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ABSTRACT

The Peterborough County Board of Education Mathematics Project is a system-wide curriculum project aimed primarily at basic skills and problem solving in grades K-10. The philosophy of the developers includes a broad conception of curriculum. Their goals include the articulation of educational goals, the establishment of relationships among goals, the creation of instructional procedures to meet these goals, and the generation of means of evaluation. In addition, they have a major interest in implementation as a part of curriculum design. Therefore, they consider the inevitable changes in materials made intentionally or unintentionally by teachers in the field as a part of the development. In this paper the history of this project is analyzed in terms of stages, the curriculum constructs are examined, and the products and evaluation procedures are discussed. The basic skills component of the project, based on 600 behavioral objectives with 10 equivalent test items per objective, is currently used by 80 percent of the relevant teachers in the system. (SD)

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Curriculum Change At The System Level:
A Four Year Mathematics Project

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Curriculum Change At The System Level:
A Four Year Mathematics Project

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The theory and practice of curriculum development may be viewed broadly or narrowly depending upon one's conception of curriculum and orientation toward the development process. Most narrowly viewed, curriculum refers to a set of planned (written) materials to be used in guiding the course of student experience including student-teacher interaction. Such a conception suggests that the purpose of development processes is to articulate educational goals in operational language, establish logical and/or empirical relationships among these goals, invent suitable materials and instructional procedures for use in achieving these goals and generate appropriate means for judging goal attainment. Even this view is considered expansive by some who would separate instructional considerations from those of curriculum development.

On the other hand, we wish to argue that this relatively narrow view of curriculum development has contributed to the now widely recognized problem of inadequate curriculum implementation (e.g., Goodlad & Klein, 1970) by allowing curriculum students, theorists and practitioners to avoid dealing with the complex of additional theories, social management and technical skills required to "make a difference" in the schools through curriculum change. A broader conception of curriculum views it as a set of experiences encountered by some particular set of identifiable students in some particular set of real classrooms, schools and school systems (a "Field of Practice"). On these grounds, the development process not only incorporates the dimensions alluded to above but the many others required to effect necessary changes manifest in student experiences. This view also requires that the intentional or unintentional modifications inevitably made by teachers when implementing packaged curricula, be conceived of as "development"

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rather than "bastardization." No written curricular materials significantly impinge on the moment to moment decision-making processes engaged in by a teacher during instruction. When "bastardization" occurs as a result of inadequate decision-making at that level, the adequacy of the development process must bear the brunt of the blame. This suggests the importance of professional development as a part of curriculum development.

This orientation toward curriculum development has close ties with more general "school change" frameworks especially those derived from sociological and administrative theory and research. But whereas our orientation makes much use of such theory and research, it is significantly modified and extended to deal specifically with curriculum problems. The result is a theoretical and practical orientation toward curriculum development that makes explicit where and when commonly identified curriculum development skills should be exercised. At least as important, however, the many other processes and skills necessary to the production of changed student experiences are identified and conceptually integrated. Earlier elaborations of this view have been presented as models of school change (Leithwood & Russell, 1973; Leithwood, Russell, Clipsham & Robinson, in press). The purpose of this paper is to extend those earlier theoretical formulations through analysis of a case study guided by these formulations. This analysis should help demonstrate the predictive power of our conceptions by indicating what the results of basing decision-making on them were under at least one set of circumstances.

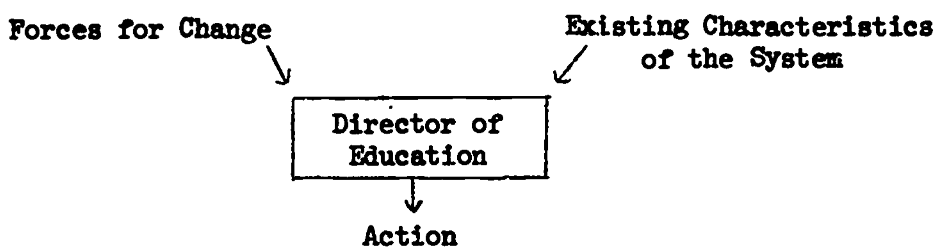
The case chosen for analysis is the Peterborough County Board of Education Mathematics Project. Underway in cooperation with the Trent Valley Centre, OISE, since 1971 (Leithwood & Russell, 1973) the Project involves system-wide (45 schools) development (in the narrow sense) implementation and evaluation of K-10 Mathematics programs primarily, although not exclusively, in basic computational skills and problem solving. At the present time data indicate that roughly 80 percent of the relevant K-10 teachers in the system (approximately 400) are using the basic skills continuum (in some manner consistent with improved instruction), the essential features of which include a sequence of 600 behavioral objectives, a pool of 10 equivalent test items to measure achievement of each objective, and some suggested instructional methodologies. The Project has also provided an opportunity for the system to build skills in leadership, curriculum development, implementation, and evaluation which support further curriculum change initiatives and, for the Trent Valley Centre, it has provided one of a series of opportunities to study the processes of curriculum development as defined here. The following analysis is in four parts.

1. An overview of the history of the Project analyzed in terms of the <u>stages</u> of the curriculum development model;
2. An examination of selected process components of the Project in terms of the <u>constructs</u> in the curriculum development model;
3. A brief description of the curriculum products;
4. A summary of the evaluation procedures used and data collected.

<u>Historical Overview: Stages In Change</u>

The first five stages of the curriculum change model (diagnosing the context for change, developing the seminal organization, developing working organizations, defining general problems and goals, and generating strategies for implementing general goals with the client) provide a framework for examining the early history of the Project, a time devoted to laying the groundwork and planning. Implementing the curriculum development plan with the clients may be described in terms of cycles through the next five stages of the model (assessing needs, developing/choosing a solution, implementing the solution, evaluating the solution, and revising the solution).

<u>Stage 1: Diagnosing the Context for Change</u>



In the fall of 1971, the Director of Education made a presentation to the Principals' Association concerning the need for an evaluation of basic skills in language and mathematics. A brief description of the context in which that action was taken helps to account for his action and the decisions made subsequently as the Project got underway. This description is reconstructed after the fact, however, and no claim can be made that it corresponds to the Director's diagnosis.

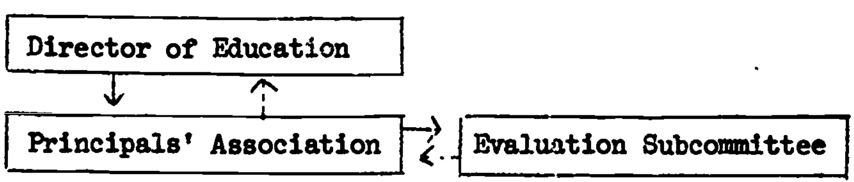
The most immediate and obvious stimulus to action by the Director derived from the 1971 Summer School Principals' report, a report which criticized student competence in the basic skills of mathematics and language. Discussion of this report by the Board's trustees led to a request that the Director take action to evaluate basic skills.

Other readily identifiable influences on the climate for change included: the accountability movement of the seventies; a core of experienced curriculum innovators in the system (POISE Project participants, see Russell, Leithwood & Baxter, 1973); prevailing but conflicting philosophical positions about mathematics education; an Ontario Ministry of Education policy favoring local curriculum development; recent Board reorganization into a county-wide system; and difficulties in satisfactorily operationalizing concepts like individualization and inductive learning.

As a result of these influences, teachers were:

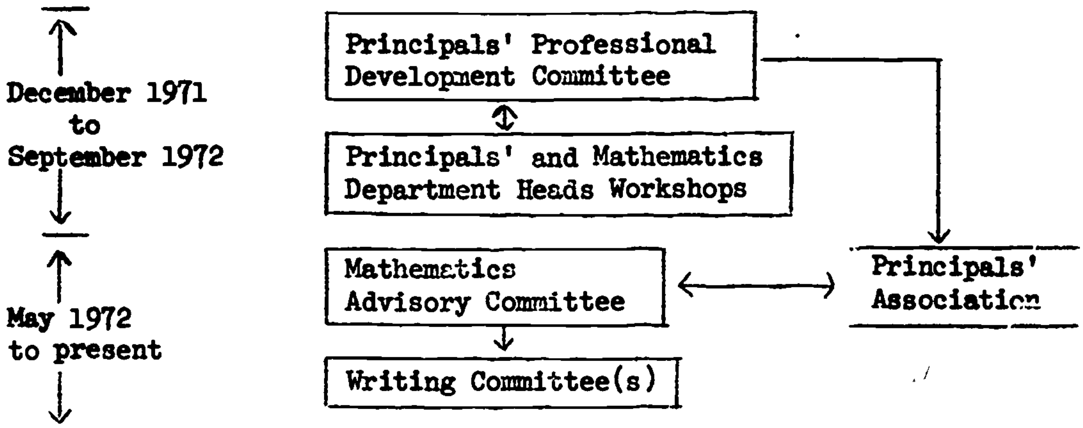
1. oriented toward basic skills, but not necessarily toward student mastery;
2. accepting of the value, but in only a few cases (chiefly POISE schools) the practice, of individualization;
3. accepting of the direction, but not fully understanding the concept or practice of the "new math" movement;
4. torn between the desire for school autonomy in curriculum, on the one hand, and a wish for clearer direction in curriculum, on the other;
5. relatively unskilled in the processes of curriculum development and evaluation (with some exceptions).

<u>Stage 2: Developing the Seminal Organization</u>



The Director of Education communicated to the Principals' Association the need for program evaluation and suggested several ways of dealing with the problem. The Association, rather than deal directly with the problem, established an Evaluation Subcommittee which, in turn, subsequently submitted a series of recommendations which were adopted by the Association and accepted by senior administration. In brief, these recommendations suggested an initial focus on both curriculum development and evaluation, in mathematics only, (including developing appropriate skills among school staffs), beginning with a series of workshops for principals to be planned by the Principals' Professional Development Committee (PPDC).

Stage 3: Developing Working Organization(s)



During the December 1971 to September 1972 period, during which six day-long workshops took place, the PPDC was both a coordinating and programing arm of the Principals' Association. In April 1972, a set of recommendations from the PPDC led to the formation of the Mathematics Advisory Committee (consisting of principals, teachers, Trent Valley Centre representation, a superintendent and mathematics consultants) to continue development and evaluation of the mathematics program, again on behalf of the Principals' Association.

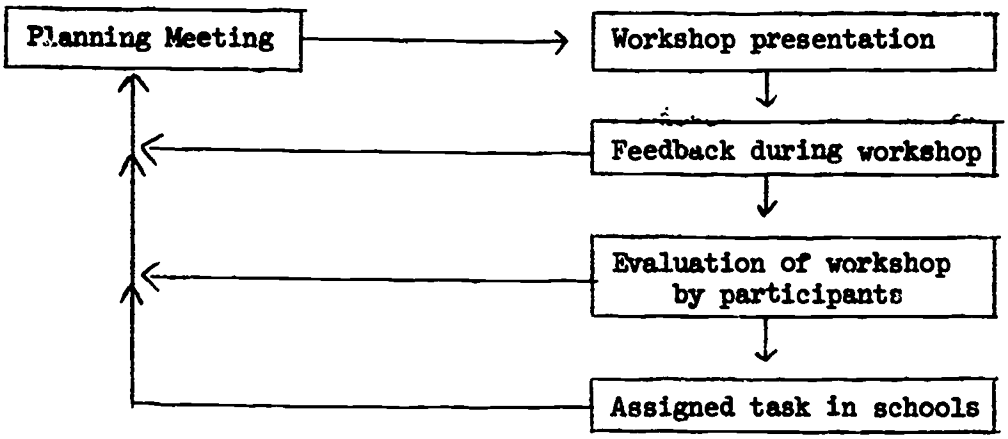
Stage 4: Defining General Problems and Goals

Initially, the goal was for individual schools to develop and evaluate their mathematics programs, and the problem for the series of workshops was to provide principals and department heads with the skills needed to meet this goal (skills in curriculum development, evaluation, and leadership). Following the first workshop, a more feasible goal was seen to be the development, implementation and evaluation of a county-wide program, with the problems of development and evaluation chiefly assigned to the

Mathematics Advisory Committee (MAC). Thus, the workshop series redefined the development, evaluation and leadership skills required as those which would contribute to effective implementation of a program largely developed by others.

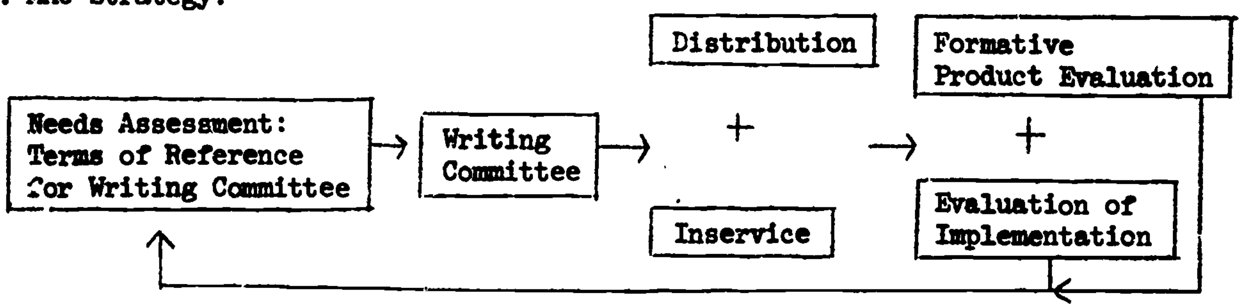
Stage 5: Generating Strategies for Implementing General Goals with Clients

1. PPDC Strategy:



Each workshop followed a general procedure of (a) presenting a problem task followed by small group discussion of problems involved in carrying out the task; (b) developing and stimulating in small groups a strategy for carrying out the task in one's school; (c) giving participants the task as an in-school assignment to actually carry out. Participant observation at the workshop, plus formal workshop evaluations and products of assignments all provided feedback concerning attitudes toward the workshop and skills acquired, feedback which was immediately utilized for subsequent planning.

2. MAC Strategy:



The last of the series of workshops planned by the PPDC corresponded with the introduction of the first version of a continuum of basic computational skills and example test items into all schools in September 1972. The MAC has since that time carried out two annual cycles of needs assessment, development, implementation, evaluation and revision and has tentative plans through to 1977. These cycles will be briefly described in the following sections.

Cycle 1: May 1972 - June 1973

During May and June 1972, the MAC collected data from the PPDC workshop concerning the curriculum development needs expressed by teachers and principals; gave as terms of reference to the writing committee the production of a continuum of basic computational skills, K-10, using draft materials produced by local teachers as a result of the workshops and existing course materials from elsewhere as starting points; and prepared a detailed task analysis which would see the production of the continuum completed in the allotted time. A writing committee of five persons worked through July and early August to complete this task.

In September each teacher of mathematics (K-10) was provided with a copy of the continuum. Principals were requested to assist their staffs with a copy of the continuum. Principals were requested to assist their staffs with implementation, and resource personnel and members of the MAC were made available to schools. The MAC used a newsletter and other approaches to impress upon teachers that the continuum was a draft version and that feedback of any sort (including samples of exercises and tests used) would be welcomed. Each teacher of staff submitting feedback received a letter of thanks from the MAC and the feedback suggestions were either followed up immediately or kept for the next summer's writing committee.

Early in the year, the MAC decided that teachers' evaluation procedures would be considerably facilitated if they had available a homogeneous pool of test items for each objective on the continuum. Accordingly, the Trent Valley Centre (using procedures described later in this paper) undertook the collection and pilot testing of these items. Evaluation of teacher and other staff attitudes to the Project was conducted in May.

Cycle 2: June 1973 - June 1974

During the first year of implementation, feedback received by the MAC suggested the following needs:

1. some revisions in the sequences of basic skills (objectives);
2. greater detail, particularly for teaching methods, in the Primary Division;
3. more test items in the continuum and some instrument for student placement;
4. materials for teaching problem solving;
5. support for a shift to the metric system.

These, in turn, were given as terms of reference to the writing committee (the last being reflected in choice of units in problem exercises and in a separate section on decimal fractions in the continuum).

In September, the revised continuum was distributed to all teachers; principals were introduced to the problem solving unit but it was distributed only on request; and all teachers were requested to administer the placement survey. Implementation was supported as in the previous year with the addition of a number of teacher workshops on the metric system, problem solving, and diagnosis of student weaknesses.

Evaluation data were collected during workshops, during the administration of placement surveys, during a series of monthly interviews with selected teachers, and through a May questionnaire survey similar to the previous year's. In addition, baseline county-wide student achievement data was collected using the placement surveys in February.

Cycle 3: Spring 1974 - Present

Lack of use of the problem solving unit pointed to the need for a radical revision, and there was general consensus that the Junior Division represented a critical period for the development of problem solving skills. Accordingly, a writing committee was appointed for that task, and the committee met several times during the spring to develop a problem solving model around which the unit would be designed during the summer. The Board's decision to "go Metric" in the Primary Division during 1974-1975 created a need for material, a need which was resolved by freeing a writing committee to work on development of an activity unit on measurement to facilitate metrication in the Primary Division.

In the fall, both units were introduced to principals followed by in-school presentations to staff and further support by resource personnel. Placement surveys in a second revision were made available with the suggestion that they be used as needed (two or three times annually).

Evaluation through participant observation, interviews and questionnaires is continuing, as is county-wide assessment of student achievement.

Several additional stages are beginning to emerge as needs. The principals have endorsed extension of the problem solving and measurement unit to other divisions, as well as first steps towards developing components of the curriculum for geometry, algebra and probabilistic thinking. Attention has also focussed on the need for more assistance for teachers with instructional methodology and resources--a need which fits with the concept of mastery learning as a vehicle for equalizing achievement opportunity. It should also be noted that use of the continuum by secondary school teachers has been slight; however, in September 1974, they were given access to student profiles of Grade 8 graduates, keyed to the continuum, and in October the placement survey was administered to Grade 9 students, giving secondary teachers a better picture of the basic skills needs of their students than they have had previously. The result has been some interest in the basic skills problem; this interest combined with interest in the problem solving unit makes it seem likely that the Project will shortly bridge the elementary-secondary gap more effectively.

Insert Figure 1 Here

Figure 1 summarizes the stages and cycles the Project has followed to this point. From the previous description and this table, the role of curriculum development processes as narrowly defined is evident. Curriculum product development is, using this model, only one of ten stages involved in bringing about curriculum change. Its importance and the amount of emphasis given it during this project should not be underemphasized, however. For example, extensive training was given all members of "writing committees" in the skills of objective and test item writing and curriculum resource identification. Similarly a significant proportion of the skills provided to principals by the PPDC workshops and to teachers through in-service training were of this type on the grounds that possession of these skills had multiple pay off: (a) enabled teachers to better understanding and therefore make more effective use of the system's math program; (b) enabled teachers to better develop additions to the program of their own choices and (c) enabled teachers to more effectively develop curricula in non-mathematics curriculum areas.

In all of these circumstances there was an appropriate context, demonstrable need, and a clearly defined purpose for the application of the particular curriculum product development skills which ensured alteration in student experiences in the intended direction. Many local curriculum development projects, recognizing the importance of these contextual variables, have focused on them to the virtual exclusion of concern for the adequacy of the curriculum product. Involving teachers in the "process" has sometimes been the major goal without much attention to either the substance of the process or the adequacy of the resulting product. Walker and Schaffarzick's (1974) analysis demonstrates the folly of this extreme by pointing out the significance of the contribution made to student learning by the content of the curriculum to which the student is exposed. Some rational model of the curriculum development process broadly conceived is necessary to avoid non-productive polarization of alternatives.

Some Processes Involved In Curriculum Change: Constructs In The Change Model

Merely moving through a set of stages in a curriculum development plan provides no assurance that widespread and effective alterations in student experiences will occur. From the outset, those planning the Peterborough Mathematics Project were concerned that their curriculum development strategy assure widespread use of the curriculum products to be developed as well as improved student achievement. For success in achieving these goals, both the overall strategy and the specific tactics employed at any one point needed to be based on sound understandings of change processes. Among the ideas found useful were the theoretical constructs in the curriculum change model. These constructs suggest dimensions on which strategies or tactics are likely to be more or less effective, in each case suggesting why some curriculum development strategies have been ineffective and also a basis for building more effective strategies. In this section, each construct will be briefly described and illustrated with respect to the Mathematics Project. The constructs are as follows: communication, the (mythical) multiplier effect, sliding client-agent relationships, screens, recapitulation, successive approximations, and the system's reward structure.

Communication

One reason some curriculum development strategies don't lead to widespread change may be that communications about the curriculum changes are effective with only a portion of the client population. Communication about an innovation should serve three purposes (not necessarily concurrently): to assist clients to understand the innovation, to persuade them of the benefits of adopting it, and to provide the skills needed for effective implementation.

Information processing theory permits one to predict and/or explain the effectiveness of a communication in terms of the relationship of the "message" to characteristics of the recipient. Effectiveness can be inferred if it results in appropriate actions or responses by the recipient, but effectiveness can be explained (or predicted) if it conveys information to the intended recipient in a way which is cognitively meaningful and affectively acceptable (i.e., if the information in the new message can be appropriately assimilated and accommodated to the prior knowledge and attitudes of the recipient). One important task of the change agent, therefore, is to design communications requiring optimal amounts of assimilation and accommodation on the part of the client.

Practically, this requires finding out as much as possible about clients' existing cognitive and affective structures and either modifying the message appropriately for different client groups or providing a wide array of communications about the change. In the Mathematics Project, the feedback solicited formally and informally at all stages was used as a basis for designing succeeding communications. Moreover, the involvement on working organizations of a broad array of client groups facilitated the design of appropriate communications. Experience soon showed (as might be predicted) that communication through memoranda, newsletters, or large groups at workshops was effective with only a small proportion of teachers. Nonetheless, these could be justified as parts of a variety of means of communication. Generally more effective were more interactive forms of communication, where immediate adaptation of the message could occur, and where the agent either knew well, or was a peer of, the client group.

The importance of two-way communication lies not only in what feedback reveals for subsequent modification of the messages about a given innovation, but also in what it reveals of needs perceived by clients or suggestions for modification of the innovation which can alter the innovation for the better. In the Mathematics Project, feedback from the principals after the first workshop changed the Project from one of local school program development to system-wide development, a change which not only appeared better to meet needs but offered the promise that the overall calibre of curriculum products would be higher.

The Mythical Multiplier Effect

Frequently, curriculum development strategies are built on a model which conceives an innovation spreading out in concentric rings from an initial adopter group, in effect multiplying the effort devoted to implementation with the initial group. In practice, however, such strategies reduce to the application of decreased forces (and resources) to increased resistance. If one conceives of the small initial group which adopts a change as representing high innovators with respect to that change--people who are cognitively and affectively predisposed to try it--such strategies may be in effect non-strategies. Conceivably, they result in very little change that would not have occurred anyway. Meanwhile, those who have less initial predisposition, and perhaps fewer appropriate skills, may well observe the special attention, the training opportunities and the extra resources devoted to the initial group and react against any expectation that they should make the change. Particularly, in the case of curriculum innovations which tend to be characterized by complexity and not readily observable benefits, there seems little reason to expect the multiplier effect to operate, and in the authors' experience it is an ineffective way to diffuse change throughout a school system, perhaps in part because of relatively impermeable subsystem information boundaries.

In the Mathematics Project, then, the choice to begin with system-wide implementation, as opposed to concentrating resources on an initial pilot group, was deliberate. Moreover, an attempt was made, where possible, to provide extra assistance and support to those most in need. Finally, there was an attempt to provide a variety of messages, any one of which might be expected to appeal to a different segment of the client population as a force motivating adoption. Some teachers, for example, responded, by using the continuum, to the message that a useful resource had been provided; others responded only when it was made clear by senior administration that teachers should be able to provide detailed information about each student's progress in basic skills and soon; still others began to use the continuum when pools of test items and placement surveys were made available. It is probable, moreover, that some teachers responded to the implicit message that this change was not a transient one; some "laggards" may well represent people who are cynical about the "band-wagon" history of many educational innovations.

One general implication is that much larger expenditures of time and resources are required than is characteristically assumed if widespread, lasting and effective implementation is to occur.

Sliding Client-Agent Relationships

Some change strategies suffer from having too few agents and too many clients. When the agents are outside the system or in the upper ranks of administration this problem may be exacerbated.

One alternative is to conceive of the curriculum development strategy as working through a series of sliding client-agent relationships: the initial change agents view their task as persuading their initial clients to act as agents with other client groups and providing the information appropriate to their doing so effectively, the process repeating until the ultimate clients (students) are reached. One consequence of this strategy is an increase in the numbers of people able and willing to support implementation; another is an increased sense of personal involvement; a third is the increased potential for modifying communications to meet the differing information needs of client groups.

In the Mathematics Project, the agent role expanded from senior administration to the PPDC and from there to the Principals' Association as a whole, through the workshops. In theory, this introduced one person as agent into each school staff. In practice, not all principals were able or willing to carry out this role well. The formation of the MAC and writing committees brought more potential agents into the process, many of whom were classroom teachers. Still others became agents as workshop leaders. In this way, individuals and groups acting as change agents provided an alternative to the principal as communication link. Within schools, teachers who led division groups of staff, as well as those teachers who provided feedback to writing committees were encouraged to see themselves as agents, rather than passive participants, in the change.

Screens

Merely passing information to the first of a series of intermediaries between initial agents and the ultimate clients may not have the desired effect, however. Because there is unlikely to be anything like one to one correspondence between the personality structures of the communicator and his audience, the message inevitably will be somewhat altered as it passes from initiator to ultimate clients, even without conscious intent on the part of intermediaries. The message created by this screening process may be more, less or equally effective vis-à-vis the subsequent clients. If subsequent actions of those who hear an altered message reflect commitment to the change and are appropriate for meeting the goals of the change, distortion can be said to be minimal even if the alteration in the message appears to be substantial. The more screens between initiator and ultimate clients, the greater the possibility of distortion. However, if there is a large role distance and little knowledge of the personality structures between initiator and ultimate clients, the screening process may be desirable. Further negative consequences of screens can be anticipated if each recipient of a message is encouraged to alter it so that (a) it is potentially more meaningful and acceptable to the next recipient and (b) the intent of the message remains unchanged.

In the Mathematics Project, principals were more likely than senior administrators or academics to be able to identify information needs and concerns of teachers, students and parents. Distortion introduced by this screen could also be compensated for by a combination of direct communications from senior administrators to teachers and communication from teachers and resource personnel closely involved in the development and implementation process, the latter kind of communication lessening the distortions introduced by role distance.

Recapitulation

If the communications along a series of sliding client-agent relationships deal only with what the client is expected to do as agent, no provision has been made for him to understand the basis for the task he is being invited to undertake and distortion of the intent of the message may well ensue. Assuming that the considerations which lead one group of change agents to choose a particular course of action are likely to be meaningful to their clients, a recapitulation of these considerations is likely to help answer the client's question: "Why should I become an agent for this process, and why should I undertake the particular actions requested?" (If the rationale is not persuasive, of course, there would appear to be good reason to re-examine the strategy.)

A straightforward summary of the original decision-making may not be the best approach, however, since those to whom the message is communicated are likely to have different roles within the system and different personality structures. Thus, certain considerations important to the initiators may require little emphasis, while those likely to be motivating for the immediate client group (and their succeeding clients) may be emphasized more strongly. Substantively, the message is likely to require elaboration to make operational for the roles of intermediate client groups the concepts imbedded in the change.

In the Mathematics Project, recapitulation was used frequently to keep personnel at all levels informed of progress on matters which concerned them. The development and introduction of the revised problem solving unit is illustrative. The superintendent in charge of mathematics explained the need for revision of the problem solving unit to the writing committee in terms of the importance of problem solving and the lack of use of the original document. Discussion by the writing committee focused on ways of making the revised unit more usable and or particular weaknesses in students' problem solving behaviors, for example, the need to break the computational set many students seem to acquire and the need for them to acquire a repertory of representational techniques. Recapitulation of these concerns and the solutions identified occurred when the revised unit was introduced to principals. To this message were added suggestions as to how principals could assist with implementation. Finally, when the writing committee presented the unit to individual school staffs, emphasis was placed on student difficulties with problem solving, the insights the writing committee had gained through observing students work on problem exercises, and the ways in which the unit could be of immediate assistance to teachers in tackling student difficulties.

In summary, the process of recapitulation at any stage in a sliding client-agent relationship must:

1. ensure that the client <u>understands</u> the goals the initiator intended the change to achieve and <u>accepts</u> the need for them to be achieved; and

2. enable the client to communicate (as agent) in terms operationally appropriate to the tasks implied for his clients.

Successive Approximations

Many curriculum innovations are complex and may require fairly radical changes in teacher behavior without providing adequate opportunities for the teacher to see the need for the changed behavior. It is not surprising, then, that many curriculum development strategies originating outside the teacher which attempt to introduce a complex innovation in one step do not succeed.

From the beginning in the Mathematics Project, many of the planners felt that there was likely to be more real change in the long run if the amount which teachers were expected to assimilate or accommodate to at any one time was relatively modest but provided a solution to some pressing problem. Through successive approximations, the long-term goals of a curriculum development process could be reached.

Of the stages to date:

1. the first approximation, production of the continuum, did not require a change in the mathematical content of a teacher's program, but it did suggest a changed instructional model, one in which precise goal identification, careful sequencing and student diagnosis would be major features. Moreover, it responded to teachers' concern about weaknesses in basic skills and answered a need for more detailed program specification;

2. the second approximation added pools of test items and placement surveys to the available basic skills resources, as well as a first version of the problem solving unit. The testing materials and accompanying in-service activities responded to a need teachers had identified as soon as they began to use the instructional mode implied by the continuum and made meaningful the possibility of (a) initiating instruction, with individuals and small groups, at levels revealed to be appropriate by testing and (b) keeping accurate records of their subsequent progress. In this way, the continuum could become more than just a guide to sequence. The problem solving unit accomplished little more than to focus attention on the importance of problem solving as an application of basic computational skills and the need to respond instructionally to student difficulties with problem solving;

3. the third approximation produced a more readily usable problem solving unit, a metric activity unit and placement survey data for the secondary school level. With teachers now more aware of the importance of problem solving and the need for acquiring problem solving skills, and at the same time, more capable of dealing with student weaknesses in basic skills (the most pressing concern for many initially) the new unit was well received. In the process, the County was adopting goals and methods which might earlier have been perceived as a radical change. Board policy mandating metrication created a need for metric instructional materials and provided, at the same time, an opportunity to introduce a more carefully sequenced program in measurement skills and concepts. Because secondary school teachers had tended to perceive basic computational skills as the province of elementary schools, earlier attempts to persuade them to use the continuum had not been successful; however, they did have a need for a systematic way of streaming students, a need which placement survey data answered. Moreover, the data on individual student weaknesses made possible a more systematic and individualized approach to remediation, an approach for which the continuum was an obvious aid.

In summary, the benefits of proceeding by successive approximations include the following:

1. the needs considered most pressing by the clients can be met at the outset, securing a willingness on their part in the future to attend to changes that the change agents see as important;
2. knowledge, attitudes and skills appropriate for achieving the long-term goals may be acquired in meaningful and manageable contexts over a period of time;
3. success in accomplishing goals at each stage of the change engenders a positive attitude to change;
4. implementation of one stage tends to make visible new needs for which succeeding stages appear to provide natural solutions.

The System's Reward Structure

Many curriculum development plans appear not to be very effective beyond the high innovator portion of the client population--those for whom some part of the message received is intrinsically motivating. Those who routinely exercise their authority and distribute rewards in support of system maintenance functions appear often to be reluctant to do so in support of innovation. When those in bureaucratic positions of responsibility within a system are convinced of the merits of a change, however, it makes sense to encourage adoption by other segments of the client population through judicious use of the structure of positive and negative rewards available to the system.

In the authors' experience, there are frequently few incentives to adopt a change and, not infrequently, substantial disincentives. For example:

1. in many cases, those who first implement a change create pressures on their colleagues to follow suit; in reaction, the less innovative often create pressures against those who are perceived as innovators;
2. usually a change in practice requires additional time for planning and additional resources. Especially for those who may have delayed implementation because the change from their current practices is a large one, these are seldom made available;
3. people tend to be comfortable in their current practices; change introduces a stage of lack of confidence and discomfort during which a climate of support and tolerance for attempts which may fail is needed but may not be provided;
4. in-school systems, teachers and administrators are confronted with a host of day-by-day and even minute-by-minute demands on their attention and concern which seem to have priority on much of whatever time they have together and inhibit sustained interaction on the problems of implementing a curriculum innovation;
5. many teachers have experienced sudden and frequent shifts in direction from their administration, encouraging a belief that "This, too, shall pass" and a consequent tendency to await the time when their existing practices will once more be in vogue.

Such circumstances frequently discourage everyone except those who are intrinsically motivated or those who anticipate positive reinforcement (praise, promotion or additional resources) by being among those who first adopt the change. This discouragement may even set in prior to giving any serious attention to the innovation. Accordingly, under some circumstances it may be appropriate to "legislate" awareness, interest, and trial to ensure that each client has sufficient evaluative knowledge about the innovation to make an adequate judgment about whether or not to adopt it.

One of the crucial events in the history of the Mathematics Project was based on this approach. By February of the first year of implementation of the continuum, several lines of evidence converged on the view that most teachers had made no serious attempt to try it. The outcome was the tactic employed by the superintendent which subsequently became known as the "March edict": principals were to sit down with each teacher on their staff to discuss the progress of each pupil on each of the basic computational skills, compiling the results for discussion at a principals' meeting a month later. Reaction was immediate and negative; however, by May when teacher attitudes to the Project were surveyed, a large proportion of teachers indicated that their initial anger was overcome by the recognition that the continuum provided not only a convenient means of providing the required information but also a useful guide to basic skills instruction. The result was a considerable increase in the proportion of teachers using the continuum. Conceivably, a less authoritarian tactic might have achieved the same result with less attendant tension and suspicion; nonetheless, it did point to the need for some strategy to ensure that clients do not simply ignore an innovation before trial.

The following procedures may be employed to reduce the arbitrariness of use of authority:

1. Foreshadow, through multiple and varied communications, the change which will eventually occur;
2. Distribute some authority among peer representatives to reduce suspicions and render psychologically more difficult the rationalization of resistance to change;
3. Provide training to clients in coping with the change in a relatively unstressful environment, prior to possible legislation;
4. Invoke the need for change in successive approximations such that recognition of the merits of each step should inhibit the mobilization of effective opposition which might arise if a radical and complex change were legislated;
5. Highlight the educational merits of the change, anticipating and answering where possible potential objections.

Apart from "legislation," the system may increase the positive rewards for making the change, decrease the disincentives to change and/or provide negative reinforcement to those who do not make the change. Positive rewards in the Mathematics Project included the status associated with membership on working organizations, remuneration to writing committee members, and, more obliquely, but very relevantly, the satisfaction of concrete data recording improved student progress. The alleviation of disincentives has occurred through ensuring public commitment of the Principals' Association as a whole, through the provision of additional resources (personnel, equipment and print material) to all potential adopters, and through the provision of professional activity days in which school staffs have opportunities for planning and program development activities.

Curriculum Products

The Project now has available for the use of teachers in the system:

1. a continuum of basic computational skills (years K-10);
2. a set of criterion-referenced tests based on the continuum (forms A, B and C; years 3-4, 5-6, 7-8);
3. a handbook describing, for teachers and principals procedures for administering and scoring the tests, and recording and analyzing test results;
4. a unit on problem-solving (years 4-6) focused on computational problems;
5. a unit on metric measurement (years K-3).

The continuum contains eight sequences (Addition, Subtraction, Multiplication and Division of Whole Numbers, Fractions, Decimal Fractions, Integers and Exponentials) in a loose-leaf format. The sequences proceed from initial concept development to levels quite adequate as a basis for algebra, and they range in length from 29 specific student performance objectives on exponents to 211 fractions. For each skill or concept identified in the left-hand column of a particular page (e.g., A26 - Addition of 1-digit numbers) the next column states one or more specific objectives (e.g., pupil adds a column of 1 digit numbers, ≤ 6 addends) and the third column provides a pool of items (5-10) for each objective. The final column identifies textbook references for appropriate exercises and/or provides teaching suggestions. No grade designations are provided on the continuum.

Each form of the placement survey at a particuler grade range (e.g., levels 3-4) provides 5 items for each of the objectives tested. Separate booklets are provided for each skill area (e.g., addition) and in each booklet a range of "plateau" objectives (those objectives representing significant steps along the way to full mastery of that skill area) suitable for placing the best and weakest students of that grade range. Hence, there is some overlap between forms (e.g., between the 3-4 test and the 5-6 test).

The placement survey handbook distinguishes among the purposes for the placement survey, pre- and post-tests; describes the placement surveys and provides directions for their administration; and provides answer lists and scoring procedures. In addition, the handbook illustrates how student scores can be recorded to yield both individual and class profiles useful for diagnosis, reporting to students, parents and administrators or making program adjustments.

The problem solving unit is intended to be integrated with instruction on basic computational skills. It analyzes the problem solving process and presents a problem solving model showing how it can be used to organize instruction and identify particular student difficulties in solving problems. The unit is broken into seven subunits (Representation Techniques, Problems without Numbers, Being Critical about your Answers, Relevant/Irrelevant Information, Problems with Too Little Information, Visualization, and Breaking Up the Computational Set), each of which is linked to a component in the model. Each subunit contains an introduction, suggested teaching techniques and example problems, a set of student exercise problems on the skill taught in that unit (roughly sequenced according to difficulty), and a set of student exercises which mix and combine skills from that subunit and preceding ones.

The metric measurement unit develops a sequence of measurement concepts and skills, using the metric system when standard units are introduced. These are presented through separate sequences of student performance objectives for the following kinds of measurement: linear, area, capacity, mass, temperature and time. For each objective, an "idea card" identifies an activity which can be carried out by students and lists such additional information as new vocabulary required, materials required, and possible supplementary activities.

Project Evaluation

Methodology

Change may be measured by comparatively examining a phenomenon at two or more points in time. While change in some form cannot be prevented, the notion of planned change suggests conscious intervention in the process in order to alter the direction and/or rate of that change. The school change model provides a useful basis for an evaluation methodology since it:

1. provides a rational basis for choosing the points in time most productive for comparative examination;
2. defines the critical features of the intervention plan;
3. identifies the subset of variables through which the intervention plan primarily acts.

Using the model as a basic framework for an evaluation methodology, the tasks were to develop methods for:

1. accurately recording, in project settings, procedures used to achieve the various stages in the Project. This required tracking the network of actions and reactions among individuals and groups of people as they made decisions regarding change. These actions constituted the objective system properties (Riley, 1963) which are best reflected in some form of observation;
2. evaluating the effectiveness of mediating procedures in achieving the substages of planned change suggested by the model. These methods concerned the subjective properties of the change system--perceived knowledge and attitude change among clients. Such data are best collected through questioning;
3. assessing achievement of the terminal goals of planned change, in this case, student performance.

With respect to objective properties of the change system, the authors' role as "planning and planned-in" components of the Project was both an asset and a possible liability: an asset because official membership on planning bodies provided a legitimate and informal access to decision-making processes and to "informants" acting as representatives of various agent and client constituencies; a liability, because lack of systematic recording system and personal involvement might lead to the class of error Riley (1963) refers to as the "biased viewpoint effect" as well as doubtful reliability. Frequently, the authors' interpretation of events could be checked informally against that of other participants; moreover, on numerous occasions a non-participant observer (sometimes acting as a committee's recording secretary) was also present and subsequent consultation between participant and non-participant observers both reduced the burden of inference on any one observer and increased inter-observer agreement. The objective records of a series of meetings (including observations, agenda and minutes) together with an interpretation of each meeting's utility in achieving intermediate and long-term goals were later examined collectively by the evaluation staff. Overall, these procedures seemed likely to reduce problems of reliability and threats to validity attributable to too great an interpretive burden on one observer. While observers were visible, their legitimate and long-term involvement seems likely to minimize that particular threat to validity.

Evaluation of the system's subjective properties attempted to determine by questioning:

1. the fact of intermediate goal attainment, including attitude and knowledge modification of intermediate clients;
2. the relative contribution or effectiveness of each of the specific procedures employed toward that end.

The observation record of actions taken by agent groups toward the intermediate clients served as the basis for questions regarding 1 and 2. Where hypotheses were being generated or the immediate effects of particular tactics or decisions being explored, the method of theoretical sampling to saturation was sometimes employed (Glaser and Strauss, 1967). For determining the effects of established processes, random sampling procedures, with some stratification, were used. An overall and growing picture of effects was obtained then, through:

1. a series of monthly interviews with small samples (approximately 5) of selected client groups;
2. interviews with a random sample of parents and of teachers towards the end of each school year (approximately 5% of teachers and an equivalent number of parents);
3. questionnaires sent annually to all principals, senior administrators and resource personnel;
4. questionnaires sent annually to all teachers (except those in 2): the questionnaire was broken into several parts and equal numbers of each part were randomly assigned to teachers stratified as to Primary, Junior or Intermediate Division (multiple-matrix random sampling);
5. questionnaires administered (at the time of achievement testing) to two randomly selected classes from each of Grades 3 to 8.

Because each client group surveyed was in contact with one or more of the others, it was possible not only to sample a group's own knowledge and attitudes but to get that group's impression of effects felt by others.

This was particularly useful in the case of principals, senior administrators and resource personnel who were in regular contact with teachers.

Student achievement was monitored by both criterion-referenced and norm-referenced testing. The norm-referenced test (Canadian Test of Basic Skills, CTBS) had been administered in Grades 4 and 7 throughout the County for a number of years. It thus provided one continuing record against which the effects of the Mathematics Project could be compared; moreover, a comparison with Canadian norms was possible. Furthermore, since comparisons between innovative and traditional programs may be contaminated by the use of measures referenced only to the innovative program and standardized tests tend to reflect traditional goals, continued use of CTBS seemed justified. Nonetheless, although the basic skills continuum was not intended to reflect novel goals, only about one-third of the items on the CTBS assessed objectives found in the continuum.

For the evaluation of curriculum, a strong argument can be made favoring criterion-referenced testing (e.g., Popham & Husek, 1967). Procedures used for the development of a criterion-referenced testing system in the Mathematics Project have been more sophisticated than those customary for local projects (Leithwood, Clipsham, Maynes, 1974). The process was intended to jointly serve the testing and information needs of teachers, principals and senior administrators: teachers should be better able to diagnose specific, individual weaknesses, identify areas of program in need of revision and report student progress; principals should be better able to identify program areas in need of further resources or of revisions (where several staff members would be involved), and to respond to community and administrative information needs; administrators should be better able to allocate system resources for curriculum development and to respond to accountability demands on the system.

From the outset, the content validity, specificity and comprehensiveness of the set of objectives established was critical to establishment of a testing system. Logical analysis by experts, feedback from trial use of the objectives by teachers, and the results of empirical testing of items referenced to the objectives were all employed to check the adequacy of the objectives and their sequencing.

A second goal was to produce a pool of interchangeably useable test items for each objective. A set of fifteen items for each objective were reviewed for content validity by a panel of "experts" and also by teachers whose classes were selected for empirical testing of the items. Booklets, each containing the items for one objective, were made up and each was piloted in two classes at the same randomly selected school, one class representing students who had first received instruction on the objective during that year and the other representing the immediately preceding grade. Items which were found to be discrepant (either substantially different from the mean performance on all 15 items or correctly completed by a different segment of students from those most successful with other items) were examined to determine, if possible, reasons for the discrepancy and either modified or rejected. Of the remaining items, eight to ten were included in the revised continuum for teacher and school use.

A third goal was to produce an instrument which could be used as a placement survey by teachers and for county-wide assessment. For these purposes only the most important objectives, those which represent "plateaus" in the mastery of a skill, were selected. Three parallel forms of the survey for each of Grades 3-4, 5-6 and 7-8 were prepared, with starting and cut-off points determined empirically by student performance in the County (from objectives which virtually all students had mastered to those which very few had mastered). This survey is now in its third version and formative data analyzed during pilot trials of each version has resulted in modification of items (those which failed to give equivalent performance), of format (changes in instructions, spacing and type size, etc.), of sequence (when the profile of performance over a sequence was discontinuous) and of scope (where objectives proved too difficult or too easy for the students to whom they were assigned).

In February of 1974 and 1975, a multiple-matrix random sampling procedure was used to obtain data from six different classes at each grade level covered by the test on each of the six basic skill areas covered. (The total number of different classes included in the 1975 sample was 108, representing 29 of the system's 38 elementary schools--in most cases students in one class were assigned more than one basic skill area, e.g., addition and division).

Evaluation Results

The observation records of objective system properties are reflected in a highly condensed form, in preceding sections of this paper. This section provides a summary of selected portions of the data on subjective properties of the change system and on student achievement.

The following excerpt from one of the monthly interview reports indicates the usefulness of such data in pursuing hypotheses and getting more adequate data on the use to which products are put. In this case a group of five first or second year teachers was selected to follow up on the suggestions made by other teachers in previous interviews that the products were particularly useful for inexperienced teachers:

> One teacher had heard general comments of a negative nature from a county teacher while still at Teachers' College, but later study of his own continuum had aroused none of the criticisms he had expected to find reason for. Another reported being initially somewhat overwhelmed by the document, but she as well as all the others are now positive, even enthusiastic. Comments made were, "The Grade 1 part is really beautiful," "Addition and subtraction really excellent," "Really glad to have it," "I really use it--really like it," "Fantastic for somebody just starting." Nor could they report negative attitudes among their colleagues. One said she hadn't heard of a teacher who didn't find it useful. One noted a colleague's criticism of the lack of specific grade levels but added she herself found the Grade levels for each objective implied by the textbook references informed her adequately of the grade at which teaching of the skill was appropriate.
>
> All reported the continuum had been recommended to them, but none felt they had been in any way pressured to use it. All welcomed leadership of this sort but noted that as inexperienced teachers they needed guidance.
>
> Their use of the program appears to be at a sophisticated level. Their students are grouped and they refer to flexibility in their grouping. All do regular posttesting, though less pretesting. One was apologetic because her attempts to individualize completely had failed, and she had settled for four groups plus four individual programs. All appear to teach their groups in turn.
>
> Except for the one teacher who had no Grade 3 students, all used and appreciated the placement survey, and felt they learned things about individual students, and retention over the summer, etc., they would not otherwise have known. Two had posted or shown the children their charts and felt this had been worthwhile, two others were thinking of doing this. One reported the parents of her students liked the charts.
>
> Only two reported an increase in workload. One regarded the extra work as worthwhile, the other thought it was initial only (she had done extensive work in organizing objectives from the different areas into an overall sequence). She and the other three now feel that use of the program reduces the work they need to do.
>
> All seem basically content with the continuum as it is, and see no need to add units on such things as time or money. One thought a unit on metric measurement, however, would be valuable. All considered these extras were obviously parts of a complete math

program, and taught them, but saw them as distinct from the sorts of things provided by the continuum, with their absence in no way diminishing the continuum. Two of the five, however, reported a deficiency they regarded as fairly serious, namely what one called "teaching 10's and 1's" and the other called teaching "place value." The latter added objectives to the sequence, the former called it a "real problem." A colleague of this individual (with five years experience), also a primary teacher and also in general quite positive, who was present during part of the interview, noted she had often asked for "a portfolio on teaching ten-ness" but had heard nothing.

Vital to the success of a new program is the attitudes toward it on the part of students. The following excerpt from the report on the student attitude survey in 1974 summarizes these data and their interpretations:

In summary, there was apparently a high level of positive affect towards mathematics among students in all grade 3-8 students in the County, at least insofar as this is accurately estimated by the sample tested and the instrument employed. In fact, for a large proportion of the younger (grade 3) students, mathematics may be their favorite subject, though perhaps students in the more advanced grades were more likely to like some other subjects more, and some less, than mathematics.

When mathematics was judged relative to the way it "used to be," (a judgement in which grade content and teacher differences, as well as changes in instruction which may have resulted from the major thrust in mathematics, would of course play a part), it appeared that a large proportion found it more interesting and "likeable," and also harder than it used to be. A quite similar proportion judged it "just about right" in terms of difficulty. This pattern of response tended to confirm that students had a good level of satisfaction with their mathematics program and suggested an increase in difficulty is, so far, associated with an increase in interest and liking.

The questionnaire asked students about the use of pretests, or placement tests, something which may have been fairly new to them, and might be expected to arouse some anxiety if there is not a good understanding of the purpose. Although there were a good number of students who were aware of doing such tests who dislike them, (about one-third) this proportion is nevertheless smaller than those who do not dislike them (about one-half). However, about half who say such tests are used in their classroom are either not sure they understand, or do not understand why they are asked to do them. Perhaps here, as familiarity with the practice increases, some improvement in attitude may be expected.

Small group instruction is preferred over working with the whole class by about one-half the students tested. The rest, however, either do not prefer it or are not sure of their preference. Perhaps this finding suggests that further exploration is required of the attitude towards this aspect of the program; and the reasons for this attitude.

Interviews with parents covered too broad a range of topics to be adequately summarized here. One interesting finding was that only about 40% were aware of the particular attention being devoted by the school system to the mathematics program; this, with several related pieces of data suggested a need for improved communications with parents, if only to assure them that professionals also shared the concern for the importance of mathematics skills that so many (almost 2/3) of the parents expressed. On communication between teacher and parent regarding a child's progress, the survey revealed the following:

> Parent opinion of methods used to report the childrens' progress reflected predominant satisfaction with interviews and reports in the form of written comments. Seven parents had the progress reports supplemented by a discussion of their children's work papers and one by student achievement profile. Grading was still considered desirable particularly in the upper elementary grades. Parents appreciated individualization and precision in reporting. More than once a year parent-teacher interviews starting earlier in the school year were suggested by several respondents. Five parents were not satisfied with the methods of reporting. Grading "by percentage" and comparative marking and more frequent personal contact with the teacher (initiated by the teacher) were deemed necessary by these parents.

Parent and student attitude data do not reveal startlingly favorable attitudes to the new program; neither do they reveal substantial negative effects from its introduction. The data suggest directions in which pursuit of the change strategy could yield improvement, but do not suggest that there were any negative effects from the strategy employed to date.

A substantial amount of data on degree and kind of use of the program by teachers is contained in the collected interview and questionnaire data from teachers, principals, administrators and resource personnel over the past 3 years. These data cover ratings of the usefulness of the program, their perceived obligation to use the program, attitudes towards different approaches to curriculum development and suggestions to the MAC for future development and revision.

Thinking of the program as a whole, 1974 evaluations show that 22% rated it "very useful," 49% "moderately useful," 4% "of no particular use" and the remainder rated it "useful but no more so than previous resources." Kindergarten teachers were most likely to select the negative option. Principals generally gave a more favorable rating than teachers (77% rating it very useful for themselves and 68% rating it "very useful" for their staffs, qualified in about half of the cases to some fraction of the staff).

Given four options ("I feel it is intended to be there if I want to use it"; "I feel it is recommended only"; "I feel required to use it by the administration"; and "My own standards require me to use it."), 38% of those giving a response to the third felt "required" to use the continuum, while 65% felt "required" to use the placement survey. Oddly, only 18% felt it would be inappropriate to require use of the continuum and 20% opposed required use of the placement survey. Moreover, 83% agreed with the first option (voluntary use) for the continuum, 78% for the placement survey; 58% agreed with the second option (recommended use) for the continuum, 48% for the placement survey; and 68% agreed with the fourth (use because of personal standards) for both continuum and placement survey. This last suggests that support for their use exists, independent of any perceived requirement.

One of the strong criticisms of the continuum at its introduction and for some time thereafter was the lack of grade designations for the objectives. By May 1974, however, 64% of teachers agreed strongly with a statement suggesting that the teacher should choose the appropriate level of content for students on the basis of placement survey or equivalent data; a further 17% agreed moderately. Moreover, only 18% agreed strongly with a statement suggesting that the administration should provide specific advice on grade content. This appears to represent substantial acceptance of the principle of continuous, individualized rates of progress.

One of the critical sources of data regarding degree and kind of use came from the May 1974 questionnaire. In the previous year, they had been asked to rate use ranging from "full" to "none," "full" being chosen by 4%, "partial" by about 40%, "little" by about 30% and "none" by over 20%. In 1974, kinds of use were specified in more detail. Use of the continuum for sequence was checked by 95%, with over half indicating frequent use for this purpose and 70% indicating they found this use helpful. The practice of frequent pretesting was only followed by 46%, but 87% frequently post-tested; each practice was found useful by most of those adopting it. As a regular source of diagnostic test items and reference to student exercises, the continuum was referred to by 40% and 33% respectively. Use of the placement survey for grouping and placing students was carried out by 41% and 64% respectively. Acceptance of one of the principles of mastery learning was revealed by the 85% who claimed that they changed their teaching approach considerably when giving remedial instruction. Moreover, 51% followed a practice of frequent regrouping on the basis of test results and 38% disapproved of the practice of maintaining virtually the same groups all year (versus only 18% who approved and followed this practice). These findings suggest substantial increases over the previous year in those making significant use of the program and substantial decreases in the proportions making little or no use of it.

As might be expected, a majority of teachers reported an increase in workload for student evaluation and a substantial proportion reported an increase in workload for classroom management and staff or committee meetings, as a result of the Mathematics Project. Over one-quarter of principals, however, felt their own workload had decreased. For teachers, only a small fraction found their workload unsatisfactory, chiefly in reaction against the burden of frequent testing.

Of the different approaches to curriculum development described in the questionnaire, the one describing the Mathematics Project strategy is most relevant here: 56% gave it strong endorsement; 24% agreed somewhat; 10% were neutral; and 10% indicated some degree of disagreement. Moreover, 94% were now satisfied with the revised continuum and 89% with the revised placement tests.

With respect to future steps by the MAC, approximately 60% expressed support for the idea of being left alone to assimilate. However, there was also strong (greater than 30%) support for more concrete tools (booklets of tests, record forms), professional development time to work on such concrete tools, and information on remedial teaching and problem solving instruction.

Generally, data from principals, resource teachers and senior administrators corroborated the data from teachers, with principals tending to add many complimentary remarks and some senior administrators tending to be less optimistic regarding the amount of change which had occurred.

Evaluation of the effects of the Mathematics Project on student achievement is not as yet complete. It can be said, however, that a steady gain of several percentile points on the M-1 section of the Canadian Test of Basic Skills has been recorded in each of the years since 1971, reversing a downward trend which had been in evidence for several years prior to that time. The net gain is difficult to estimate because of a change in norms introduced in the most recent year, but a 15-20 percentile gain would represent a conservative estimate. Comparative results on criterion-referenced random sampling of the County population are not yet available. The attached table and graph (Figures 2 and 3) represent, however, the 1974 results on the multiplication portion of the test. On the table the objective numbers

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Insert Figure 2 Here

(M-6 to M-31(iv)) represent the particular objectives from the continuum tested on the various grade level forms of the test (from additive combination of equivalent sets to multiplication by a three-digit multiplier); the "%" column records the percentage of all students tested (given by "N") who correctly answered at least 4 of the 5 items on that objective (i.e., had mastery); the bracketed numbers under each represent the percentage with mastery in the poorest and best classes tested. The graph records the overall

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Insert Figure 3 Here

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performance in visual form. Generally, a high level of mastery is in evidence for the earliest objectives tested at each Grade-level form, with performance dropping off considerably by the last objective tested.

Conclusion

This case study analysis provides some evidence that our conceptual orientation toward curriculum change includes sufficient conditions for predicting strategies that potentially alter the behavior of large numbers of students within the constraints of typical school environments. The centrality of meaningful communication in effective strategies for change warrants emphasis. Three purposes for communication have been outlined: to assist clients to understand the innovation, to persuade them of the benefits of adopting it, and to provide the skills needed for effective implementation. An important feature to emerge from analyses of the case study data is the multidimensional nature of strategies that are effective in accomplishing the above purposes with a large proportion of the target clients. During the first stages of implementation, data indicated that extensive training for principals alone would not ensure change among a large proportion of teachers even though principals were in an ideal position to act as change agents and many did make a serious effort. During later stages, involving intensive in-service training to teachers, the flagging support of some principals detracted from adequate implementation in some schools. Similarly, even though spoken communication in relatively small groups, especially among peers, appeared to be the single most powerful form of information transmission, memos and large group presentations seemed necessary more for tone setting and motivational purposes for some teachers and principals.

These data also provide some support for the introduction of change in successive approximations as another method of meaningfully communicating information about a change in curriculum. Features of the initial version of the basic skills continuum seemed to be useful for teachers who desired some guidance in sequencing instruction, especially. The addition of pools of test items made use of the continuum meaningful for an additional group of teachers while the problem-solving unit involved still another (and additional) group. Proceeding in successive approximations allowed target clients, through feedback to agents, to guide the course of product development so that their concerns were being adequately met.

The requirement of multidimensional communication supports theoretical formulations that posit highly individualized client personality structures requiring highly individualized messages to be meaningful. The main practical implication seems to be that, given an adequate theory for curriculum change as a guide, the committed change agent and administration can, in fact, improve levels of student performance on a system-wide basis. But commitment (or tenacity) is essential because the necessary communication must not only be varied to be effective but extend over a significant period of time in a dense and continuous fashion.

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Figure 1

LAYING THE GROUNDWORK AND PLANNING

DIAGNOSING CONTEXT	DEVELOPING SEMINAL ORGANIZATION	DEVELOPING WORKING ORGANIZATION		DEFINING GOALS	GENERATE STRA[...]
External Forces .Accountability movement. .Ministry policy on curriculum development. ."Greening" of Ontario's education system. **Internal Forces** .above + .conflicting philosophies of math education .recent school board reorganization .previous innovation .summer school report **Diagnosers** .senior administration .elected board. .Director of Education.	Director/Senior Administration Principals' Association	Principals' Professional Development Committee	CYCLE 1	.Improve CD and E and leadership skills of Principals.	.Series of 6 [...] with in-scho[...]
	Evaluation Sub-Committee of Principals' Association		CYCLE 2	.Identify basic computational skills.	.Feedback fro[...] and Teachers.
	Principals' Association	Mathematics Advisory Committee (MAC)	CYCLE 1 1972-73	.Develop, Implement Evaluate Basic Skills Program.	.Writing Comm[...] .Teacher React[...] .Teacher Works[...]
			CYCLE 2 1973-74	.Improve basic skills continuum .Implement with more teachers .Evaluate student achievement .Initial problem-solving unit	.Teacher works[...] .Writing Commi[...] .More interact[...] principals .More emphasis[...]
			CYCLE 3 1974-75	.Implement with more teachers .Evaluate problem-solving unit .Edit and publish curricula .Plan for new additions	.in-school wor[...] .evluation str[...] .special commi[...] on problem-so[...] editing.

IMPLEMENTING THE CURRICULUM DEVELOPMENT PLAN

DEVELOP/ CHOOSE SOLUTIONS	IMPLEMENT SOLUTIONS	EVALUATE SOLUTIONS	REVISE
<u>Workshops</u> .Much small group interaction .Structured presentation .In-school exercises .Problem orientation	January - June 1972 - 6 full days - 1, 2-day workshop - monthly basis	<u>Method</u> .Participant observation .Non-participant observation .Questionnaires .Telephone Interviews .Content Analysis <u>Needs</u> .Should develop program for system	Focus on system needs for program development and evaluation.
.Sub-sample of schools work on 1 of 6 operations	February - June 1972 - in workshops - between workshops	<u>Method</u>: as above <u>Results</u> .Initial list of basic skills.	Carried out by next Working Organization (MAC).
.by writing committee Summer 1972	.September 1972 - June 1973 .All teachers use .Teacher workshops (in-school)	<u>Method</u> .Interviews .Questionnaires .Written suggestions to MAC <u>Results</u> .Changes in sequence of objectives .Improve evaluation tools	.Rewrite basic skills program Summer 1973 .Begin to focus on problem-solving (Junior Division).
.by writing committees -Summer 1973 -Winter 1973/74	.September 1973 - June 1974 .All teachers use .County-wide criterion-referenced evaluation .Teacher workshops (in-school, county-wide)	<u>Method</u>: as above + .Student achievement .Establish baseline data	.Revise problem-solving unit (Junior Division). .Units on metric measurement (Primary Division).
.MAC and sub-committees	September 1974 - June 1975 .Teacher workshops (in-school)	<u>Method</u>: as above including problem solving	

Figure 2

MULTIPLICATION

Objective	Gr. 3 %	Gr. 3 N	Gr. 4 %	Gr. 4 N	Gr. 5 %	Gr. 5 N	Gr. 6 %	Gr. 6 N	Gr. 7 %	Gr. 7 N	Gr. 8 %	Gr. 8 N
M-6	76.1	109	80.5	154								
	(58.8-96.0)		(70.0-95.5)									
M-8												
M-12(ii)	92.7	109	96.1	155								
	(88.2-100)		(83.3-100)									
M-15(ii)	90.8	109	96.8	155								
	(83,9-960)		(94.4-100)									
M-21												
M-22	33.9	109	80.0	155								
	(0.0-70.6)		(66.7-92.3)									
M-27(ii)	31.2	109	89.0	155								
	(6.5-64.7)		(73.9-100)									
M-28(vi)	3.7	109	76.1	155	85.5	83	91.7	84				
	(0.0-8.0)		(43.5-93.3)		(64.3-100)		(84.0-100)					
M-29(iv)	0.0	109	29.0	155	53.0	83	80.7	83				
	(0.0)		(17.4-44.4)		(28.6-80.0)		(60.0-100)					
M-30(iv)					56.6	83	75.0	84	84.2	139	88.8	134
					(28.6-85.7)		(46.7-90.0)		(61.5-100)		(82.8-91.7)	
M-30(vi)					21.7	83	21.4	84	43.9	139	48.5	134
					(7.1-40.0)		(7.1-32.0)		(19.2-66.7)		(25.0-73.9)	
M-31(iv)					14.5	83	22.6	84	34.8	138	38.8	134
					(6.7-40.0)		(6.7-45.0)		(15.4-48.3)		(24.1-44.8)	

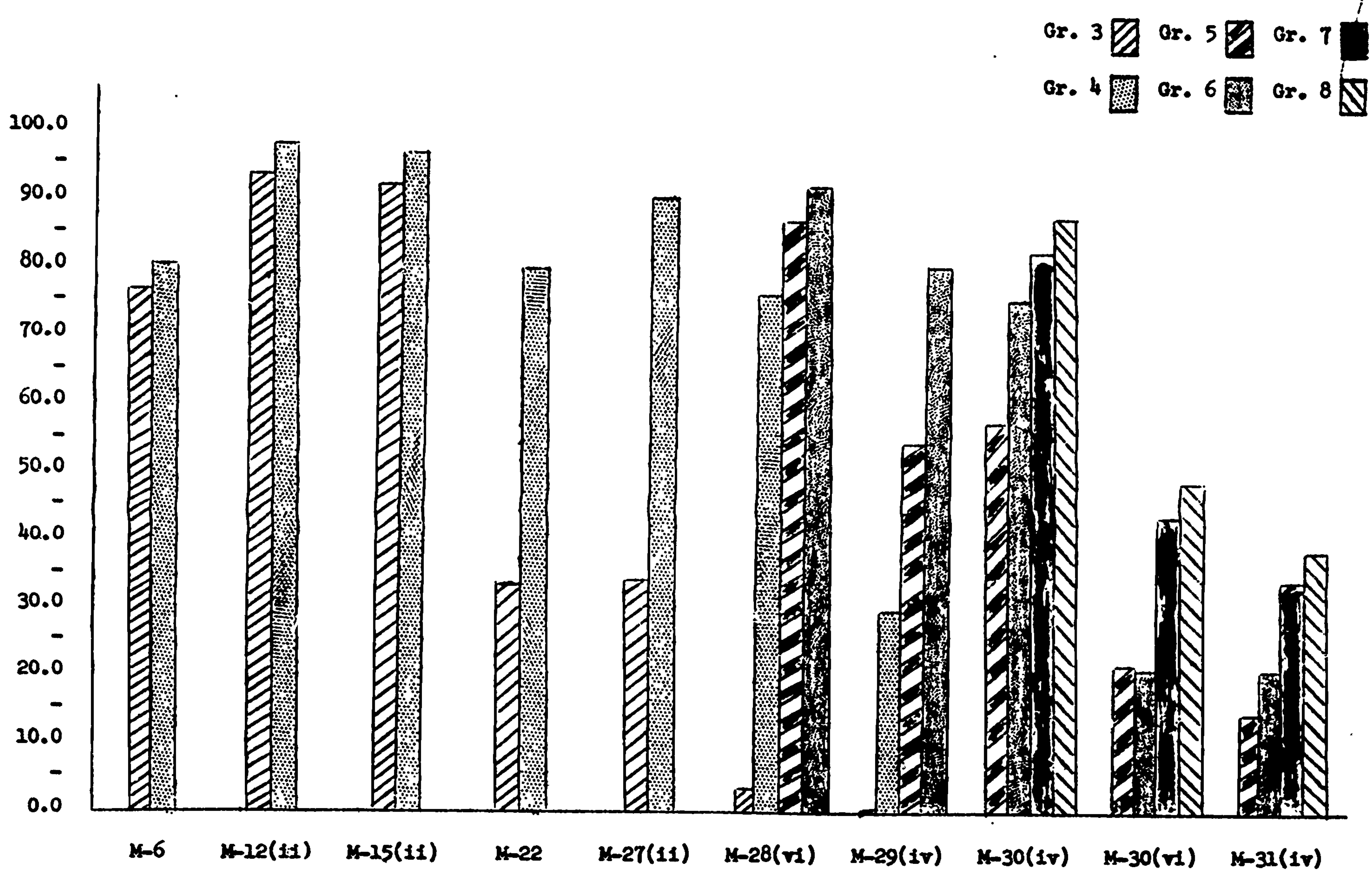

Figure 3...MULTIPLICATION