MATHEMATICS IN GENERAL EDUCATION:

Changes, Constants, Concerns

LEROY G. CALLAHAN *

CHANGE is the constant of the times. No doubt each generation has felt that its generation was changing more rapidly than any previous one and that a slow-down, a period of consolidation, was just over the next rise for the more fortunate descendants.

Mathematics education has experienced a period of change. There is every possibility that these changes will continue and accelerate. In the following discussion, a consideration will be given to these changes; but also, consideration will be given to certain constants that have served as guidelines in determining the instructional program in mathematics for the general education of students. Consideration will also be given to certain concerns and challenges in the years ahead if the "changing" mathematics curriculum is to be a "progressing" mathematics curriculum.

These themes will develop within a figure-ground context. The "figure" is the instructional program in mathematics for general education; the "ground" is the *Zeitgeist*—the spirit of the times—in which the program is carried out. The assumption is that this "spirit" interacts in subtle ways in influencing our judgments regarding mathematics in general education. This "spirit" tends to be quite blithe in character—changing, and influencing change in turn. The "figure"—the instructional program in mathematics—changes and influences change in return, but has exhibited some constant kinds of boundaries within which the constant of change has occurred.

Each of these two—"figure" and "ground"—will be discussed separately. Following this, certain concerns will be put forth that must be considered if the instructional program in mathematics is to evolve, not only in a changing sense, but in a progressing sense.

Mathematics in General Education

Obviously, the content of mathematics has a direct contribution to make as man selects and transmits societal skills from generation to generation. Mathematics is a tool to aid man to know and translate more accurately his objective world. These objectives may be thought of as Level I kinds of mathematical behaviors in general education (See Figure 1).

Intriguingly, the *form* of mathematics may also have an indirect contribution to make as man strives to transform society. The logical reasoning associated with the study of mathematics is thought of as an indispensible study in the general education

* *Leroy G. Callahan, Assistant Professor, Faculty of Educational Studies, State University of New York at Buffalo*

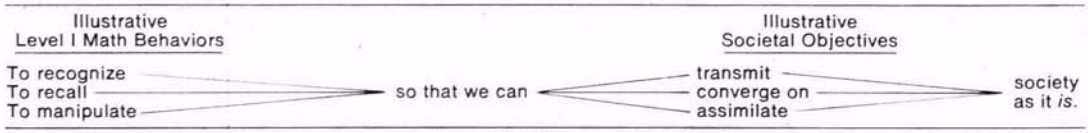

Figure 1. Level I Mathematical Behaviors

of man. These objectives may be thought of as Level II kinds of mathematical behaviors in general education (See Figure 2).

Realistically, the intellectual and emotional development of the student is also a determinant of mathematical objectives in general education. As suggested by Fromm, "The aim of education—in fact the aim of life—is to work joyfully and to find happiness." [1]

Happiness and joy are very uniquely personal things. Pervading and influencing the objectives of mathematics are its contributions to the individual adjustment of each individual student involved in general education.

These three objectives of mathematics in general education—the utilitarian contribution, the speculative or "thinking" contribution, and the affective or "humanizing" contribution—have influenced mathematics in general education for many years. They may act as guideposts for curriculum workers in the whirling, kaleidoscopic world of change in which we are involved. In a sense they have been constants in an ever-changing drama.

The Zeitgeist

The "new math" movement of the 1950's and 1960's flourished within a spirit of optimism at the *operative* potential of the human ability. Man had successfully overcome many of nature's forces in making the "good life" for man. Might it not be possible for man to overcome other forces and, through the educational process, develop and mold more students who could function at a relatively early age as mathematicians and scientists in our rapidly developing culture? Various means developed to accomplish this objective.

Curriculum reforms that focused on structure of arithmetic and other branches of mathematics were nourished by the spirit of the times. Similar reform suggestions during the previous quarter of the century by such men as William A. Brownell and Charles Hubbard Judd had tended to fall on generally unreceptive ground. In a somewhat similar vein, the concept of a "teaching machine" hardly caused a ripple in the 1930's when developed by Sidney Pressey, but caused a significant wave to form 30 years later when the "spirit" caught it. A "we can overcome" spirit was dominant in educational thinking during the time.

Mueller [2] chronicled the "new math" era by examining discussions of the topic in the public press. Beginning in 1956 the tenor of articles in the press generally reflected a discontent with the contemporary teaching of mathematics in the schools. The period 1956-1965 were the "happy" years for the "new math" movement. The year 1965 began to reflect a feeling that there may be some questions and perhaps some misgivings as to what was going on.

It well may be that a new "spirit" was emerging by the mid-1960's. A convergence of circumstances, that is, assassinations, lack of rapid progress in integration, the war in Vietnam, may have contributed to an emergent "spirit" which valued the affective, humanizing goals of education rather than the cognitive, subject matter objectives. A feeling was emerging that it was of little use for society to develop the most capable scientists and mathematicians if this potential might be used in non-constructive pursuits. The emerging spirit suggests that the more

[1] Erich Fromm. Foreword to: A. S. Neill. *Summerhill: A Radical Approach to Child Rearing.* New York: Hart Publishing Company, Inc., 1960. p. xii.

[2] Francis J. Mueller. "The Public Image of 'New Mathematics.'" *The Mathematics Teacher* 59: 618-23; November 1966.

cognitive, subject matter objectives of the "new math" era are necessary but far from sufficient in the total program in general education. Maslow writes:

> We are witnessing a great revolution in thought, in the Zeitgeist itself: The creation of a new image of man and society and of religion and science. . . . This is not an improvement of something; it is a real change in direction altogether.[3]

If the description of the emerging "spirit" is accurate, it well may be that the people involved with the instructional program in mathematics will strike the receptive chord by rededication of effort to the total, intellectual, and emotional development of the student in general education. The great challenge, I believe, will be for the persons involved in developing the programs in mathematics to consolidate on the gains made during the "new math" era while extending their concerns in the area of affective, "humanizing" objectives. If this desirable, but difficult, task can be achieved we may be able to say that we are not only involved in a changing instruction program in mathematics, but in fact a *progressive* program. Following are developed some *concerns* if a progressive program is to be achieved.

Concerns for the '70's

A clarification and delimiting of the legitimate objectives of the mathematics program in general education are needed. A corollary involves the development of more accurate measuring devices, given the clarified objectives.

An illustration of this need might be the role mathematics instruction plays in the development of higher level (Level II) intellectual skills. The authors of the Cambridge Report[4] write of the "building of confidence in one's own analytical powers" through a program in mathematics education. What needs to be clarified is what aspects of the program contribute to this objective. Is it *what* is being taught that contributes to the objective? Is it *who* is doing the teaching or *how* it is being taught that makes this contribution? Also, what non-educational factors may be involved in developing the objective? Could societal values play a dominant role in influencing the development of these intellectual skills? Could the chemical makeup of the human cell determine the extent to which an individual may develop these skills?

More accurate knowledge in regard to some of these questions would allow people involved in the instructional program in mathematics at the general education level to focus on those aspects of the program where a significant impact on development could be anticipated. Lesser "mass" amounts of energy would be spent chasing elusive rainbows. This "chase" would be the concern of a small group of specialists whose time and energies are freed and financed to pursue the "possible dream."

Once the intellectual skills that can be effected by the program in mathematics have been clarified, efforts must be made to develop measurement techniques to accurately gauge the impact of curricular changes. At our present level of sophistication in measurement, curriculum "transplants" are performed and we have little hard evidence as to the success, or failure, of the operation.

There must be concern for development

[3] Abraham H. Maslow. "Some Educational Implications of the Humanistic Psychologies." *Harvard Educational Review* 38: 685-96; Fall 1968.

[4] *Goals for School Mathematics.* The Report of the Cambridge Conference on School Mathematics. Boston: Houghton Mifflin Company, 1963. p. 9.

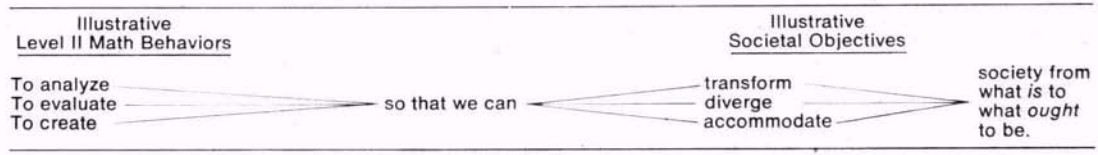

Figure 2. Level II Mathematical Behaviors

of survey techniques that can describe and project the mathematical needs of society.

This is a concern for the "How to . . ." (Level I) types of intellectual skills in mathematics. It may be perceived by some as an old-fashioned view. It has been fashionable of late to downgrade, if not in fact to denigrate, such direct, immediate, and utilitarian objectives in the mathematics program. Yet, reports of the death of the social utilitarian objectives in mathematics for general education may be somewhat premature. The development of salable skills in the contemporary market place, the development of intelligent consumer skills, the development of quantitative skills needed to enable one to enjoy increasing leisure-time activities may have their legitimate place in the development of "the good life" for students in general education.

Needed are techniques for constant surveillance of societal needs and for projecting societal needs. These needs must constantly be reflected in the mathematics curriculum of the schools. There must not be any "saber-toothed" hang-ups. As suggested by Suzzallo:

> If arithmetic is to serve life, life must be examined. . . . The social survey will reveal the archaic and the unimportant as well as the substantial and necessary in arithmetic.[5]

As changes in the quantitative needs of society accelerate, scientific means and technological methods must be brought to bear on describing and projecting these changing social needs.

The challenge to people involved in developing the mathematics program will then be to use this information, regarding the mathematics of social needs, in harmony with the development of higher level intellectual skills (Level II) that are judged to be attainable and desirable for the students in general education.

There must be an increased concern for determining broader applications of the concept of "individualized learning" in general mathematics programs.

[5] In: Guy M. Wilson. *What Arithmetic Shall We Teach?* Boston: Houghton Mifflin Company, 1926.

Many of the contemporary attempts at individualization involve simply changing the rate at which individual students, or fewer homogeneously grouped students, proceed through the same mathematics curriculum. This procedure is no doubt an improvement over one in which every student does "the same thing at the same rate," but it may be far from a concept of real "individualized learning." Real individualization may require some very basic shifts in curriculum and methodology, given a knowledge of certain dimensions of the student involved in the instructional process. Following are illustrated a few of the human dimensions which could motivate shifts in the elementary school mathematics instructional program if true individualization in learning is to be accomplished.

One basic dimension to be explored in the "individualization" process is that of genotypical factors involved with learning. Jensen has hypothesized two genotypically distinct basic abilities underlying the learning process which he labels Level I (associative ability) and Level II (conceptual ability). Level I involves the neural registration and consolidation of stimulus inputs and the formation of associations. Level II abilities involve self-initiated elaboration and transformation of the stimulus input before it eventuates in an overt response. Jensen, in reflecting on the present educational philosophy, comments:

> If a child cannot show that he "understands" the meaning of $1 + 1 = 2$ in some abstract, verbal, cognitive sense, he is, in effect, not allowed to go on to learn $2 + 2 = 4$. I am reasonably convinced that all the basic scholastic skills can be learned by children with normal Level I learning ability, provided the instructional techniques do not make "g" (general intelligence, i.e., Level II functioning) the *sine qua non* of being able to learn. (We) must discover and devise teaching methods that capitalize on existing abilities, accepting this differentiation in a non-hierarchical valuing sense, and adapting our instruction to the differentiation along this cognitive skill dimension.[6]

[6] Arthur Jensen. "How Much Can We Boost IQ and Scholastic Achievement?" *Harvard Educational Review* 39: 117; Winter 1969.

An obstacle to "individualization" on this dimension will involve the emotion-laden racial problems in which education is involved. In regard to the dualisms of black and white students, or urban and suburban students, every effort must be made not to overgeneralize on this dimension. Certainly teachers in white suburban situations can cite many examples of Level I-type functionaries in their schools; likewise teachers in black urban situations can cite many examples of Level II-type functionaries in their schools. The challenge is to develop an awareness on the part of the teacher of the possible influence of this dimension on learning no matter where the school is located; then, to have a repertoire of instructional experiences and techniques that will allow for efficient and unfrustrating learning in mathematics on the part of each individual student.

Another dimension that may be worthy in considering "individualization" is the personality of the student. An illustration of one sub-dimension that has received attention recently is that of conceptual tempo.[7] It has been suggested from empirical data that the impulsive child will tend to report the first hypothesis that occurs to him and that this response is often incorrect. The reflective child delays a relatively long time before reporting a solution and is usually correct. Two other "neutral" groups tend to be definable; those who report the first hypothesis that occurs and are usually correct, and those who delay a long time and yet are usually incorrect in their responses.

There are many classrooms where rapidity of response is highly prized and where the reflective (plugger) is misjudged as a poor student. One interesting problem may involve hours of enjoyable contemplation and work by a reflective student, whereas a "typical" assignment of five problems may be so overwhelming to the same student that there is withdrawal and the resultant judgment that the reflective student is lazy and

[7] Jerome Kagan. "Impulsive and Reflective Children: The Significance of Conceptual Tempo." In: J. D. Krumboltz, editor. *Learning and the Educational Process*. Chicago: Rand McNally & Company, 1966.

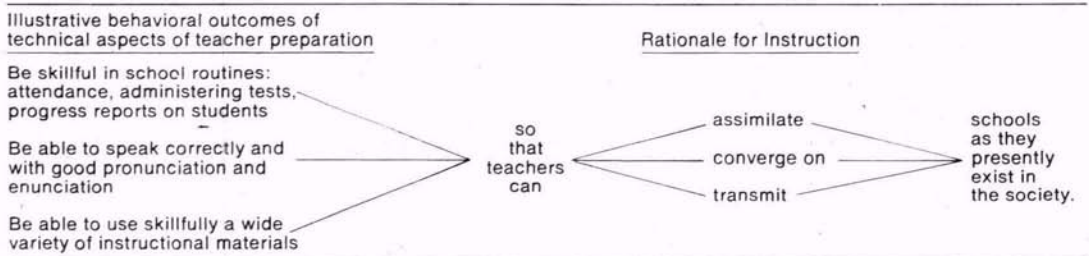

Figure 3. Technical Aspects of Preparation and Their Objectives

not very bright. It may well be that there is a time to be impulsive and a time to be reflective within the instructional program in mathematics. If the reflective child is to function adequately in Level I-type quantitative situations, he should be encouraged and rewarded for increasing his speed of operation. On the other hand, if the impulsive child is to function adequately in Level II-type quantitative situations, he should be encouraged and rewarded for slowing down and being more reflective in his work.

What has been suggested by means of a few illustrative dimensions is that true "individualization" of learning may be a much broader concept than is now recognized in many individualized instruction attempts. The rate at which a student proceeds through the instructional program should be individualized; however, *what* is included in the program as well as *how* the material is presented should also be worthy considerations in true "individualized learning" in mathematics for general education.

A third concern in mathematics in general education must be in the area of teacher preparation. The development of a valid curriculum for the preparation of teachers may be conceptualized in a parallel sense with the previously conceptualized curriculum in mathematics education. The challenge is the attainment of an appropriate balance between the theoretical considerations and the technical aspects in the preparation of preservice teachers. Schematically the technical aspects of preparation and their objectives are illustrated in Figure 3.

The theoretical preparation of teachers and the objectives of such preparation are illustrated in Figure 4.

Just as in judgments affecting the mathematics curriculum in general education, the emotional development and growth of the prospective teacher must also be considered in the preparation program in teacher education. This position is alluded to by Carl Rogers when he writes:

> Perhaps the most basic attitude (for the teacher) is realness. When the facilitator (teacher) is a real person, is what he is, and enters into a relationship with the learner without presenting a front or a facade, he is much more likely to be effective.[8]

In implementing the practical, technical

[8] Carl Rogers. In: D. B. Gowin and C. Richardson, editors. *Five Fields and Teacher Education*. Project One Publication. Ithaca, New York: Cornell University, 1965. p. 60.

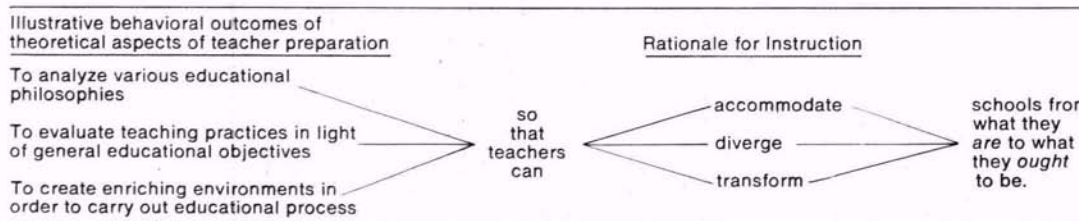

Figure 4. Theoretical Aspects of Preparation and Their Objectives

training of preservice teachers, there must be increased opportunity for preservice teachers to be immersed in real teaching situations in the public schools. These opportunities should range from extensive experiences to gain general knowledge of the structure of the educational system in our country to intensive diagnosing of learning difficulties of individual students. The implementation of such broad programs dictates much closer cooperative ties than are usual between the colleges and the public schools.

If increased cooperative attempts are to be beneficial there must be a mutual respect between the public school teachers and the college personnel. Each must recognize and respect the fact that, though their roles differ, they each have their legitimate and complementary role to play in the preparation of preservice teachers. The dominant role of the public school person involves the development of the technical tools for teaching; the dominant role of the university professor involves the development of the intellectual awareness of the various theoretical parameters within which the prospective teacher assumes his role. Both must be aware of the emotional development and well-being of the preservice teacher.

Improvement in the more theoretical aspects of teacher preparation must develop at the college level. This requires the upgrading of the various foundation courses (such as Educational Philosophy, Educational Psychology, and Educational Sociology) as well as the upgrading of the "methods" courses offered in the subject matter areas. Good teaching must be encouraged and rewarded at the college and university level. Too many are too quick to suggest that because a "foundations" or "methods" course is boring or irrelevant, such courses should be discontinued. Rather, efforts should be made to find people who can make these courses come alive—who have the depth of scholarly preparation and the breadth of experience to bring relevance to these courses at the college level. As stated by Burns and Brauner:

> In education, as in all other areas of life, it is not enough to have a technology—to know that X will produce Y. We must also know, that is, make the value decision, that we want Y; we must adjudge Y to be desirable. . . . All educational questions have an inescapable axiological and epistemological dimension. But obviously education is also an empirical affair, so it has an inescapable scientific dimension as well. To ignore the philosophic dimension is to condemn the educational process to a bland intellectual wandering. . . . to ignore the scientific dimension is to divorce education from reality. . . .[9]

In summary, it has been suggested here that the curriculum worker is faced with various constants, challenges, and concerns when working in the area of mathematics for general education. A constant parameter was developed within which the value decisions can be made regarding *what* mathematics is of most value to the general education students. It was also suggested that the "spirit of the times" affects these value decisions and, therefore, there is a constant change. Various challenges were discussed which must be met if we want to say that the mathematics curriculum is not only changing, but—more important—progressing. □

[9] Hobert W. Burns and Charles J. Brauner, editors. *Philosophy of Education: Essays and Commentaries.* New York: The Ronald Press Company, © 1962. p. 11.