DOCUMENT RESUME

ED 196 706 SE 033 686

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TITLE Change and Stability in the Curriculum: An Overview of the Questions. Research Reports from the Curriculum Laboratory, College of Education, University of Illinois at Urbana-Champaign, Number 6.
INSTITUTION Illinois Univ., Urbana. Curriculum Lab.
PUB DATE 80
NOTE 28p.: Revision of a paper presented at a conference on Stability and Change in Mathematics Curricula, 1960-1980.

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Curriculum Development: *Educational Change: *Mathematics Curriculum: *Mathematics Education: Modern Mathematics: Problem Solving: *Public Schools: School Districts: *Systems Analysis: Teacher Attitudes
IDENTIFIERS *New Math

ABSTRACT

The process of change and development of the mathematics curriculum in the United States is reviewed. Fundamental changes of implemented curricula from 1960-1980 are discussed in the light of the considerable efforts at reform during the 1950's and 1960's. Elements of the educational system are mapped out, and reasons for the lack of effective implementations of reform are suggested. (MP)

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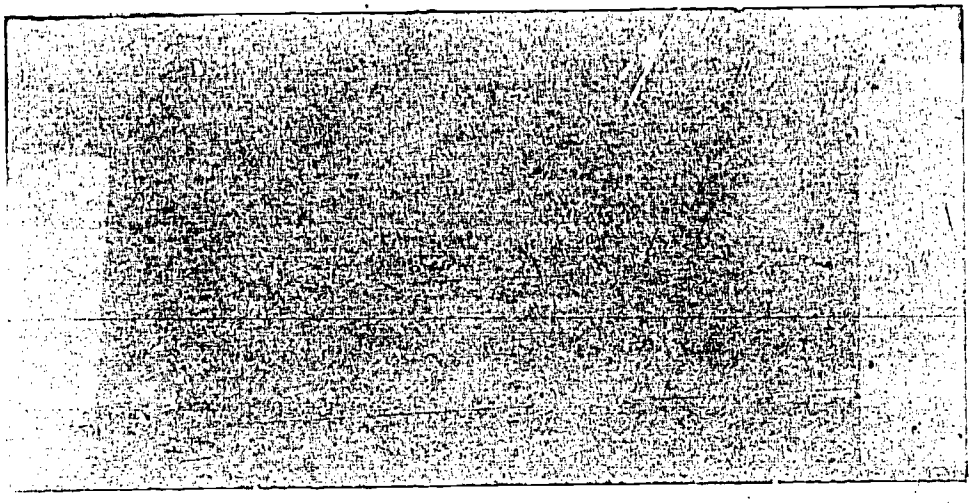

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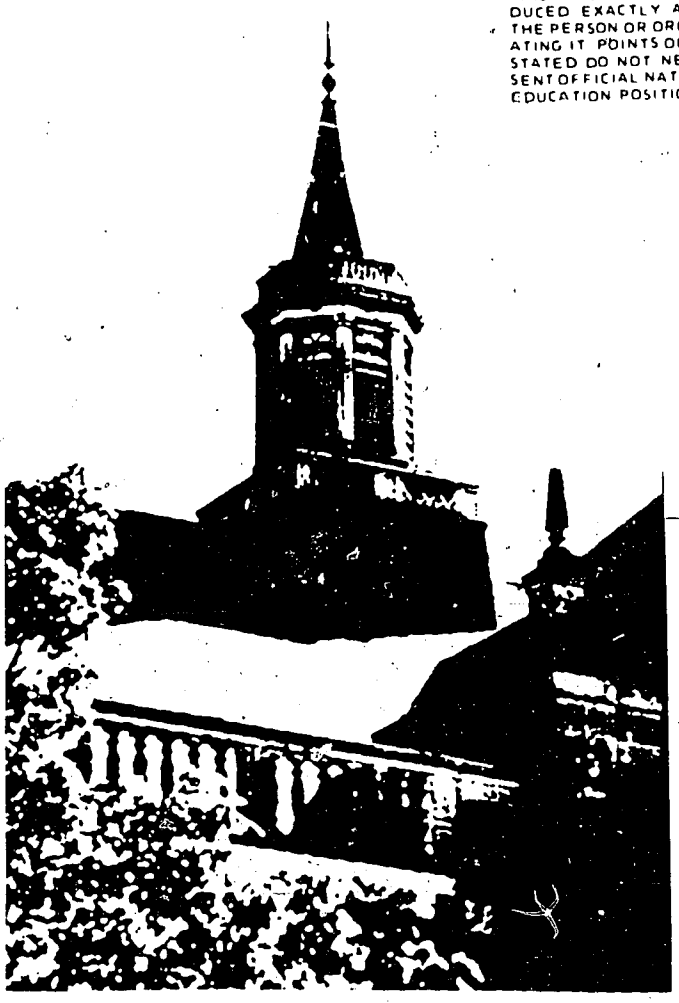

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Research Reports
from the

THE CURRICULUM LABORATORY
COLLEGE OF EDUCATION
UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Number 6

Change and Stability in the Curriculum: An Overview of the Questions

Ian Westbury

Revision of a paper presented at a conference on Stability and Change in Mathematics Curricula, 1960-80, a International Conference on Comparative Studies of Mathematics Curricula organized by the Institute of Mathematical Didactics, University of Bielefeld, FRG and the Second International Mathematics Study of the International Association for the Evaluation of Educational Achievement. The conference was supported by a grant from the Deutsche Forschungsgemeinschaft. This paper will be published in a forthcoming volume in the University of Bielefeld, Institute of Mathematical Didactics Materialien und Studien Band.

CHANGE AND STABILITY IN THE CURRICULUM: AN OVERVIEW OF THE QUESTIONS

Ian Westbury, Urbana, USA

> Nations, sometimes in response to ambitions, often in response to worsening international position may question the efficacy of their institutions...and look abroad for solutions. International comparative evaluation is then a partial, long-run way of challenging monopolies of form and group control at home. Of course, certain functions, ...lend themselves more readily than others to comparisons among nations, and have been considered more directly involved in the national welfare. For cultural and institutional reasons, nations vary greatly in their willingness to look to the outside... And finally, what is imitated and borrowed across national lines is subject to extensive bending and twisting as it is blended into a different configurations of interests and beliefs.
>
> Burton R. Clark (1978)

> The normal development of science shows the more difficult and complicated areas becoming elementary by the incremental explanation of basic concepts and by their simplication...The task of the school is then to see if the inclusion of the simplified subject would enhance general education.
>
> In our time, this necessary process has been obstructed, especially in mathematics. The high science given to a teacher-candidate at the university has no importance for him in his later profession. The school curriculum isolated itself from university science and stagnated, leading to the idea that there is an invariable canon of school mathematics.
>
> F. Klein and R. Schummack (1907)

Our theme is Change and Stability in Mathematics Curricula, 1960-80. Our purpose is to continue the analysis and assessment, using cross-national experience, of the mobilization undertaken during the 1950's and 1960's in the name of "curriculum reform" and "new mathematics". In common with the other groups and commissions who have shared this purpose we have two clusters of

problems to pursue if we are to come to terms with our task. First, we have to see if we can discern the end results of the curriculum change and development movement that began so confidently twenty or so years ago; second, we have to begin an exploration of the lessons that emerge from our data, with the goal of enhancing our understanding of what curriculum development of the kind associated with the "new math" mobilization entails.

Our terms of reference and our perspective are conditioned to a large extent by the goals of the reforming movement of the 1960's; we are assuming that one important task of the research and development systems which surround mathematics in the school is to open school mathematics to impulses from "current university practice" when this is defined broadly to mean advanced or research mathematics. Our case studies of the curriculum reform movement of the 1960's become then a vehicle for the exploration of the larger problem of the nature of the relationship between a school discipline and an enquiring endevour with our specific problems being those associated with the questions "How does a curriculum change?" and "Are there policies, practices and programs which can support and hasten 'natural' processes of curriculum change?"

These are our problems as I see them. My task, is to offer an overview of the issues in this inter-organizational or inter-systemic relationship between a school subject and its disciplinary analogue. Some analysis of these issues has begun within mathematics education and such analysis will be pursued in the case studies in this volume reporting developments in geometry, algebra, and statistics and probability. In this paper I will seek to complement specific analysis of internal and external intellectual or cognitive and cultural processes in this reform movement with some comments on the general social processes which I see lurking in all kinds of subject-focussed curriculum change.[1] My per-

1. For these distinctions, see Van Den Daele and Weingart (1976).

spective is inevitably restricted in the view it gives of the issues which concern us but can, I hope, complement and broaden the insights offered in the other papers of this volume.

I believe this limitation of perspective to social processes can be helpful to our purposes. I am less certain about the usefulness of the other limitation I will bring to this paper. I am writing here in the light of experience of the American tradition of governance of education and the American "curriculum reform" movement. I will suggest soon that some parts of this American perspective are helpful analytically and might be usefully turned to the resolution to the definitional and conceptual problems that are endemic in all international discussions of the curriculum. Other parts of this conditioning are more problematic. Thus, I cannot escape from a mood of some pessimism when I think about the outcomes of the curriculum renewal and educational reform movements of our 1960's and 1970's. American research, such as the surveys, recently conducted by the National Science Foundation, shows for example little impact persisting from the new math of the 1960's (Stake and Easley, 1978). As Gibney and Karns (1979) conclude after their review of this work:

> Despite the 'new math' thrust...there appears to be little change in mathematics instruction evident in grades K-12...Few instances of modern mathematics are found in the NSF-sponsored case studies; for most classrooms around the country, modern math never touched down.

There is some indication in some of the national case studies of curriculum change (e.g., Unenge, 1978) that similar conclusions might be reached in other countries although it might be that many readers of this paper will not resonate with the burden of this American frustration and puzzlement. Nevertheless I suspect that it is likely that the outcome of the international experience with the mathematics reform movements of the 1960's and early 1970's is similar to the American and that there is much to be learned that is of significance for educational policy in general from the variety

of responses to the Royaumont impulse reflected here about both the school-disciplinary interface and the more general problems of curriculum change, renewal and development.

I offer these last remarks diffidently. I am more confident about the utility for the purposes of a volume such as this of the increasing tendency in the US to see the root meaning of the vexing concept "curriculum" as referring to the actual activities, with all of their undergirding intentionality, of teachers and students in schools. From this point of view the question What is the curriculum in mathematics in this place? is an invitation to description and analysis of the curricular reality of the schools (i.e., the Implemented Curriculum), not an invitation to a recapitulation of the written schedule of proposed or prescribed activities that might be found in a syllabus, curriculum guide, or läroplan (i.e., the Intended Curriculum). It is an invitation to move via aggregation of descriptive accounts of practice to a characterization of that practice in appropriate units of analysis. With such a working characterization in hand, we can then move to explore such issues as (1) the kinds of clusters of curriculum types that might be found in different places and school types within a country or jurisdiction, (2) the exploration of how the existing state of affairs is "controlled" (in a sociological sense) to produce given patterns of stability and change, and (3) the relationship between Intended, Implemented and Realized Curricula.

Such a view invites us to consider what the relationship is between the formal and informal institutional apparatuses, procedures, forms and rituals which surround the schools and their practices, to (in Reid's [1975] words), "the appreciation of forces tending to preserve the status quo as well as those making for change and...a recognition that change involves the abandonment of practices as well as their adoption" (p. 247). It leads us to an examination of factors influencing the curriculum in what might be called the deep structure of the curriculum system of the schools and to the recognition that many of the elements of the surface

structure of those systems (for example, syllabi, guidelines, given kinds of examination, given kinds of communication, rhetoric and advocacy, etc.) may have, in particular cases, a problematic influencing relationship on both the curriculum as it is found and attempts to modify or change that curriculum.[2] The reality of a claim for or belief in the influence of a given factor on curriculum practice is, from this perspective, always open to empirical investigation and the functions and interests which underlie the use of given channels of influence and the messages carried by those channels can be seen as ever present issues and problems. Such channels, and the messages they carry, are always contextually embedded and function when they are able to initiate responses that derive from long established repertoires of social behavior. Conversely, if such signals are to invite teachers to venture new paths, we can always consider their power to require people to attend to the novel elements of their messages in the face of both the real exigencies of moments and long habituated modes of functioning; they must have the power to override existing institutional practices and the all-too-human tendency to resist changes in patterns of practice. Recent American research exploring the residue of many reforming initiatives suggests that the channels and methods that have been used in my country's educational system to communicate new possibilities to teachers have not been able to secure their, and their system's, real and sustained attention to new messages -- with the consequence that has been minimal fundamental change in the character of implemented curricula (Giacquinta and Kazlow, 1980).

These problematic circumstances are all too often the case, particularly when the impulse to change derives from intellectual considerations which have their origins in understandings which are outside the ken of practicing teachers. We must remember

2. The relationship between "curriculum" and the control of the practices of schools is discussed in an interesting way in Lundgren (1977).

that the common disciplinary universe which scholars and teachers seemingly share by virtue of a common indentity as "mathematicians" or "historians" masks a deep gulf of perspective, and often socialization, between what are really different kinds of people. A subject as taught in school or college is a selection of elements, typically made in identifiable periods, from an enquiry or cultural endevour which becomes over time an on-going entity in its own right and an institutionalized vehicle for the common endevours of the school system -- its educative, certification and assessment tasks, for its teacher training, for its writing of texts and examinations, for its planning of buildings and the like, and for the ways in which "education" and the curriculum are seen (McKinney and Westbury, 1975). In other words, a subject in the schools is an institution in the schools, a structural frame which specifies tasks and meaning contexts within which education takes place. It has a different function than does the structure which, despite a shared label, surrounds the world and work of the researcher or the technologist. "Mathematics" means something quite different for the teacher, the researcher or the technologist.

This gulf in perspectives is inevitable and flows inexorably from the processes which convert a curriculum as an idea into a thing in the schools. It is, for example, the topics in the thing "mathematics" which determine much of what teacher trainees learn about their subject, not the demands that might derive from either the idea of mathematics or the different mathematics of the university teacher or applied mathematician. And, even in those places where this demarcation is not clear, differences in perspective emerge as a result of the forms of curriculum in many fields; as Ziman (1968) and other have noted, baccelauriate-level work in many fields is essentially dogmatic having the two fold tasks of socialization into a known culture and selection of neophytes who later will come to see the discipline as an enquiring field.

These tendencies have been exacerbated by the conditions which have influenced public education is almost all countries over

the past thirty or so years. It has been the subject-as-thing which has been the real and continuing focus of attention by the school system. In the face of the ever-present need to deploy subjects as they are known to ever burgeoning populations of clients, under conditions of resource constraint, it has been the existing order with its problems that has been the only truly constant object of concern by the school system. In this context the appearance of a sustained concern for the appropriateness of the match between the existing selection of elements making up the existing school subject and the possibility of other more appropriate selections has been essentially adventitious, and too often even the meaningfulness of this problem has been seen as mysterious.

So far I have been implicitly painting a picture of the school system which takes the point of view of a reformer and considers the balance of forces leading to given patterns of stability and change in a given system. I have emphasized the problematic nature of the relationship between the reformer whose interests are motivated by ideas that come from outside the trajectory of the school system as an institution and the drags that inhere potentially or actually in the forms of the institution. In so doing I have offered, indirectly, an interpretation of the forces which we have seen playing themselves out as I have pondered the fate of the new math impulse in the United States: there reformers whose roots lay outside the existing subject system in the schools were not able to mobilize enough influence to override the existing predispositions of a fragmented, decentralized education system.

But these are conclusions emerging from an assessment of the short-run and are observations about interactions between one group of change agents within an existing system at one time and the tendencies of that system at that time. They are, in other words, comments on the problems which inhere within given social systems and reflect the perspective of one whose focus is on the successes and failures of policies of particular kinds which were pursued in given places to effect planned curriculum implementa-

tion. The perspective ignores, for example, the social and cultural processes which led to the recognition of a problem in the mathematics taught in schools and the deliberations which led to the particular kind of selection from mathematics represented by the "new math". There is a more fundamental perspective to be taken on these matters than I have suggested to this point.

So far I have used the terms subject as "thing" and "social system" fairly loosely to characterize mathematics in school. By social system I mean, of course, the set of ways of doing things and the organizations that interact with the work of teachers to control and order the way that go about their work. Three sets of elements can be seen as making up this social system: there are (1) resource providing institutions (e.g., publishing houses, development centers, teacher training institutions, teacher recruitment practices, teacher education faculty and developer recruitment practices and educational funding agencies) which together provide the human, curricular and instructional resources which are used by the schools, (2) regulating institutions (e.g., inspectorates, examining bodies, curriculum approving bodies, teacher certification agencies) which evaluate what schools achieve and set criteria for their personnel and graduates, and (3) interest groups (e.g., political parties, scientific societies, teacher associations) which seek to see their view of education reflected and represented in the schools (Wirt and Quick, 1975). Figure 1 sets out one representation of this kind of system for the United States.

These elements of a subject's social system interact in different ways and are linked in different ways but two aspects of their interaction seem important for our purposes. There is in the work of all such institutions (1) a service delivery aspect which is concerned with the problems of deployment of schooling and subjects of known kinds to client populations and (2) a curriculum policy aspect which is concerned about such questions as the ultimate quality of the work of the service delivery system, its directionality, its articulation within itself and with national goals for

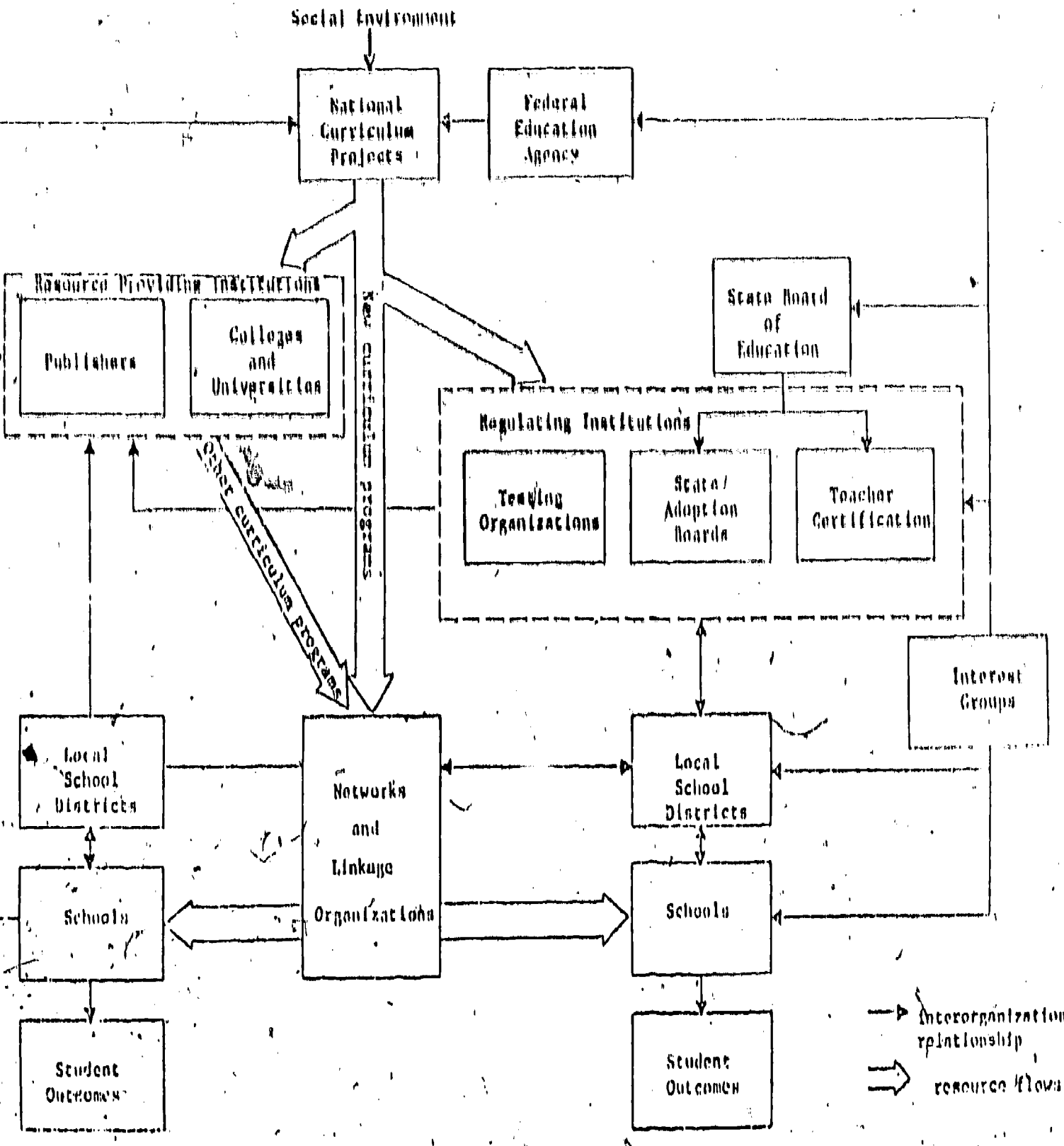

FIGURE I: THE U.S. CURRICULUM SYSTEM
(FROM WIRT AND QUICK, 1975)

policy, etc.. The two systems intertwine but it is this latter aspect, as it is reflected in curriculum policy systems, which determines much of the ambience which surrounds the work of given teachers -- as curricular platforms are articulated, defended and criticized, as new or old courses and texts considered and proposed and given kinds of people are entered into the labor forces of teaching, teacher education and the education of teacher educators. The curriculum management system of a given polity functions to mediate between these aspects of the curriculum as it seeks, in Reid's (1978) words:

> clarification of purposes, the identification of possible system states that would contribute to the realization of these purposes, and decisions on how and when to operate on the factors controlling curriculum stability to try to bring about states chosen as most suitable (p. 91).

Almost all of the issues which circle around the trajectory that a subject takes in a given society can be seen as centering on the kind of mediation achieved by curriculum management system of particular kinds between the needs of service delivery and the demands that are made by those who would assert the desirability of different curriculum policies. And the problems faced by all curriculum managers are always the same: they must transfer information and attitudes across subsystem boundaries that we know all too well are relatively impermeable. And while in some places, the different elements and means that might be seen as parts of a total curriculum policy and management system are tightly coupled together in theory and practice, this is not inevitably the case.

Thus, we might see this set of structures in a different way, as resources which can and might be used by contending parties in a struggle for domination over the ambience, and perhaps the practices of the schools. Within such a perspective any group or party wishing to assert its views of a proper balance between differing educational and systemic ends must seek to forge its own

management system out of existing elements, to create its own intersection of elements to permit it to actualize its sense of its mission. Such coalition may be created by concrete networks of particular people but more usually they must be created by cooption, by persuasion or inducement and coercion of existing organizations, institutions, and people (Archer, 1979).

There are obvious impediments to any simple act of creation of a curriculum management system of a particular kind if the kind of system required is different from those already functioning in particular places. Nowhere are there reasons to believe that there are routinely available well-oiled networks that can be called into place to meet the full variety of goals, platforms, and programs that assertive groups might articulate. But at the same time there is the possibility that different countries' subject systems do have different capabilities to adapt to the variety of criterial expectations that one might have for such a system sub specie aeternitatis. And, clearly, different national subject systems do have such differing capabilities to explore the interface between the disciplines as they are seen within higher education, industry and learned societies and school subjects. If such differences emerge they will, I hypothesize, correlate with structures which lead to greater openness, to a movement of authentic real information and attitudes across the boundaries of different systems and subsystems. We will see curriculum management systems which are effectively integrated with university-based interest groups having open-ended views of their subjects which, at the same time, control the forms of resources which the schools are given and the mechanisms of regulation of the schools. (This does not mean, of course, that systems which are effective in these terms will be centralized in character. Impulses which lead to a particular claims about the view of a subject which might be reflected in the schools do not necessarily emerge from within centralized organizations and claimants indeed can often be inhibited by such systems).

One can distinguish different kinds of considerations as one ponders the effectiveness with which systems solve the value problems that inhere in curricular deliberation: most fundamentally there are questions to be explored about the kinds of curricular problems that assertive groups identify and seek to effect in the practices of the schools. There are also issues in the mesh between these assertive groups and the ongoing service delivery system and the availability over time of networks that facilitate appropriate meshing between the variety of different elements (and organizations) within a particular system. A well-oiled and well functioning service delivery system may well inhibit the penetration of new curricular policies and programs into the schools of a jurisdiction. Given the scale of most school systems and the complexity of their tasks, the task is one of integration of different perspectives in a way that allows for incremental, emergent shifts in point of view, not a single-minded devotion to restricted goods however important they may be.

Where does this kind of approach to the analysis of the problem-solving capabilities of a curricular system leave us? One task of the curricular system in mathematics education is to ensure that the stock of resources for an appropriate general education contained within the culture of mathematics, as this culture is conceived and practiced within industry, higher education and learned societies, is searched and made available to our students. It also implies that one result of this search should be represented in the curricula in mathematics that appropriate numbers of our students experience. I suggest that we can evaluate the effectiveness of our different polities' curriculum management systems to perform these tasks. Of course, the use of this kind of criterion should not be taken to imply that at a given time all systems should have equivalent capability to engage in any appropriately complete act of educational and curricular problem-solving. Indeed, these qualifications raise some of the most important problems which the approach I have been outlining should permit us to explore. Yet despite this, I suspect that many of us would not be entirely hap-

py with that which the approaches that have been used in the recent past have yielded: too much that was ventured has had to be abandoned both on intellectual and practical grounds, too much that was proposed posed problems for the teacher forces of our countries given the expansion of the school system and our inability to handle two system development tasks simultaneously. I suspect we would all agree that more might have been achieved than was in fact achieved.

If the kind of approach to assessment of the outcomes of our natural experiment in curriculum renewal makes sense and if the kind of embedding of our analytical approaches to this task in terms of the social systems which contribute to stability and change of school systems likewise makes sense, we will have, I hope, one way of ordering the issues we might discuss. We can ask how well the social systems represented by mathematics education in our different countries have achieved what I am suggesting is one of their fundamental purposes, that of a problem-solving engagement of mathematics education with mathematics seen as a resource which contains both ends for mathematics education and means which might be used for other, more explicitly educational ends. Our goal as we take such enquiry is not prescription but an enhanced understanding of possibilities and problems as these seem to emerge from our case studies.

Let me now turn to the further explication of some of the tasks that seem to lurk around this conception by way of the two-way table set out below. Obviously, terms like "problem-solving" and "systems" alone are not robust enough to carry the freight of the discussions that we will enter at this conference. I will focus these remarks on the problem-solving axis of my figure because my experience suggests that this is the dimension of our larger problem which is least well understood at this point in time.

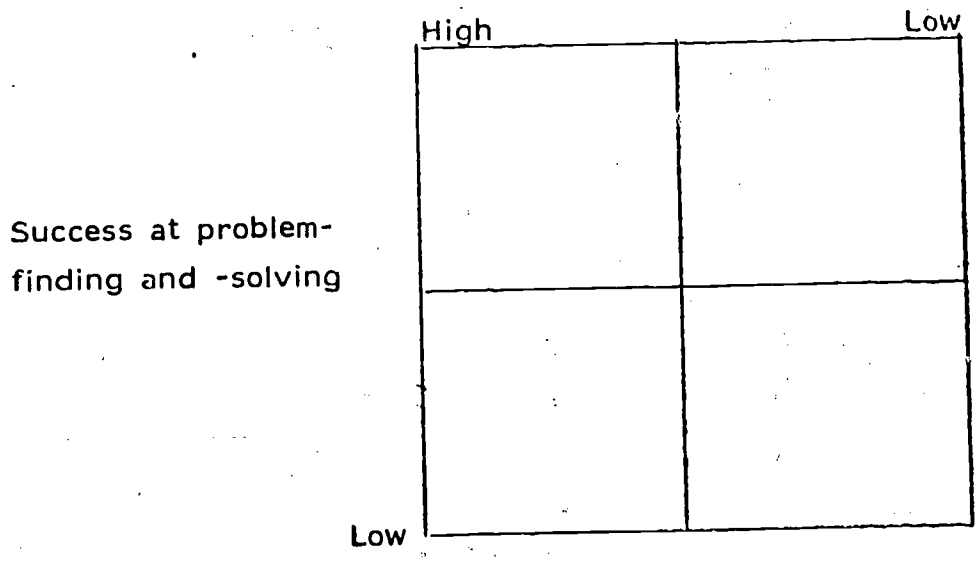

Figure 2: The "Success" of National Curriculum Systems in Problem-finding and -solving and Implementation

Let me first break apart the notion of "problem-solving" into a set of subtopics representing different types of problem-solving and problem-finding tasks that one might expect to be undertaken by components of any curricular system. I see four sets of such tasks each with a problem-finding, a problem-solving and a critical-evaluative aspect:[3]

1. The discerning of gaps and/or problems within existing curricula (privations) and the articulation and elaboration of platforms or general approaches (resources) which, if implemented, would ameliorate the perceived problems or privations. E. g. the privation represented by a lack of attention to applications of mathematics, or a lack of attention to "modern" mathematics in the school; a perceived inadequacy of existing methods and content in the experience they offer students of mathe-

3. I am endebted to Robert Davis for these distinctions.

matical modeling, axiomatic approaches, proof, or problem-solving.

2. The original invention of school-appropriate and school-useable approaches, contents and methods that could, if available, give operational meaning to platforms and programs.
3. The subinvention and/or elaboration of ideas and possibilities embedded in work done under (2).
4. Replicative elaboration and adaption of developments within all of the above categories to make their outcomes available and useable by particular communities. Such replication and/or adaptation can be subinventive activity requiring considerable local development or can focus on the substitution of pawpaws for pears, to use Howson's (1979) terms. Such adaptation can be either culturally-targetted (the Entebbe Project) or "mathematical" (recent elaborations in the US of transformational geometry).

To the extent that any particular mathematics education system can be regarded as a participant in a larger international system we can discern two different kinds of approaches to this set of tasks, each of which plays a necessary role in the division of labor within international and national problem-solving. Thus, most obviously, we can presume that a system might and should have a capability for autonomous and original creative functioning in any or all of these task areas; at the same time, however, we should also emphasize that systems more often than not participate these task areas (particularly in areas (1), (3) and (4)) by virtue of their capacity to scan and evaluate the work of other systems.[4] It is this latter approach to problem-solving (via scan) that has perhaps the longest tradition within most educational system as texts and more general approaches are transferred across national boundaries. The reform movement we are consider-

4. I am endebted to Curtis McKnight for these distinctions.

ing is, when all is said and done, largely the result of such processes. I would want however to deemphasize such transfers of packages of ideas or specific curricula as we consider the issues that circle around this notion of the problem-solving capabilities of school systems and, instead, emphasize the quality of participation by our different curriculum systems in both internal (i.e. national) and international processes of problem-solving. The transfer of materials and know-how is, when all is said and done, a problem of dissemination and implementation and, as such, to be judged as an authentic example of curricular problem-finding and problem-solving only in the light of a knowledge of contexts.

A set of interesting and important questions arises as one ponders abstractly the kinds of problem-solutions that mathematics education produced in recent years. Why, for example, was this and not that kind of issue seen as problematic or not that by particular assertive groups with the capability of dominating elements of the curriculum policy system? Why ever did we believe that axiomatic approaches would provide a serviceable basis for school mathematics? What kinds of theoretical-cultural approaches determined that systems saw their needs in this area and not that? Here, of course, we need to ask questions about the kinds of cultural geists which led us to see needs in some ways and not others and possibilities in some areas and not others. Such considerations soon come to center on the forms of mathematics institutionalized in particular milieus and on the kind of intersection to be found in a place and time between the systems which surround the school system and that which surrounds research or higher mathematics. But while cognitive considerations are important in determining the form of particular local creative developments, there is always a broader set of potential cognitive resources available internationally than is ever exploited by the schools by the schools or their supporting institutions. In other words institutional factors determine the nature of assertions about "needs," not cognitive factors.

Three sets of considerations emerge at this point. We face on the one hand the sets of institutionally-based factors which serve to limit the perspective of a problem-solving curricular system: a social perception develops that some issues are significant, others less so. One could ask, for example, what "mathematics" is within a particular total system and what this definition might mean for that system's institutional capability for problem-solving? One could likewise ask questions about the kinds of institutionalized conceptions of schooling or education which determine what actors in a particular milieu will regard as a real problem or solution. And, perhaps most interestingly, we can ask questions about the institutional circumstances which lead actors to even have a concern for problem-solving in general or in particular.

It is this last observation which leads me to another set of considerations about the problem-solving capabilities and achievements of school systems. Ideally one might expect that a concern for problem-finding and solving would be a constant and continuing function of parts of all curricular systems. My experience suggests however that this expectation is rarely fulfilled and that, as in the case the curriculum reform movement of the sixties and early seventies, problem-solving takes places by way of spurts and stops, via projects and mobilizations. We might use a term like "fixing" to characterize this style and compare such styles with the methods and means we would associate with such terms as "deployment" or "incremental muddling-through". I am hypothesizing, in other words, that few if any of our curriculum management systems have a clear capability for continuing, institutionalized problem-solving. Why might this be so?

Van den Daele and Weingart (1976) write in the course of an exploration of the cognitive and instutional factors that bear on the emergence of new scientific specialities that:

> The emergence of a speciality which can be described as a form of change is to be analysed sociologically as a process of institutionalization. What

> from the viewpoint of the philosophy of science constitutes cumulative research, appears sociologically as a stable continuous activity. In these terms it is possible to indicate structures, conditions and consequences of the formulation of scientific specialities on the institutional level (p. 255).

They go on to identify three clusters of social processes as critical to the nurturance of an emergent scientific specialty:

> ...a process of differentiation which ensures the autonomy of the specialty and demarcates it in relation to other research areas; a process of social integration which creates the stable interrelationship of scientific work and enables its 'social accumulation'; a process of reproduction with essentially ensures the recruitment of members of the social community constituted within the specialty (p. 255).

In the volume in which this paper appears, it serves to offer an implicit commentary on a set of case studies of the emergence of such scientific specialties as radio-astronomy, physical chemistry, tropical medicine and the like. But this approach would also be of considerable value within a field like mathematics education: It would structure a country-by-country analysis of the capabilities of policy and management systems for curricular problem-solving to give a clearer sense of the woof and the warp of the patterns of activity we might identify. It also permits us to make some more global observations about the state of the general international systems that we have at hand to support curricular problem-solving. I would suspect that in most countries problem-solving has typically been unable to differentiate itself from other roles and tasks within curricular systems. In particular, it has found itself inextricably linked with routine tasks of teacher education and, equally characteristically, has found itself in a confounding relationship with communicative and controlling tasks within school systems -- both national and internationally. This failure of differentiation has led to an almost globally inadequate development of the means necessary for autonomous social integration and reproduction.

But these kinds of observations are, because they are obvious, albeit crude, generalizations, less significant than are analyses of systems and times in which an authentic on-going institutionalization of problem-solving has occurred and does occur. Such institutionalization may be seen emerging, for example, in embryonic form around some curriculum projects in the US, although in these cases the failure of the groups to secure on-going formal organizational support has minimized the long run effect of their "invisible" structures of collegiality and collaboration. However, as we attempt such analyses, following the lead of such volumes as Perspectives on the Emergence of Scientific Disciplines (Lemaine, 1976), we will find that the institutionalization of curricular problem-solving capabilities cannot be simply assimilated into the terms used to discuss the social organization of "conventional" science. Curriculum problem-solving must be intimately related to a domain of practice that denies the possibility of the kind of autonomous development of specialist laboratories, schools or seminars that occurs within science. Theory and practice must merge into a praxis which involves a sense of the schools and their needs as well as a sense of the possibilities that inhere in the domain of mathematics. Research and practice must be linked for even formal didactics to move forward fruitfully and some level of acceptance by schools systems and teachers is a necessary quality of the endevour.

Two further sets of considerations, both circling around issues of "labor quality", flow from this conclusion. First, given that problem-solving must extend from laboratory or seminar to school and back, it would seem absolutely essential that there be people in schools and management systems who can and do participate as true collaborators in all systemic invention, subinvention, replication and adaptation. Over time one might envisage the necessity of a movement by individuals from schools as one kind of site to other sites, with the implication being that activities in different sites is an instance of functional rather than status differentiation. I would hypothesize that the presence of such

invisible colleges spanning a variety of such functionally differentiated sites would be an inevitable precondition for long run problem-solving as a stable continuous activity.

This prerequisite for institutionalized curriculum problem-solving requires of course personnel who can move freely within mathematics to explore its implications for problem identification and solution. Without a critical mass of such personnel the notion of careers and institutionalized evaluative and repute structures, and expertise, become moot. But even when such specialist groups exist their endevours become practically meaningless unless they are able to communicate their findings and their work to broader publics. For their authentic development such groups need support from school systems, they need mechanisms for the institutionalization of the transfer of their findings to appropriate publics and constituencies, and they need to be incorporated in some way within school system as the domain of application of their work. Without such institutionalized support a problem-solving system faces the danger of being seen as an exotic luxury that has no continuing function within and implications for the school system -- with all of the entailed consequences for both political support and intellectual irrelevance.

In other words, in offering these observations I am raising questions about the general capacity of school systems to support problem-solving as an activity undertaken in its own terms and, concomitantly, about the tasks that a problem-solving speciality faces in both creating constituencies and translating constituency support into resources over the long run. In the real world these tasks presume, I suspect, the existence of integrated cadres within the school system whose experience gives them an understanding of the problem-solving function and linkages between the problem-solvers and their constituences and clients. In short, we face the task of developing forms of teacher education and socialization which lead to shared understanding of roles and shared experience of cognitive worlds. In particular it presumes the pos-

sibility of shared experience of mathematics as an endevour which contains many conceptions and approaches which might serve students. Needless to say such a sharing cannot develop where the mathematical experience of teachers and problem-solvers are vastly dissimilar. And this is the case too often.

This observation permits to turn to a brief consideration of the second axis of my figure, the problem of implementation and dissemination. My discussion so far has presumed the possibility that significant numbers of teachers, teacher educators and the like can participate, by virtue of commitment, in the application and testing of new notions, new developments, and new ideas. But, even when comparatively large numbers of people participate in such change-oriented networks, there will always be larger numbers who do not participate. The forces for stability within a school system make this inevitable. We face then the issue of understanding how ideas and programs are introduced into a curriculum or subject system and how, after introduction and critical evaluation, they can be implemented by target systems. How, in other words, is controlled change controlled? What kinds of control systems can be invoked to effect such change?

One can identify two different kinds of controlling processes which play roles in such endeavors, those associated with socialization and those associated with various kinds of organizationally-embedded coercion. The kind of experience teacher-trainees and teachers have (socialization) is in principle determinable in the long run as are the means of organizational coercion. The question then that the advocate of the possibility of open-ended change must ponder is how long is the long run? And who is controlling the means of control over this long run?

What are the implications that flow from these general questions? First, as Otte (1979) and Howson (1979) note those who are concerned with systemic capabilities for curriculum renewal and incremental change must broaden their sights to include teacher

education broadly conceived within their concerns. I believe that we will find that it is the kinds of socialization which teacher forces have experienced which, more than any other single factor, has set limits of what curriculum reform movements have been able to achieve. At the same time, however I would also proffer the less well accepted observation that the ways in which the means of coercion that are availabie within school systems are used will determine the short run viability of curricula initiatives; initiatives that are not supported by coherent programs of coercion are not able to command the attention of teachers and, as a result, fall foul of the forces for stability within the on-going world of the schools.

1 am prepared to offer this hypothesis with some confidence. The problem is that in my experience it is difficult to talk within progressive education circles of "coercion" and have a positive hearing. All such discussion runs against many of the needs that teachers have as consequences of the ways in their work is structured by the most school system. The ambiguous role of the curriculum worker who is always involved in complicated negotiations with schools and school people that require him to accept the assumptions and presuppositions of his audiences and constituencies bedevills these questions further.[5] It is difficult in this context to secure a forum for even a beginning exploration of this question.

Yet issues of central importance on curriculum change and renewal lurk here. Purves (1979) has shown now examinations can effect what students do to minimize the impact of curricular intentions. Tamir (1979) has shown that external examinations can be used effectively to achieve change in teaching practices. My experience in Australia and Canada suggests also that who controls these powerful mechanisms, how they are integrated with the on-

5. For a discussion of the complexity of the curriculum worker's role as he attempts to "sell" his ideas and materials, see MacDonald and Walker (1976).

going curriculum management system, affects the role that they play in leading curriculum change: where they are in the hands of those whose commitments are to a discipline they lead in one way, where they are in the hands of those whose commitments are to the existing of the school or subject they lead in quite different ways. In other words I am suggesting that as we consider our case studies in the light of a concern for the effective implementation of the "reforms" that we are concerned with it we might give considerable attention to questions like What coercive mechanisms were used to support change endeavours? Who controlled these mechanisms? How effectively? and Why were some mechanisms and not others used? How effectively? With what effect? As was noted by McMullen (1973) in an OECD seminar on Creativity in the School:

> Teachers in general will not change fundamentally of their own free will, even though there is a small proportion who will. To rely for the spread of innovation on this small percentage of change-motivated teachers is not a viable strategy for large-scale change. This leaves inducement or coercion as possible methods; it does not, however, imply that a fundamental change so introduced is not greatly facilitated by methods persuasion, by harnessing the energies of the self-motivated teacher, and by creating appropriate social relationships within the school.

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