In summary, the responsibility of the teacher of mathematics to the student of mathematics takes him far beyond the immediate classroom. This list of responsibilities is by no means complete. Does this mean that the teacher who is not exercising these responsibilities is not a good teacher? No, not necessarily. However, the teacher who is not exercising these responsibilities, while he may still be an acceptable teacher, is not as good a teacher as he could be.

IT behooves each of us to ask ourselves if we are moving toward realizing our full potential as teachers and are giving our students the best we can offer. Are you the teacher who, at the end of 25 years of teaching, has 25 years of experience, or are you the one who has had one year's experience 25 times? Are you a teacher of mathematics, or someone merely holding down a job and holding a job down?

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Flow Charting and Mathematics

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Many pupils experience difficulty or failure in mathematics and other disciplines as well because of their inability to proceed logically in the solution of problems. Much of this inability to solve problems can be attributed to the use of the formalized results of rote learning without having any concepts underlying the facts involved. The situation is further compounded by their frustrating experiences in regard to problem-solving which tends to undermine any confidence in their thinking abilities. Several pupils in slow learner classes have been observed to berate and downgrade themselves and their classmates with expressions such as "dumbie", "dodo", "dumbbell", and many other like expressions. With such a negative self-image and attitude of mind, it seems likely that scant achievement, if any, will be experienced by these individuals.

There are, no doubt, many different approaches to eradicating a negative self-image or attitude of mind. The underlying theme in all approaches must be to engage in activities that tend to lead to heightening self-confidence. Flow charting, properly and enthusiastically used, can be an excellent vehicle on which to develop such activities.

A flow chart is a pictorial outline of a sequence of steps to be accomplished to solve problems. It is actually similar to a road map in that it shows the routes from a starting point to an ending point. Any procedure involving a series of operations may be flow-charted. The skill of flow charting has been found to be very valuable, both in mathematics and in everyday life situations. Each flow chart is a linear diagram from start to end and there-

fore requires the person making it to have a thorough knowledge of all the steps involved.

Flow chart symbols have been standardized to facilitate understanding among people who use these charts. Experience has shown that in teaching slow learners the following symbols have proved to be satisfactory:

This is a standard symbol for *terminal* and is used to show the start or end of a series of steps.

Operation or annotation. Used to show a step, a specific operation or function.

Printed output. Item or answer that may be printed or written down.

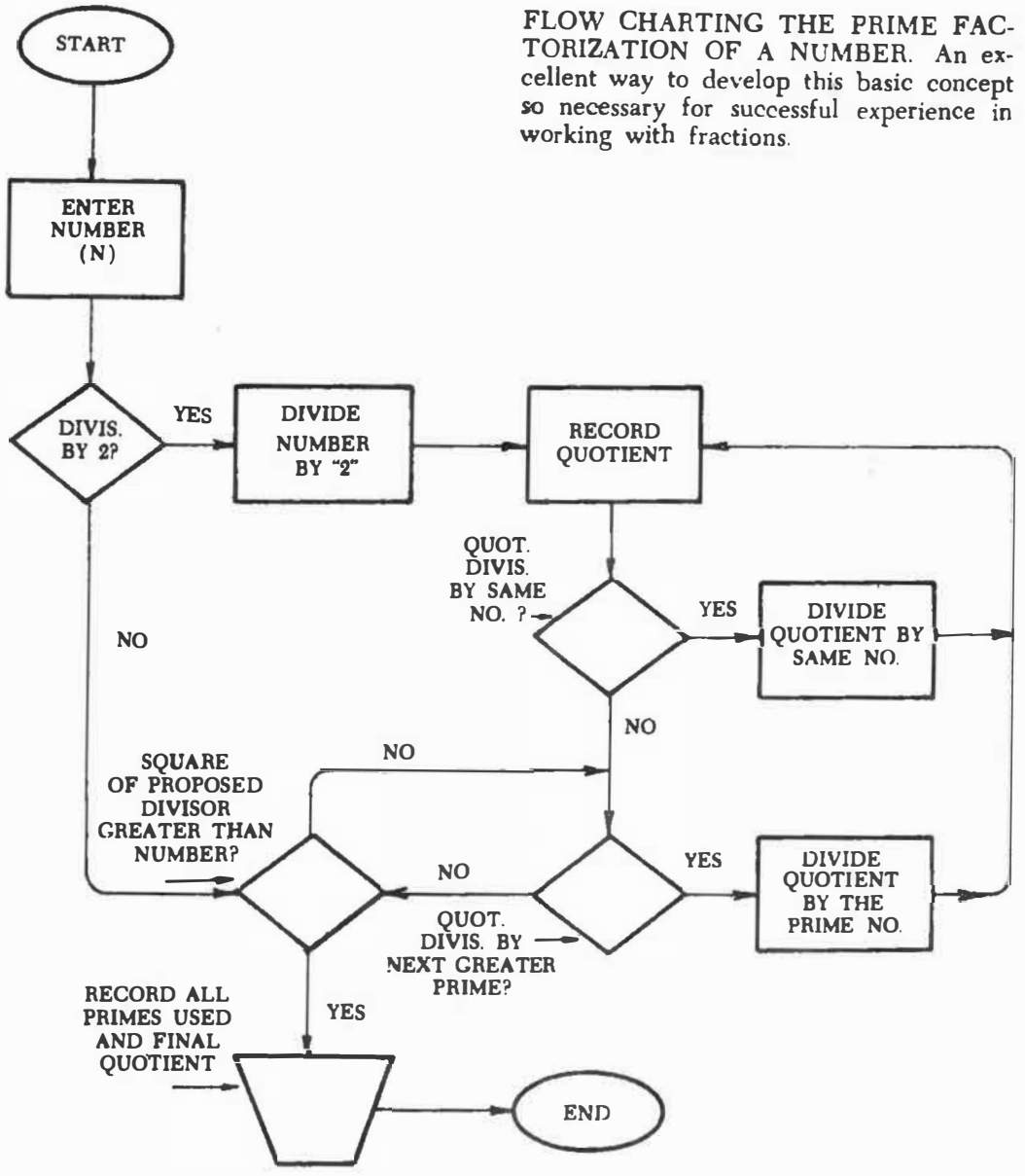
Decision. Used when flow or direction is variable.

These symbols may be drawn freehand or with the aid of a specially prepared template. Students are more likely to be motivated by using the templates which are available from various business machine companies.

Since flow charting is a pictorial language used to design logic for the solution of problems, the method has significant advantage for teaching mathematics:

1. It assures understanding. If a problem cannot be flow-charted, it is not fully understood.
2. It reduces complex mathematical problems to simpler and more easily understood sections.
3. If the flow chart is correct, the problem solver receives the proper instructions, and a correct answer is more likely.
4. Flow charting introduces your students to symbols and terms that are becoming more common every day in a computerized world.
5. A flow chart is a pre-plan for solving a problem. It saves time and increases motivation for solving more concepts.
6. Flow charting encourages disciplined thinking. It may be used effectively in many subject areas.

Flow charts may be drawn from left to right as a line (horizontal) or top to bottom as in a column (vertical). Either method is acceptable and valid. More important is the need to analyze the problem before beginning. With practice, one will be able to visualize the flow chart before drawing the outline.



FLOW CHARTING THE PRIME FACTORIZATION OF A NUMBER. An excellent way to develop this basic concept so necessary for successful experience in working with fractions.

EXAMPLES: (1) $3\,|\underline{2385}$
$3\,|\underline{795}$
$5\,|\underline{265}$
53

$3 \times 3 \times 5 \times 53 = 2385$

(2) $2\,|\underline{1496}$
$2\,|\underline{748}$
$2\,|\underline{374}$
$11\,|\underline{187}$
17

$2 \times 2 \times 2 \times 11 \times 17 = 1496$

Start with simple non-arithmetical problems at first to learn the technique of flow charting. Pose a simple problem and ask leading questions of the

students to solicit from them a step-by-step procedure for the solution of the problem. One problem that has a basic familiarity to many students is "how to sharpen a pencil". In this first attempt, one can usually expect from 12 to 18 steps to be developed by the class. After the steps have been listed, the flow chart can be drawn at the chalkboard or on the overhead projector. (The author constructed a set of template from bristol board for use at the chalkboard.) Encourage the students to participate in choosing the proper flow chart symbols for the various steps. After the students have participated in a class exercise such as just described, it is appropriate to assign a problem or two as homework. The author has used such problems as "how to comb your hair" and "how to get dressed for school". Results have varied from brief four- or five-step procedures to quite elaborate procedures of as many as 52 steps. Several procedures were then selected and transparencies made for the purpose of class discussion concerning completeness, accuracy, and efficiency. It is important to point out that while there are several ways to solve most problems, our goal is to select the most efficient way. Some examples of non-arithmetical problems are:

How to sharpen a pencil
How to get dressed
How to wash your face
How to get a book from your locker
How to get up in the morning
How to tie a necktie
How to shift with a "straight stick"
How to catch a fish
How to open a door
How to brush your teeth
How to wash dishes
How to start a lawn mower
How to fix a sandwich
How to fix a bed
How to change the oil in a car
How to plant a flower

After the students have had some experience making flow charts for non-arithmetical actions, it is well to apply this skill to common arithmetic problems. *Pupil participation is very important* even if the problems may seem long and take time to develop. Time is of less importance compared to understanding of a concept.

This is also a good introductory approach to teaching mathematics students to make mathematical proofs in algebra and geometry. In fact, flow charting will probably make the proving of theorems in algebra and geometry a far more enjoyable task as well as leading to greater achievement. An imaginative teacher will find many opportunities to use flow charting to great advantage in the teaching of most areas of mathematics. Flow charting must not become an end result in itself, but rather it must be utilized as one of the valuable tools or devices that teachers use in the teaching of mathematics students.

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