions, to think of ways to answer these questions, to design and conduct experiments and to collect data and assess its meaning, as much of the survey presents facts and does little more than support these facts with illustrations, is as much a part of the survey, and uses a smaller number of selected science topics to develop a depth of knowledge through active participation in investigative activities by students, as programs that follow this pattern in-
Quantitative ideas development.
The mathematics that children learn should be used as a tool in their investigative activities.

Inquisitive attitudes.
It is only when the child discovers that he can do something, succeed at it, and find out for himself that he can do something that he discovers that he can do something. It is only when the child discovers that he can do something that he discovers that he can do something.

Depth vs. breadth.
Content that represents a selected collection of conceptual schemes developed in depth, as contrasted with shallow surveys of a multitude of topics, is the final criterion on which we feel decisions can be made.

For schools planning to use MINNEMAST materials in Grades K-6, there are flexibility and alternatives. In particular, the third grade MINNEMAST materials can be stretched into Grade 4, and portions of the selected successor can be introduced in Grade 3.

Schools that are just beginning to use MINNEMAST Curriculum will have certain free-dom of choice in their K-6 program development.

For each, general and specific suggestions for transition procedures are offered for guidance purposes. For schools that are just beginning to use the curriculum, certain free-dom of choice in their K-6 program development is offered for guidance purposes. For each, general and specific suggestions for transition procedures are offered for guidance purposes. For transition procedures are offered for guidance purposes. For transition procedures are offered for guidance purposes. For transition procedures are offered for guidance purposes. For transition procedures are offered for guidance purposes.
The independent science packages of the ESS Program represent the first choice of MINNEMAST in science transition materials. It is suggested that several of the ESS units be inserted during Grade 3, and the MINNEMAST Program be extended into Grade 4. A second procedure involves the use of the Measure and Find Out program and selected ESS units. We suggest such alterations only after considering that several of the ESS units be inserted during Grade 4. A second model involves the use of one or more commercial text series. Certain problems arise having to do with teaching mode and material appropriateness for students in the intermediate grades. Three commercial programs illustrate transition models that can satisfy transition criteria. Those included as illustrative are Concepts in Science, Experiences in Science, and Science Through Discovery. We feel that when commercial series are selected, it would be appropriate to select those that do not lend themselves to concrete activities, and to substitute activities from ESS units. These suggestions are made with reference to research in learning and the learning process. We find that other special needs in the illustrations are met by the transition models illustrated. These models, Concepts in Science, Experiences in Science, and Science Through Discovery, have been selected as illustrative because they can satisfy transition criteria for students in the intermediate grades. A second model involves the use of one or more commercial text series.
Piaget and co-workers have been interpreted by the MINNEMAST Project as supportive of a science program that provides continuing manipulative and investigative activities by students. Units that require active involvement should be given preference over those treated in a vicarious reading and discussion format. Further, certain concepts require formal intellectualization. According to Piaget, many children in the intermediate grades are not mature enough for formal operations. These concepts and conceptual schemes cannot be handled in a mode even approaching experiment or investigation. For this reason the illustrations suggest only minimal treatment of molecular theory and the fundamental particulate nature of matter. In their place we suggest the use of such ESS units as Kitchen Physics, Gases and Airs and Mystery Powders. There is a second reason for reducing emphasis on the development of concepts related to theories of the particulate nature of matter: when some of these students are in junior high, they will be able to operate on information in a formal way. At this time, among programs available, schools may select one called "Intermediate Physical Science" (IPS). Concepts of the particulate nature of matter are developed through a carefully planned series of experiences and activities. The student is given a chance to develop and consider general inferences about the nature of matter and is led through a historical-logical development of atomic theory. The aims of the IPS program, which include treating the learner as an active investigator, would be difficult to achieve if — through prema-
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The following five models represent, in the opinion of this author, acceptable transitional procedures. They are intended to illustrate the many ways schools, using materials appropriate to their philosophy, can capitalize on the investigative strengths that have been developed in children through MINNEMAST Program activities. The models are intentionally terse, for we believe that the best programs are developed when concerned, knowledgeable teachers, subject matter specialists, psychologists and children all work together to share ideas and build programs.

1. The ESS Program, Webster Division, Grade 3
2. Measure and Find Out and ESS Concepts in Science and selected insertions
3. Concepts in Science and selected insertions
4. Science Through Discovery and selected insertions
5. Experiences in Science and selected insertions

The models are intentionally terse, for we believe that the best programs are developed when concerned, knowledgeable teachers, subject matter specialists, psychologists and children all work together to share ideas and build programs.
The Measure and Find Out Program, Scott, Foresman and Company; and ESS Units.

Grade 3 - MINNEMAST Unit 23
MINNEMAST Handbook

Grade 4 - MINNEMAST Unit 26
MINNEMAST Handbook

Grade 5 - MINNEMAST Unit 28
MINNEMAST Handbook

Classroom Living Things in Field and Pond Water
Small Things Peas and Particles
Units 3 and 4

Grade 5

Classroom Living Things in Field and Natural Systems
Cardboard Carpentry
Units 2 and 5

MINNEMAST II
ESS

MINNEMAST II
ESS

MINNEMAST II
ESS

MINNEMAST II
ESS

MINNEMAST Handbook

What are Things Made Of?
Activities 7 - 17
Activities 28 - 32
Activities 18 - 23
Activities 7 - 17

MINNEMAST Unit 28
MINNEMAST Unit 28
MINNEMAST Unit 28
MINNEMAST Unit 28
MINNEMAST Unit 28

Mapping the Globe

MINNEMAST Handbook

MINNEMAST Unit 29
MINNEMAST Handbook

MINNEMAST II
ESS

MINNEMAST II
ESS

MINNEMAST II
ESS

MINNEMAST II
ESS

MINNEMAST Handbook

Living Things in Field and Classroom
Living Things in Field and Classroom

Cardboard Carpentry

Units 2 and 5

MINNEMAST II
ESS

MINNEMAST II
ESS

MINNEMAST II
ESS

MINNEMAST II
ESS

MINNEMAST Handbook
Units 3 through 6

CIS

ESS

Grade 5

Grades 4

MINNEMAST Handbook Living Things in Field and Classroom

Unit 8 - Air Pollution and Its Pollution and the MINNEMAST Handbook, Living Things in Field and Classroom, Book 6, Chapters 6 and 7

Discover: Book 5, Chapter 7, Water and Its Pol-

An Ecology Study Developed from Science Through

MINNEMAST Handbook Living Things in Field and Classroom

Units 2 - 6

Animal Activities

ESS

Grade 6

MINO Book III

Grade 4

MINNEMAST Program omitting Unit 26

MINNEMAST Handbook Living Things in Field and Classroom

Grade 3

World

Model 3: Concepts in Science, Harcourt, Brace,
Grade 6

STD

ESS

MINNEMAST Handbook

Units I - 4

Gases and Airs

Battery and Bulbs

Units I - 4

Grade 5

STD

ESS

MINNEMAST Handbook

Units 5 - 7

Living Things in Field and Classroom

Grade 4

STD

MINNEMAST Handbook

Units 26

What are Things Made Of?

Heat Earth, Sun and Seasons

Conditions Affecting Life

Grade 3

MODEL S: EXPERIENCES IN SCIENCE, WEBSTER DIVI.
Complete EIS Program

Grade 6

Complete EIS Program

Grade 5

Complete EIS Program

Grade 4

Complete EIS Program

Grade 5

Complete EIS Program

Grade 4

Complete EIS Program

Grade 6
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<th>Generalization</th>
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Perhaps one of the most significant contributions that the MINNEMAST Project has made to education is that its curriculum demonstrates the feasibility and advantages of coordinating the teaching of mathematics and science. At any rate, present interest in such coordination is high. The authors believe that when sufficient federal funds are again available for this purpose, significant amounts will be allocated to the development of coordinated curricula that will be adaptable to the needs of students in the United States.

Perhaps one of the most significant contributions of the NUFFIELD Project of Great Britain is that it has demonstrated the feasibility and advantages of coordinating the teaching of mathematics and science. At present there are two projects concerned with this area. You may wish to keep abreast of the materials they are producing:

USMRS (Unified Science and Mathematics in the Elementary School) Project
Education Development Center
55 Chapel Street
Newton, Massachusetts

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