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ABSTRACT

This paper, based on the inquiries of the General Mathematics Project, makes a case for naturalistic research in mathematics classrooms. In explicating the case, consideration is given to the need for information on classroom practices and the consequence of those practices on teaching and learning. Also considered is the need for research that addresses the problems of practice from the practitioner's perspective. Included is a discussion of the General Mathematics Project's evolution and tentative results. Some of those results are that teachers do teach general-math students differently from algebra students and that most teachers have unusual difficulty teaching general math and often feel only marginally or not at all successful. (Author/MP)

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MATHEMATICS CLASSROOM INQUIRY: THE NEED, A METHOD, AND THE PROMISE

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Abstract

This paper, based on the inquiries of the General Mathematics project, makes a case for naturalistic research in mathematics classrooms. In explicating the case, consideration is given to the need for information on classroom practices and the consequence of those practices on teaching and learning. Also considered is the need for research that addresses the problems of practice from the practitioner's perspective. Included is a discussion of the General Mathematics Project's evolution and tentative results. Some of those results are that teachers do teach general-math students differently from algebra students and that most teachers have unusual difficulty teaching general math and often feel only marginally or not at all successful.

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In ascertaining what life for teachers and students is like in these classrooms, we have used field research methodology. Basically, this is an adaptation and extension of ethnography--the method of the anthropologist--for purposes of studying educational settings. Field notes from classroom observations have been the primary data source, but these have been augmented by teacher interview data, student artifacts such as tests, and limited use of videotaping. The participant observers (data gatherers) have been educational anthropologists and teachers or mathematics educators trained to conduct field research. As participant observers we have attempted to not intervene at all in the flow of instructional activity. We have departed from this stance only when it was expedient to interact with a student or students who had asked for assistance or otherwise initiated a dialogue with us. Our task was to be as unobtrusive as possible; we made every effort to study the classroom in its naturalness and wholeness.

The Need for Practical Investigation in Mathematics Classrooms

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> The question, "What goes on in the ordinary classroom in the United States?" is surely an important one, but attempting to survey the status of mathematical education at "benchmark 1975," one is immediately confronted by the fact that a major gap in existing data occurs here. Appallingly little is known about teaching in any large fraction of U.S. classrooms. (NACOME, Note 1)

In 1980 a review of the 580 entries appearing in the tenth annual listing of research on mathematics education, published in the Journal for Research in Mathematics Education, showed that 25 studies, slightly more than 4%, were conducted to address questions of classroom practice (Suydam & Weaver, 1980).

In one sense this last piece of information is encouraging--that there are nearly 600 persons studying some aspect of mathematics education in a given year is commendable. Yet one wonders about the apparent imbalance between the practical and the theoretic when the need for practical/action research has been noted by scholars, teachers, and study groups for at least five or 10 years. Only 25 of the 580 studies (reported in 1979) were directed toward investigating the quality and nature of life in mathematics classrooms, and the remainder are primarily theoretic.

Clearly, the mathematics education research community, as evidenced by its actions and writings, is not unanimously convinced that the classroom is a promising arena for investigation. I contend that the field of science education, as represented by mathematics education, is in need of classroom research. Further, I hope to show, through relating my experiences in the study of general-mathematics classrooms, how such research can uniquely lead to the improvement of science teaching and science-teacher education as well as advancing the science-education research field.

Tom (1980), in an argument for a conception that portrays teaching as a moral craft rather than an applied science suggests both a need for and a use of research knowledge from the classroom. He observes:

> Despite the obvious differences in pedagogical knowledge and skill between, the experienced teacher and the typical novice, the craftsperson teacher rarely attempts to pass systematically this accumulated wisdom to the next generation...teacher training programs contain little such codified knowledge and skills, and many professors...deny that such craft culture is valuable. Even experienced teachers often deny that their skills and knowledge...could be of value to other teachers.... In other words, all teachers must discover, "what works for them individually"--of matching strategies and ideas to one's personality and to one's unique classroom of youngsters. The result of not receiving craft culture in preservice training--except perhaps in student teaching--and of believing that all teachers must develop a personal teaching style is the conception of teaching as an individualistic enterprise that must be learned by trial and error. (p. 320)

Certainly, anyone who has either taught or closely observed others teaching or learning to teach is familiar with the preponderance of learning by trial and error. If one outcome of classroom research were the reduction of an overdependence on trial and error, it seems certain that practice would be improved. Further, it is conceivable that perusal and use of practical research would begin the extinction of the anti-research attitude common among teachers and would subsequently generate an appreciation of theoretic research as well. Such a state is as desirable for teachers as for researchers because it is the theoretic that provides new ideas that practitioners can adapt to practice.

Given the case for classroom research, what do researchers want to find out? What do they want to become smarter about? Why do they want to become smarter about it? Schwab (1978) contends;

> What is wanted is a totally new and extensive pattern of *empirical* study of classroom action and reaction; a study, not as basis for theoretical concerns about the nature of teaching or learning process, but as a basis for beginning to know what we are doing, what we are not doing, and to what effect; what changes are needed, which needed changes

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can be instituted with what costs or economics, and how they can be effected with minimum tearing of the remaining fabric of educational effort. (p. 313)

Clearly Schwab is asking that researchers establish "what is" as objectively as possible, then follow that assessment with evaluative judgments of "what should and could be." On the point of "minimum tearing of the remaining fabric of educational effort," could he have been saying that had these things been considered, the curriculum reform movements of the post-sputnik era would have been implemented differently with different consequences? For example, had educators thought in terms of a soft revolution versus a revolution in school mathematics, what would they have needed to know? What would they have done differently? This information of conditions and their implications for change can only be validly obtained from serious and systematic investigation of classrooms. Furthermore, the implementation of any innovation is perilously endangered without such information.

In summary the need for classroom research appears to be two-fold. First, a knowledge picture of teaching is incomplete without classroom consideration. Second, the knowledge derived and communicated from classroom research is likely to have explicit and useful things to say to the practitioner (a phenomenon which may subsequently endear the teacher to research). Inherent in the two-fold need for practical knowledge and its use are the questions that should be addressed in the context of the classroom. What's happening in the prelude to, during the flow of, and following instruction? What are the teacher's thoughts and actions relative to the classroom experience? What are the learner's thoughts and actions relative to the experience? How is the content of instruction enacted?

Mathematics Classrooms. Are They All Equally Worthy of Investigation?

Given the need for research in mathematics classrooms, one is confronted with the question of classroom selection, research-site selection. Intuitively, it seems obvious that every potential research site is not as good as every other potential site, but that intuition generates the question of selection criteria. To address this question I will relate the evolution of the General Mathematics Project. The selection of a research site is a complex matter requiring serious thought.

Guidelines for Selecting Classroom Research Sites

Shulman (Note 4), in an invited address to the American Educational Research Association special interest group for Research in Mathematics Education, argued that the "strategic research site" as a concept was a useful guide to educational researchers. His argument attempted to discern those features or qualities that appear to distinguish strategic research sites from other potential loci for empirical investigation. He proposed that striking discontinuity, aberration, anomaly, or error can serve as a strategic research site for studies of human functioning in general and mathematics education in particular.

Mathematics teachers and supervisors express a discontinuity of relative satisfaction regarding their lowest algebra class versus their general mathematics class. Though they are not always satisfied and happy with their algebra classes, there is a noticeable positive-to-negative shift when considering general mathematics. Bruce Mitchell, a mathematics teacher educator and teacher of geometry and general mathematics, stated, "I just can't be me in the general mathematics class"-- a discontinuity in terms of his normal and expected style of teaching.

Similarly, he noted a discontinuity in student demeanor and attitudes, "Last year you'd walk down the hall and hear kids say in a positive manner, 'I'm in Mitchell's geometry.' You sure don't hear anyone saying anything about being in Mitchell's general-math class."

A further consideration in selecting a classroom research site is that of complexity. The site should be rich enough to warrant being looked at from several perspectives rather than being a relatively barren single-issue phenomenon. The general-mathematics class, for instance, represents multiple problems: learner problems (computation, reasoning, or reading deficiencies), curricular problems (scope of content), context problems (no one likes to be there, and this has consequences), and teacher problems (how to motivate students, what to expect).

General Mathematics, A Strategic Research Site

My decision to focus on ninth-grade general mathematics as a research site emerged from three distinct but nonsimultaneous events. The first of these was the release, distribution, and subsequent deliberations of the 1975 NACOME report (NACOME, Note 1). Though the report contained six chapters, two of them, "Patterns of Instruction" and "Teacher Education" were, for mathematics educators, especially dissonance-producing. It was in the "Patterns of Instruction" chapter that the jarring observation was made that appallingly little is known about what goes on in mathematics classrooms across the nation. The impact of the observation was intensified by reflecting on the level of effort exerted during the sixties on curriculum development and teacher development (though limited primarily to secondary education) and the level of effort (almost nil) exerted on ascertaining what happens to students in classrooms with these curricular materials and teachers. Having some achievement data on students in these classrooms provided little solace for there was such an obvious gap in the knowledge base.

The significance of the gap was made more disquieting by the reports of teachers in the "Teacher Education" chapter that their most significant problems were those of dealing with motivation, laboratory learning, slow learners, learning styles of students, and the like. "Lowest on the list are content topics" (p. 92). For many in mathematics education, these problems were ones they could finesse by suggesting or implying that they could be dealt with by focusing on interesting and neat mathematical content. However, any distillation or interpretation of what was known and unknown suggested the need for classroom inquiry. But which classrooms? And by what means? In retrospect, the NACOME report was a most influential precursory event in the evolution of the General Mathematics Project.

The second influencing event was the creation, in 1976, by the National Institute of Education (NIE) of the Institute for Research on Teaching (IRT) at Michigan State University's College of Education. Retrospectively, this event had as much influence on how to look as it did on where to look. The IRT focus was to be on the study of teacher thought, but teacher thought in terms of learner, curriculum, and setting. Reading was the curricular area specified, with the option of considering other subject matter areas. In 1977 the IRT sponsored an invitational conference to consider research on teaching mathematics (Institute for Research on Teaching, Note 5).

In addition to the mathematics conference, the Institute also held a conference on field research methodology (Cusick, Note 6). Subsequently, the Institute recruited a field researcher and the MSU College of Education began offering a field-research seminar sequence designed to train personnel to conduct research in educational settings. As a result of the two conferences, I was prompted to take the field-research seminars. A practicum component in this training led me to observe in a general-mathematics classroom taught by my colleague in mathematics education, Bruce Mitchell.

Mitchell's presence in the general mathematics classroom is the third key event in the evolution of the General Mathematics Project. In a revision of the undergraduate secondary mathematics-methods class, Bruce had negotiated with a local school district to teach a geometry class on a daily, year-long basis. He wanted his methods students to have a weekly field experience in his geometry classroom. During the year in which he taught (1976-77), he discovered that the regular teachers, in their informal exchanges in the hall and lounge, frequently expressed concerns about their general-mathematics classes. For two reasons, his own enlightenment and that of his methods students, he arranged to teach a ninth-grade general-mathematics class in the same high school during 1977-78. This was the site selected for satisfying the practicum requirement of my field research training.

During the course of the year, two inquiries, prompted by my observations in Mitchell's class, furthered the emergence of the General Mathematics Project. The first of these was a question of clarification directed to mathematics supervisor Charles Zoet, who, in a presentation at the annual University of Michigan mathematics education conference, asserted that he and his Livonia (Michigan) secondary teachers were not reaching half their students. His response revealed that these students were similar in many ways to those in Bruce's general-mathematics class. Following this, I made an informal telephone poll of several mathematics supervisors across Michigan and found that at least half the students did take general mathematics. Furthermore, it was not only a class that generated disquietness and concern among the teachers, but it was equally disquieting to and disliked by the students.

Hence general mathematics was clearly problematic for students, teachers, and supervisors. It was a problem that could only be significantly addressed by study of the problem where it existed--in the thought, actions, and consequences of and for the teachers and students in the general-mathematics classroom. It was indeed a setting worthy of study, a strategic research site.

Participant Observation
A Method For Classroom Inquiry

The primary observation method used in the General Mathematics Project has been that of participant observation. Since it is virtually impossible for an adult to come across as an adolescent student in any naturalistic sense, as participant observers we have had to establish ourselves as a natural part of the scene in the role of observer.

Since the general-mathematics classroom is, by reputation and consensus, exceedingly complex, the phenomenological approach to participant observation seemed most appropriate for our proposed study. As Carini (1975) states, "The function of observing in phenomenological inquiry is to constitute the multiple meanings of the phenomenon." The task is therefore not to determine the single meaning of an event, but to reveal the multiplicity of meanings. Thus, we chose the phenomenological approach because it was likely that many explanations of the general-mathematics phenomenon are plausible.

Given these theoretical underpinnings of participant observation study, what are the domains where this method is most applicable?

Diesing (1971) responds to this question in this summary paragraph describing the method.

> The participant-observer method was first developed by anthropologists, though it is also frequently used by sociologists, social psychologists, political scientists, and organization theorists. Its primary subject matter is a single, self-maintaining social system. The system may be a small community with its own culture, or a larger society with its culture, or a small and relatively isolated neighborhood, or a gang, clique, voluntary organization, or family, or a formal organization or institution, or a person (clinical method), or a historical period. In each case the emphasis is on the individuality or uniqueness of the system, its wholeness or boundness, and the ways it maintains its individuality. The primary objective is to describe the individual in its individuality, as system of rules, goals, values, techniques, defense of boundary-maintaining procedures, and decisions procedures. In one important variant, the primary interest is in recurring processes within or around such individual systems. (p. 5)

Diesing's description shows the method extremely well-fitted for attaining the objectives of the General Mathematics Project--identification and characterization of the manner in which the group identity, classroom organization and process, peer culture, and teacher processes interact to influence mathematics learning both cognitively and affectively, and to focus on the contrasting perspectives of teachers and students on the meanings, events, and purposes of these classes.

As a method, participant observation seems particularly well suited to the investigation of mathematics (science) classrooms, if the researcher's overarching questions emanate from a practical problem. As an example, the two sets of questions we were concerned about in a study funded by the National Science Foundation (The Ecology of Failure in Ninth-Grade General Mathematics: An Ethnographic, Experimental and Psychometric Inquiry) were as follows:

1. Who are the students who become the mathematically disadvantaged ninth-grade population? What are their mathematical abilities, attitudes toward mathematics, learning histories, and learning expectations? How do they wind up in general mathematics?

2. What effects do the two primary instructional environments--general mathematics or first-year algebra classes--have on the cognitive and affective mathematical development of early adolescents? How are those settings experienced by both teachers and learners, whose interactions define those learning environments and their consequences?

If these are representative of the questions that typically characterize a practical problem of the classroom, then the form of the answers to such questions becomes a concern. Clearly, the answers will not be in the form of statistical generalizations. Rather, they are more likely to be in the form of retrospective generalizations. According to Stenhouse (1978), retrospective generalizations are

> organization(s) of experience in retrospect...are attempts to map the range of experience rather than to perceive within that range the operation of laws in the scientific sense.

Though our analysis of the data gathered to answer the above questions is incomplete, the preliminary form of the answers appears to be that of retrospective generalization. The final section of this paper includes examples of these preliminary conclusions.

Findings From Classroom Research: Of What Use?

The following preliminary findings of our investigation are presented as an example of outcomes of classroom research where the primary method is participant observation. Perusal of these preliminary findings will, I hope, be illuminating in terms of their usefulness to teachers, policy makers, and researchers.

1. Tracking, the policy commonly used for placing students within ninth-grade mathematics--whether into algebra or general mathematics--is usually highly correlated with students' records in mathematics classes during junior high school.

2. Teachers instruct general-mathematics classes differently than they instruct algebra classes. Further, these differences appear to be critical factors since they include aspects of teaching that are recognized as clearly related to student learning.

3. Most secondary mathematics teachers find it easier to think about, to plan for and to teach mathematically advanced classes than to do so for general-math classes. Part of this imbalance stems from their difficulty in comprehending that students in general mathematics can have serious problems in learning basic content.

4. Most teachers assigned to teach classes with a high percentage of youngsters identified as having low promise for successful achievement in mathematics (i.e., general-mathematics classes) have unusual difficulty in teaching these classes and often feel only marginally or not at all successful.

5. The low incidence of success and high incidence of frustration and failure encountered by both teachers and learners in general mathematics classes have created unique instructional settings that are notorious for their unpleasantness.

6. Though educators know that most general-mathematics students have a diversity of learning problems at a critical level, they do not know the precise nature of these problems.

7. Well established is the troublesome and problematic nature of teaching and learning general mathematics at the ninth-grade level. Not well established are practices that alleviate the problem.

8. Overall, students placed in general mathematics classes appear to be different, in certain important ways, from students placed in algebra classes.

Given these preliminary findings let me conclude by returning to the quote of Schwab that I used in my argument for the need of classroom research:

> What is wanted is a totally new and extensive pattern of *empirical* study of classroom action and reaction; a study not as basis for theoretical concerns about the nature of teaching or learning process, but as basis for beginning to know what we are doing, what we are not doing, and to what effect; what changes are needed, which needed changes can be instituted with what costs or economics and how they can be effected with minimum tearing of the remaining fabric of educational effort. (p. 313)

I suggest that our findings are informing researchers and educators about what teachers are and are not doing in general-mathematics classrooms and to what effect. Teachers reading these findings may become aware of some changes they could and should make. In short, I believe our findings hold promise for improving the practice of teaching mathematics in particular and teaching in general.

In school mathematics there are numerous phenomena that mathematics educators are ethically and professionally responsible for becoming smarter about. For many of these there is no more appropriate method than *observing* in the natural setting of the classroom. I urge mathematics educators to be responsive to this need in the field of mathematics education.

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