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ABSTRACT

GRADES OR AGES: 7-12; SUBJECT MATTER: Mathematics. ORGANIZATION AND PHYSICAL APPEARANCE: The guide has an introduction and four chapters: 1) A Sample Mathematics Curriculum; 2) The Exceptional Student in Mathematics; 3) Mathematics Components for Comprehensive Occupational Education; 4) Reference Materials. The guide is printed and spiral bound with a soft cover. OBJECTIVES AND ACTIVITIES: The guide makes no attempt to detail objectives or activities for each grade. General outlines are given for the low achiever and the mathematically talented in chapter 2. Chapter 3 lists activities and the related mathematical concepts for auto mechanics, electronics (electricity-radio), graphic communications, hospitality occupations, industrial drawing and drafting, and metal processing occupations. INSTRUCTIONAL MATERIALS: Chapter 4 lists texts, pamphlets, periodicals, sources of free and inexpensive materials, sources of transparencies for the overhead projector, sources of models and equipment, computer training kits, computer companies, and toys, games, and puzzles for learning mathematics. STUDENT ASSESSMENT: No specific provisions are made for evaluation. (MBM)

Wyoming Mathematics Curric

Grades 7-12

Wyoming
Education
Department

1970

Prepared by
THE SECONDARY MATHEMATICS CURRICULUM COMMITTEE OF WYOMING under a grant with the U.S. Office of Education, as authorized under Title V, Elementary and Secondary Education Act, 1965.

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Published by

THE STATE DEPARTMENT OF EDUCATION
Cheyenne, Wyoming 82001

HARRY ROBERTS
State Superintendent of Public Instruction

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FOREWORD

Mathematics education has been undergoing rapid changes during the last few decades. Technological advances in our society require a better background in mathematics. The mathematics program should provide each individual student, according to his ability, with an understanding of mathematics adequate for his current and future needs.

The program of mathematics in our schools should be modernized in such a way that our students can understand the basic principles involved and become acquainted with new concepts. Instruction should involve periods of exploration, experimentation and inquiry. Through the program the student should become aware of the power and influences of mathematics in his continuing occupational and personal development.

The State Department of Education gratefully acknowledges the contribution of the members of the Secondary Mathematics Curriculum Committee of Wyoming who prepared this guide.

It is my hope that curriculum development in Wyoming will be an on-going process. Through this process, further developments and revisions can be looked for in the future.

I believe that you, the mathematics educators of the state, will find this guide a useful resource and hope that you feel free to react to it so that your suggestions can be incorporated in future developments.

HARRY ROBERTS
State Superintendent of Public Instruction

June, 1970

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In order to meet the demands of a rapidly changing society, and in order to face the challenges of the 1970's, the mathematics curriculum in today's schools must be flexible. It must be designed to meet the needs of the students as they face the world of work, and designed to meet the needs of the society itself.

The mathematics teacher is charged with the responsibility of developing and maintaining this flexible program. The mathematics teacher is urged to examine carefully the existing curricular program as it exists for the students of his district.

A flow chart should be developed to chart the possible avenues of student alternatives in the program. This flow chart should be studied for flexibility and it should reflect the needs of all students. (See example, page 2.)

It is important to understand the purpose of modern mathematics, viewing it as a whole, rather than just gaining knowledge of a few of the topics. In teaching mathematics today, we hope to produce pupils who understand the "why" of numbers and operations in addition to the "how" of computational skills. Furthermore, pupils need to be presented with the basic principles that underlie mathematics, whether mathematics is being studied at the primary or the high

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school level. Knowledge of the principles and their applications not only reduces the number of rules to be memorized but helps the pupil become cognizant of the fact that there is a structure and organization to mathematics. Through using discovery techniques, pupils become actively involved in finding patterns, generalizations, and rules for themselves, thus retaining what they learn more easily and developing more effective reasoning ability as well.[1]

Most of what has been written and of what we try to teach can be summarized under four major headings. Modern mathematics is an attempt to: (1) emphasize the "why" just as much as the "how," (2) teach mathematics as a structure, (3) allow pupils to discover relationships for themselves whenever possible, and (4) teach the social utility, or practical applications of mathematics and of arithmetic computation. It is important for teachers or parents upon being introduced to a new concept to take time to see how it contributes to these major purposes. There are many false impressions about "modern" mathematics. An attempt is made in the following discussion to correct some of these erroneous ideas.

[1]Paul R. Trafton, *Insight Into Modern Mathematics* (The New Math), Ideal School Supply Co. (1963) pp. 4-10.

WHAT MODERN MATHEMATICS IS AND IS NOT

Modern mathematics is just a downward shifting of topics .... *False*

While there has been a downward shifting of the grade placement of certain topics, this is not a basic purpose of modern mathematics. Where this downward shift has occurred, the emphasis has not been so much on mastering a skill earlier as it has been on carefully developing a concept or intuitively dealing with a mathematical idea that will be treated more formally in future years. In most cases enrichment materials have been included along with extensive amounts of supplementary or additional materials. The additional materials have, in a large part, been included to teach the structure of mathematics.

Modern mathematics is an attempt to teach the "why" of mathematics .... *True*

Adults today have little idea why they do certain things in arithmetic. Upon hearing an explanation of "regrouping" or "borrowing" in subtraction, it is not unusual for adults to state that they now understand for the first time what they are doing. Arithmetic begins to make sense to them.

Modern mathematics means throwing out many previously taught topics .... *False*

Undoubtedly there are many teachers who wish that this statement were true, particularly with more difficult ideas. However, a close inspection of curriculum materials will indicate that few topics are being discarded. It is true that many concepts are being presented from a different viewpoint and that certain applications are not receiving as much emphasis as formerly.

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Modern mathematics is an attempt to teach mathematics as a structure ---------------- *True*

In mathematics, there are a few key principles, usually considered to number less than twelve, around which most of the development of arithmetic can be built.

Modern mathematics means doing away with drill ------ *False*

This is not true. Drill still plays an important role in mathematics, and children are still expected to learn basic facts. Yet it is true that drill for the sake of drill is being de-emphasized. Attempts are also being made to make drill more creative by using it in situations that call for reasoning at the same time.

Attempts are made to lead pupils to discover mathematical relationships for themselves. A balance between drill for reinforcement and intuitional understanding is necessary if a mathematics program is to be successful.

Modern mathematics seeks to use "discovery" techniques ---------------- *True*

The idea of "discovery" can be referred to as the method of modern mathematics. The topics taught are important, yet if they are taught in a rote, mechanical manner, with an emphasis on symbol manipulation instead of insight, little advantage is gained. However, when the concepts involved in the new emphasis are presented in an interesting manner, and pupils are given an opportunity to explore, raise questions, and generalize, there is much to be gained.

Modern mathematics is just for the "bright" kids ------ *False*

If modern mathematics is to be of value, it must be able to help all levels of learners. It is true that the new emphasis does allow pupils with mathematical insight a chance to use more of their talent, and it keeps them from becoming bored. However, while the need to challenge able pupils is being met more adequately, the mathematical needs of average and below average pupils are also being met more satisfactorily than has usually been done in traditional programs. The new emphasis can be of great value to them. It is these pupils who became "bogged down" in rules and manipulations in the past and who can profit from the emphasis on key concepts and greater insight.

It should be recognized that there will be a few pupils who will continue to have difficulty with mathematics. Special programs in terms of a slower pace and limited context should be used to best provide for these people's needs.

Modern mathematics is just sets, bases, revised terminology, geometry and number lines .... *False*

To view modern mathematics only as a series of topics is to miss what it is really trying to accomplish. While these topics are important, their inclusion is for more than just knowledge of them. They are included because they contribute to a much larger picture.

Modern mathematics means we have been doing a bad job .... *False*

There are many teachers who have worked hard at teaching arithmetic for many years who unfortunately see the new approaches as an indication that they have been doing a poor job. Many of these people have been doing a fine job. In fact, it is not unusual to hear teachers in a modern math course exclaim, "Why, I've been teaching modern math and didn't even know it!"

QUESTIONS BASIC TO MATHEMATICS CURRICULUM DEVELOPMENT

Just as the nature of our society is continuously changing, so the mathematics curriculum must be constantly re-examined and revised in the light of new societal and intellectual conditions.

As teachers, administrators and others interested in mathematics curricula consider changes in programs, they should try to find answers to these key questions which are basic in curriculum development.

- What are the goals of teaching mathematics? What is the role of mathematics in the life of pupils of different abilities and cultures? Are we teaching mathematics for occupational needs, for improved citizenship, or for success in advanced courses? Are we teaching mathematics to change our society or to establish values which will maintain our social order?
- What mathematical ideas, skills, attitudes, and habits can be most effectively developed at a given grade level? The new programs have found that we can teach complex ideas to very young children. Now the question is what ideas should be taught to our pupils and at what age should they be introduced? What new topics should be introduced? What traditional topics should be dropped?
- How should programs be varied to provide for different levels of ability? How do we accelerate the learning of the talented at all levels? How can small schools provide several curriculum tracks? Should enrichment include probability, calculus, or computer programming?
- How do we teach for transfer so that mathematical ideas will be used in solving problems? What specific applications need to be included in the mathematics class? Are the social applications or the applications in science to be taught by some department other than the mathematics department?
- What degree of rigor or mathematical precision in language and logic is appropriate at various grade

levels? Should mathematical ideas be presented in simple language which, because of its simplicity, is somewhat lacking in precision? What vocabulary and symbolism is appropriate at a given grade level? How important is it to stress the basic axioms of our number system such as commutivity, associativity, or distributivity? One of the greatest dangers of the new programs is that the reorganization may go too far and confront students with concepts whose degree of abstraction exceeds the youngster's mathematical maturity. Excessive abstraction might result in students' bewilderment and hostility toward mathematics rather than understanding appreciation.

- What emphasis should be given to computational skill? Can this skill be attained by means other than drill? What level of competence is considered satisfactory at a given level?
- What is the role of the computer in the mathematics program? Should mathematics courses teach computer programming? Should the computer be used as a tool to teach mathematical ideas and problem solving? Are computers and calculators appropriate tools for low-ability students?
- How do we prepare teachers for the new programs? How is the effectiveness of a teacher measured? What are appropriate mathematics courses for the teacher?
- How do we evaluate the effectiveness of a new mathematics program? What behaviors demonstrate the attainment of objectives? What tests can be used to compare two programs each based on different content?
- What criteria should be used in selecting instructional materials? What sequence of textbooks is most appropriate? Should each mathematics class have several texts and supplementary books or pamphlets? What is the role of programmed texts? What is the role of concrete representation of abstract ideas?

- How shall the achievement of students of different ability be graded? Should the general mathematics class as well as the accelerated class receive the entire range of grades from A to F?
- How are students selected for different curriculum tracks? How can provision be made to transfer from one track to another?

In a time of change such as the present there are two extremes which can lead to difficulties. On the one hand, there is the inflexible, traditional, and conservative point of view which resists any change. On the other hand, there is the extreme liberal point of view which is ready to accept any innovation that seems popular. We need to avoid these extremes by having criteria whereby we accept, reject, or modify proposals for new programs. There are a variety of new models of school mathematics available for your school. You must make your choice. The discussions that follow might help you make a wise choice.[2]

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[2]Donovan A. Johnson, *Bulletin of the National Association of Secondary School Principals,* quoted in *The Continuing Revolution in Mathematics* (Washington: National Council of Teachers of Mathematics, 1968), pp. 2-3.

FLOW CHARTING THE CURRICULUM

The Wyoming Secondary Mathematics Curriculum Committee recommends that each school district carefully evaluate its present mathematics curriculum.

One technique of this review might be to develop a flow chart of possible alternative student routes through the existing program. Thought should be given to the grouping process, to the procedures for entry into and exit from courses, and to whether the program is structured to meet the needs of all students.

The district flow chart can then be matched against the sample shown in this section. This chart is in no way intended as a requirement but is simply a sample toward which some districts may want to work.

The mathematics program should be flexible, allowing the student to move both horizontally and vertically.

There should be a variety of course offerings to meet the occupational and academic needs or deficiencies of each student.

To realize the most from the mathematics curriculum, grouping strategies are recommended. Criteria for these groupings are extremely important. When grouping a student in mathematics, attention should be given to his achievement and attitude in mathematics, English and other language arts, other subject areas as measured by his grades, and teacher recommendations. Other criteria should be his performance on standardized tests, the results of conferences with

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CHAPTER I
A SAMPLE MATHEMATICS CURRICULUM

the student and his parents and, least important, his intelligence quotient.

Effective grouping involves cooperation and communication among the teachers, the guidance personnel and the administration. Close liaison between the mathematics staff and the guidance people in the district is highly recommended.

To assure a success-oriented program, each student should be periodically re-evaluated and regrouped. This re-evaluation should be made in accordance with the success, abiilty and needs of the student, and should be continual and not made just at the completion of certain levels.

The flow chart is offered as a possible curriculum offering. The areas emitting from each level show the possible selections and alternatives that are available to a student at that level.

Note that the sample curriculum permeates the occupational education concept for all students served. Student offerings are also suggested for a wide range of other individual and societal needs in mathematics. The committee believes that each of these components and offerings is necessary for a total program.

The solid lines show a student who is progressing through the program with average success or better. The dotted lines refer to students who need programs to give them additional background or remedial work.

The "low achiever" courses referred to on the left-hand side of the chart can be specially designed for "low achievers." The traditional approaches are often what have caused these students to fail, and programs should be designed with many creative and individualized components.

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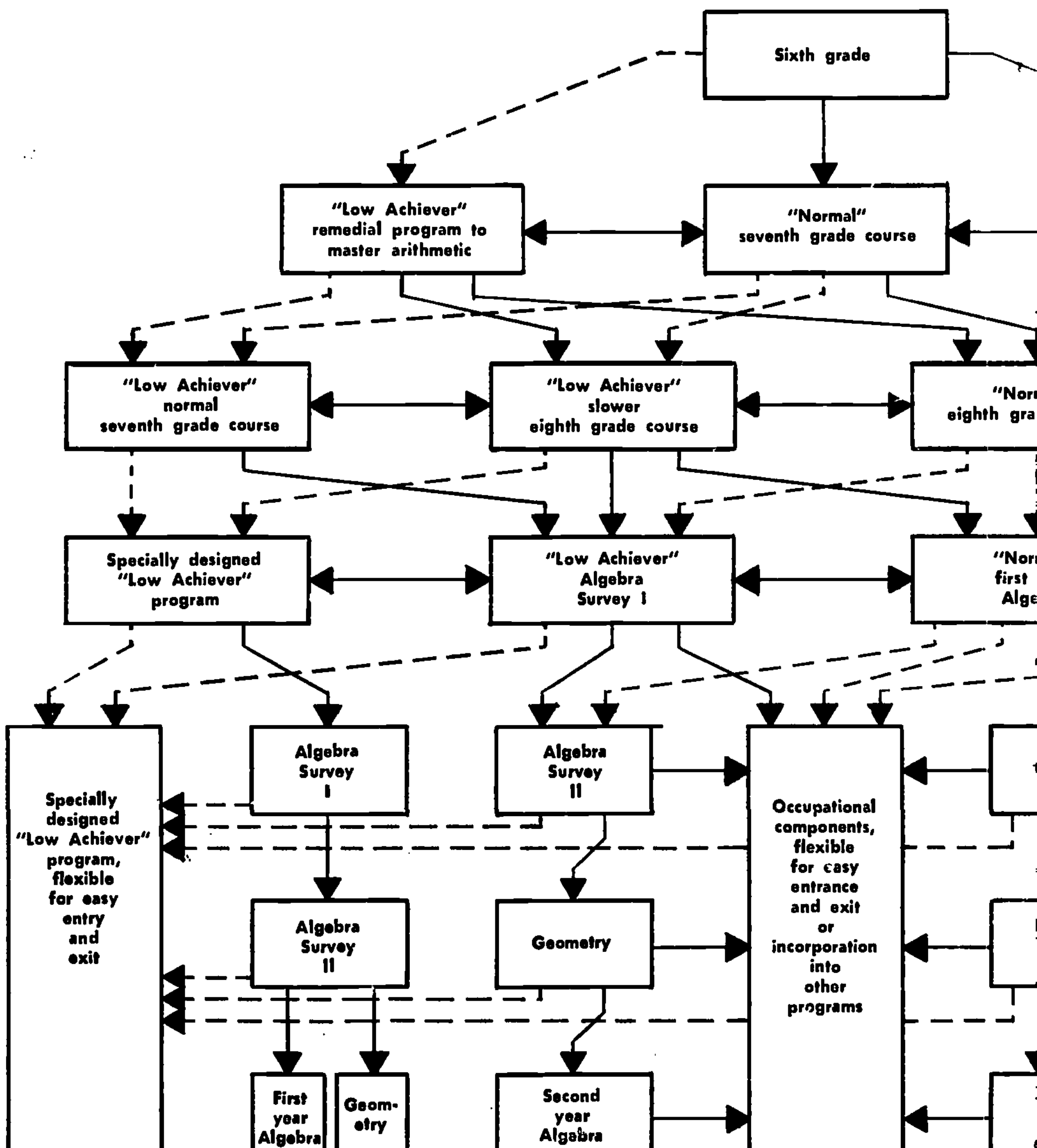

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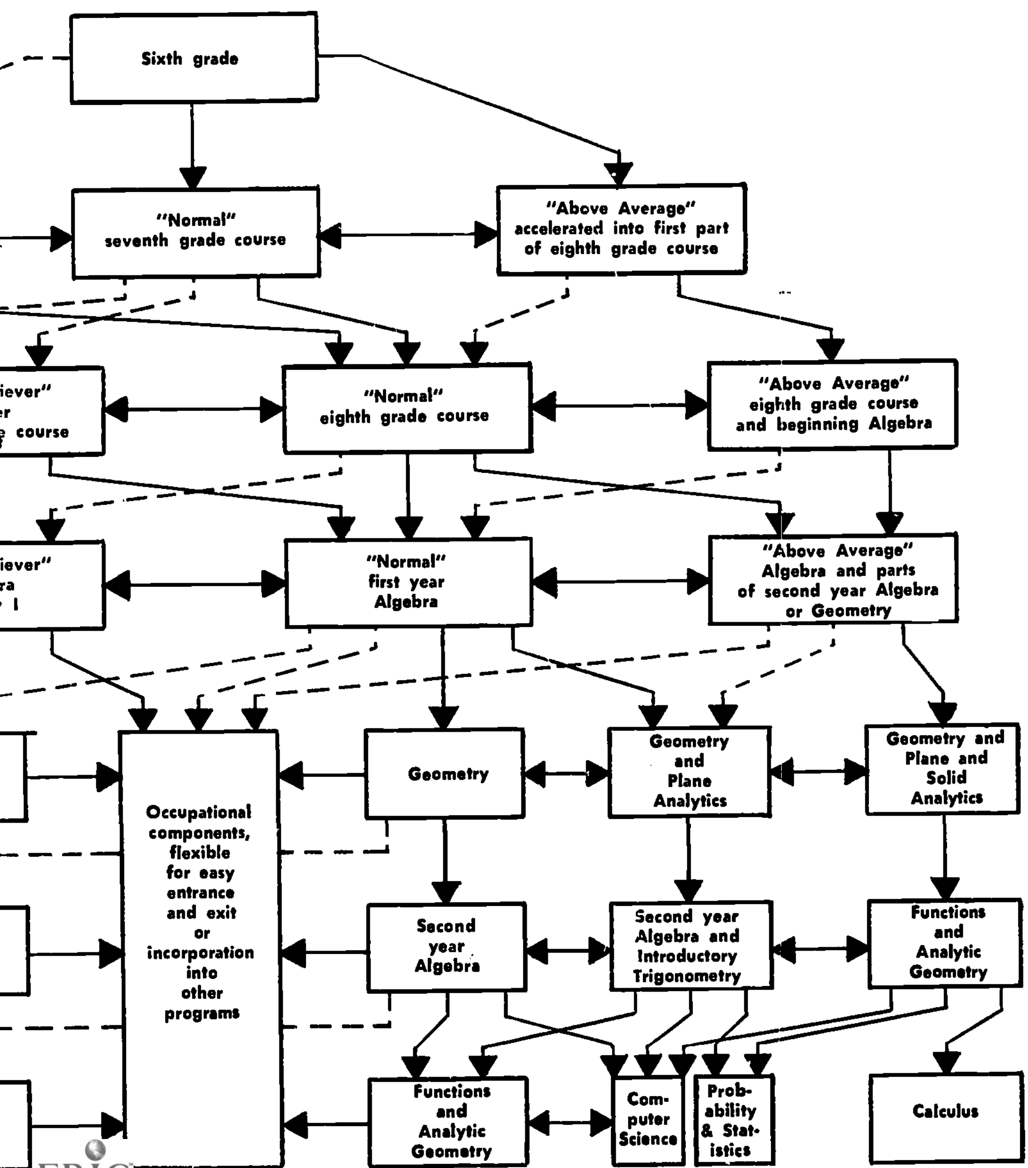
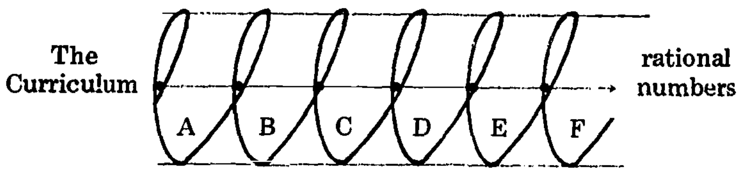


THE SPIRAL APPROACH TO LEARNING

The spiral approach to learning is often emphasized in teaching modern mathematics. This method or approach develops a concept from the intuitive level to the analytic level by spacing instruction. The method will also develop a concept from exploration to mastery.

The following diagram will help illustrate the spiral approach to learning:



In the elementary school, pupils study the rational numbers by participating or by considering parts of regions and subsets (A). The rational numbers are studied on the number line (B). Soon the rational numbers are studied by using equivalent subsets (C). Later the rational numbers are ordered (D). Then the operation of addition is performed upon the set of rational numbers (E). The operation of multiplication is then performed upon the set of rational numbers (F). The operations of addition, subtraction, multiplication, and division are reviewed and extended (G). Rational numbers of arithmetic are extended to rational expressions of algebra (H). The rational expressions of trigonometry are studied (I).

This approach involves the teaching of rational numbers and its related concepts at several points in the curriculum separated by a period of time. With each new exposure to the rational numbers a new approach is taken and a higher level of sophistication is gained.

The student studies the rational numbers in terms of regions and subsets. This is followed by studying the rational numbers on the number line. Later the rational numbers are

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al numbers in terms of by studying the rational the rational numbers are studied by using equivalent subsets. Complete mastery is not necessary on any one level as the rational numbers will be reviewed and extended on each level.

"BEHAVIORAL OBJECTIVES" FOR SECONDARY MATHEMATICS

All instruction should be based on a set of criteria expressed in the form of measurable purposes, goals, aims, or objectives.

The model behavioral objectives presented in this section are primarily concerned with the cognitive level of learning. These are objectives which emphasize remembering or reproducing something which has been learned, and objectives which involve the solving of some intellectual task for which the individual has to determine the essential problem and then reorder given material or combine it with ideas, methods or procedures previously learned. Cognitive objectives vary from simple recall of material learned to highly original and creative ways of combining and synthesizing new ideas and materials. We find that the largest proportion of educational objectives fall into this domain.

The Secondary Mathematics Curriculum Committee wishes to emphasize the importance of cognitive objectives, but does not wish thus to imply that objectives in the affective domain should not be developed. These affective objectives are those which emphasize a feeling, a tone, an emotion or a degree of acceptance or rejection. Affective objectives vary from simple attention to selected phenomena to complex but internally consistent qualities of character and conscience. These objectives are often expressed as attitudes, interests, appreciations, values and emotional sets or biases. Objectives in the affective domain are much more difficult to incorporate into the curriculum, but it is important to keep these affective ideas in mind when developing a mathematics program.

The success of an instructional program is dependent on the common understanding of the objectives by the persons who developed the program and the persons who measure the effectiveness of the program. The key is the clear understanding of the instructional program and its objectives. Therefore, the objectives used must be stated in a clearly defined form that has little chance of being misinterpreted by anyone.

The use of "behavioral objectives" in curriculum plans is based on this premise. In a mathematics program, the objectives should be so stated that there is a definite understanding about the desired goal towards which a student is striving. The objective clearly states the desired performance of the learner and can be clearly measured.

Terminology is important in the writing of behavioral objectives. Words used must be meaningful and must eliminate as many misinterpretations as possible. Some words and phrases that should *not* be used are "to know," "to understand," "to appreciate," and "to believe." These phrases sound fine but are difficult to interpret and evaluate.

Some more desirable words and phrases to use are "to recite," "to name," "to write," "to list," "to solve," "to identify," and "to construct." Then there is little question as to what kind of response the learner should exhibit.

In using this approach in a classroom, the plan normally would be, first to identify certain concepts that are to be taught. Then a number of behavioral objectives are written for each concept. The objectives are organized in an ordered sequence. As a student moves through this sequence, often on a self-pacing basis, each concept should be learned.

The use of behavioral objectives can best be implemented when a teacher recognizes the fact that a student must be accepted where he is and taken as far as possible. This suggests the need for some form of individualization in the classroom. The technique used in reaching an objective is not as

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A valuable reference for developing an understanding of behavioral objectives is *Preparing Instructional Objectives* by Robert Mager (Fearon Publishers, 1962). Excellent samples of instructional objectives in mathematics are available from the Instructional Objectives Exchange, Center for the Study of Evaluation, UCLA Graduate School of Education, Los Angeles, California 90024.

Following is a partial list of objectives for concepts taken from the flow chart on page 2. The objectives are stated as samples, and the percentages are listed as a part of the sample objective. These percentages should be determined locally, and should be subject to constant evaluation and review.

Seventh Grade Mathematics

("average class")

- Given a group of problems consisting of adding, subtracting, multiplying, and dividing mixed numbers, whole numbers, fractions, decimals, 90% of the students will show a proficiency of 80%, in a written test.
- Given a group of geometric solids, 90% of the students, using rulers, meter sticks, paper and pencil, will be able to determine their surface area, and volume, with an allowable error of 10%, 80% of the time.
- Using per cent, 90% of the students will correctly solve 20 out of 25 problems on a written test dealing with interest.

Eighth Grade Mathematics

("average class")

- Given a list of numbers in base 2, base 5, and base 12, 85% of the students will show a proficiency of 80% when adding, subtracting, and multiplying them on a written test.

- Using a compass and straight edge, 90% of the students will be able to construct congruent triangles, bisect lines and angles, draw perpendicular and parallel lines, and divide lines into three and five congruent line segments, 85% of the time.

- Given a group of compound sentences, 85% of the students, using graph paper and a straight edge, will be able to find the truth set of the sentences 80% of the time.

General Mathematics

- Given a group of problems consisting of adding, subtracting, multiplying, and dividing whole numbers, fractions, and decimals, 90% of the students will show a proficiency of 90% on a written test. Ninety per cent of the students will show a proficiency of 90% when taking an oral test on time conversions, dry measure conversions, liquid measure conversions, and length conversions.

Algebra I

- Given a group of polynomials the students will be able to add, subtract, multiply, and divide them with 85% proficiency.

- Given a group of equations, complete and incomplete, 90% of the students will be able to solve them by completing the square, factoring, and by formula, in 20 out of 25 tries.

- Ninety per cent of the students, when given a group of pairs of linear equations, will be able to solve them by graphing, adding and subtracting, substitution, and slope intercept, to a proficiency of 85%.

Geometry

- Given a group of statements, 95% of the students will be able to determine the hypothesis and conclusion, 85% of the time.

- When given a problem such as circumscribing a track around a football field with a limited amount of space, all students will be able to determine the maximum distance using geometry.

Algebra II with Trigonometry

- Given a group of quadratic equations, 90% of the students will be able to graph them with a proficiency of 90%.

- Given a group of imaginary, irrational, and complex numbers, 85% of the students demonstrate at least 80% proficiency when adding, subtracting, multiplying, and dividing them.

- Given a group of oblique triangles, the students will demonstrate a proficiency of 80% in using the Law of Sines, Law of Cosines, and the Law of Tangents.

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THE LOW ACHIEVER

The past decade has seen much advancement in the mathematics curriculum and the teaching of mathematics. At most levels, however, the emphasis has been directed at the above-average student. While new materials and strategies have given the better student a finer insight into the structure of mathematics, they have not relieved much tension in the low achiever. This section of the guide will present some suggestions for low achiever mathematics in grades 7-12, with emphasis on course structure and classroom methodology.

In our discussion of low achievers, we are considering approximately one-third of our students who for some reason learn at a slower rate. They are generally one or more years below grade level in mathematical skills. The low achiever is apt to terminate his education in high school, a circumstance which makes his secondary mathematics program very critical.

The identification of the low achiever must be accomplished as early as possible. Good vertical coordination needs to exist between the elementary and secondary school administration and faculty.

A basic aim of this program is to insure some degree of success by placing the low achiever in a mathematics course which best meets his needs and abilities. To accomplish this, the counselors, teachers and administrators should consider the level of mathematics achievement, English and reading achievement, the performance on standardized tests, the motor skills, the physical and emotional health, the attitudes of the student in other areas, student conferences and the I.Q. Provisions for movement between low achiever and regular class

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offerings (see flow chart) is vital. For these students, growth is very often erratic and hence "pigeonholing" a student in a given track through the secondary mathematics curriculum (or in any given year) must be avoided.

While the committee deems it very important that a comprehensive grouping procedure be used, it emphasizes that what goes on in the classroom after the grouping is accomplished determines a successful low achiever mathematics program.

Both the course content and classroom methodology must be new and exciting. Certainly an effective program will give serious attention to both aspects of the learning situation.

The flow chart suggests two tracks of ability-grouped low-achiever offerings. The "higher" of the two is based upon the premise that the low achiever takes essentially the same mathematics as the regular student, only at a slower pace. The Algebra Surveys, I and II, will approximate a regular first year algebra course. The pace will, of course, be slower and the usefulness of algebra to the student's environment will be emphasized. While it is highly desirable that these students appreciate mathematical structure, it is more important that they learn the mathematics that will be needed in the social world.

The basic or lower track of low-achiever mathematics must *not* be a rigid, structured, repetitious review of topics from arithmetic. The low achiever finds this material uninteresting, and quite logically so, since it represents his "failings" from several years. The classroom should serve as a *laboratory* for learning, with educational *activity* a main feature of the class. Basic instructional objectives, determined in light of the student and his environment, should be identified. This done, a variety of instructional media such as adding machines, filmstrips, mathematical games and manipulative devices should be used as physical models and tools for learning concepts and skills. Since abstractions usually come slowly to the low achiever, problem-solving should be approached by generalizing cautiously the results of many concrete examples. Every explanation given should be simple, direct, and objectively illustrated.

Courses should be structured in such a way as to allow considerable student independence. If a student shows great interest in a particular topic, he should be allowed and encouraged to pursue it independently. To permit this, the courses should be made up of a series of small units. The units should be constructed and arranged so as to be as independent of one another as possible. This will enable the student doing independent work, as well as the student who may be currently confused, to have many opportunities to start "fresh." Also recommending the small-unit approach is the high absence rate of low achievers. A student returning to class will become a part of the class again much faster if he is not faced with endless hours of review (which he probably won't do!).

Perhaps the most important ingredient in a successful program for low achievers is the teacher who will be in charge of the classroom. A good student will learn in spite of a poor teacher but the low achiever will learn only because of a good one. It has long been the practice in our educational system to give the low-achiever classes to a less qualified and less competent teacher than is found in the college preparatory classroom. This practice among administrators and teachers must be changed. As a means of creating a more positive attitude among teachers toward programs for low achievers,

- school districts should try to stimulate teacher interest in this area by in-service education and workshops; and
- the administration should give the teacher of the low

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achiever proper recognition, provide additional planning time, and stress the importance of his work.

In summary, the principal features of any program for the low achiever are success and respectability. The program must contain real problems, be flexible and provide for different rates of learning. However, the best curriculum, and the best of physical facilities and materials will not replace the quality teacher.

The low achiever can learn mathematics and he can make an effective contribution to society. It is our responsibility to create a program which will allow this to happen.

THE MATHEMATICALLY TALENTED

This section of the guide is intended to provide some guidelines for programs to provide for the above-average student in mathematics. A program of this type would be accelerated to the point that a student could take at least one additional year of mathematics. Whether this additional year would be advanced placement or supplementary mathematics would be the decision of the local school system. The committee hopes that the following will be of some help in determining the type of program.

If a school desires to enter into a program for its mathematically talented students, several factors need to be recognized. These include: (1) the size and character of the school population; (2) the availability of qualified teachers; (3) the attitudes of teachers, administrators, and parents; and (4) the availability of outstanding college-bound students.

Schools have a choice of several possible actions regarding mathematics for the above-average student. The option that is most appropriate for a particular school depends upon local conditions and resources.

Because of the sequential nature of mathematics, schools that plan an accelerated program must design the mathematics curriculum so that a full college preparatory program can be completed by the end of grade 11. This can be accomplished in one or more of the following ways: (1) starting the study of secondary school mathematics in grade 8; (2) reorganizing the content of the courses; (3) establishing accelerated sections for the more capable students; (4) encouraging the election of more than one mathematics course in grade 9, 10, or 11; (5) instituting programs of summer study or guided independent study during the academic year.

After the regular college preparatory program has been completed, the 12th year program could include a course in the first year of college calculus and perhaps supplementary courses in probability and statistics, matrix algebra, modern (abstract) algebra, linear algebra, finite mathematics, or computer science. The Advanced Placement Program of the CEEB is one possibility for the calculus offering; however, the committee does not feel the Advanced Placement Program is necessarily the only alternative in providing an adequate program for the above-average student in mathematics. Some schools have enriched their curriculum offering at each level without accelerating.

When an Honors Program is planned for the above-average students, teachers and administrators must be aware that the course must be taught by able, ambitious people, using rigorous textbooks and materials and meeting high standards. It is a course involving college material taught at the high school level to college-ability students. Administrators should be aware of the extra demands imposed on teachers by these courses, especially on those teaching them for the first time; and should schedule additional time for planning.

In curriculum design, teachers should carefully consider not only the content but also the level of sophistication at which new concepts are introduced. With accelerated groups, this can be of great importance because maturity level may

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not have reached sophistication level. Intuition is extremely important in mathematics; on the other hand, a deep understanding of some mathematical concepts is best acquired by formal, rigorous treatment. Many mathematicians attempt to achieve both of these objectives—intuition and precision—by using a spiral approach in which an idea is first introduced intuitively and later reexamined, perhaps several times, at gradually increasing levels of rigor. Use of the word "intuitive" is not meant to suggest a reduction of either clarity of concept or precision of expression. Rather it attempts to distinguish between a course that emphasizes precise proofs of all theorems—rigor in a formal sense—and a course that states definitions and theorems correctly but that defers some proofs until a later course.

When a school desires to accelerate its mathematics program, it is necessary to identify potential students as early as possible, grades 7 and 8, or earlier if possible. Though these students should be identified early, the committee urges that schools adopt a "swinging door" policy for these students. Occasionally, even a student who has been screened before entrance into an accelerated program does not perform as well as expected. Such a student should be allowed to decelerate and rejoin a regular group; there is little gain in forcing acceleration on an unreceptive student. On the other hand, often a mathematically-talented student is overlooked for a year or two; or a student may discover and develop in himself talents that were not evident at the time of the initial screening. Such a student should be encouraged to join the accelerated group, perhaps with some guided independent study to help him catch up. As was mentioned in the area of low achievers, it is not the aim to "pigeonhole" a student in a particular program at the seventh or eighth grade level, or even for that particular year.

In identifying, evaluating and re-evaluating mathematically talented students, counselors, teachers, and administrators should consider mathematical achievement, English and reading achievement, performance on standardized tests, attitudes in other subject matter areas, student conferences, physical and emotional health of the student, and lastly, I.Q. The student who thinks creatively or imaginatively in mathematics is rare. The lack of some of the other desirable traits should probably be overlooked in one who possesses this flair. The

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committee feels that guidance at all levels in the curriculum is desirable; and interpersonal communication among mathematics instructors, guidance personnel and administrators is an essential part of effective grouping.

Wyoming's approach to Comprehensive Occupational Education is based upon a model that is currently being developed in the schools throughout the state.

The major aspects of the model are shown in Illustration I.

During the elementary years, emphasis is placed upon development of attitudes toward the world of work. Projects to develop in all children a respect for all work and a motivation for productive citizenship in the world of work will be implemented. Desirable attitudes for employability are emphasized.

Grades seven and eight are devoted to a career orientation program. The program is developed to provide the students with an understanding about broad areas of our economy such as manufacturing, construction, service, marketing, agriculture, business and professions. Emphasis is placed upon job information and orientation.

In grades nine and ten, students are given opportunities to explore various occupational clusters through a broad career program leading toward a tentative choice of an occupational goal by age sixteen.

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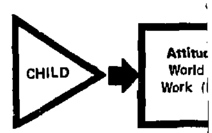

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CHAPTER III
MATHEMATICS COMPONENTS FOR COMPREHENSIVE OCCUPATIONAL EDUCATION

A career preparation broad skill program is provided for grades eleven and twelve. Cooperative education programs are emphasized and close liaison with business and industry is encouraged.

WYOMING MODEL

A Comprehensive Occupational Education Program Design

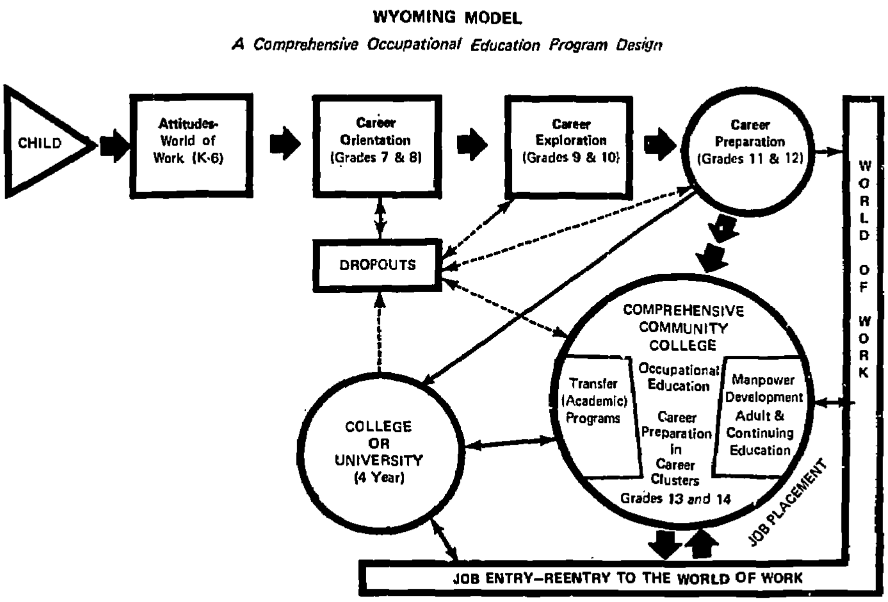

ILLUSTRATION I

As schools of the state actively move toward the incorporation of comprehensive occupational education, the increased responsibility of mathematics educators for developing mathematical components is evident.

Mathematical educators need to cope with these new occupational programs by developing creative new subject material directed toward the occupational clusters. Business mathematics for the commercial student, applied mathematics for the construction, trade or industrial oriented student, mathematics for the mechanic, and occupational mathematics components for the mathematically talented, are just a few of the areas where further development is definitely needed.

Along with the development of creative new subject material—and this is definitely needed—new or better ways of classroom instruction of these topics will be necessary. Mathematics educators must remember that if these courses, strategies and components are to be useful and meaningful to the students, they can't be a replay of a general mathematics course taught in a traditional manner. Techniques and strategies such as those used in mathematics laboratories, and individualized learning activity packets could be looked at as models.

The mathematics material can be developed and tailored to each school's needs. Creative strategies with individual or small group orientations, packet formats and relevant activities must be developed.

Examples of how mathematics problems and activities can be related to occupational and industrial orientation are given in the accompanying listings.

As these programs are extended, the development of activitics can be expected to expand into other fields as well as within the fields listed.

AUTO MECHANICS

Occupational Activity	*Mathematical Concept*
Determine the size of each wrench in a given set of wrenches.	Common fractions

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AUTO MECHANICS

ity	*Mathematical Concept*
of each set of	Common fractions

Occupational Activity	*Mathematical Concept*
Measure the wheel base of a Dodge Dart.	Linear measurement, conversion of units
What feeler gauges should be used to set valve tappet clearance? .012, .009, .004, etc.	Decimal fractions
Measure intake-manifold vacuum and test fuel pump pressure.	Fundamental operations
Determine ignition timing in degrees of crankshaft rotation.	Angles, ratios
Determine foreign car specifications.	Metric units to English units
Compute cost of labor and parts for a tune-up.	Costs, percent
Measure cylinder bore with micrometer and interpret reading.	Linear measurement, metric units, tables
Make a bar graph to compare motor vehicle traffic death rates by states.	Graphs, tables
Compute "stopping distances" at various speeds.	Formulas, reading tables
Compare the weight per horsepower of a Mercury and a Volkswagen.	Ratios, fundamental operations
Figure cost of owning and operating a car.	Estimates, formulas, interest, percent
Determine time needed to charge a battery.	Common fractions, formulas

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Occupational Activity	*Mathematical Concept*
Determine amount of antifreeze mixture for adequate protection at various temperatures.	Percent, tables
Find speed in M.P.H. of race car which travels 2.31 miles per minute.	Formulas, averages, fundamental operations
Determine the error in speedometer and odometer readings caused by a change in tire size.	Circumference, ratios

ELECTRONICS (ELECTRICITY-RADIO)

Compute amperage and voltage of a given number of dry cells connected in parallel.	Fundamental operations
Calculate voltage and amperage of dry cells connected in series.	Common fractions
Compute cost of operating an electrical device for a given period of time.	Decimal fractions
Read instrument scales in making checks of circuit values.	Interpolations
Determine total resistance of two or more resistors connected in series.	Conversion of units
Calculate current in a simple, direct current circuit when voltage and resistance are known.	Common fractions, formulas
Calculate horsepower rating of an electric motor.	Formulas, fundamental operations

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Occupational Activity	*Mathematical Concept*
Find length of magnet wire needed to wind a coil with a given number of turns on a coil form of a specified size.	Circumferences, common fractions, decimal fractions, tables
Find value of a resistor needed to drop voltage in a given electronic circuit.	Decimal fractions, formulas
Calculate length of a half-wave, dipole antenna designed to resonate at a given frequency.	Conversion of units, decimal fractions
Calculate voltage drops of given electrical circuits.	Decimal fractions, formulas, tables
Find impedance ratio of transformer.	Decimal fractions, formulas, ratios
Determine time constant of resistance-capacitance (BC) combination.	Conversion of units, formulas, powers of ten
Determine resonant frequency of a series circuit.	Decimal fractions, formulas, powers of ten, square root
Find power output of an electron tube with given characteristics.	Decimal fractions, formulas
Determine decibels resulting from power gain.	Decimal fractions, formulas, logarithms

GRAPHIC COMMUNICATIONS

Determine number of picas in an inch.	Conversion of units, linear measurements

Occupational Activity	*Mathematical Concept*
Figure cost of paper for a job on basis of price per pound.	Fundamental operations, conversion of units
Determine number of job-size pieces that can be cut from stock-size sheets when papei grain is a factor.	Areas, linear measurements
Determine cost of mounted linoleum blocks.	Ratios
Scale illustrations to proper proportions for paste-up prior to photographing.	Geometry of right triangles, ratios
Compute diameter of camera aperture in relation to focal length of lens for a given value.	Formulas, ratios
Calculate press output for fractional parts of an hour.	Analysis of relationships, common fractions
Determine spoilage allowance on a given job to be printed.	Percent, tables
Find dimensions of rectangles by proportion when given the ratio of the width to the length.	Geometry of right triangles, ratios, square root
Determine shutter speeds for a camera used in photographing copy to be printed by the offset method.	Ratios, tables
Determine various spacing combinations when the em-quad is assigned a value of 60 units.	Analysis of relationships, areas, conversion of units

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Occupational Activity	*Mathematical Concept*
Calculate number of words in a type area containing a given number of square inches.	Areas, conversion of units, tables
Determine time-temperature ratios in a photographic film development.	Decimal fractions, percent
Figure quantities required by given ratios for mixing and matching colored inks.	Common fractions, decimal fractions, ratios, weight measurement
Calculate major and minor conjugates for enlarging or reducing reproduction copy on a graphic arts camera.	Formulas, ratios, tables

HOSPITALITY OCCUPATIONS

Take a restaurant order and compile the final bill with taxes, etc.	Fundamental operations, decimals
Order the necessary food for a week's restaurant operation.	Fundamental operations, decimals, fractions, ratios and proportions
Plan a convention involving 300 people for two days with large and small group meetings.	Blueprint layout, area determination, fundamental operations, ratios, proportions
Plan the kitchen and bakery activities for a banquet of 50 people.	Fundamental operations, decimals, fractions, ratios, volumes

Occupational Activity	*Mathematical Concept*
Simulate the cashier functions of a large restaurant.	Machine operations and computations
Maintain the hospitality accounts for a 35 room motel.	Basic computation involving machine work and fundamental operations
Lay out a kitchen for 90 person capacity restaurant.	Areas, ratios, proportion
Maintain the custodial supply accounting for a large building for one month.	Areas, ratios, fundamental operations
Simulate the time keeping functions for a large motel for one week.	Fractions, decimals, fundamental operations
Develop household budgeting procedures for a family of four.	Money management, fundamental operations, decimals
Simulate the role of a hostess or maitre d' in seating and party arrangements for 50 people.	Fundamental operation, space perception, area
Establish bartender procedures for a group of 30 people for three hours.	Volume, ratio and proportion
Simulate the role of an airline stewardess in the planning for a two hour flight.	Measurements

INDUSTRIAL DRAWING AND DRAFTING

Enlarge a design by the squares method.	Areas, linear measurement, ratios

Occupational Activity

Make an enlargement of a matic diagram to a given

Draw a pattern for tile to used in a tile-top coffee tab

Make a dimensioned drawi a book-binding project.

Make a scale drawing inter ing directions given in lat turning.

Locate 5 ornamental lamps around the edge of a circul park so that they will be eq spaced.

Represent a given location means of construction.

Illustrate graphically the re tionship of valve timing to crankshaft rotation.

Compute the length of rafte for a warehouse.

Construct a rectangular coor ate line chart of motorcycle stopping distances.

Lay out a sprinkler system.

Design an elliptical-shaped ta top.

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Concept	*Occupational Activity*	*Mathematical Concept*
ions ns	Make an enlargement of a schematic diagram to a given ratio.	Common fractions, rat' is
ion in- e work al oper-	Draw a pattern for tile to be used in a tile-top coffee table.	Common fractions, decimal fractions, linear measurement
ropor-	Make a dimensioned drawing of a book-binding project.	Linear measurement
unda- ons	Make a scale drawing interpreting directions given in lathe-turning.	Ratios
mals, pera-	Locate 5 ornamental lamps around the edge of a circular park so that they will be equally spaced.	Angles, circumference of circles
ment, pera-	Represent a given location by means of construction.	Geometrical constructions
pera- ception,	Illustrate graphically the relationship of valve timing to crankshaft rotation.	Graphs
and	Compute the length of rafters for a warehouse.	Pythagorean theorem
s	Construct a rectangular coordinate line chart of motorcycle stopping distances.	Analysis of information, analytic geometry, graphs
	Lay out a sprinkler system.	Areas, geometry of circles, linear measurement, ratios
measure-	Design an elliptical-shaped table top.	Geometry of angles, circles, ellipses, linear measurement

Occupational Activity	*Mathematical Concept*
Lay out the design and angular setting for a plaque of polygon shape.	Angles, geometry of angles and regular polygons

METAL PROCESSING OCCUPATIONS

Occupational Activity	*Mathematical Concept*
Determine the size of hole to be drilled for a reaming operation.	Common fractions, decimal fractions, tables
Find dimensions of a standard screw when only the diameter is known.	Tables
Find total length of a steel bar when a series of dimensions are known.	Common fractions
Figure ratio of acid to water in etching solution.	Liquid measurements, ratios
Calculate length of metal strip required for reinforcing a container.	Conversion of units, formulas, sketches
Find dimensions necessary in threading a specified shaft.	Common, decimal fractions, linear measurements, tables
Calculate amount of material to be left on a turned shaft for finishing.	Fractions, linear measurements

Occupational Activity

Make a stretchout of metal container or ho

Calculate distance bet dividers in a metal co

Determine taper in in foot.

Find size of a metal obj is to be made proporti smaller than a model.

Determine length of wi to make a wired edge a circular metal containe

Find cost of welding r sary to complete a spec job.

Determine the percent c age in a casting.

Determine length of a s strip to encircle an ellip metal tank.

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Occupational Activity	*Mathematical Concept*
Make a stretchout of a simple metal container or holder.	Geometry of lines, angles, squares, and rectangles, linear measurement
Calculate distance between the dividers in a metal container.	Decimal fractions, linear measurement, tables
Determine taper in inches per foot.	Conversion of units, formulas, ratios
Find size of a metal object which is to be made proportionately smaller than a model.	Common fractions, formulas
Determine length of wire needed to make a wired edge around a circular metal container.	Decimal fractions, formulas
Find cost of welding rod necessary to complete a specific shop job.	Common fractions, costs, decimal fractions, ratios, tables
Determine the percent of shrinkage in a casting.	Fractions, percent
Determine length of a steel strip to encircle an elliptical metal tank.	Formulas, sketches, square root, tables

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Yoder Instrument, East Palestine, Ohio 45352. (Computation with Approximate Data.)

Wesleyan University Press, Education Center, Columbus, Ohio. (Mathematics Clubs; Mathematics Through Pictures.)

Wesleyan University, Department of School Services and Publications, 100 Middleview Ctr., Middletown, Conn. 06457. (Bibliography of Mathematics for Secondary School Libraries.)

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Arkay CT-650 Computer Trainer ($250). Arkay International, 3272 Linden Blvd., Brooklyn, N.Y. 11208

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Calculo: Analog Computer Kit ($15). Edmund Scientific Co., Barrington, N. J., NASCO Science Materials, Fort Atkinson, Wis.

Compact Electronic Logic Demonstration ($40). Lano Company, Ann Arbor, Mich.

Digi-Comp ($5). E.S.R. Inc., 350 Main St., Orange, N.J.

Digiac 3010 ($800). Digital Electronics, Westbury, N.Y.

Minivac ($235). Scientific Educational Products Corp., New York, N.Y.

Cardiac (Free). Bell Telephone System. Available through local representatives.

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