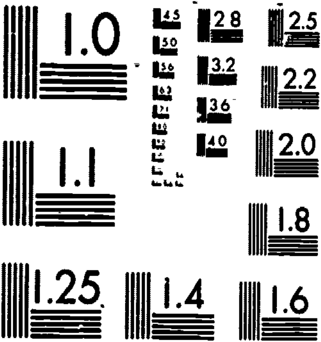

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ABSTRACT

This paper describes the evolution of a model for expanded teacher education initiated by the Minnesota School Science and Mathematics Teaching Project (MINNEMAST) and later developed as an experimental college-school project (called Project Interface) within the Division of Elementary Education at the University of Minnesota. The report details a systems model for evaluating curriculum change using behaviorally stated criteria which are measured within the student teaching framework and the college laboratory. A conceptual model is presented suggesting conjunctions of various methods courses with standard elementary school subjects. (Author/JB)

PROJECT INTERFACE

A Systems Model for Elementary School Curriculum Evolution and Teacher Education

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December 1972

INTRODUCTION

During the decade of the sixties the integration and coordination of school mathematics and science reached a world-wide level of interest. Here and abroad curriculum development projects have produced materials which, to varying extents, require a coordinated approach. Among these are: the Elementary Science Study (ESS), Science Curriculum Improvement Study (SCIS), the Madison Project, the Elementary School Science Project (ESSP), the University of Illinois Science Curriculum Project (UISCP), Science, A Process Approach (SAPS-AAAS), the Minnesota School Science and Mathematics Teaching Project (MINNEMAST), the Conceptually Oriented Program in Elementary Science (COPES) and the Nuffield Mathematics and Junior Science Programs from Great Britain. In 1969, the Cambridge Conference Report* on the correlation of Science and Mathematics in Schools supplied further support to the premise that such changes in elementary school curricula would better serve the interests of tomorrow's citizenry. In this country, the National Science Foundation has been the primary financial supporter of such curriculum development efforts. The NSF is in the process of terminating financial aid for many of the projects which it once supported. It is currently underwriting the Unified Science and Mathematics for Elementary Schools Project (USMES). USMES is currently developing and testing coordinated materials.

Considerable effort has been, and is being invested in mathematics and science integration for school populations. The authors believe that such efforts will continue. This paper describes the evolution of a model for expanded teacher education initiated under a grant from the NSF to the Minnemast Project and later developed as an experimental college-school project (called

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*<u>Goals for the Correlation of Elementary Science and Mathematics</u>. Education Development Center. Houghton Mifflin Company, Boston, 1969.

Project Interface) within the Division of Elementary Education at the University of Minnesota. This paper attempts to detail the elements of the model and suggests considerations for future direction.

ORIGINS OF THE INTERFACE MODEL

By 1965, the Minnemast Project had produced sufficient coordinated mathematics and science materials to warrant the initiation of dissemination studies. Several problems needed solution: Who would use the modern curriculum materials? What role should school districts, and colleges play in curriculum change? How could the new content and spirit become a part of undergraduate teacher education programs? The first action taken by the Minnemast Project was the development of a summer workshop. Thirty teachers, some using Minnemast trial materials and others interested in becoming familiar with the output of the project, enrolled during the 1965 summer. As the workshop progressed more questions arose; What are the essential components of a successful workshop? What factors influence behavior change? What elements inhibit accomplishment of agreed-upon goals? Other questions were being asked by the funders: How can the workshop initiate a system that will be self-expanding? (The multiplier factor). How could successive expansions of use of curriculum materials be accomplished without loss of innovative elements, such as operations, processes, and modes of inquiry? (The fidelity factor). How could large numbers of elementary school teachers and curriculum people be reached? (Need estimates indicated that prime workshops would have to generate an expansion potential and provide means as well as motivation for each participant to function at a later time as a workshop teacher). As the problems posed by fidelity and expansion were addressed in the initial workshops a new possibility emerged. If the nature of curriculum in mathematics and science in the elementary school were one of evolution, then why not build into the system the necessary ties between the teacher training institutions, the elementary schools, and disciplined researchers so that this multiplicity of expertise could maintain communications and could continue to function as a team to the end that curriculum development not be a crash mounted program one decade and an artifact the next, but a continuous evolutionary process? From seven years of workshops and concurrent activities in college classrooms and schools, a procedure evolved which can be viewed as a systems model for curriculum change.

OVERVIEW: THE SUMMER WORKSHOPS - EARLY PROTOTYPES - LINKS WITH ELEMENTARY SCHOOLS

In early Minnemast workshops participants enrolled not as individuals but as members of a team representing a specific college, school or school district. Team members included a professor who is directly connected with a college teacher education program, a principal and two teachers from an adjacent elementary school. The workshop became the first element in the model. The college professor, responsible for the undergraduates' program, uses part of the workshop to plan and develop in-school undergraduate activities. Later, undergraduates come to the school to work with the teacher as part of their undergraduate course requirements. The teacher and the undergraduate try new lessons, units and materials and in a real sense, learn one from another. Participants were recruited as teams from college-school sites so that when the workshop terminated, each team would have the skills and expertise necessary to implement the newer curriculum in the school classroom and in the undergraduate methods course laboratory. It was hoped that these teams would mount new workshop programs in their region the following year.

The professor, using the elementary school, and receiving help from the experienced principal and teachers begins a second generation workshop. In following the prime model, teams coming from other regions learn about the Minnemast program or other modern curriculum projects. Through this multiplier concept, the taught become the teachers and the dissemination structure expands. In following an alternative model, the team may choose to mount a workshop for other teachers from schools in the district. In this way curriculum expansion into many local schools is facilitated. Precision incorporation of newer programs into regional schools is further enhanced since the schools are now able to recruit young teachers who have recently been graduated and have worked with local schools as part of their science and mathematics methods programs.

The teams play another vital role. They can function as consultants to other school districts, make presentations at professional meetings, and serve on regional, state or national task forces responsible for long range educational policy development.

Section 2

Summer In-School Workshop

Before bringing undergraduates to an elementary school, it seemed appropriate to provide in-service training for the teachers. A summer workshop designed to parallel the desired school science and mathematics programs was developed. Early workshops were offered under the auspices of the National Science Foundation; current workshops are a regular catalog offering of the Division of Elementary Education of the University of Minnesota. Although the two differ somewhat, there are commonalities critical to the promotion of desired teacher behavior. The workshops are held in the elementary school building where the teachers and undergraduate students will later work. Specific plans are developed through several conferences with the school principal, librarian and teachers. The workshop is scheduled for a period of 2½ to 3 weeks. The principal registers sixty to seventy children for a 10 day Summer Science program which occurs within the workshop. Children are grouped into two primary sections and two intermediate sections. An effective workshop enrollment has been found to be 24 teachers although as many as 50 have been accommodated. The 24 teachers are divided among the four classes, six teachers per class. Needed curriculum materials are purchased by the school for use both during the summer workshop and the ensuing school year. (It should be noted that part of the purpose of the workshop was to give the school staff a chance to gain an understanding of newer materials before making school program commitments.) Science teaching materials are sorted into instructional units by the teachers, stored in the school's instructional materials center and distributed by the librarian during the workshop. Children attend the workshop for 10 mornings from 9:00-11:30 a.m. The mornings are divided into two instructional sessions of one hour each with a 30-minute recess period.

Teacher groups divide responsibilities. On a rotating basis some organize and conduct the lessons, some observe and critique, and some work on material preparation. Thus, each workshop member carries out teaching tasks that will enable him to utilize newer curriculum materials and at the same time provide guidance and suggestions for undergraduates during small group teaching sessions to be scheduled during the ensuing school year. The workshop teaching is followed by discussions, in which the instructor suggests related, effective teaching procedures. These procedures are consistent with recommendations of curriculum development projects such as SCIS, AAAS, Minnemast, ESS, The Madison Project and the Nuffield Mathematics Project.

The authors (as workshop instructors) have found it useful to conduct occasional lessons for children in order to demonstrate the use of certain materials and/or teaching procedures.

Section 3

The On-Campus Undergraduate Mathematics/Science Methods Course

The authors responsibilities with the Minnemast Project provided the original impetus in addressing the problem of interdisciplinary studies in the pre-service teacher education program at the University of Minnesota.

If one accepts the premise that tomorrow will find a greater degree of mathematics and science integration in the schools of the nation, then pre-service and in-service teachers must be prepared to teac those ideas found in coordinated programs.

This concern has led to the development of a methods course designed to provide experiences in the teaching of mathematics and science to children both as separate disciplines and in concert with one another. The course is further designed to eliminate certain of the theory and research overlaps common to separate mathematics and science methods courses. It was realized from the outset that such experiences could not be provided for pre-service students without substantive input from the public schools. It was further concluded that such a university public school interface should ideally be developed in a manner which is mutually beneficial. If successful, such interaction should enhance efficacy of the university methods course, and serve as a catalyst to public school curriculum improvement. The interaction would subtly modify the behavior of the classroom teacher toward the promotion of student inquiry, active student participation in a material-based program, and toward the realistic development of problem solving skills. In short, the teaching behavior of the teachers should ultimately move in the direction of "facilitator" of student learning as compared with the more traditional role of content expositor. (The authors assume here that active student involvement in learning activities and the concommitent lessening of direct teacher influence is desirable and will ultimately result in greater problem solving skills on the part of school children. There exists research evidence to support this contention. A review of such literature, however, transcends the purpose of this paper.)

At the University of Minnesota, the decision to combine existing but separate mathematics and science methods courses had immediate advantages. It provided more time (9 hours per week divided into three - 3 hour blocks for one quarter) in which to address the issues, without altering the total student in-class time commitment for these two courses. In addition, the three hour blocks provided needed time for the in-school course component: the public school/university course interface, treated in section 4.

Topical areas illustrative of the mathematics/science interface formed an important component of the on-campus experience. The areas considered included classification and sets, measurement, functions, order relations, graphical analysis, proportions, motion, symmetry, probability, statistics and various aspects of geometry (particularly geometric algorithms appropriate for problem solving.) As an example, one of the Piagetian experiments having to do with displacement of liquids provided us with an excellent vehicle through which the students explored: (1) sequential development of concepts in children, (2) concepts related to buoyancy, (3) weight volume and density, and (4) concepts related to the graphical analysis of data - where slope represents a derived measure (density) as a function of two measurable properties expressed numerically. (weight and volume)

When one considers the effective modes of learning when dealing with children in the period of concrete operations, it seems reasonable to carefully combine mathematics and science into child-appropriate activities. This neither downgrades the power of mathematics nor relegates science to a superficial read-about and look-at the pictures activity. Mathematics thus becomes a useful, powerful tool in helping the child understand the world about him. Such activities also help the child to recognize some of its beauty, orderliness and elegance.

The undergraduate students were thus involved in quantifiable process activities: observing, describing, counting, measuring, gathering and displaying data and subsequently verifying or rejecting hypotheses generated. Although the emphasis was on process, the vehicle, (the laboratory activities of the course) exemplified selected elements of mathematics and science appropriate for the elementary school child. It was hypothesized that university student involvement in activities which incorporate significant intellectual ideas from mathematics and science and concomitantly utilize the processes appropriate to both disciplines would have a synergistic effect: their learning, and problem solving ability within each discipline would be enhanced while cross-disciplinary understandings would be generated. Clearly, this goal is relevant for, and directly translatable to elementary school children. Through assignments, students were encouraged to further explore subject integration and to investigate existing mathematics, science and mathematics/science curricular materials. Subsequent in-school small group teaching of selected parts of the exemplary concrete activities of the course was also used to achieve this end.

In actual practice, the authors team-taught the pre-service methods course. Both were present for almost all classroom sessions. Although this represented an additional time commitment, the new teaching dimension, that of professorial interaction through discussion, pooling of expertise, and occasional defense of specific positions in the presence of the undergraduates, demonstrated what was described by many of the undergraduates in anonymous evaluation instruments as the most exciting, stimulating and human element of the course. Often one professor would select a particular topic for discussion and laboratory focus. The other professor would ask questions, encourage students to take part in dialogue, and often support students in pedagogical positions which they wished to explore. The end result was an openness, an air of mutual cooperation, and a cooperative working toward established goals. Often one professor would pose a problem, the answer to which the other did not have. The other professor, in concert with the students would work through the problem utilizing process skills and considering modes through which the problem could be modified appropriately for classroom use with children. Many of the preconceived attitudes of college students were dispelled. They found that the professor was not always right, that hypotheses could be changed as new evidence was uncovered, and most important, that through the successful solution of problems, whether they be academic or pedagogical, the worth perception and confidence of the individual was enhanced. Indeed, the human relations element, often so elusive to grasp and actualize, became a critical factor in the course to the end that students experienced success in problem solving and were determined to make that kind of success experience a part of the school child's education.

Section 4

Small Group-Teacher Interface

An integral part of the mathematics/science methods course was the off-campus in-school component. Thirty per-cent (3 weeks) of the course was spent in a local elementary school. The timeline below indicates the on-campus/in-school laboratory course sequence.

Begin — End

#1	#2	#3	#4	#5
on campus 4 weeks	in school laboratory 1 week	on campus 2 weeks	in-school laboratory 2 weeks	on campus 1 week

The stationing of undergraduates within the school represents what is considered to be an essential follow-up step after the summer workshop in effecting teacher behavior change and placing supportive constraints on reversion to the more "traditional" non-inquiry, non-discovery mode of teaching. Classroom teachers within a particular building who had previously been involved in the summer workshop were identified as those persons who would aid in the supervision of university undergraduate students. Only those teachers who had been exposed to and were currently using modern programs were so identified. The course instructors were generally familiar with the types of pedagogical techniques utilized in each of the cooperating classrooms and knew them to be supportive of and consistent with suggested classroom interaction models.*

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*The course instructors were particularly interested in indirect teacher-pupil interaction patterns. The Flanders interaction analysis model was applied to two groups of teachers in a related study currently undergoing analysis. Preliminary indications are that teachers undergoing the summer "treatment" are significantly less direct in their approach to classroom instruction and spend considerably less time exhibiting didactic or expositive behaviors. This was indicated by a shift in the Indirect/Direct ratios.

Children in selected classrooms were already working cooperatively (for the most part) in small groups, relying less on the teacher and more on their own resourcefulness. They were assuming a large part of the responsibility for their own actions. In addition, the curricular programs used were among those examined on campus. University students were thus involved in elementary classrooms where the programs used and the modes of teacher behavior utilized were familiar. This removed many of the apprehensions which university students have regarding initial experiences with children and concurrently reinforced desired behavior patterns. At this time students were encouraged to work with small groups of children. (#2 timeline). This school/university interface was found to be mutually advantageous. Classroom teachers were able to gain new insights while observing their children working with other adults; university students gained valuable experience with children. Their behaviors were occasionally guided and generally reinforced by the observing teacher. The initial in-school experience was devoted to curricular materials currently used in the school. During the second in-school experience (timeline #4) university students were charged with the responsibility of working closely with the classroom teacher and were to assume one of two roles: teaching regularly scheduled materials from the currently used program or bringing in new materials and ideas gained directly or indirectly from the on-campus course component. Most classroom teachers choose the second of these options. Since this decision was made near the end of the first in-school experience, the university student had two weeks on campus (#3 timeline) to generate ideas, develop materials and lessons and prepare activities for the ensuing two-week period in the school (#4 timeline). A portion of class time was set aside for such activities. During this time the course instructors functioned as resource-consultants to students, directing them to additional hardware and software, discussing strong and weak points of anticipated lessons, holding individual conferences and guiding large and small group discussions. The remaining portion of class time focused on the further broadening of student experiences and the development of needed insights into the discipline and methodologies of mathematics and science teaching. When students returned to the elementary school they were ready to assume responsibility for whole class teaching. Other students assigned to that class would observe, and take notes for post-teaching discussions. In this way, operational facility in "team" teaching was gained. It was during this second in-school experience that classroom teachers were exposed to new curriculum materials, ideas, and specialized lesson equipment.

The success of the objectives of this second in-school experience became apparent when many of the materials utilized by university students were subsequently adopted by classroom teachers. In a certain (although admittedly limited) sense, this aspect served to keep school personnel abreast of current curricular developments in mathematics and science. Thus, the undergraduate/teacher interface portion of the model: (1) Places performance demands on teachers and provides rewards in the form of professional leadership opportunites; (2) provides undergraduates with children, facilities and trained teachers to the end that in-school experiences serve to bridge the methods course theory/school practice gap, and (3) utilizes students to demonstrate (for teachers) new curriculum ideas, and teaching devices while simultaneously allowing the teacher and the school to provide opportunities for undergraduates to use a variety of school supportive facilities.

During the second in-school course component, a video tape was made of each university student working with school children. These tapes were then reviewed with the class upon returning to campus (#5 timeline). Time and equipment constraints did not permit more than one tape (usually about 20 minutes in length) per student. Students found it valuable to see themselves on tape and to discuss their behaviors with other class members and the course instructors. It would be desirable to have made two tapes per student, one during the first and one during the second visit to the school. The authors believe that university students exhibited teaching behavior change in a desired direction. "Pre" and "post" samples of teaching behavior would permit a more objective vehicle for verifying or refuting that assumption.

Evaluation

The behaviors of university students and course instructors were constantly evaluated. Students were asked to react (anonymously) to on-campus sessions. Course instructors provided feedback to students in the form of conferences and notes on submitted papers and lesson plans. The methods courses at the University of Minnesota are offered on a mandatory A through F basis. A contract system was used. Students determined the grade they wished to receive, and negotiated individually with the instructors as to the specific components of their contract. As expected, a good deal of variability existed among contracts. It should be noted that students had difficulty in developing the contracts, and were more demanding than would have been the case if the instructors had devised the criteria and measurement techniques.

Section 5

Perceived Outcomes and Future Directions

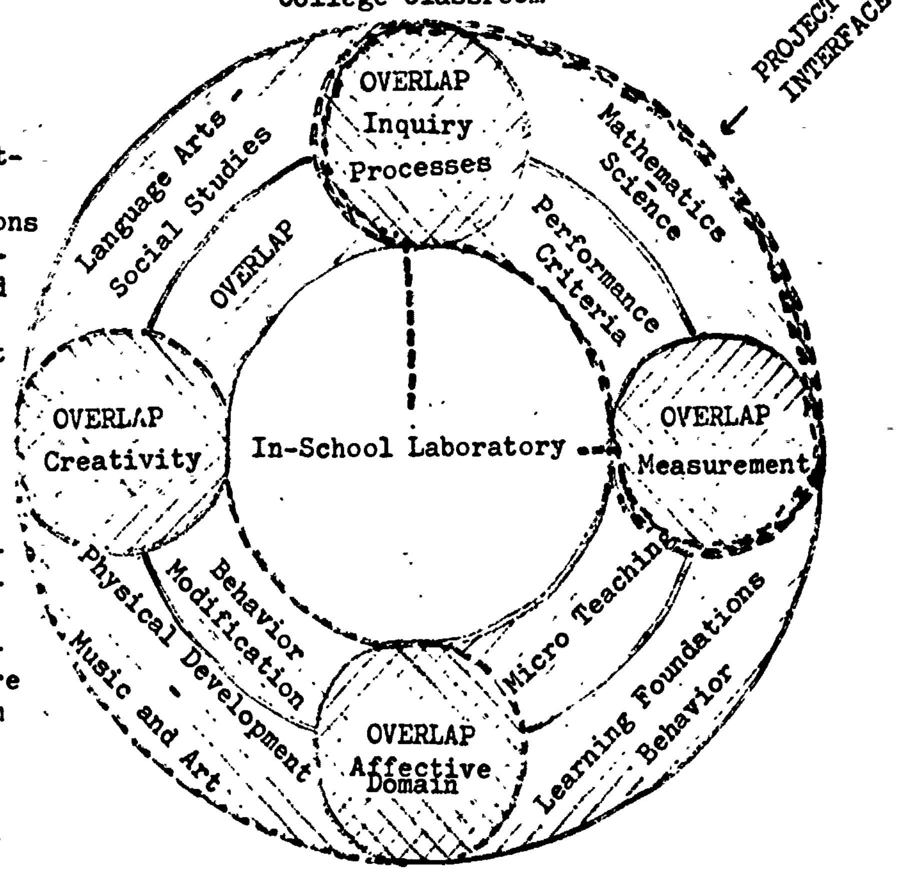
The joint mathematics-science methods course for undergraduates has been piloted for two consecutive years, Winter Quarter 1971 and Winter Quarter 1972. Summer in-service courses for teachers were conducted in two pilot schools during Summer 1970 and Summer 1971. Finally, the undergraduate course-school interface was established in one school during Winter Quarters 1971 and 1972 and for comparison purposes was not established in the second pilot study school. Data were gathered in the undergraduate courses, in the in-service courses, and during the period of interface. At the present time, these data suggest that the period of interface is effective in maintaining and strengthening teacher behavior changes initiated during the summer workshops. Because of the need for "lead time" in conducting an experiment, the authors are presently working with two new school systems to the end that such a total experiment can be carried out.

Because the activation and completion of such a model requires at least two years of school commitments, it seems necessary to make certain inferences and move forward as if these were demonstrable outcomes. All of the subjective evidence from both teachers and undergraduates suggests that the aims of the model (to develop a system in which the competencies of the undergraduate are matched with the evolving curriculum demands of the schools) are being accomplished in ways that motivate and produce sustained follow-through.

What are the impl--ations of such a model? The authors believe that the day of "assembly line" undergraduate teacher education programs is fast closing. Proficiency based undergraduate programs are needed. Teacher education institutions and school systems must continually work together to develop appropriate educational programs and define the proficiencies needed by beginning teachers.

Teacher education programs such as the one currently used at the University of Minnesota are based on strong liberal arts foundation followed by a professional junior and senior year curriculum composed of learning, behavior foundations and methodology courses, capped with an in-school apprenticeship. Envisioned is a model in which the in-school experience represents a central laboratory to be used for two years by the undergraduate. Diagrammatically, the central laboratory (the school/college interface) systematically touches each of the several integrated, professional areas:

The diagram is suggestive of the possible methods course junctions and the areas of overlap. Topics indicated in the overlap areas are suggestive but not inclusive. One might visualize a student moving from the perimeter of the model through the course areas, the supportively programmed school - college concentric overlap and to the in-school laboratory where student teaching, team teaching as an intern and finally certified teaching become the reality.



AN

INCOMPLETE CONCEPTUAL MODEL

In practice, students will encounter fewer courses but will be expected to satisfy proficiency requirements as measured against behaviorally-stated criteria while operating within the school and college laboratories. Course beginnings and endings will be flexible. Theory, frequently the province of the college, would be blended with school practice in a way that understandings would be assumed when demonstrable performance criteria are met.

This model would require the development of several elements. An extensive set of behavior statements will have to be generated, performance levels will need to be specified and measurement techniques of both external and self-appraisal types will need to be adapted or developed.

In the future, undergraduate and graduate programs should be developed in such a way as to utilize the emerging talents of the graduate student in concert with schools: To develop the criteria, to apply the measurement techniques, and to analyze the generated data. It is possible to visualize how this might be accomplished. It is an article of faith that demonstrable results, at a significant level, will provide the positive evidence on which this model is predicated.