DOCUMENT RESUME

ED 270 314 SE 046 613

TITLE	A Study of Exemplary Mathematics Programs. Final Report.
INSTITUTION	Northeast Regional Exchange, Inc., Chelmsford, MA.
SPONS AGENCY	National Inst. of Education (ED), Washington, DC.
PUB DATE	85
CONTRACT	400-83-0010
NOTE	248p.; Pages 64-71 may be marginally legible due to small print.
PUB TYPE	Reports - General (140)
EDRS PRICE	MF01/PC10 Plus Postage.
DESCRIPTORS	Academic Achievement; *Demonstration Programs; *High Achievement; Mathematics Education; National Programs; *National Surveys; Program Descriptions; Program Effectiveness; *Recognition (Achievement); Secondary Education; *Secondary School Mathematics; *Success

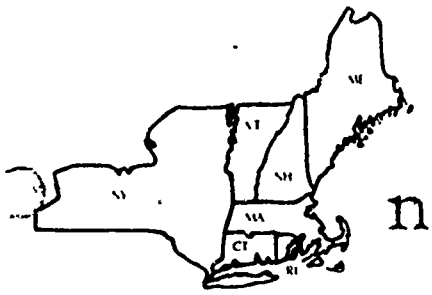
ABSTRACT

This is the final report of a two-year study of exemplary mathematics programs in the United States. The schools chosen were selected on the basis of test scores above national norms, test scores above expectations for particular subpopulations (e.g. women, minorities), participation in critical courses, participation above expectations for particular subpopulations, participation beyond the classroom (e.g. clubs, teams), awards for excellence in mathematics by students or the school, postgraduate success in mathematics and other measurable outcome data. A project summary, findings, recommendations, and hypotheses about what aspects of community, curriculum, teaching and leadership are important variables in exemplary programs are presented. Appendices include a bibliography, abbreviated case studies, ten case studies and a selection of journal articles developed from the study. (JM)

A Study of Exemplary Mathematics Programs

Northeast Regional Exchange, Inc.
34 Littleton Road
Chelmsford, Massachusetts 01824

National Institute of Education
contract # NIE 400-83-0010



northeast regional exchange, inc.

the resource exchange for educational services

To: Kent Viehoever
copy to Dorothy Jones

From: Mark Driscoll

Date: February 8, 1985

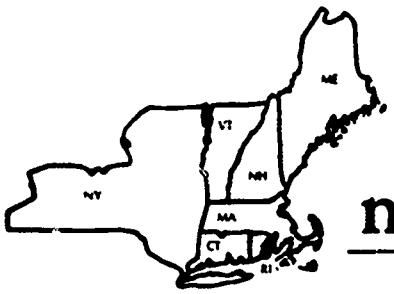
Re: A Study of Exemplary Mathematics Programs
NIE 400-83-0010

Enclosed are five copies of our Final Report for the Study of Exemplary Mathematics Programs. It includes:

- The final report with project summary, findings, and recommendations
- Report to participating schools (in part)
- Bibliography
- Attachment 1 -- study advertisements, correspondence, etc
- Attachment 2 -- correspondence with participating schools, etc.
- Attachment 3 -- abbreviated case studies
- Attachment 4 -- 10 case studies
- Attachment 5 -- a selection of journal articles, correspondence

Even though the study has officially ended, I am continuing to write articles for submission to various journals, (for example, the School Boards article I mentioned to you). I will send you copies, of course. The Northeast Regional Exchange, Inc. is providing opportunities for dissemination through the newsletter, The Northeast Perspective, and through regularly scheduled conferences, meetings, and roundtables. We hope and expect to build on the foundation of this research study. Interest in our work, especially by educators in this region, has remained high. Almost weekly we receive requests for information about the study and NEREX is committed to working with me to find the best ways to disseminate the results. Those of us on the staff -- Elsa Martz, Larry Vaughan, Lynn Griesemer, and I -- certainly appreciate your assistance and support throughout the project.

PS Bob Herriott's consulting notes were not complete enough to include with the deliverable. I will pass them along as soon as they are available.



northeast regional exchange, inc.

the resource exchange for educational services

M E M O R A N D U M

To: Kent Viehoever

From: Mark Driscoll

Date: April 30, 1985

Re: NIE 400-83-0010

Enclosed is the revised findings section of the final report. I trust that this will permit you to close out the project. If you have any comments, suggestions, or questions, of course, please call.

ACKNOWLEDGMENTS

One of the greatest blessings for me in the two years of A Study of Exemplary Mathematics Programs has been the opportunity to work with and learn from the people who have been part of the project.

I have observed and been affiliated with several educational task groups in the past decade. Never have I witnessed as much energy, intensity of effort, and effectiveness as I witnessed in the work of our Expert Panel, who met twice during the project -- in the first year to rate the 146 programs on the basis of student outcomes; in the second year to provide ratings for the presence of the hypothesized factors in the programs that were studied. Because of their careful work, we were assured from the start that we had 28 exemplary programs to visit, and I am grateful. The members of the Panel were Marty Badoian, Peter Castro, Mary Grace Kantowski, Ferd Prevost, Bob Reys, and Sheila Rosenblum.

I am also grateful to the seven Field Researchers who joined me in the site visits. They too worked very hard, and they brought a variety of skills and backgrounds from which I learned much. Jere Confrey brought her sharpened classroom observation skills and keen sensitivity to equity issues; Bob Kenney and Steve Leinwand, as state mathematics coordinators, brought their wealth of knowledge about what is typical in school situations; Sue Martin and Kay Tobin brought, from their teaching, textbook, and school union backgrounds, their finely honed instincts about what makes school programs and districts tick; Larry Vaughan brought his deep knowledge of school research and his seasoned ability to see patterns in a variety of phenomena; and Elsa Martz brought her infectious enthusiasm and unquestioned ability to discern the degree to which children's needs are being met in school situations. I learned from all of these Field Researchers, and they share largely in the study's success.

I am grateful to Lynn Griesemer, Bob Herriott, and Larry Vaughan at NEREX for their constructive criticism, suggestions, and guidance in the research design of the project, and to Gloria Gilmer and Kent Viehoever at NIE for the same. Support staff Joan King, Sharyn Sullivan, and Ann Cadogan helped the mechanical aspects of the project to proceed smoothly.

Finally, I am deeply grateful and indebted to Elsa Martz, Project Associate, for her abiding enthusiasm, continuing encouragement, and friendship throughout the project. She has been a superb model of energy and effectiveness throughout the two years.

Mark Driscoll

FINAL REPORT

A STUDY OF EXEMPLARY MATHEMATICS PROGRAMS

Introduction

In December 1982, A Study of Exemplary Mathematics Programs, to be conducted by the Northeast Regional Exchange, Inc. (NEREX), was funded by the National Institute of Education. The purpose of the project was to collect a pool of exemplary programs in middle schools, junior high schools, and high schools; to examine a portion of that pool in considerable detail in order to hypothesize what factors are associated with their exemplary qualities; and then to provide a systematic means to test those hypotheses.

The contract required that schools nominate themselves, based on characteristics of exemplariness in student outcomes. Thus, in order to generate interest, we advertised in newsletters and national publications, and letters were sent to over 700 supervisors of mathematics education and to the state commissioners of education. The letters described the project and asked the supervisors and commissioners to identify the schools in their districts in which exemplary mathematics programs were to be found.

Approximately 800 schools from all 50 states responded and asked for more information about the study. Each school was asked to submit evidence of their program's exemplariness according to the following categories of criteria:

- test scores above national norms
- test scores above expectations for particular subpopulations (e.g, women, minorities)
- participation above expectations in critical courses
- participation above expectations for particular subpopulations
- participation beyond the classroom (e.g.,clubs, teams)
- awards for excellence in mathematics (both students and school)
- postgraduate success in mathematics
- other measurable outcome data.

Our final pool of program submissions numbered 146. Approximately 60 percent of these were high schools, 25 percent were junior high schools, and 15 percent were elementary/middle schools. Geographically, about 80 percent of the programs were located east of the Mississippi River. Approximately 90 percent were public schools. The pool included a variety of interesting programs: high schools with superb records in the American High School Mathematics Examination competition, junior high schools with tremendous student involvement in learning algebra and geometry, and middle schools with impressive records in achievement, to cite just a few examples. There were many whole programs in the pool,

but also honors programs, computer science programs, remedial programs, and calculus programs were submitted. The responses ranged from 1-page summaries to 40-page descriptions, with a 200-page master's thesis submitted to support inclusion of one non-traditional program. The vast majority of responses required follow-up telephone calls to gather data on student learning outcomes, a task which consumed most of late spring 1983.

Expert Panel

The design of this research project included use of an expert panel to rate the school data. Our six-member panel comprised an expert in middle school/junior high school mathematics education research (Robert Reys), an expert in secondary school mathematics education research (Mary Grace Kantowski), an award-winning mathematics teacher (Martin Badoian), a representative of the state supervisors of mathematics (Fernand Prevost), a representative of postsecondary/industrial mathematics (Peter Castro), and an expert in educational field research (Sheila Rosenblum).

In early August, our expert panel met to rate all of the program submissions based on the categories of criteria of exemplariness. For reliability's sake, the expert panel rated an hypothesized program, then discussed their individual ratings to reach consensus. During the discussion, they decided to drop postgraduate success as a separate criterion and handle it, when it appeared, under the last category. The panelists worked in pairs. Each file of school data was read individually and the criteria were rated by each expert; then the file was read and criteria rated by the other expert in the pair. They rated each program for each category, using a 1-to-9 scale and appealing to normative data acquired from the National Center for Educational Statistics, Educational Testing Service, and other similar sources. The two rating sheets were compared and consensus reached on a rating for each category. When it was impossible to reach consensus, the file was turned over to another pair. In this way, all 146 schools were rated during a three-day working meeting. The panel also provided a relative weighting for each category, and each program's final score was computed as the sum of its weighted ratings over the seven categories.

(The weightings, determined by consensus, were:

- test scores above national norms -- 1.5
- test scores above expectations for particular subpopulations (e.g, women, minorities) -- 1.75
- participation above expectations in critical courses -- 2
- participation above expectations for particular subpopulations -- 1.5
- participation beyond the classroom (e.g.,clubs, teams) -- 1
- awards for excellence in mathematics (both students and school) -- 1
- other measurable outcome data -- 1)

Study staff then took the top-rated 50 programs and began the process of selecting our sites for fall visits. We sought variety according to school level, geography, school type (public or private), socioeconomic factors, and types of outcome evidence. We pared the 50 down to 28 sites in 16 states and the District of Columbia.

In late August, the eight site visitors were trained by a field research consultant in techniques of observation and interview and the use of such field research techniques as a topic outline and topic-source matrix. As in the expert panel meeting, some consensus was necessary to standardize site visits as much as possible. We did this through open discussion about the design of the topic source matrix and agreement on the categories of topics deemed essential for the matrix.

The matrix settled on had as topics: background, curriculum features, curriculum implementation, staffing, support from outside the program, extracurricular features, other. The matrix had as data sources: district administration, school administration, department head, teachers, students, guidance staff, documents. Information was provided for each cell of the matrix from each program's original submission of information and at least 2 follow-up individualized telephone interviews with each program.

The site visit schedule was arranged to allow a maximum number of two-person site visits, in order not only to validate perceptions but to increase the variety in probing strategies to be used in gathering data. We were able to conduct 15 of our 28 site visits with two-person teams; each site visitor conducted a first visit with the Principal Investigator. The schools chosen included 20 with high school grades, 9 with junior high school grades, and 6 with at least 1 elementary grade.

Before the first site visit for the study, a three-day pilot site visit to a Massachusetts high school was conducted in late September to test the materials and make any modifications necessary. As a result of this data gathering, additional forms were developed for use by the field staff. Ultimately we had a package of materials for each school that included (in addition to a copy of the material submitted by the school) observation and interview forms, checklists, a topic-source matrix to aid as a checklist in gathering data, and interview notes.

Site visits began in October and continued on a steady basis throughout the next ten weeks. The Principal Investigator conducted 17 of the 28 site visits, 14 of them with another site visitor, 3 of them alone. We were pleased to find that five of the schools had been selected in Secretary of Education Terrel H. Bell's Secondary Schools Recognition Program, and five of the mathematics teachers and two of the science teachers from schools we visited received Presidential Awards as their state's outstanding mathematics and science teachers.

In December 1983, site visitors submitted notes of their observations and interviews, completed checklists and forms, and a summary overview of each exemplary program.

Findings

There were two stages in the isolation of factors and conditions deemed potentially important to the success of exemplary mathematics programs. First, there were the raw data and fresh impressions gathered by the eight site visitors which were used to generate hypotheses. Second, there was a formal testing of the hypotheses.

To capitalize on the freshness of the impressions, we convened a meeting of the eight shortly after the completion of the visits -- in January 1984. A list of about 60 speculative hypotheses was used to stimulate discussion, the list having been drawn up from speculations of the site visitors during their training before the site visits, and from conversations about the raw data between the project director and the visitors during the period when the visits were taking place.

Anticipation of the second stage -- the formal testing -- guided the design of the site visitor meeting. Our research design for testing hypothesized factors called for studying the degree to which the factors were present in three groups: a group from which the hypotheses were derived, a second group of programs with a comparable exemplariness profile, and a third group of programs generally ranked lower on exemplariness. Because we suspected that site visits were a far preferable method by which to gather data, and because we were unable to visit more than 28 programs, we decided not to choose the entire group of 28 as our hypothesis group, but a subset, and place the balance in the comparable group. In this way, we would increase the chances that the quality of data on the programs in the latter group would be similar to that of the hypothesis group.

Thus, the site visitors focused on the 17 sites chosen to be the hypothesis group (denoted G-1) -- the 17 visited by the project director and, in all but 2 cases, with 1 of the other site visitors -- and each of them worked with the list of 60, added candidate hypotheses of their own, and produced an individual list of favored hypotheses. The group then worked with the 8 lists to reach consensus on the strongest candidate hypotheses and the wording which each should carry into the next phase of the study. The result of the meeting was a list of 11 hypotheses, all of which were, by consensus, considered strong contenders for explaining the excellence at the 17 sites in the hypothesis group. The list of these 11 hypotheses appears on the next page.

The second stage then began -- that is, the isolation process to gather evidence pertaining to the 11 hypotheses for the 2 additional groups of schools. The groups were drawn from our pool of 146 programs rated for excellence the previous year by the panel of experts: 32 programs with excellence ratings comparable to those in the hypothesis group (first comparison group, denoted G-2) and 27 programs with excellence ratings in the bottom quarter of the original pool (second comparison group, denoted G-3). As noted above, there was considerable data already available for 11 of the 32 because they constituted the complement of G-1 in the 28 visited sites. Some data were available for the remainder of the two comparison groups from their initial submission of evidence to the study. (In many cases, programs had sent more information than evidence directly connected to student outcomes.) Individualized telephone interviews were conducted with these programs to supplement the information already available.

HYPOTHESES
FROM
A STUDY OF EXEMPLARY MATHEMATICS PROGRAMS

Background

1. The community values mathematics achievement and these values are effectively communicated to students -- the students want to learn.

Curriculum and Implementation

2. Homework plays an important role -- in amount and frequency, in the feedback given, and in its connection to classroom practice.

3. The whole program is structured, and understood by staff and students, so that students can and do move flexibly within an array of courses and levels to maximize success.

4. The curriculum has the blessings of the mathematics staff. If they have not had a hand in developing the curriculum, they have at least adapted to it and developed a sense of ownership of it.

Teaching and Staffing

5. High expectations for success in mathematics are consistently and effectively communicated to students.

6. There is a consistently supportive environment for learning in the classroom that accommodates risk-taking.

7. Class time is used efficiently by both teachers and students.

8. Mathematics teachers spend considerable extra time working with students and/or preparing materials.

9. Staff are dedicated and function as a cohesive, sharing, and mutually supportive unit.

Leadership

10. Exemplary programs are characterized by the kind of leadership that results in a well-run, well-organized department that frees teachers from non-instructional distractions.

11. Exemplary programs are characterized by leadership that makes it possible for teachers to feel and act as professionals, and that stimulates questioning, sharing, and taking part in ongoing professional interactions.

Typically, an interview lasted from 45 minutes to an hour, was conducted with the person who had originally communicated with us about the study, and was designed to supplement, in the 11 categories corresponding to the hypotheses, the information which that person had sent. Because of the individualized and open-ended nature of the interviews, no two were identical. Furthermore, the detail in the information gathered varied from hypothesis to hypothesis and from program to program, depending on the level of detail in the records of a particular program and on how well versed was the person being interviewed. Of course, those interviewed were told nothing about the 11 hypotheses, nor were they given any indication of the existence of the two comparison groups. As throughout the entire study, we were both very impressed with, any very grateful for, the high level of cooperation we received from the schools in the study.

At this point, a few words should be said about groups G-1, G-2, and G-3. In choosing schools for G-2 and G-3, we wanted the groups to be approximately comparable with G-1 in several categories: geographic region, grade level, setting (rural, suburban, urban), and racial makeup. With regard to these categories, the 3 groups look this way:

	region	grade level	setting	race
G-1 N=17	7 NE 2 SE 6 MW 2 SW	13 with high school grades 5 with junior high grades 2 with elementary grades	2 rural 6 suburban 8 urban 1 statewide	8 which have 10% or more minorities
G-2 N=32	16 NE 8 SE 7 MW 1 NW	22 with high school grades 8 with junior high grades 5 with elementary grades	7 rural 20 suburban 5 urban	6 which have 10% or more minorities
G-3 N=27	11 NE 8 SE 2 MW 5 NW 1 SW	15 with high school grades 12 with junior high grades 7 with elementary grades	10 rural 13 suburban 4 urban	9 which have 10% or more minorities

The following statistics describe the three groups with regard to the exemplariness ratings given by the expert panel:

	N	mean	standard deviation
G-1	17	63.5	11.7
G-2	32	58.5	7.4
G-3	27	19.6	5.3

(With the weightings listed earlier for the 7 categories, the maximum rating a school could obtain was 87.75.)

When the interviews were concluded, we reconvened the expert panel whose members had rated the 146 programs for exemplariness the previous year, and gave them the task of evaluating the collected data and rating the programs in G-1, G-2, and G-3 on the degree to which each of the hypothesized factors was present. Once again they worked in pairs and rated each program for each factor, using a 1-to-9 scale, after working together to rate a set of data for a fictional site, thus maximizing the reliability of their ratings. Even though this was the same panel which had rated the 146 schools for exemplariness, a possible risk to objectivity, we were able to capitalize on the length of time -- one year -- which separated the two ratings to maximize the blindness of the second rating. Thus, schools in the three groups were numbered, not named, and information from the interviews was presented in a way that disguised each school's identity.

In our first level of analysis, using the raw scores, we computed means and Student's t-tests between groups for each of the 11 hypotheses (groups G-1, G-2, and G-3). We found the initial data somewhat confusing. It was anticipated that the hypothesis group (G-1) and the high scoring comparison group (G-2) would yield approximately equal ratings. Additionally, we anticipated significant differences in comparing lower rated schools (G-3) with either of the two higher rated groups. While G-1 and G-2 scores were somewhat close, the group means differed enough to indicate significance. In fact, as the following table indicates, all comparisons yielded significant differences -- including comparisons between G-1 and G-2.

Several reasons for this unanticipated outcome are possible. First, because we selected programs to be in G-2 not only on the basis of their exemplariness ratings, but also with a desire to match the programs with the G-1 programs on the basis of other criteria -- e.g., wanting some large schools, some small schools, some urban schools, some rural schools, and so on -- there is the possibility that the programs in G-1 could be generally more exemplary than the programs in G-2. Second, the methods of gathering data -- site visit versus telephone interview -- could have a significant effect on the data. Third, we discovered during our interviews of G-3 schools that several exhibited strong programs which belied their relatively lower ratings by the expert panel last year. For example, it appeared that several had failed to send us a complete picture of their student outcomes in mathematics. Thus, on average, G-3 could have been more exemplary than last year's expert panel ratings would indicate.

Consequently, we investigated each of the above three possible explanations for the unanticipated results. As the above statistics indicate, G-1 and G-2 differ on scores of exemplariness -- their means are 5 points apart -- and 11 of the schools visited in G-2 were clearly documented from site visits as fine mathematics programs. In order to test our hunch about the differences in the methods of data collection, it was decided that the second group (G-2) should be partitioned into sub-groups and re-analyzed. Also, the third possible explanation regarding false negatives in G-3 was not dismissed because interviews for several schools in G-3 revealed new evidence of stronger programs than was originally documented in their submitted evidence.

The individual hypothesis ratings from the programs led us to investigate the second possibility. Toward that end, we further divided G-2 into two sub-groups, G-2A and G-2B, according to whether or not the program had been visited. We then recomputed between-group means and t-tests:

G-1 vs. G-2
G-1 vs. G-2A
G-1 vs. G-2B
G-1 vs. G-3
G-2A vs. G-2B
G-2A vs. G-3
G-2B vs. G-3
G-2 vs. G-3

The statistics related to exemplariness for G-2A and G-2B are:

	N	mean	standard deviation
G-2A	11	61.8	8.65
G-2B	21	56.4	5.96

[In the following data, 1, 2, 3, 2A, and 2B refer to the respective groups G-1, G-2, G-3, G-2A, and G-2B.]

Table 1

STUDENT'S t-TESTS BETWEEN GROUPS FOR EACH OF 11 HYPOTHESIZED FACTORS OF EXEMPLARINESS

1. The community values mathematics achievement and these values are effectively communicated to students -- the students want to learn.

$\bar{X}_1 = 6.29$

$\bar{X}_2 = 4.95$

$\bar{X}_3 = 3.36$

$\bar{X}_{2A} = 6.41$

$\bar{X}_{2B} = 4.11$

	t	DF	α
t1-2	4.427	45	.0005
t1-3	8.605	42	.0005
t2-3	4.977	55	.0005
t1-2A	.297	26	NS
t1-2B	6.556	34	.0005
t2A-3	7.770	36	.0005
t2B-3	1.588	44	.1
t2A-2B	6.080	28	.0005

2. Homework plays an important role -- in amount and frequency, in the feedback given, and in its connection to classroom practice.

$\bar{X}_1 = 6.75$

$\bar{X}_2 = 5.125$

$\bar{X}_3 = 3.70$

$\bar{X}_{2A} = 6.85$

$\bar{X}_{2B} = 4.17$

	t	DF	α
t1-2	5.185	42	.0005
t1-3	9.268	36	.0005
t2-3	4.985	48	.0005
t1-2A	.248	24	NS
t1-2B	7.518	24	.0005
t2A-3	8.247	30	.0005
t2B-3	1.454	38	.1
t2A-2B	6.803	26	.0005

3. The whole program is structured, and understood my staff and students, so that students can and do move flexibly within an array of courses and levels to maximize success.

$\bar{X}_1 = 6.82$

$\bar{X}_2 = 5.89$

$\bar{X}_3 = 4.67$

$\bar{X}_{2A} = 7.18$

$\bar{X}_{2B} = 5.06$

	t	DF	α
t1-2	4.468	42	.0005
t1-3	8.214	41	.0005
t2-3	4.478	52	.0005
t1-2A	.138	26	NS
t1-2B	6.345	32	.0005
t2A-3	3.874	34	.0005
t2B-3	1.236	41	.15
t2A-2B	5.486	26	.0005

4. The curriculum has the blessings of the mathematics staff. If they have not had a hand in developing the curriculum, they have at least adapted to it and developed a sense of ownership of it.

$\bar{X}_1 = 7.24$

$\bar{X}_2 = 6.27$

$\bar{X}_3 = 5.2$

$\bar{X}_{2A} = 7.32$

$\bar{X}_{2B} = 5.71$

	t	DF	α
t1-2	3.230	47	.005
t1-3	6.631	43	.0005
t2-3	4.131	58	.0005
t1-2A	.214	26	NS
t1-2B	4.662	36	.0005
t2A-3	7.285	35	.0005
t2B-3	3.567	47	.0005
t2A-2B	4.309	30	.0005

10

5. High expectations for success in mathematics are consistently and effectively communicated to students.

$\bar{X}_1 = 7.62$

$\bar{X}_2 = 5.81$

$\bar{X}_3 = 3.68$

$\bar{X}_{2A} = 7.36$

$\bar{X}_{2B} = 4.75$

	t	DF	α
t1-2	5.917	42	.0005
t1-3	12.237	40	.0005
t2-3	7.691	50	.0005
t1-2A	.732	26	.25
t1-2B	8.317	31	.0005
t2A-3	10.181	34	.0005
t2B-3	3.342	39	.005
t2A-2B	6.672	25	.0005

6. There is a consistently supportive environment for learning in the classroom that accomodates risk-taking.

$\bar{X}_1 = 6.29$

$\bar{X}_2 = 4.72$

$\bar{X}_3 = 3.71$

$\bar{X}_{2A} = 6.59$

$\bar{X}_{2B} = 3.43$

	t	DF	α
t1-2	5.076	42	.0005
t1-3	8.369	34	.0005
t2-3	5.865	43	.0005
t1-2A	.766	26	.25
t1-2B	8.201	31	.0005
t2A-3	7.602	28	.0005
t2B-3	.814	33	.25
t2A-2B	8.051	25	.0005

7. Class time is used efficiently by both teachers and students.

$\bar{X}_1 = 7.41$

$\bar{X}_2 = 5.13$

$\bar{X}_3 = 3.82$

$\bar{X}_{2A} = 6.59$

$\bar{X}_{2B} = 4.07$

	t	DF	α
t1-2	7.149	48	.0005
t1-3	9.832	32	.0005
t2-3	3.609	42	.0005
t1-2A	2.124	24	.025
t1-2B	9.292	29	.0005
t2A-3	6.697	27	.0005
t2B-3	.111	31	NS
t2A-2B	6.358	24	.0005

8. Mathematics teachers spend considerable extra time working with students and/or preparing materials.

$\bar{X}_1 = 7.41$

$\bar{X}_2 = 5.6$

$\bar{X}_3 = 4.02$

$\bar{X}_{2A} = 6.77$

$\bar{X}_{2B} = 4.95$

	t	DF	α
t1-2	6.013	46	.0005
t1-3	11.68	40	.0005
t2-3	5.947	54	.0005
t1-2A	1.651	26	.1
t1-2B	7.462	35	.0005
t2A-3	7.608	34	.0005
t2B-3	3.1	43	.005
t2A-2B	4.855	29	.0005

9. Staff are dedicated and function as a cohesive, sharing, and mutually supportive unit.

$\bar{X}_1 = 7.15$

$\bar{X}_2 = 5.64$

$\bar{X}_3 = 4.98$

$\bar{X}_{2A} = 7.23$

$\bar{X}_{2B} = 4.76$

	t	DF	α
t1-2	4.915	47	.0005
t1-3	6.808	43	.0005
t2-3	5.489	57	.0005
t1-2A	.207	26	NS
t1-2B	7.310	36	.0005
t2A-3	6.108	37	.0005
t2B-3	1.010	47	.2
t2A-2B	6.623	30	.0005

10. Exemplary programs are characterized by the kind of leadership that results in a well-run, well-organized department that frees teachers from non-instructional distractions.

$\bar{X}_1 = 6.91$

$\bar{X}_2 = 5.5$

$\bar{X}_3 = 4.44$

$\bar{X}_{2A} = 7.18$

$\bar{X}_{2B} = 4.47$

	t	DF	α
t1-2	5.777	44	.0005
t1-3	7.708	42	.0005
t2-3	7.010	53	.0005
t1-2A	.214	26	NS
t1-2B	8.256	33	.0005
t2A-3	7.652	36	.0005
t2B-3	.091	43	NS
t2A-2B	7080	27	.0005

13

11. Exemplary programs are characterized by leadership that makes it possible for teachers to feel and act as professionals, and that stimulates questionning, sharing, and taking part in ongoing professional interactions.

$\bar{X}_1 = 7.26$

$\bar{X}_2 = 5.57$

$\bar{X}_3 = 4.62$

$\bar{X}_{2A} = 7.45$

$\bar{X}_{2B} = 4.42$

	t	DF	α
t1-2	5.777	44	.0005
t1-3	14.902	40	.0005
t2-3	.311	50	NS
t1-2A	.490	26	NS
t1-2B	8.421	33	.0005
t2A-3	7.834	34	.0005
t2B-3	.657	41	NS
t2A-2B	7.937	27	.0005

Table 1 reveals that, with two exceptions (t1-2 for hypothesis 4 with α = .005 and t2-3 for hypothesis 11), t1-2, t1-3, t2-3, t1-2B, t2A-2B all reflect significance at the level .0005 for all hypotheses. Thus, generally, the two higher-rated groups outperformed the lower-rated G-3 on all hypotheses (except for hypothesis 11 between G-2 and G-3). Furthermore, the fact that G-1 outperformed both the entire group G-2 and its subgroup G-2B, seem to imply that the method of data-collection -- site visit versus telephone/mail -- was critical. This conclusion gains strength from an inspection of the significance levels across the 11 hypothesized factors for t1-2A: with the exception of one (.025 for hypothesis 7), all are greater than or equal to .1. Since fully 5 of the 11 hypotheses relate to how teachers interact with students or with each other, the conclusion seems reasonable.

The comparisons between groups G-2B and G-3 vary considerably. G-2B outperformed G-3, for three hypotheses (4, 5, and 8), but the comparisons are insignificant for the other eight hypotheses. The reasons for the variance are not clear, though as we mentioned above, some of the programs in G-3 appeared from telephone interviews to be more exemplary than their original submissions of evidence and panel ratings would have indicated.

While the t-test data show the strength of all 11 hypothesized factors, 3 of them appear especially strong because of the consistency of the t-scores across all group comparisons. They are hypothesis 4 (curriculum ownership), hypothesis 5 (consistently high expectations), and hypothesis 8 (extra teacher time).

Correlation analysis was the next stage of analysis. Our purpose was to attempt to learn which hypotheses demonstrate relatively more or less impact. We therefore carried out two kinds of analysis:

A. Within- and across-group correlations between individual hypothesis raw scores and the sum of all hypothesis scores. This is analogous to an item analysis of test scores to determine which items contribute most to the overall effect.

B. Within- and across-group correlations between hypothesis raw scores and the total score of exemplariness ratings by the expert panel in the first year of the study (the weighted sums of ratings in seven categories of student outcomes). This was done to indicate which hypotheses are most strongly related to outcome measures of exemplariness.

We carried out Task A and Task B, and the relevant numbers follow in Table 2:

Table 2

Task A. The Pearson Product Moment Correlation Coefficients for the across-group analysis between individual hypothesis raw scores and the sum of all hypothesis scores are (for hypotheses 1 through 11): (N=76)

1.	.69
2.	.77
3.	.82
4.	.80
5.	.87
6.	.84
7.	.84
8.	.83
9.	.78
10.	.86
11.	.86

Task B. The coefficients for the across-group correlations between individual hypothesis raw scores and the panel's ratings on exemplariness (in year one) are: (N=76)

1.	.47
2.	.52
3.	.51
4.	.44
5.	.66
6.	.49
7.	.50
8.	.57
9.	.30
10.	.42
11.	.38

Findings from Tasks A and B.

The results from Task A lead to one clear conclusion: all of the hypotheses are highly correlated with the sum of hypothesis scores, implying a strong role for each. Furthermore, the coefficients in Table 2 for Task A serve as approximate measures of the reliability of each of the hypotheses. With that in mind, one can note that, while the first hypothesis -- the background hypothesis -- is highly correlated with the sum of hypothesis scores, it sits relatively lower than each of the others. This might imply slightly less reliability for the first hypothesis.

Using this notion that the coefficients in Table 2 - Task A reflect approximate reliability, one can note that the hypothesis concerning high expectations (hypothesis 5) and the two concerning leadership (hypothesis 10 and 11) have the highest approximate reliability.

The statistics from Task B also lead to several conclusions. They tend to corroborate the sense of our site visitors that all 11 of the hypothesized factors are positively correlated with the excellence of programs as measured by student outcomes. A glance at the two hypotheses most highly correlated with excellence is also telling, in that they tend to corroborate the site visitors' sense about the importance of the teachers' behavior (reflected in 5 of the 11 hypotheses). The hypothesis with the highest correlation (hypothesis 5) pertains to the communication of high expectations, and the second highest (8) pertains to the amount of extra time teachers spend with students or preparing student-related materials. The fourth highest hypothesis (3) pertains to one of the major ways in which we observed teachers devoting their extra time -- making sure each student's chances for success are maximized through flexible and appropriate placement. Recall that hypotheses 5 and 8 appeared especially strong in the t-tests of Table 1.

A comment should be made about the fact that Task B coefficients are lower than Task A coefficients. Task B coefficients express the correlation between process scores and outcome scores, while Task A coefficients express the correlation between individual process scores and the sums of individual process scores. In the latter case, there is less independence between the groups of scores being correlated, and hence there is a greater chance for higher correlation coefficients.

At this point, it is interesting to compare the t-test and correlation statistics from Tasks A and B with the qualitative data reflected in the 28 brief case-study profiles of the visited sites (Table 3, Attachment 3 Abbreviated Case Studies). In these profiles, the 20 programs that included high school grades or junior high-high school combinations are grouped together, as are the 8 programs that included no high school grades.

We believe that the information in these brief case studies corroborates the relative importance of the following three hypotheses in the correlation analysis:

- High expectations for success in mathematics are consistently and effectively communicated to students.
- Mathematics teachers spend considerable extra time working with students and/or preparing materials.
- The whole program is structured, and understood by staff and students, so that students can and do move flexibly within an array of courses and levels to maximize success.

For a few hypotheses, however, the statistics and the brief case-study data appear at odds with each other -- in particular, these two hypotheses:

- Exemplary programs are characterized by leadership that makes it possible for teachers to feel and act as professionals, and that stimulates questioning, sharing, and taking part in ongoing professional interactions (abbreviated "vision, stimulates professionalism").

- Staff are dedicated and function as a cohesive, sharing, and mutually supportive unit (abbreviated "mutually supportive, sharing, collegial").

We believe that a reading of the 10 full case studies and a reading of the profile remarks for the 28 programs corresponding to these 2 hypotheses reflect the power of these factors that we, the site visitors, saw in many of the 28 programs. There are several possible explanations for the discrepancies between quantitative and qualitative data for these two hypotheses. First, as we have noted before, there was no infallibility about the excellence ratings. Despite the extensive written correspondence and telephoning that went in to the collection of the data on which the ratings were based, some schools sent us insufficient or incomplete data. School 27 from Table 3 (Attachment 3) is a good example. Of the 28 programs visited, it was one of the lowest rated, in part because they failed to communicate the full extent of course participation and extracurricular involvement in mathematics. Second, for the schools not visited, the persons interviewed by phone were most often the program leaders, and this may have affected the quality of data gathered about leadership. Finally, the profiles reflect how informal much of the staff collegiality and communication was, and so it was a difficult factor to pin down by telephone or mail. Given their apparent roots, the discrepancies appear to argue once again for the value of the site visit as the primary mechanism for gathering data about teachers' or leaders' behavior.

These two hypotheses, along with several of the others, are discussed in more detail in the separate project reports, "Leadership in Exemplary Mathematics Programs" and "A Formula for Success in Teaching Mathematics." The information there amplifies on what is contained in Table 3 (Attachment 3).

Implications/Recommendations.

A Study of Exemplary Mathematics Programs has been an exploratory study, the purpose of which has been to identify and investigate factors associated with excellence in precollege mathematics, and to identify which of those factors are strong candidates for further, more focused research.

We believe that, through the 11 hypotheses discussed above, a list of some of these factors has been identified. Both the quantitative data in Tables 1 and 2 and the qualitative date in Table 3 bear this out. Consequently, we have several implications and they are of two different kinds: implications for further research and implications for practice.

Implications for Further Research

1. We recommend that any study of the teacher or leader factors among the eleven hypothesized factors include a component of on-site research that is longer -- perhaps through repeated visits -- than the two- or three-day visit that typified our study. As noted before, in certain of their manifestations, some of the 11 hypotheses pertain to qualities of teacher and leader behavior that can be most appropriately captured in on-site research. Furthermore, we were limited to a maximum of two and a half days per site visit and, while this proved adequate for most aspects of our investigation, we felt that our study of several of the more subtle factors -- visionary leadership and teacher collegiality, for example -- was too circumscribed by time constraints. Also, we were generally able to interview 4 or 5 individual teachers and 3 or 4 individual students per site. A larger number at each site, interviewed without the constraints of such a hectic schedule, would have been preferable.

2. We recommend that a study similar in objectives to ours be conducted with an elementary school focus. The relatively small percentage of elementary school programs among the 28 programs visited was consistent with the relatively small percentage of elementary school programs in our original pool of 150 programs which sent us evidence of excellence in student outcomes. Therefore, though we find the depiction of elementary school factors contained in the case study called "Dawson Elementary School" and School 4 in Table 3 to be generally consistent with what we found in secondary school programs, we hesitate to generalize.

One intriguing possibility for such investigation presented itself at "Dawson Elementary School", a school which has adopted the Comprehensive School Mathematics Program (CSMP), a K-6 curriculum developed at CEMREL with NIE funding in the 70s and early 80s. The teachers at Dawson seemed remarkably adaptive and innovative, and have been adept at supplementing CSMP where they have felt it appropriate. One fourth-grade teacher remarked about a particularly imaginative exercise she had designed for her class, "I couldn't have done that before CSMP." We are unaware of any research that profiles the ideal adopters of such comprehensive curricula as CSMP or Developing Mathematical Processes (DMP). Such a study would be both interesting and beneficial.

3. We recommend further research into hypothesis 3, related to flexible placement of students, to enumerate and analyze successful strategies. Both the quantitative data in Table 2 and the qualitative data in Table 3 confirm how noticeable were the efforts at flexible and appropriate student placement in the programs we visited. Some of the programs were outstanding in their refusal to accept a student's placement as a self-fulfilled prophecy. An example of such a program is the junior high school called Sampson Middle School in its case study and listed as school 5 in Table 3.

The norm for American schools is apparently different. As Lanier mentions in a discussion of ninth-grade mathematics, "A survey (Belli, 1980) of mathematics chairpersons in Michigan secondary schools revealed that . . . regardless of how students entered their respective tracks, there is a strong tendency for them to remain there as long as they stay in school."(6, p. 63) Our study was able to sense that many exemplary programs employ mechanisms -- usually based on fluid teacher-teacher or teacher-guidance communication -- to keep placement flexible. Our study was not set up, however, to probe deeply into how effectively these strategies touch individual students, especially in the lower tracks.

4. We recommend that there be further, more focused study into the implementation of exemplary strategies for general mathematics courses. One of the persistent messages from the General Mathematics Project has been that general mathematics students consistently get short-changed.(6) Unfortunately, this was also true at some of the programs we visited. There were quite a few exceptions, however, and so further research is in order.

Examples from our study of exemplary approaches to the lowest-level 9th-grade student:

- School 27 (Table 3), case study "Trinity High School"
- School 20 (Table 3), case study "Taylor High School"
- School 24 (Table 3)

In all 3 of these cases, as well as in others, the teachers thought carefully about general mathematics and put considerable effort into their curricula -- in the case of School 27, 150 teacher-developed worksheets were created .

5. We recommend further research into the conditions under which teacher collegiality is conducive to improving the quality of school mathematics programs and conditions under which collegiality can be enhanced for teachers. Conditions in several of the 28 programs (e.g., School 9, case study "East High School") were such that collegiality is almost impossible. But our qualitative data reveal that many of the staffs we visited value it highly -- using it in many instances to unify and sustain their intolerance of failure. If, as Rosenholtz and Kyle have recently written, "without professional dialogue there is little opportunity for teachers to develop common goals and the means to attain them"(7, p.13), such further research would seem to be highly advisable.

6. We recommend research into conditions under which consistency -- with a single teacher and across an entire department -- can be sustained as a component of the several hypothesized factors in which it appears essential. In particular, we recommend attention to the very promising hypotheses concerning the setting of high expectations and the maintenance of a supportive classroom environment, where consistency seems to be of paramount importance.

7. We recommend that there be further research into the effects of teacher subject matter knowledge on mathematics instruction and student learning in mathematics. In his paper, Good notes that "there has been little study of the effects of teachers' subject matter knowledge on student learning in classroom settings."(3, p.12)) Our study was not set up to make conclusions about the issue, but there were several reasons for us to wonder about it. For example, the mathematics chairman of School 16 in Table 3 (case study "The Summit School") told us that he thought subject matter knowledge is important "because it frees my teachers up to share ideas about teaching and curriculum with each other. They're not so defensive about not knowing the material." As a result of such intriguing prospects, we recommend further research.

Implications for Practice

8. We recommend that there be concerted efforts to provide training for school mathematics leaders -- primarily department heads, but also teachers who assume leadership roles, and certain administrators. The leadership profiles from Table 3 run counter to the norm in school programs, as the research in high schools of Gene Hall and his colleagues indicates. In a recent article, they describe the typical situation:(4,p. 61)

> "All too often, department heads report that their role is basically one of checking books in and out, keeping records, passing on communications from 'above,' and ordering supplies. In general, they do not appear to have the time or opportunity to serve as active leaders, nor do they see themselves as having responsibility for initiating or facilitating change. Their selection typically has little to do with leadership ability and training for the role is nonexistent. . . . Further, there frequently is not enough staff unity and identity with the department for it to automatically serve as a unit for the adoption of major changes in high schools."

As Table 3 indicates, many of the mathematics leaders we encountered were quite different from this typical profile. The capsule description of the department head in School 19 given by the site visitor stands as a description of many others in the 28 programs: "He is a strong, competent, supportive, and aggressive department chair, who holds it all together."

Much that these leaders do so well can be learned by others in similar positions. They facilitate the communication within their programs and between their programs and persons and entities outside the programs. They maintain high levels of professionalism and involvement among their programs' teachers. They maintain consistent and clear focuses within their programs on student success and involvement in mathematics. And so on. Yet, as Hall points out, training for these leaders has been practically nonexistent. Therefore, we recommend that training programs be initiated to take advantage of what we see as a viable force for improvement in school mathematics programs.

9. We recommend that there be some organized and focused mechanisms for communication among mathematics leaders. Like Recommendation 8, this is a corollary of our conclusion that leaders at the program level can play a key role in program improvement. Among the exemplary program leaders from our study, there was a small but significant list of items about which they were not in total agreement. For example, we heard both sides of the issue of whether to teach algebra in the eighth grade. Furthermore, many of these leaders are highly enthusiastic about mathematics competitions, but a few others wondered whether competitions don't merely encourage the learning of tricks at the expense of learning how do do mathematics. The list continues, through opinions about computer programming languages and the usefulness of software, the limitations of texts, and so on.

The communication mechanisms could take the form of occasional local or regional roundtable discussions under the auspices of the National Council of Supervisors of Mathematics, or a series of broader, foundation-funded conferences. In any case, it is important that school mathematics leaders have some vehicle through which they can talk and listen to each other.

10. We recommend the development of a teacher-training tape that illustrates exemplary teaching applied to difficult concepts and processes. We observed over 125 classes in our site visits. As our hypotheses reflect, we were generally favorably impressed with the teaching skills we observed. As our case studies reflect, however, there were several points of dissatisfaction -- namely, in the large number of classrooms where teacher questioning patterns were too tied to the textbook and built around sequences of single-answer questions, and in the large number of classrooms where the teachers' flow of instruction left sizable pockets of students who gave no indication of understanding or not understanding. In particular, we saw few attempts to use questions in the mathematics classroom for all of the purposes identified by Johnson and Rising:(cf 5 or 2, p.4)

1. To motivate students to consider a new topic: "What are some four-sided geometric figures you can think of?"
2. To challenge: "What evidence do you have for thinking that?"
3. To provoke student interaction: "Bill, do you agree with what Martha said?"

4. To get students to evaluate: "How do you think your method would work on this next problem?"
5. To focus on process: "What method did you use on that problem?"
6. To guide: "Do you remember a problem similar to this one?"
7. To diagnose: "How did you get that answer?"
8. To review: "What are some of the things you've learned so far about triangles?"
9. To encourage exploration: "Can you find a pattern in those numbers?"
10. To invite student questions: "What questions does this information leave unanswered?"
11. To enhance transfer: "How could you use that result in this new situation?"

In a recent paper, Good has written, "I believe that teachers would benefit from viewing videotapes of competent, talented teachers conducting classroom activities related to key concepts or issues (variable, quantum theory, place value, equivalent fractions.)"(3, p.16) We would extend that recommendation and recommend that such a videotape include exemplary questioning behavior and illustrations of clinical interviewing [cf Confrey (1)].

REFERENCES

1. Confrey, Jere "Clinical Interviewing: Its Potential to Reveal Insights in Mathematics Education." In Proceedings of the Fourth International Conference for the Psychology of Mathematics Education. Berkeley, California. August 1980.

2. Driscoll, Mark Research Within Reach: Secondary School Mathematics. Reston,VA: National Council of Teachers of Mathematics. 1984.

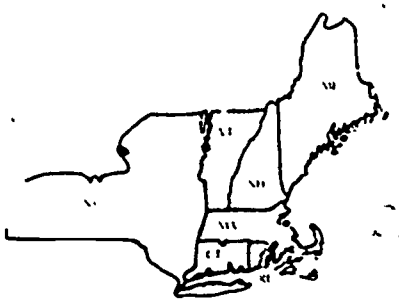
3. Good, Thomas L. Recent Studies of Teaching: Implications for Research and Policy in Mathematics Education. Paper presented at 1984 meeting of American Educational Research Association, New Orleans.

4. Hall, Gene E. et al. "Change in High Schools: Rolling Stones or Asleep at the Wheel?" In Educational Leadership, March 1984, pp. 58-62.

5. Johnson, Donovan and Rising, Gerald. Guidelines for Teaching Mathematics. Second edition, Belmont, California: Wadsworth, 1972.

6. Lanier, Perry. "Mathematics Classroom Inquiry: The Need, a Method, and the Promise." In Research in Science Education: New Questions, New Directions. James T. Robinson, ed. ERIC Clearinghouse for Science, Mathematics, and Environmental Education. June 1981.

7. Rosenholtz, Susan J. and Kyle, Susan J. "Teacher Isolation: Barrier to Professionalism." In American Educator. Winter 1984.



northeast regional exchange, inc.

the resource exchange for educational services

February 8, 1985

Dear Colleague:

The two-year Study of Exemplary Mathematics Programs is over, and I have enclosed some of the products of the study, which I thought might interest you. The full complement of products includes 10 full case studies, 28 brief case studies, a final report, 6 articles, and several papers from which the articles have been drawn.

I have expressed my gratitude to you before, and won't belabor the point, except to say that you are the heart and soul of the project. And I don't want our contact to end with this letter. I have enclosed a sheet of paper on which we would like your comments. In particular, we would like your comments about the 11 factors which the 8 site visitors hypothesized as influential in the excellence of the programs we visited and studied, and which were all shown to be influential (to varying degrees, of course) in subsequent analysis. What do you think of them, as they apply to your program? Have we left anything out? We would be delighted to hear from you.

We are also pursuing other means to stay in touch with you and other exemplary programs. I am seeking funding for a Conference on Excellence in Mathematics and for the development of a videotape to be used for the training of teachers, which will highlight the exemplary teaching of some of the teachers from our study. Finally, and most ambitiously, we are hoping to launch a School Mathematics Leadership Center. The research literature implies that, at the program level, leadership (usually in the form of department heads) is not very effective in bringing about change. We saw many, many exceptions to this in our study and want to set up a mechanism -- our Center -- by which mathematics leaders can train to be more effective.

So, chances are you will be hearing from us again. In the meantime, all of us -- Larry, Elsa, Sue, Steve, Jere, Kay, Bob, and I -- hope you and your colleagues continue to thrive.

Sincerely,

Mark Driscoll, Ph.D.
Principal Investigator

encls.
MD:em

NEREX, 34 Littleton Road, Chelmsford, Massachusetts 01824 617/256-3987

Please rate the importance for your exemplary program of some of these hypotheses.

1. The community values mathematics achievement and these values are effectively communicated to students -- the students want to learn.

2. Exemplary programs are characterized by the kind of leadership that results in a well-run, well-organized department that frees teachers from non-instructional distractions.

3. Exemplary programs are characterized by leadership that makes it possible for teachers to feel and act as professionals, and that stimulates questioning, sharing, and taking part in ongoing professional interactions.

4. Homework plays an important role -- in amount and frequency, in the feedback given, and in its connection to classroom practice.

5. The whole program is structured, and understood by staff and students, so that students can and do move flexibly within an array of courses and levels to maximize success.

6. The curriculum has the blessings of the mathematics staff. If they have not had a hand in developing the curriculum, they have at least adapted to it and developed a sense of ownership of it.

7. High expectations for success in mathematics are consistently and effectively communicated to students.

8. There is a consistently supportive environment for learning in the classroom that accomodates risk-taking.

9. Class time is used efficiently by both teachers and students.

10. Mathematics teachers spend considerable extra time working with students and/or preparing materials.

11. Staff are dedicated and function as a cohesive, sharing, and mutually supportive unit.

COMMENTS:

Return to: Mark Driscoll
Northeast Regional Exchange
34 Littleton Road
Chelmsford, MA 01824

Many thanks!

Annotated Bibliography

Field research for the Study of Exemplary Mathematics Programs developed the following hypotheses for factors associated with excellence in precollege mathematics:

1. The community values mathematics achievement and these values are effectively communicated to students -- the students want to learn.

2. Homework plays an important role -- in amount and frequency, in the feedback given, and in its connection to classroom practice.

3. The whole program is structured, and understood by staff and students, so that students can and do move flexibly within an array of courses and levels to maximize success.

4. The curriculum has the blessings of the mathematics staff. If they have not had a hand in developing the curriculum, they have at least adapted to it and developed a sense of ownership of it.

5. High expectations for success in mathematics are consistently and effectively communicated to students.

6. There is a consistently supportive environment for learning in the classroom that accommodates risk-taking.

7. Class time is used efficiently by both teachers and students.

8. Mathematics teachers spend considerable extra time working with students and/or preparing materials.

9. Staff are dedicated and function as a cohesive, sharing, and mutually supportive unit.

10 Exemplary programs are characterized by the kind of leadership that results in a well-run, well-organized department that frees teachers from non-instructional distractions.

11. Exemplary programs are characterized by leadership that makes it possible for teachers to feel and act as professionals, and that stimulates questionning, sharing, and taking part in ongoing professional interactions.

Further research has indicated that the factors seem to vary in importance, but researchers for the study believe all are worthy of some attention. Therefore, we have developed the following annotated bibliography of articles, documents, and books that touch on one of more of the hypotheses. These are suggested readings, and in no way constitute a comprehensive list. They are grouped under four categories: General, Curriculum and Its Implementation, Leadership, Teachers and Teaching.

I General

Alexander, William M. and Paul S. George. The Exemplary Middle School. New York: Holt, Rinehart and Winston, 1981.

A basic textbook for students in the field of middle school education. It defines the middle school concept, describes in detail the characteristics of exemplary middle schools and illustrates the implementation of these characteristics in practice.

Hurd, Paul DeHart. "State of Precollege Education in Mathematics and Science." Paper presented at National Convocation on Precollege Education in Mathematics and Science, May 12-13, 1982. Washington, DC: National Academy of Sciences and National Academy of Engineering.

This report identifies trends and issues facing precollege education in mathematics and science. By synthesizing a variety of reports and surveys, it provides a clearer statistical profile of such converging trends as achievement declines, the growing shortage of qualified teachers, and so on.

Driscoll, Mark J. Research Within Reach: Elementary School Mathematics. Reston, VA: National Council of Teachers of Mathematics, 1981.

Driscoll, Mark J. Research Within Reach: Secondary School Mathematics. Reston, VA: National Council of Teachers of Mathematics, 1982.

These two books, based on interviews of national samples of teachers, identify topics of special interest to teachers and interpret the research literature for each topic in a separate chapter. Each chapter contains suggestions for classroom practice.

Penick, John E. and Richard Meinhard-Pellens, editors. Focus on Excellence. Vol. 1, numbers 1-5. Washington, DC: National Science Teachers Association.

These five monographs have been drawn from the 1982 Search for Excellence in Science Education of the National Science Teachers Association. They describe exemplary programs and practices in the following areas: Science as Inquiry, Elementary Science, Biology, Physical Science, and Science/Technology/Society.

Carpenter, Thomas P., et al. Results from the Second Mathematics Assessment of National Assessment of Educational Progress. Reston, VA: National Council of Teachers of Mathematics, 1981.

This book summarizes the results of the Second Mathematics Assessment -- a profile of what American students know and don't know in mathematics at ages 9, 13, and 17.

Hart, K.M., editor. Children's Understanding of Mathematics: 11-16. London, England: John Murray Ltd., 1981.

From a British enterprise similar to the American National Assessment, this report describes in detail what British children know and don't know about mathematics. The study included interviews and some attempts at remediation. Hence, suggestions for instruction abound.

Clement, John, Jack Lochhead, and George S. Monk. "Translation Difficulties in Learning Mathematics." The American Mathematical Monthly. vol. 88, No. 4, April 1981, pp. 286-289.

Herscovics, Nicolas and Carolyn Kieran. "Constructing Meaning for the Concept of Equation." The Mathematics Teacher. Vol. 73, No. 8, pp. 572-581. November 1980.

Rosnick, Peter. "Some Misconceptions About the Concept of Variable." The Mathematics Teacher. Vol. 74, No. 6, September 1981, pp. 418-420.

These three articles discuss various aspects of students' difficulty in learning algebra. Each, especially the article by Herscovics and Kieran, offers suggestions for instruction.

Confrey, Jere and Perry Lanier. "Students' Mathematical Abilities: A Focus for the Improvement of Teaching General Mathematics." School Science and Mathematics. Vol. LXXX, No. 7, November 1980, pp. 549-556.

Some results from a study of general mathematics curricula, citing some of the mathematical abilities where general mathematics students compare unfavorably with many of their peers who are in higher tracks.

Erlwanger, Stanley H. "Case Studies of Children's Conceptions of Mathematics - Part 1." Journal of Children's Mathematical Behavior. Vol. 1, No. 3, Summer 1975.

Interviews with several elementary school students that revealed some basic misconceptions about mathematics.

Hansen, Viggo P., editor. Computers in Mathematics Education: 1984 Yearbook. Reston, VA: National Council of Teachers of Mathematics, 1984.

This yearbook gives a comprehensive look at the impact of the computer on the mathematics curriculum.

Hilton, Peter. "Current Trends in Mathematics and Future Trends in Mathematics Education." For the Learning of Mathematics. Vol 4, No. 1, February 1984, pp. 2-8.

A proposal for changes in elementary and secondary mathematics curricula and instruction in light of trends in mathematics.

Hoffer, Alan. "Geometry is More than Proof." The Mathematics Teacher. Vol. 74, No. 1, January 1981, pp. 11-18.

The article describes, with examples, the five levels of development in geometrical thinking as represented in the van Hiele model. It also discusses the kinds of instructional activities that correspond to each level.

Usiskin, Zalman. "What Should Not be in the Algebra and Geometry Curricula of Average College-Bound Students?" The Mathematics Teacher. Vol. 73, No. 6, September 1980, pp. 413-426.

The article's title is self-explanatory. A set of fervid and somewhat controversial recommendations about eliminating topics from the algebra and geometry curricula.

III Leadership

Ad Hoc Committee on Applied Mathematics Training. The Role of Applications in the Undergraduate Mathematics Curriculum. Washington, DC: National Academy of Science, 1979.

Conference Board of the Mathematical Sciences. New Goals for Mathematical Science Education. Washington, DC: Conference Board of the Mathematical Sciences, 1984.

Two committee reports that raise issues and recommendations demanding the attention of leaders in mathematics education.

Hall, Gene E., et al. "Change in High Schools: Rolling Stones or Asleep at the Wheel?" Educational Leadership. March 1984, pp. 58-62.

A report of a study that showed, among other things, how limited the high school department head is as an agent of change.

Stanford Engineering and Management Systems Company, Inc. Visionary Leaders (Interim Report). Arlington, VA: Stanford Engineering and Management Systems, Inc., July 1983.

A report of a study of business leaders revealing distinctions between leader as manager and leader as visionary. It offers food for thought for educational leaders, in particular, leaders in mathematics education.

IV Teachers and Teaching

Floyd, Ann, editor. Developing Mathematical Thinking. London: Addison-Wesley, 1981.

A collection of articles on the theme of how children learn to investigate and solve mathematical problems. It contains case studies, articles on the psychology of learning, etc., with suggestions for classroom activities. It is especially targeted to the nonspecialist teachers of mathematics of children between the ages of 5 and 14.

Good, Thomas L., Douglas A. Grouws, and Howard Ebmeier. Active Mathematics Teaching. New York: Longman, Inc. 1983.

A description of the Missouri Mathematics Effectiveness Project, a study of intermediate and junior high school classrooms, with a discussion of implications for classroom teaching. The project has identified an effective program for mathematics instruction -- a combination of problem solving, review, practice, and new material.

Lochhead, Jack and John Clement, editors. Cognitive Process Instruction: Research on Teaching Thinking Skills. Philadelphia, PA: The Franklin Institute Press, 1979.

A set of presentations from a 1978 conference on teaching thinking skills in all disciplines.

Mason, John, with Leone Burton and Kaye Stacey. Thinking Mathematically. London: Addison-Wesley, 1982.

This is a manual for developing mathematical thinking, a series of mathematical questions posed throughout. It is designed "to show how to make a start on any question, how to attack it effectively and how to learn from the experience."

Whimbey, Arthur. "Students Can Learn to be Better Problem Solvers." Educational Leadership. Vol. 37, No. 7, April 1980, pp. 560-565.

The author suggests and describes some innovative techniques for students to interact in a way that facilitates problem solving.

A Study of Exemplary Mathematics Programs

ATTACHMENT 1

Study announcements, correspondence

If there are aspects of your mathematics program that are particularly strong in your middle school, junior high, or high school, we are looking for you.

The National Institute of Education has funded the Northeast Regional Exchange, Inc. to conduct a nationwide STUDY OF EXEMPLARY MATHEMATICS PROGRAMS. We ask your help in identifying exemplary programs. If your district or building is producing excellent results, please write to us and ask to participate in this important study. We will send you more information about the study and a questionnaire to assist in the description of your mathematics program.

Each school that completes the questionnaire will receive complimentary mathematics resource materials for their efforts.

Requests for participation in A STUDY OF EXEMPLARY MATHEMATICS PROGRAMS may be addressed to:

Dr. Mark J. Driscoll, Principal Investigator
Northeast Regional Exchange, Inc.
101 Mill Road
Chelmsford, MA 01824
(617) 256-3987

A STUDY OF EXEMPLARY MATHEMATICS PROGRAMS

CAN YOU NOMINATE SOME SCHOOLS TO BE INCLUDED IN A STUDY OF EXEMPLARY MATHEMATICS PROGRAMS?

THE NATIONAL INSTITUTE OF EDUCATION HAS FUNDED THE NORTHEAST REGIONAL EXCHANGE, INC. TO CONDUCT A NATION-WIDE STUDY OF EXEMPLARY MATHEMATICS PROGRAMS IN MIDDLE, JUNIOR AND HIGH SCHOOLS. WE WILL COLLECT QUESTIONNAIRE DATA FROM SEVERAL HUNDRED SCHOOLS AND VISIT APPROXIMATELY TWENTY-FIVE SITES IN AN EFFORT TO DETERMINE WHAT FACTORS CONTRIBUTE TO THE SUCCESS OF EXEMPLARY SCHOOL MATHEMATICS PROGRAMS. YOUR ASSISTANCE IN IDENTIFYING SCHOOLS WHICH HAVE STRONG PROGRAMS WILL CONTRIBUTE TO THE THOROUGHNESS OF THE STUDY. PLEASE URGE THE LOCAL DISTRICT OR SCHOOL TO WRITE FOR MORE DETAIL ABOUT THE STUDY AND FOR A COPY OF A BRIEF QUESTIONNAIRE TO ASSIST IN THE DESCRIPTION OF THE MATHEMATICS PROGRAM.

PARTICIPATING SCHOOLS WILL RECEIVE COMPLIMENTARY MATHEMATICS RESOURCE MATERIALS FOR THEIR EFFORTS.

REQUESTS FOR PARTICIPATION IN A STUDY OF EXEMPLARY MATHEMATICS PROGRAMS MAY BE ADDRESSED TO:

Dr. Mark J. Driscoll, Principal Investigator
Northeast Regional Exchange, Inc.
101 Mill Road
Chelmsford, Ma 01824
(617) 256-3987

sent to approximately 700 mathematics super

February 14, 1983

Dear Colleague,

On December 10, 1982 we began a two-year study, funded by the National Institute of Education, of exemplary mathematics programs in middle schools, junior high schools, and high schools. We are writing to enlist your help in locating such programs.

In the first phase of the study, we intend to screen several hundred school-based programs that have been nominated by the schools' mathematics department heads or principals. Programs must have been in operation for at least one year. In order to be a candidate, a school program need not be exemplary throughout. Indeed, we expect to find many programs that have one or more outstanding components — for example, exemplary honors, geometry, remedial, or computer science programs, to name but a few of the possibilities. We want such schools to participate in our study, as well as schools that consider their entire programs exemplary. Please note that this is a research project and not a contest.

Schools that request to take part in the study will be sent a summary of the study's objectives and procedures, and they will be asked to complete a questionnaire to collect background information about their mathematics program. After schools have completed the questionnaire, we will convene a panel of mathematics experts to help screen questionnaire data and select approximately 25 schools for further study through telephone interviews and site visits.

There are many ways in which a mathematics program might demonstrate exemplary qualities. This study will identify mathematics programs that can be judged as exemplary on the basis of a variety of objective measures of student achievement, such as:

- scores on standardized tests
- number of students of particular distinction (e.g., Mathematics Olympiad, etc.)
- percentage of students taking advanced courses
- degree of student participation in mathematics-related extracurricular activities
- number of graduates taking postsecondary mathematics courses
- extent of student entry into technical fields requiring mathematics
- other manifestations of exemplariness proposed by individual schools.

As a mathematics supervisor, you are in an excellent position to recognize successful mathematics programs in the schools with which you work. Your help in urging schools with exemplary mathematics programs to participate in the study will contribute to the success of this important research.

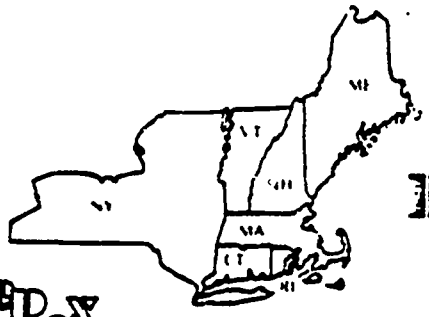
We are asking you to contact schools that have mathematics programs that are exemplary in one or more of their components. Schools which you believe have exemplary mathematics programs can participate in the study by requesting the questionnaire application form prior to April 15, 1983. For each school you contact, please give the appropriate person for the mathematics program one of the enclosed self-addressed postcards so that the school itself may request to participate. Three self-addressed postcards are enclosed for this purpose. Schools that choose to submit questionnaires will receive free mathematics resource materials and a report of the study's findings regarding which factors contribute to exemplary mathematics programs.

Sincerely,

Mark J. Driscoll
Principal Investigator
Study of Exemplary
Mathematics Programs

MJD:em
encls.

sent to all Chief State School Officers



northeast regional exchange

101 MILL ROAD, CHELMSFORD, MA 01824 • 617 / 256-3987

March 7, 1983

Dear

On December 10, 1982 the Northeast Regional Exchange began a two-year national study, funded by the National Institute of Education, of exemplary mathematics programs in middle schools, junior high schools, and high schools. The Principal Investigator of the study is Mark Driscoll, author of the two volumes, Research Within Reach: Elementary School Mathematics and Research Within Reach: Secondary School Mathematics. We are writing to enlist your help in locating exemplary programs for the study.

In the first phase of the study, we intend to screen several hundred school-based programs that have been nominated by the schools' mathematics department heads or principals. In order to be a candidate, a school program need not be exemplary throughout. Indeed, we expect to find many programs that have one or more outstanding components -- for example, exemplary honors, geometry, remedial, or computer science programs, to name but a few of the possibilities. We want such schools to participate in our study, as well as schools that consider their entire programs exemplary.

Schools that request to take part in the study will be sent a summary of the study's objectives and procedures, and they will be asked to complete a questionnaire to collect background information about their mathematics program. After schools have completed the questionnaire, we will convene a panel of mathematics experts to help screen questionnaire data and select approximately 25 schools for further study through telephone interviews and site visits.

There are many ways in which a mathematics program might demonstrate exemplary qualities. This study will identify mathematics programs that can be judged as exemplary on the basis of a variety of objective measures of student achievement, such as:

- scores on standardized tests
- number of students of particular distinction (e.g., Mathematics Olympiad, etc.)
- percentage of students taking advanced courses
- degree of student participation in mathematics-related extracurricular activities
- number of graduates taking postsecondary mathematics courses
- extent of student entry into technical fields requiring mathematics
- other manifestations of exemplariness proposed by individual schools.

We have advertised in several professional journals, and we have written to members of the National Council of Supervisors of Mathematics asking for their assistance in locating candidate schools for our study. We realize that school superintendents constitute a rich source of knowledge about exemplary school mathematics programs. We hope that you will help us to tap into this source. In particular, we have enclosed a copy of a project description with return mailer which you can reproduce and send to superintendents, perhaps in your state newsletter. We are willing to send you additional copies of this enclosure if you wish.

We are looking for schools which have programs that are exemplary in one or more of their components. Schools which are believed to have exemplary mathematics programs can participate in our study by requesting the questionnaire application form before April 15, 1983. They can do so by sending us the bottom half of the enclosed form. Schools that choose to submit questionnaires will receive free mathematics resource materials and a report of the study's findings regarding which factors contribute to exemplary mathematics programs.

Once we have identified some of these factors, we will be in a position to alert the entire educational community to ways to inject the best into school mathematics programs and, in the process, to make mathematics teaching a more attractive profession. We do not need to remind you of the importance of that enterprise.

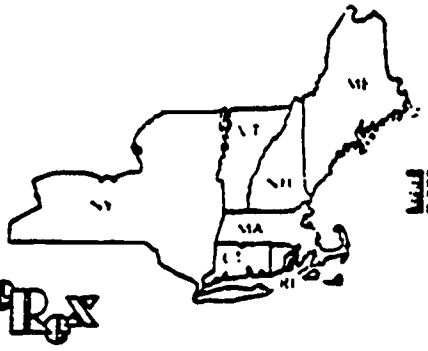
Thank you very much for your cooperation. We will be pleased to respond to any questions or suggestions you wish to pass along.

Sincerely,

J. Lynn Griesemer
Executive Director
Northeast Regional Exchange, Inc.

Mark Driscoll
Principal Investigator
A Study of Exemplary
Mathematics Programs

MD:em
encls.



sent to . . participants
of Mathematics and Science Roundtable

northeast regional exchange

101 MILL ROAD, CHELMSFORD, MA 01824 • 617 / 256-3987

March 5, 1983

Dear:

As I described at the recent Mathematics and Science Roundtable, we are appealing to mathematics supervisors, through ads and a letter, for help in identifying exemplary mathematics programs. I have enclosed a copy of the letter for you as a reminder of the nature of our study, and as a reminder of my request that you help us to identify candidates for the study.

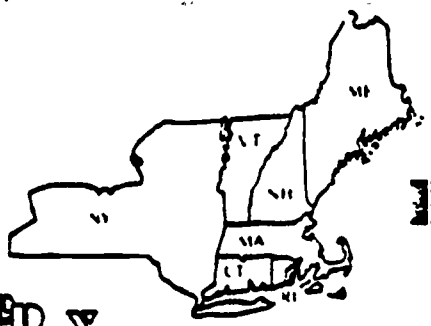
Please give the enclosed cards to school programs you think should be part of the study. If you have any questions about our request, please call Larry Vaughan or me at NEREX.

As you may know, the Roundtable occurred shortly after I moved from St. Louis. If any part of me was unaware of the richness that defines mathematics and science education in this region, I was keenly aware of it after the Roundtable. Thank you for your part in that stimulating day.

Sincerely,

Mark Driscoll
Principal Investigator
A Study of Exemplary
Mathematics Programs

MD/jmk
Enclosure



northeast regional exchange

101 MILL ROAD, CHELMSFORD, MA 01824 • 617 / 256-3987

March 6, 1983

Education Week
Deadlines Section
Suite 560
1333 New Hampshire Ave, NW
Washington, DC 20036

Please include the following in your Deadlines Section. Thanks.

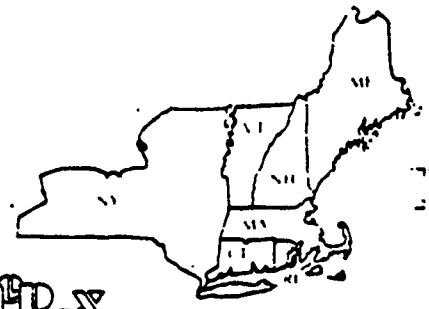
April 15 -- Exemplary Mathematics Programs: Self-nominations of school mathematics programs, grades 4 through 12, to participate in "A Study of Exemplary Mathematics Programs," funded by the National Institute of Education. Schools that choose to participate and fill out a questionnaire will receive complimentary mathematics resource materials. Contact: Dr. Mark Driscoll, Principal Investigator, Northeast Regional Exchange, 101 Mill Road, Chelmsford, MA 01824.

Mark Driscoll

A Study of Exemplary Mathematics Programs

ATTACHMENT 2

Correspondence with participating schools



Northeast Regional Exchange

101 MILL ROAD, CHELMSFORD, MA 01824 • 617 / 256-3987

April 8, 1983

Dear

Thank you for your interest in "A Study of Exemplary Mathematics Programs," which is being conducted by the Northeast Regional Exchange, under contract from the National Institute of Education. A brief description of the project is included. Schools that respond, as you have, and request to take part in the study are asked to supply information about their mathematics programs. We are asking you to describe what you think makes your program exemplary, by sending whatever information is readily available in the areas outlined on the enclosed yellow sheet, "Guidelines for Submitting Information on Your Exemplary Mathematics Programs."

We need to have your information by May 15, in order to allow some time, if necessary, for any further clarification by telephone. On May 27, we will consider our pool complete, and our panel of expert consultants will select the sample of approximately 25 sites for visits next Fall.

This study has tremendous importance for the future of mathematics education in our schools, and therefore for our country. As members of that mathematics education community, we are all acutely aware of the present crisis in our field. We are convinced, however, that there is much that is exemplary in school mathematics programs throughout the country. Your contribution will allow us to identify and describe the makings of excellence for all of our country's pre-college mathematics programs.

As a show of our appreciation for your contribution, we will send you two documents. First, we will send you a summary of Research Within Reach, a collection of detailed answers to questions raised by teachers about the teaching of mathematics. Second, we will send you an annotated bibliography of articles and documents relevant to each of the components of exemplariness which our research unveils.

Again, thank you for your willingness to participate. We appreciate the time you are giving to this study. If you have questions, do not hesitate to call me or Elsa Martz at 617/256-3987.

Sincerely,

Mark J. Driscoll
Principal Investigator

A Study of

Exemplary Mathematics Programs

The Study of Exemplary Mathematics Programs began on December 10, 1982 with funding from the National Institute of Education, and it will continue for two years. The aims of this project are to: (1) collect a pool of exemplary programs in pre-college mathematics beginning at grade four, (2) examine a portion of that pool in considerable detail in order to hypothesize what factors are associated with their exemplary qualities, and (3) provide a systematic means to test those hypotheses. Please note that this is a research project and not a contest. Participation is voluntary and data or names of individual programs will not be publicly released.

In the first phase of the study, we will screen several hundred school-based programs that have been nominated by the schools' mathematics department heads or principals. Programs must have been in operation for at least one year. In order to be a candidate, a school program need not be exemplary throughout. Indeed, we expect to find many programs that have one or more outstanding components -- for example, exemplary honors, geometry, remedial, or computer science programs, to name but a few of the possibilities. We want such schools to participate in our study, as well as schools that consider their entire programs exemplary.

The process of collecting our pool of mathematics programs will continue throughout the spring. We will telephone many of our respondents for clarification or further information. On May 27, 1983, we will consider our pool complete. Then we will convene a meeting of expert consultants to guide us in analyzing the data and in selecting approximately 25 sites from our pool of candidate programs. The selection of sites will represent diverse aspects of exemplary quality and types of programs, since the purpose will be to maximize potentially useful information. These schools will be visited during the Fall of 1983.

The site visits constitute the second major stage of the study. The sites will be throughout the country. Some visits will extend over one and a half days; others over two and a half days. The total set of information collected will result in a set of case histories of several of the visited programs, and a set of hypotheses about the factors associated with exemplariness.

In the third and last stage of the study, we will test all of our hypotheses about exemplariness. We will then report our results to participants, to the federal government, and at meetings and in journals to the mathematics education community. Through these reports we will make mathematics educators aware of the various aspects of exemplariness, how school programs can be improved, and of the implications for further research. Indeed, all study participants will share the primary reward by contributing to this significant research study.

Mark Driscoll, Principal Investigator
Northeast Regional Exchange, Inc.
160 Turnpike Road
Chelmsford, Massachusetts 01824
617/256-3987

GUIDELINES FOR SUBMITTING INFORMATION ON YOUR EXEMPLARY MATHEMATICS PROGRAM

send us any information you have that supports your belief in the excellence mathematics program you are presenting. Keep in mind that we welcome the ement of schools that consider only certain components of their program as ary, as well as schools that believe their entire mathematics program to be ary. We hope that you will be able to provide your information in 4-5 pages, eferably no more than 10 pages; so that our Expert Panel can readily identify gnificant elements of your program. In order to provide some guidelines for e, we offer the following suggestions; however, we do not expect you to information in every category.

escription of exemplary program. This might include:
courses, grade level(s), or populations involved
program objectives
length of time program has been in existence

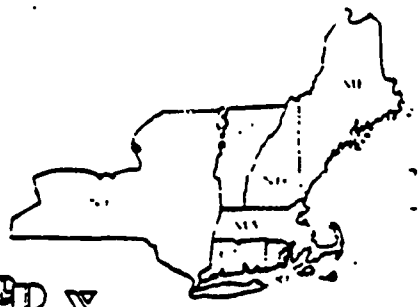
phic information that will assist us to group similar programs, yet select programs for examination. This information might include:
type of school and grade levels
numbers of teachers and students in the school and in the program
ethnic mix of students

e of excellence of results, or greatly improved results, in your mathematics . This might include:
test scores significantly above national norms
test scores significantly higher than might be expected from the student population
participation in critical mathematics courses (e.g., geometry, algebra, advanced mathematics)
participation of typically underrepresented ethnic and socio-economic groups and females
recognition of the excellence of your program from your peers in the mathematics education community (e.g., through awards to your program or the students in your program)
postgraduate involvement in mathematics (e.g., in technical jobs involving mathematics, in mathematics-related majors in postsecondary institutions)
student participation in mathematics beyond classroom walls (e.g., through homework, clubs, and so on)
any other measures you use to determine how well the program is meeting its objectives.

characteristics of your school or mathematics program that, in your account most for the excellent results. These might include:
special curriculum features (e.g., required and elective courses, articulation, evaluation techniques)
special instructional features (e.g., instructional time, teaching strategies, management systems)
special learning opportunities for students, either inside or outside the classroom
special training, development, or preparation activities for staff
external support (e.g., principal, school district, community)

ou for providing us with information about your exemplary program and for pating in our study. In case we need further information, please include , address, and telephone number(s) of the person to be contacted regarding ormation you are submitting on your program. If you have any questions, lo not hesitate to call us at 617/256-3987.

Mark Driscoll, Principal Investigator
Elsa Martz, Project Associate



101 MILL ROAD, CHELMSFORD, MA 01824 • 617 / 256-3987

April 8, 1983

Dear

Thank you for your interest in "A Study of Exemplary Mathematics Programs," which is being conducted by the Northeast Regional Exchange, under contract from the National Institute of Education. A brief description of the project is included. Schools that respond, as you have, and request to take part in the study are asked to supply information about their mathematics programs. We are asking you to describe what you think makes your program exemplary, by sending whatever information is readily available in the areas outlined on the enclosed yellow sheet, "Guidelines for Submitting Information on Your Exemplary Mathematics Programs."

We need to have your information by May 15, in order to allow some time, if necessary, for any further clarification by telephone. On May 27, we will consider our pool complete, and our panel of expert consultants will select the sample of approximately 25 sites for visits next Fall.

This study has tremendous importance for the future of mathematics education in our schools, and therefore for our country. As members of that mathematics education community, we are all acutely aware of the present crisis in our field. We are convinced, however, that there is much that is exemplary in school mathematics programs throughout the country. Your contribution will allow us to identify and describe the makings of excellence for all of our country's pre-college mathematics programs.

As a show of our appreciation for your contribution, we will send you two documents. First, we will send you a summary of Research Within Reach, a collection of detailed answers to questions raised by teachers about the teaching of mathematics. Second, we will send you an annotated bibliography of articles and documents relevant to each of the components of exemplariness which our research unveils.

Again, thank you for your willingness to participate. We appreciate the time you are giving to this study. If you have questions, do not hesitate to call me or Elsa Martz at 617/256-3987.

Sincerely,

Mark J. Driscoll
Principal Investigator

northeast regional exchange, inc

the resource exchange for educational services

COPY

September 23, 1983

FILE

Dear

After an extensive review of evidence sent by 150 schools from around the country, we have determined that your mathematics program is indeed exemplary, and we would like to visit your program as part of A Study of Exemplary Mathematics Programs.

As you may recall, the study has been funded by the National Institute of Education for two years. During the coming Fall we will visit approximately 25 exemplary programs around the country, covering grades 4 through 12, to identify factors which are associated with excellence in mathematics instruction. Thus, when we have visited the 25 exemplary programs, we will have a set of hypotheses about factors contributing to excellence. During the first half of 1984 we will test those hypotheses with another set of schools and then report our results in the latter half of the year. As I have mentioned to you before, we will keep all of our interactions with you completely confidential and, indeed, as we report our results, we will keep all of the 25 programs anonymous.

A few words about the organization we represent. The Northeast Regional Exchange, Inc. (NEREX) is an educational service and research organization serving Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. The seven Commissioners of Education and other educators on the NEREX Board determine regional priority areas for the Exchange. These include writing, mathematics, science, computer technology, effective schools, and teacher education. At the present time, the primary research focus at NEREX is our national Study of Exemplary Mathematics Programs.

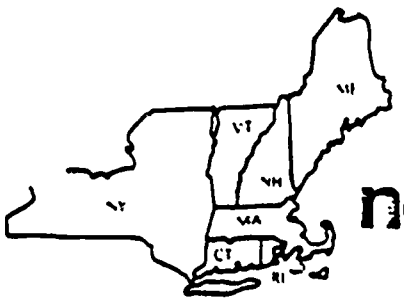
As I arranged with you on the phone, two of our field team members will visit you on November 14, 15, and 16. We will follow this letter with a more comprehensive phone call in which we will lay the groundwork for our visit - classes we will want visit, people we will need to speak with, and so on. We are very excited about visiting with you and learning from you, and we are grateful for your cooperation.

Sincerely,

Mark J. Driscoll
Principal Investigator
A Study of Exemplary
Mathematics Programs

MJD/jmk

cc: Miss Mary Lee Guillot, Principal



northeast regional exchange, inc.

the resource exchange for educational services

October 14, 1983

I am writing to you concerning A Study of Exemplary Mathematics Programs, about which we communicated last Spring. Our task during the summer has been to select 25 sites to visit for our study. We convened a panel of experts in August to rate the 150 programs which, like your program, sent us evidence of excellence. We then chose sites that were not only in the exemplary range but which represented a cross-section of grade levels, geographical locations, and so on.

I regret to pass along the news that your program was not selected for a site visit, but let me qualify that news with some very important information. We are a research study, not a contest. As I mentioned above, we required some diversity in our pool, so we could not just select the top 25 programs. When we had 3 or 4 top-notch programs which were similar in geographical setting or socio-economic factors, we were obliged to eliminate 1 or 2 of them from consideration.

Our staff and expert panel have been very impressed with the quality of most of the programs in our pool of 150. In fact, we are convinced that the bounds of our study are too confined, that there is much to be learned from a larger group than the 25 selected programs. Therefore, we will continue to explore avenues by which you can continue to benefit the educational community with knowledge about your program. At the very least, we will keep you informed of the results of the study as it winds to a close late in 1984. We will also send you other materials related to our work.

In closing, we are very grateful to you for your participation, and we wish you continued success.

Sincerely,

Mark J. Driscoll
Principal Investigator
A Study of Exemplary
Mathematics Programs

MJD/jmk

NEREX, 160 Turnpike Road, Chelmsford, Massachusetts 01824 617/256-3987

TUESDAY, APRIL 24
AFTERNOON

16:00 - 17:30 CABRILLA ROOM

TOPIC: THE LEARNING AND TEACHING OF ALGEBRA

ORGANIZER: Sigrid Wagner,
Emory University

PRESENTERS: Sigrid Wagner,
Emory University

Sidney L. Rachlin, University of Hawaii

John Bernard, University of Hawaii

Some current research on learning processes in algebra and implications for teaching. Discussion of what we know and what we need to know about the learning and teaching of algebra.

TUESDAY EVENING PLENARY SESSION

19:30 - 21:00 CONTINENTAL BALLROOM

TOPIC: TECHNOLOGY, TRIANGLES AND TEACHING

PRESIDER: Douglas Owens,
University of British Columbia

PRESENTERS: Professor Hugh Burkhardt,
Director, Shell Centre for Mathematical Education,
University of Nottingham, England

Professor Rosemary Fraser,
Director, Investigations on Teaching with Microcomputers as an Aid,
Shell Centre for Mathematical Education,
University of Nottingham, England

The introduction of a microcomputer in the role of a "teacher's assistant" has many possibilities. Research based on systematic classroom observation shows long sought shifts of teaching style, and their basis.

WEDNESDAY, APRIL 25
MORNING

9:00 - 12:30 ANZA ROOM

TOPIC: RESEARCH ON TEACHING MATHEMATICS

ORGANIZER: Perry Lanier, Michigan State University

PRESENTERS: Linda Patriarca Nancy Brubaker
Anne Nason Perry Lanier
Institute for Research on Teaching,
Michigan State University

This session will focus on several aspects of an ongoing research project of I.R.T. concerned with improving the quality of instruction in general mathematics. Consideration will be given to: teachers' changes, the use of field work to capture those changes, achievement data as a means of assessing the effectiveness of the changes, and the role of classroom consultation in generating the changes.

9:00 - 10:30 BALBOA ROOM

SPONSOR: National Council of Supervisors of Mathematics

TOPIC: A STUDY OF EXEMPLARY MATHEMATICS PROGRAMS - SOME PROMISING HYPOTHESES

ORGANIZER: Mark Driscoll,
Northeast Regional Exchange, Inc.

PRESENTERS: Mark Driscoll; N.E.R.E.X., Inc.

Fernand Prevost,
New Hampshire Department of Education

Robert Kenney,
Vermont Department of Education

Catherine Tobin, Mathematics Consultant

The two-year Study of Exemplary Mathematics Program began at the Northeast Regional Exchange, Inc. in December 1982 with funding from the National Institute of Education. So far, this project has: (1) collected a pool of exemplary programs in pre-college mathematics beginning at grade four, (2) examined a portion of that pool in considerable detail in order to hypothesize what factors are associated with their exemplary qualities, and (3) provided a systematic means to test hypotheses.

HARVARD UNIVERSITY
Graduate School of Education
Monroe C. Gutman Library, Appian Way
Cambridge, Massachusetts 02138

617-495-1825/6

December 20, 1983

Dr. Mark Driscoll
NorthEast Regional Exchange, Inc.
160 Turnpike Road
Chelmsford, MA 01824

Dear Dr. Driscoll:

This letter confirms your presentation at the Harvard Principals' Center. Enclosed please find a copy of the January-May calendar (which includes a description of your presentation), a temporary parking permit for the Everett Street garage and some background information on the Center.

As agreed, your workshop on "A Study of Exemplary Mathematics Programs" will be held Tuesday, March 20 from 4:00-6:00 pm. It would be helpful if you could plan to arrive at the Gutman Library Conference Area I about 15 minutes ahead of time to handle any last-minute arrangements.

Several weeks before your presentation is scheduled, I or another staff member will be in contact with you to discuss further details of your presentation and to determine what, if any, special equipment (e.g., blackboard, over head projector, etc.) you will be needing. Also, in anticipation of introducing you, would you please send me a copy of your resume or vita?

We look forward to your presentation at the Principals' Center. Center members are especially interested in effective mathematics instruction. Please do not hesitate to call if you have any questions.

Sincerely,

George

George Lowery
Program Coordinator

GL:MWT
Enclosures

RESOURCE CENTER ON SEX EQUITY

February 16, 1984

Mr. Mark Driscoll
Principal Investigator
Northeastern Regional Exchange
160 Turnpike Road
Chelmsfoid, Massachusetts 01824

Dear Mr. Driscoll:

Thank you for your willingness to participate as a guest presenter at our Leadership Training Institute on Mathematics and Science Education scheduled for April 8-11, 1984 at the Ramada Inn in Princeton, New Jersey.

The Institute will focus on the leadership role that state education agencies (SEAs) can take to improve mathematics and science education with particular emphasis on increasing opportunities for the participation of women and minority males. The objectives of the Institute are to:

- bring together teams from SEAs with recognized experts in math and science education to explore successful approaches to major issues in these fields;
- help SEAs integrate a concern for increasing the participation and achievement of women and minority males into all math and science initiatives; and
- promote effective actions by selected SEAs and encourage other SEAs to adapt and adopt such actions.

The Institute is designed to provide an opportunity for staff from various projects focusing on equity considerations in math and science programs to share their expertise with state education agency personnel. We believe that this is a unique opportunity for the institutionalization of equitable policies, programs, and practices at the elementary and secondary school level. Teams from the following states have been selected to participate in the Institute: Iowa, Kentucky, Massachusetts, Minnesota, Montana, New Jersey, New York, North Carolina, Ohio, and Washington.

Based on recommendations of the project's Advisory Committee, we have developed a conference agenda that focuses on issues considered critical to a discussion of the state role in improving mathematics and science education: teacher training and development, elementary

education programs, partnerships, and effective use of technology. Equity concerns will be treated as a cross-cutting issue to be integrated into all sessions of the Institute.

Your presentation will be part of a panel on Research on the Participation of Minorities and Women in Science and Mathematics, to be held Tuesday, April 10th from 8:45 a.m. to 10:15 a.m. In a 10-15 minute presentation, we ask that you provide an overview of your efforts to date in identifying model mathematics programs and documenting attributes of successful efforts, especially those that contribute to increased participation and achievement rates for minorities and women.

While our funding is limited, we will cover all travel and lodging expenses associated with your stay in Princeton. Enclosed is a Presenter's Attendance Questionnaire. Please complete and return as soon as your travel plans are firm. This will allow us to make the necessary hotel accommodations and arrangements for you. You are invited to stay the full duration of the Institute as a resource for state teams in attendance.

For your information, a short project description is enclosed as well as background on the Council and the Resource Center. A tentative agenda is forthcoming. Please call Julia Lara or Glenda Partee at (202) 393-8159 if you have questions.

Sincerely,

Susan Bailey

Susan Bailey
Director

SB:als

Enclosures

A Study of Exemplary Mathematics Programs

ATTACHMENT 3

Abbreviated case studies

INTRODUCTION

ABBREVIATED CASE STUDIES

A STUDY OF EXEMPLARY MATHEMATICS PROGRAMS

Following a list of our 11 hypotheses is a chart that comprises abbreviated case studies from the 28 sites visited in the study.

Key words to identify each hypothesis are across the top of the chart; the 28 sites are numbered on the left. Each cell on the chart contains manifestations of each hypothesis, or lack thereof. The miscellaneous column at the far right has been used to provide additional data that was obtained from some, but not all, sites. When information was available on staff turnover, it was placed in this column.

Representative sites were selected on a basis of variety according to school level, geography,school type (public or private), socioeconomic factors, and types of outcome evidence. The final list of 28 sites were located in 16 states and the District of Columbia.

The Study of Exemplary Mathematics Programs looked at programs in grades 4-12. On the chart of abbreviated case studies, schools numbered 1 through 8 are elementary or middle schools. Schools 9 through 28 are high schools, some of which include junior high grades. We were able to conduct 15 of our 28 site visits with two-person teams. The Principal Investigator conducted 17 of the 28 site visits.

Highlights of our findings in relation to the hypotheses are shown in the following abbreviated case studies for the 28 sites visited. For 10 of these schools, complete case studies have been written by the Principal Investigator. In all cases, by agreement with the National Institute of Education, we have not identified the actual schools but have used pseudonyms.

HYPOTHESES
FROM
A STUDY OF EXEMPLARY MATHEMATICS PROGRAMS

Background

1. The community values mathematics achievement and these values are effectively communicated to students -- the students want to learn.

Curriculum and Implementation

2. Homework plays an important role -- in amount and frequency, in the feedback given, and in its connection to classroom practice.

3. The whole program is structured, and understood by staff and students, so that students can and do move flexibly within an array of courses and levels to maximize success.

4. The curriculum has the blessings of the mathematics staff. If they have not had a hand in developing the curriculum, they have at least adapted to it and developed a sense of ownership of it.

Teaching and Staffing

5. High expectations for success in mathematics are consistently and effectively communicated to students.

6. There is a consistently supportive environment for learning in the classroom that accommodates risk-taking.

7. Class time is used efficiently by both teachers and students.

8. Mathematics teachers spend considerable extra time working with students and/or preparing materials.

9. Staff are dedicated and function as a cohesive, sharing, and mutually supportive unit.

Leadership

10. Exemplary programs are characterized by the kind of leadership that results in a well-run, well-organized department that frees teachers from non-instructional distractions.

11. Exemplary programs are characterized by leadership that makes it possible for teachers to feel and act as professionals, and that stimulates questioning, sharing, and taking part in ongoing professional interactions.

ABBREVIATED CASE STUDIES

Schools #1 thru #8 -- Elementary, Middle, & Junior High Schools

Schools #9 thru #28 -- High Schools & High School/Jr. High Combinations

BRIEF CASE-STUDY PROFILES FOR 28 EXEMPLARY MATH PROGRAMS, IN

Elementary, Middle, & JHS	BACKGROUND	CURRICULUM/IMPLEMENTATION			TEACHING	
	1 Community Values Math Education	2 Homework	3 Flexible Placement	4 Ownership of Curriculum	5 High Expectations	6 Risk-Free Environment
1	Upper Middle class suburb; comm. uses sch often for evening functions; parents come in often for teacher conferences. No special attention to mathematics	Seems very important and occupied almost too much of class time.	Teacher teams monitor carefully through daily meetings. School is putting a lot of energy into meeting needs of gifted and talented. Frequent day time meetings with parents by teams to discuss kids having trouble.	Teachers were involved in developing curriculum, and they meet in their teams daily to discuss its use and any necessary changes-curriculum based on teachers - developed outline.	8th graders are made to believe that they are doing better in algebra than local high school students. They give "student of the month" award in school. They emphasize their efforts for the talented, having 30% 7th graders take SAT each year.	To coordinate with high school algebra, 8th grade algebra taught quite rigidly, with stress on "the right way". Even so, all teachers observed were very respectful of students, making it safe for students to step forward if they were having trouble understanding.
2	Rural Appalachian middle school. Not much evidence of high value of mathematics in community.	Homework is a requirement that is "measured every day".	Excellent. They have designed "Mix and Match" program that is a blend of homogeneous and heterogeneous! Students evaluated on a particular objective, then split up temporarily into an enrichment group and a group working on that objective.	Staff has strong sense of ownership. They adopted various programs, such as Good-Grouws, R. Charles Problem - Solving Program; Mini-Math daily exercise program. They adapted Elements of Math program for their talented.	Site visitor cited staff sense that "mathematics should be far more interesting and exciting" communicated to students.	Site visitor reported exceptionally comfortable learning environments.
3	8 year-old rural middle school. Financially strapped district. Parents volunteer for resource work - in all subjects. Math people send home weekly "math challenge of the week for parents." Not much evidence of strong community math interest beyond this.	Work not finished in class is assigned homework - - assigned everyday.	Daily monitoring of students for assignments to Resource Room. Having staffs meet in separate "rivers" helps facilitate this. School has innovative model of Resource Room that mixes gifted & remedial. Counseling staff plays vital & central role.	Math activities for Resource Room are home-grown and circulated for enrichment use in regular classrooms.	Assertive discipline program helps students to recognize and assume responsibility for their behavior. Advanced 6th grade students expected to do independent projects. There is "Student of the Week" award.	Site visitor: "Continuous positive reinforcement" "Lots of touching of kids", "No sarcasm."
4	Small city, middle class. Near a large university. Some university influence. A few parents volunteer to monitor kids' use of computers before school. Parents expressed deep confidence in the quality of the mathematics program, when interviewed.	Grades 4-6. Homework not a big factor, though teachers will send home basic fact sheets supplementing the CSMP curriculum	Children are grouped heterogeneously. Large classes work against teachers' having the best awareness of whether students are fully understanding what is taught.	Very strong. Each teacher has learned to adapt to and, in several cases, really like the CSMP curriculum. Each has developed own ways of supporting it. There is a lot of calculator use. LOGO, weekly problem solving sessions, etc.	6th graders are expected to act responsibly -- a conscious agenda of the 2 6th grade teachers. In early grades, students are challenged with problem-solving and computer sessions to exceed the usual. Display case in school entryway has math exhibit.	The teachers are very student-centered. Their good skills combine with the structure of CSMP to produce a high number of invitations for student involvement in each class.
5	Suburban junior high (grades 7-8) have lower middle to middle class. Thanks to turnaround in scores and a math team that keeps improving, and a newspaper that gives lavish coverage, community is becoming appreciative of math -- strong values for math don't have deep historic roots.	Mandated homework policy in the district that the superintendent sees as one of the crucial steps in the turnaround. Guidance people see an improvement in student attitudes toward homework due to district-wide policy.	Strong -- the guidance people were about the best we saw -- careful assessment of student needs, discussions with elementary schools, frequent contact with parents. They lunch frequently with math staff -- High mutual regard with math staff.	Saturday revision sessions have brought them a sense of ownership. Superintendent and principal had them design their own competency tests and then match curriculum.	Not openly expressed in class, but they are there. Students, teachers, the community at large, all feel the expectations on the basis of the powerful test score and math team turnarounds in the past decade. They have upped their texts and standards several times.	A quiet respect for students a universal quality in classroom. From computer teacher cajoling girls to overcome their reluctance, to remedial teacher who showed tremendous patience and sensitivity.
6	Rural elementary school with strong educational values, though voters turned down 4 pleas for financial support. 6th grade only	Required daily with a special stress on student responsibility for getting it done.	School has a school-within-school model (called "quads") -- 3 quads. They maintain an honors program, using their own placement test for placement in it, along with previous record. They keep remedial classes small. (Good articulation with feeder schools).	Textbound, but the 3 teachers changed the program and developed its curriculum.	A real conservative, "no coddling" approach to "bright but lazy" kids in honors (their words).	Three different teaching styles by the 3 teachers. The interaction varied: site visitor reported a lot of support in several classes, boys slightly ridiculed in another.
7	Small city. Normal range of values. Only about 50% of students will eventually go to college. 7th-8th grades completely individualized program.	A strict policy about having it, though it varies from teacher to teacher. Parents called, students detained if doing homework becomes a problem.	Completely individualized program with aides. Kids get a lot of attention -- teachers, aides, math lab room. Not much flexibility in scheduling. Only math staff sent home monthly progress rep.	On paid Saturdays staff revises curriculum which was put together by a couple of staff on the state grant.	School held town meeting with parents and kids on "How we can improve the school." They keep regular parent contact to spur student self-motivation. Active math club recruitment.	Not especially relevant -- totally individualized program, but aides and math lab director very motherly -- a comfortable setting.
8	Middle-class suburb-High-tech family influence. School board discusses issues such as the number of girls in honors. Board members sit in on classes. Our focus was a 7th-8th grade program for talented students.	About 20 minutes a day used to develop class discussions.	District-developed screening procedures for this talented program -- about 1/6 of kids in district admitted. There are only informal procedures for dropping students from the program.	Primarily put together by 1 teacher with help from 2 others. Revised each summer	There is a conscious & openly expressed goal of the program to make students "independent problem solvers." They have students write essays about their computer experiences and learning.	Site visitor: "They work on confidence with the kids." They employ student-centered discussions. Conscious attempt to enhance student math self-concepts.

TERMS OF FACTORS HYPOTHESIZED AS ASSOCIATED WITH EXCELLENCE

Elementary, Middle, JHS	STAFFING			LEADERSHIP		MISCELLANEOUS
	7 Use of Class Time	8 Spend Extra Time	9 Mutually Supportive Sharing, Collegial	10 Smoothly Managed. Removes Distractions	11 Vision, Stimulates Professionalism	
1	No wasted time that we saw. Teacher teams meet daily, adjust time allotments to suit immediate needs for each subject. A bit too much time spent on going over homework in a few classes.	Teachers seem to be available to students after school, after class for help. Otherwise, nothing extraordinary noted.	Daily team meetings for at least 1/2 hour, (4 teachers per team).	Principal started "school within - a - school" model. He makes sure its implementation works well. He is strong on delegating authority. He fought successfully (over sch. bd.) for funding of a gifted director.	Principal delegates much of authority for curriculum, diagnosis, evaluation to his team of teachers. Works closely with superintendent to maintain high standards with them. He is avid to expand and enrich gifted program.	low teacher turnover
2	Site visitor: "High time on task." A careful, organized program of time use-reflecting their adoption of the Good-Grouws Study & Program. Daily 45 min. math period..	The program calls for 7 1/2 -hour official teacher schedules. Since they usually meet during planning periods, their individual planning must extend beyond this 7 1/2 hour schedule.	Principal described math teachers as "interlocking, mutually supportive, and diversely unique people." They spend their daily planning periods for sharing, discussing mutual needs, and mutual planning. 4 math teachers	Strong bonds of communication and mutual respect among 4 math teachers, the principal, and the assistant superintendent in charge of curriculum.	Assistant superintendent reads, sends ideas to math staff. They ponder, buy pieces of it, and implement. Administrators openly encourage and demonstrate their regard for teachers' innovation in the curriculum.	
3	Classes begin with quizzes on math facts -- No wasted time.	Informal lunchtime meetings plus weekly meetings.	Teachers within each "river" take responsibility for running it. Teachers help in choosing new teachers. 4 math teachers + 1 resource teacher	Principal an active and open planner, who makes plans for school explicit to staff.	School run on a "school within school" model - called "rivers". Principal gives teachers in each of 4 rivers a fair amount of autonomy - even in hiring approach. Superintendent talks with teachers about what he plans to discuss with Board.	low teacher turnover; principal a former math teacher
4	CSMP use guarantees full 55 minutes of math every day. This is supplemented by weekly problem-solving sessions. Teachers get kids working right away in each class.	Math Club, supplementary materials, a math newsletter, computer use -- all combine to demand extra teacher time.	A sharing group -- articles, materials, ideas, etc. A teacher: "This is the first school (of 6) I've been in where the teachers share." 4 math teachers	Principal and district math coordinator have worked together to implement K-6 adoption of CSMP math curriculum. Principal has shuffled teachers to move toward subject specialization. There is a bit of staff resistance to both CSMP & specialization that he glossed over in making changes [illegible]	Principal and district coordinator strong advocates of innovative math curriculum, esp of CSMP. They support and encourage teachers to be innovative, to adapt to CSMP, to interact professionally.	
5	Efficient use of time - little wasted from instruction -- even in the lowest classes.	Nothing very extraordinary -- They are paid for their Saturday work.	They lunch with guidance people almost daily. This keeps lines of communication open. 7 teachers	Principal keeps school quiet, orderly. Superintendent provides much of the instructional leadership. Has developed an extremely well-managed program of curriculum revision conducted by the teachers on Saturdays.	Superintendent has infused the teachers and the community with enthusiasm for turning math program around. He invested early in staff involvement on Saturdays. Math teachers also get quiet, solid leadership from chairman, who is both a lawyer and union representative.	
6	Site visitor: "Little nonsense. The period begins and class starts."	Site visitor: "Teachers spend long hours." one cause: math competitions	Informal planning through group "chatting." All 3 active in professional math teachers organizations. 3 teachers	Site visitor: The principal is a strong leader who sets high expectations, disdains compensatory programs as interfering with high expectations.	Frequent progress reports sent home - principal's way of keeping ties with parents strong -- she facilitates the implementation of the school-within-school model.	No teacher turnover
7	Superbly efficient -- the main benefit of a totally individualized program.-- Though kids sometimes have to wait idly to have work checked.	Principal: "My math staff exceeds what is required (1/2 hour before, 1/2 hour after school)." One teacher has, on his own, instituted an extra after-school class for those needing help.	Lots of sharing. Formally meet twice a month. An aide described the teachers as "very congenial and helpful to each other." 5 teachers plus aides	This is a state demonstration program, with a director who handles some of administrative. Department head supervises curriculum reform, works closely with principal.	Principal instituted meetings of department heads as group, to improve communication. She believes in "teacher as leader" concept. Sent staff to Madeleine Hunter training.	No teacher turnover
8	High time-on-task Class time divided into: 1/3 homework review 1/3 lecture 1/3 problem-solving practice and discussion	Free time plus time before school and 1/2 hour after school available to students. This means teachers do planning on their own time.	Site visitor: "Lots of informal exchange and sharing." all located together in same wing. 3 teachers	Site visitor: "Dept. head is perfunctory honor" -- Has same teaching load as everyone else; doesn't observe teachers. The program was submitted to our study by its designer, one of the teachers.	The teacher who designed the program got money from the district to develop the program during the summer.	No teacher turnover

BRIEF CASE-STUDY PROFILES FOR 28 EXEMPLARY MATH PROGRAMS, IN

High School & High Sch. Junior High Combination	BACKGROUND	CURRICULUM/IMPLEMENTATION			TEACHING /	
	1	2	3	4	5	6
	Community Values Math Education	Homework	Flexible Placement	Ownership of Curriculum	High Expectations	Risk-Free Environment
9	Too large a city to gauge. Large city school.	An expected daily routine. Students start classes by putting homework on the board (on their own in a few classes).	Stringent placement exam to get into school. After that nothing stands out.	Computer courses teacher-written. Otherwise, texts plus supplemental materials. -- t[illegible] seemed satisfied th them.	Exceptional -- for themselves and the students -- they talk in class of their expectations of students--"you should know that." "You can be more clear."	With exception of one class, good balance of challenge and accommodating risks.
10	6 yr-old magnet school -- large city school with 51 feeder schools	Minimum of 1/2 hr/night required	They have a tough time in 9th grade -- 51 feeder schools. Advanced courses favor honor students.	Staff discusses curriculum decisions -- e.g. decision not to water down Algebra II - Trig. three of the staff have become avid about International Baccalaureate (IB).	All frosh required to take Algebra I - when a student wants out of honors, first must tutor with teacher 1/2 hour twice a week on weaknesses.	Yes -- seemed to be universal. No exceptional classroom interactions.
11	Influenced by nearby Ivy League School. Mix of rural and university kids.	Regular requirements	Special plan set up to accommodate small group of needy students in individualized program. Middle school coordinated by department chair; good articulation Math resource center always busy.	Many applied, practical, homegrown courses. Staff designed resource center.	They are deliberate about trust in student responsibility --e.g., they can reschedule tests, they can move around during free time.	"Friendly atmosphere" in classes(visitors). Student suggestions regularly used in class discussions.
12	A mix of students from all over a large city -- old, established academic high school -- grades 7-12	An expected daily routine. Students said they got approximately 1 hour of math homework a night.	Contains junior high so articulation smoothed. They lose a lot of minority kids, though, despite tutorial program; kids join honors program all the way into junior year -- 2 levels of honors.	Mainly texts, though they seem satisfied. Computer courses teacher - developed --. Teacher-made homework A.P. Calculus not text-bound.	Less openly expressed in class than school number 9, but the school's long tradition of excellence looms.	Teachers firm, but no threats to students, no abuse. On the other hand, no special class interactions except in A.P. Calculus.
13	small 7-12 school for gifted -- loose connection with university. Strong academic values	A regular feature. Some difficult problems assigned	Becoming an issue. Dept. head concerned that some kids are misplaced above their ability -- not sure what to do	Curriculum primarily developed by dept. head and one staff member. The others use it and like it.	Some inconsistency - I heard 7th grade teacher say "You'll have to get yourself more organized" but much less of that direction in later grades. Few openly expressed expectations. Implicitly high, given quality of students.	Okay, but in one teacher's class, sarcasm and grade competition a bit out of control. These bright students create their own tensions and this one teacher didn't help.
14	Nearby university and military base; some high academic value:. However, a teacher complains about School Board's cursory treatment of issue of math requirements. University is helpful.	A regular feature, not extraordinary	"philosophical differences with middle school." "Very few kids don't have a friend on the staff" -- Daily lunch time meetings assure proper placement	Daily lunchtime meetings provide groundwork. Example: decision to keep multiple approaches to geometry. Lots of teacher-adapted activities.	Success of math team has engendered expectation of further success. Saw teachers openly expressing expectation of full attention by checking out students who seemed inattentive.	Class observation notes: "relaxed atmosphere" "evident respect for students"

TERMS OF FACTORS HYPOTHESIZED AS ASSOCIATED WITH EXCELLENCE

High School & High Sch. Junior High Combination	/ STAFFING 7 Use of Class Time	8 Spend Extra Time	9 Mutually Supportive Sharing, Collegial	LEADERSHIP 10 Smoothly Managed, Removes Distractions	11 Vision, Stimulates Professionalism	MISCELLANEOUS
9	Superb--several carry own erasers and chalk so that there won't be any delay in starting class.	A mix. Several moonlight as computer salesmen, but others--especially younger ones --deeply involved in extracurriculars.	Few formal meetings, no office--minimal collegiality. 23 teachers	chair's first year. Tremendous energy and efforts to keep the program running smoothly, dealing with equipment problems, budget problems etc.	Vision: he is avid to continue tradition of winning math team and Westinghouse prizes -- plans new courses like numerical analysis.	Low teacher turnover
10	consistently full use of time.	Principal: "There is not one of the math people who doesn't stay every day after the time when the union says they can go home." 8 of them involved in math team.	Spend time together outside school. They share materials, ideas. They have within-course teams. 10 full time, 1 part time	Dept. head doesn't have much official clout. Until recently, strong influence was former principal, who is now assistant superintendent.	She (chair) fosters sharing and team spirit among staff. Also, she fosters enthusiasm for International Baccalaureate Program.	No teacher turnover
11	Not addressed in site visit notes--	Staff make selves available for students during unscheduled periods.	Resource area combined with staff area--facilitates staff interactions, sharing, collegiality. 6 full time, 2 part time	Chair has lots of authority: he hires, evaluates. He set up resource center where they can interact. Effective in securing budget approvals.	Uses resource center to stimulate staff communication.	
12	No wasted time--staff monitor hallways to rush students to next classes, where work begins immediately	Chair and assistant put a lot of time into math team. Computer teacher puts a lot of time into her new courses. Other than that, nothing special.	Headmaster cited their willingness to talk with each other and to share. "Knowledge is revered" among the staff, a teacher told us. A small crowded lounge is the scene of a lot of professional interactions. 20 teachers	Chair works tightly with headmaster. Strong mutual respect. Headmaster a strong advocate for math department. Distractions hard to remove -- old noisy school	Department chair and assistant strong advocates of math competition. He models a deep commitment to the school's tradition of excellence and works long hours: 6:00 a.m. to 10:00 p.m.	
13	Generally, especially in the department head's classes, it's all business from the start.	Teachers make selves available to students in their office at all times all day long. Some kids even hang out in offices to chat with teachers.	Desks all together. Lots of interactions. New teacher learns by observing, discussing. 4 teachers	Not much managerial leadership. Department small, loosely structured. Dept. head feels little support from above for the kind of program he has and wants to develop	Dept. head's vision of math education and instruction a deep part of program and its success. He thinks deeply about "what mathematics ought we be teaching?"	
14	Nothing wasted	Two teachers spend lots of time with math team. Almost all spend time with professional organization.	Tight-knit group thru daily lunch meetings--offices in same wing. 6 teachers	Staff is run democratically. Chair is rotated. Principal noted, with disapproval, their inattention to "selling themselves" to the community.	They provide their own direction through lunchtime meetings.	

BRIEF CASE-STUDY PROFILES FOR 28 EXEMPLARY MATH PROGRAMS, IN

High School & High School-Junior High Combination	BACKGROUND 1 Community Values Math Education	CURRICULUM/IMPLEMENTATION 2 Homework	3 Flexible Placement	4 Ownership of Curriculum	TEACHING/ 5 High Expectations	6 Risk-Free Environment
15	female private school -- grades 7-12. Parents get involved	a central role--official repercussions for late or missing homework; counts for 1/3 grade	7-12 school - automatic articulation. Principal and 7th grade teacher involved in placement into 8th gr. algebra.	Computer work, with home-grown software, part of every course.	Unavailable from site notes	Conscious attention to math anxiety-teachers seem to get majority of students involved in discussions in class.
16	4 yr-old state-supported statewide gifted school--located in a high-tech area.--grades 11,12-school specializes in science and math, but has stiff humanities requirements.	A regular, integral part. In all but top courses, students did problems at the board and teacher led discussions.	Dept. noted by administration for their attention to kids having trouble -- new courses started midyear; peer tutoring program that reaches 10% regularly.	They have a strong sense of doing it on their own. Several courses are far different from what is available elsewhere.	Conscious coaching of kids toward self-discipline. School requires evening study skills course-kids aspire openly to self-discipline.	Teachers very accepting. Manage to offset what risk there might be among this intense and potentially competitive group of kids.
17	Well-to-do suburb with attitude toward math typical of such a setting--quietly value it a lot.	Mandated detention for students not doing it -- at all levels	Dept. head monitors closely, works closely with feeder schools to smooth articulation -- have computerized record of placement discussions with parents	More than half the teachers have strong ties back to New Math and have adapted materials. Have put together strong computer curriculum. Ownership not quite so strong among younger teachers.	Strong expectations that you take math and you work at it e.g.(homework requirement)	Saw lots of coachlike exhortations in class.
18	Small midwestern city. School people reported that "parents expect kids to take 4 years of math." Parents professional, academic.	Homework a regular part of courses from algebra I on.	Outstanding -- courses scheduled back-to-back so students can move up or down easily. Math staff counsels each student on course choices. Kids are tracked in middle school and come to high school in 4 levels.	System-wide scope and sequence. Teachers do their own supplementary materials. Three of them handle computer program. International Baccalaureate Program for some students.	Both kids and parents expect 4 years of mathematics. They appeared to take it as serious business "good training" and "needed for college".	Student. ..en in lowest courses, "treated with respect." Treated as prospective customers" (site visitor).
19	Upper middle class community Site visitor: "The kids are the big factor here"	Site visitor: "Lots of homework." Teachers carefully monitor their use of class time on homework review.	Site visitor: "Amazingly high amount of tutoring." "Very flexible placement," due to fluid staff communication and cooperation.	Changes are slow to happen due to countywide curriculum and approved texts -- County has decided to drop Unified Math, which staff liked	Staff openly expresses high expectations for student responsibility.	Site visitors, "Lots of sensitive encouragement and reinforcement" --in advanced geometry, however, not so.Quality varied, but weighted to good.
20	Small city; nearby large university, which has some influence, though not a tremendous amount.	A regular part of the program, exception very lowest course. Computer students do a lot of programming assignments.	Teacher in the lowest courses (a variety of 3 courses to meet needs at that level) monitors curriculum appropriateness, Math lab carefully monitored.	Staff-developed tests. Staff-developed computer modules for each course. "When a new text comes, we adapt it with our materials."	Staff avoids curving grades, which they want to reflect levels of understanding. "It's okay if no A's are given for a particular test." There is an engineering club for black students that conducts projects.	Staff highly conscious needs of girls and minorities. At all levels, kids seemed relaxed in class. Free exchange of banter.
21	8 yr. old urban magnet program-- academic school with focuses math and science, music, performing arts. Many kids from oil company families and university families.	A daily affair, with 1st 1/3 of each class used for review.	There is a waiting list for white students -- students accepted and placed according to middle school recommendations and their diagnostic test. There is a sizable before-school peer-tutoring program. They are displeased with middle-school prealgebra.	They are bound to state-adopted texts and pretty satisfied with being text-bound -- except in calculus.	95% attendance required in school. Students declare a major (math, science, music, theatre). "We want them to think about why they came here."	Students generally encouraged to ask questions and to say, "I don't understand"--one exception the lowest class.

TERMS OF FACTORS HYPOTHESIZED AS ASSOCIATED WITH EXCELLENCE

High School & High Sch-Junior High Combination	/ S T A F F I N G 7 Use of Class Time	8 Spend Extra Time	9 Mutually Supportive Sharing, Collegial	LEADERSHIP 10 Smoothly Managed, Removes Distraction	11 Vision, Stimulates Professionalism	MISCELLANEOUS
15	Unavailable from site notes.	A teacher: "Unlike elsewhere, here the norm is extra time." Teachers make selves available all day in computer room for help.	Math/computer lab. a natural meeting place for teachers--they make use of it. They are located together. 2 teachers plus several part time	Dept. head shares some of hiring responsibilities with rest of the staff	site notes: dept. head influential in setting tone of cooperation among staff--he worked to bring staff together into one building.	
16	Wonderful use of time--mostly all on task;save small space in most advanced courses for a bit of goofing off. These kids work so hard, they deserve it.	Kids talked of being able to find teachers for help anytime between 8 a.m. and 10 p.m. Teachers all push burnout, thrivingly.	Superb esprit. Dept. head: "Teachers ask healthy questions about what we teach and how we teach it"-- they interact in hallways, offices and in weekly 2-hr mtgs.	Dept. head a dynamo. Appears to have tremendous cooperation of administration. Makes himself very visible to them and argues persuasively for what he wants. Does all hiring etc.	Dept. head shows superb vision. He fosters "teacher-as-learner" atmosphere, and serves as very good model	No teacher turnover
17	Deliberate, maximal use of time--modeled after book by department head on use of time in math classroom.	Nothing extraordinary--kids say that they can always find some teacher to help them.	Understated collegiality but it is there. Teachers all have desks in dept. head's outer office. 12 of them have worked together for more than 10 years. 16 teachers	Best-managed program visited. Principal and dept. head work closely to tighten, facilitate management.	Dept. head keeps standards high (e.g. leans on staff to enforce homework rules), delegates authority; models effective teaching behavior; has one of the best computer set-ups.	Lost 4 teachers in recent years to computer industr
18	Site visitor: "No wasted time."	Each teacher spends at least 1 hour/day in a lab. helping with math and computers.	"Daily informal planning and sharing" (site visitor) 8 of the 10 teachers "act as a team". Site visitor compared them to a project team at Digital. 10 teachers	Principal takes "no-nonsense" approach to handling environment and "leaves teachers free to teach." In 7 years, has turned school's image around. Evaluation done by him and assistant principal.	Dept. head is strongly committed to keeping kids from failing or dropping math - - personally reviews every record of every kid.	Low teacher turnover
19	Excellent, except in general math, where there was "lots of wasted time."	Teachers tutor, before, during, and after school hours.	Site visitor: "A high degree of sharing and mutual questioning." They eat together and sit in on each other's classes and proof each other's tests. 10 full time, 2 part time teachers	Dept. head hires, supervises, makes teachers earn course assignments--done fairly, however. He is a resource teacher, visits each teacher's class at least 3 times a year.	Dept. head has formed a close-knit, conservative department around his values. Teachers: "We are treated like professionals."	3 computer teachers lost to industry in past 2 years
20	Very efficient--they matter of factly go about their business.	Lots! Principal says 3 or 4 on math staff spend at least 70 hours/wk in the school--the computers, black engineering program, etc.	Best office arrangement I saw for staff interaction -very conducive to regular meetings. 11 full time, 2 part time teachers	Dept. head works very closely with principal and district coordinator. Lots of strong mutual respect and support. Has pushed for computer support.	She was cited by her staff as an excellent listener and model. She strives to maintain attitude of "we are a team working toward a goal."	
21	Some homework done in class (They have 90-min. classes). Otherwise class time used very efficiently.	Almost all pitch in for help in math contests. They are generally available to students all day long.	6 or 7 women very close--eat lunch every day with guidance people (ex-math teachers)--lots of sharing, discussing instructional concerns. 8 full time, 2 part time teachers	Dept. head has minimal authority. "Primarily a liaison with the principal." She seems satisfied with a rather democratic approach.	They have a strong commitment to keeping kids in math and successful, but that vision is pretty much a group-developed phenomenon. "We push students to stay in math."	low teacher turnover

BRIEF CASE-STUDY PROFILES FOR 28 EXEMPLARY MATH PROGRAMS, IN

High School & High Sch. Jr. High Combinations	BACKGROUND	CURRICULUM/IMPLEMENTATION			TEACHING/	
	1	2	3	4	5	6
	Community Values Math Education	Homework	Flexible Placement	Ownership of Curriculum	High Expectations	Risk-Free Environment
22	Large suburban school. Rapidly growing. Nothing especially outstanding about community values.	A regular feature-Site visitor noted one class where time was wasted going over homework.	4 tracks, placement by teacher recommendation -- parents can veto for 1 semester. In 3 of the tracks, courses are rigorous.	In the upper classes, math competition used as part of lessons. General math, "generally uninspiring." Basically, school tied to state curriculum.	Site visitor: "Teachers continually expressing and reinforcing high expectation." Contest info broadly displayed.	Some good questioning in top 3 tracks. The 5 honors teachers "more like coaches" in their exhortation (site visitor
23	Large suburban, middle-class. Nothing outstanding about community values.	Not available from site notes	12 teams of teachers meet regularly after school to discuss placement. They aim for an individualized approach, based on objectives. A strong commitment to bringing success to students..	Strong teacher- developed unified blend of algebra-geometry, etc. in 75 units. A real teacher-owned curriculum.	Site visitor: "Staff maintains attitude of 'we do it better than any other department we know!' -thus, their expectations of selves are high.	"Students are treated with respect "/Site visitor class observations).
24	Suburban; influence of local high-tech industries. Math coordinator: "It helps that you don't have to win over the parents first."	A regular feature -- nothing out of the ordinary.	School has 4-house system. Articulation across grades hurt a bit by this. Students can drop down a level all the way into 3rd term. Remedial kids get a lot of attention.	Teachers supplement texts; teacher of Advanced Math uses 1/3 his own notes. There is an advanced calculus course, a rarity that helps staff perceive curriculum as special; summer teacher work on remedial curriculum.	Expectations are high that kids will do a lot of math. 138 kids in calculus. Kids openly aspire to honors program. Math team record a matter of much pride--trophies displayed.	Classes sort of traditional, straightforward; saw no student hesitation. One teacher: "Kids too unwilling to question. I have to prod them."
25	A new program in math/science within large inner-city high school. They do get a lot of parent support--as volunteers.	A regular feature	Students chosen for this program after 8th grade - recruited city-wide -- students write an essay, take Stanford Achievement test, get teacher recommendation.	Math Program head adapted Columbia Unified Math Curriculum. They use a variety of texts and supplementary materials.	They look for motivated kids at the start, then keep themselves pumped up with such things as a newsletter.	Site visitors reported many healthy interactions with students in class and lots of healthy humor; cited "relaxed, non-threatening atmosphere
26	Small rural town. In recent years, town has begun to value mathematics, as the mathematics team has gained fame.	Students allowed to do some homework in some classes -- a rarity among schools we visited.	Situation took a turn for the worse when the valued former guidance director left -- math teacher will put in prealgebra course to meet needs of incoming students.	1 - woman department. She chooses texts, etc.	They feel the pressure to continue to do well in math contests.	Sort of--though sarcasm and impatience evident in lower-level courses.
27	Suburban community. No signs of outstanding community values of math education. Part of the community at odds with department over attention to lower middle students.	An important component -- several imaginative ways it was reviewed in class -- e.g., small groups. On Friday, problem sheets with non-trivial and non-traditional problems handed out for extra credit.	A strong commitment to keeping kids in math. Several innovative and effective tutorials and help programs. Weak connections with guidance and middle schools.	Strong identification -- they developed general math curriculum, the curriculum for Algebra 1A, 1B, work-sheets for every course, computer curriculum.	The message is firmly communicated, "We want you in math." Students proud of math team, their work on Friday problem sheets, etc.	School has universally tense atmosphere--generally good tension-- However, we saw no non-accepting behavior toward students, in class or out. Very caring teachers.
28	Suburban community which is very conscious of success of math program -- thanks to publicity about math team. A case however, of the program affecting their values more than the other way around.	A feature that is stressed.	Lunchtime conversations among staff seem to get a lot done for proper placement. Dept. head is also math coordinator for middle school students; "teachers always available."	Staff meets in groups to develop ex[illegible]. Innovative lower-level course "Math for the Real World." Computer teacher develops own materials.	In the top levels, maintaining the school's top record in math competitions a strong motivator. Students at the to[illegible] reflected a lot of self-responsibility in interviews.	Lots of cajoling, kidding in classes. Generally teachers showed very accepting and respectful in-class demeanor.

TERMS OF FACTORS HYPOTHESIZED AS ASSOCIATED WITH EXCELLENCE

High School & Jr. High Combinations	/ STAFFING 7 Use of Class Time	8 Spend Extra Time	9 Mutually Supportive Sharing, Collegial	LEADERSHIP 10 Smoothly Managed, Removes Distractions	11 Vision, Stimulates Professionalism	MISCELLANEOUS
22	Site visitor: "High time-on-task."	The core of 5 spend lots of time on contests. (They teach all the advanced courses)	"A spacious math/sci planning area" where each teacher has cubicle. Each course has a course committee. 14 teachers	Chair primarily managerial. A core of 5 females really run department.	Dept. head spearheaded dept's ambitious math contest program. She is seen as "nonautocratic, caring, supportive."	10 teachers lost in past 8 years
23	Unavailable from site notes.	The 12 staff teams meet regularly after school with no compensation.	Team-teaching, they take care of each other. Site visitor: "Teachers really feel they have responsibility for department." 24 teachers	5 changes in principal in the past few years, yet school is smoothly run "because dept. heads run it." (site visitor)	Math dept. head does outstanding job of delegating authority, allowing staff to experiment with curriculum. He pushes them to meet often.	11 teachers lost, mostly to industry, 2 years ago
24	Lower-level classes do a lot of worksheets in class--a practice of mixed value. Otherwise, we saw good solid use of class time.	Superintendent says, "They stay later than any other dept." Math team consumes 3-4 days of one teacher's after-school time. Others appear to put in a lot of time too -- student contact during prep periods means prep done after school.	4 - house system works against real collegiality. Within each house, however, teachers share materials and ideas with each other. 18 full time, 5 part time teachers	Superintendent a strong advocate of the program and of the coordinator with the board. Coordinator acts as dept. head, but loses some contact because of K-12 duties.	Supt. and math coordinator act in concert to nurture professionalism of staff--coordinator has taken leadership in computer use, maintains good communication with science dept. Math staff shows a lot of own initiative.	low teacher turnover
25	Excellent--they have 7 or 8 50-minute classes a week and use every minute of it well. Kids: "There's no time to misbehave."	Not addressed in site notes	Students told site visitors: "Program works because the teachers work together." 5 teachers in the program	Nothing clear emerges from site visitor notes. There have been five principals since 1975.	Program arose through collaboration between teacher and district coordinator for math -- other than that, notes uninformative.	
26	So - so -- Some students not engaged, or doing homework during class.	Yes, teacher spends all available time with students,	Not really relevant 1 full time, 1 part time teacher	The former principal and superintendent brought success to the program by developing, with the math teacher, a winning math team and changing popular perceptions of the program.	Former principal and superintendent's vision of excellence through math team success now sustained by math teacher.	
27	Very efficient use of class time--	Extraordinary: curriculum, worksheet development; monitoring supplementary programs; math team. Chair: "I spend most of my time between 5:30 A.M. and midnight on this program."	At least the 5 or 6 at the core of the dept. obviously care about each other a lot- "Us against them" attitude. They develop worksheets in teams. 8 teachers	Dept. head works well with staff; somewhat antagonistic to administration -- a sense of going it alone.	The 5 core members of the dept. admire her, share her vision -- e.g., about keeping quality of general math high -- but are almost independent of her.	
28	Very efficient use of class time-- very little wasted-students at the board a lot	Dept. head's time spent is exceptional. Sells refreshments at athletic events with his math team kids to get travel money for teams. Other teachers avail. to students 1 to 2 hrs. after school.	10 or so have lunch together every day -- a semi-conscious attempt to facilitate communication. Staff meets by in-course groups 11 full time, 1 part time	Dept. head stands way above other dept. heads in the school in his effectiveness with administration. He gets what he wants -- separate wing for math dept., hiring, etc.	Dept. head has powerful vision about the value of math team. He leans on staff to be involved with students outside of class; gets most of staff together each day for lunch.	low teacher turnover

A Study of Exemplary Mathematics Programs

ATTACHMENT 4

Case Studies

INTRODUCTION

We chose the ten case studies that follow on the basis of several criteria. First, we chose on the basis of variety in school setting: two are schools in the Northeast, one is a West Coast school, one is in the Southeast, and six are in the Midwest; two are schools in large cities, four are schools in small cities, three are suburban schools, and the last is a small rural school.

Second, we chose on the basis of school level: one is an elementary school, one is a junior high school, and eight are high schools, one of which includes junior high grades.

Third, we chose them because of the variety of outcomes. Test scores are very high at seven of the schools; course enrollments in mathematics are exceptionally high at six of the high schools; the elementary school and several of the high schools have programs which immerse students in problem solving; four of the schools make extraordinary efforts to nurture the success of minorities in mathematics; five of the schools have superb records in extracurricular involvement in mathematics and in contest activities; four of the high schools have expansive and imaginative programs in computer use.

Fourth, we chose the programs because they represent a blend of interesting educational experiments and programs long established as exemplary. The man behind the success in Sampson Middle School has his "top-down" philosophy of program improvement; the person who began the success at Deer Run talked of his conviction that "results follow perceptions;" Greeley has its commitment to excellence with equity; Dawson's staff has immersed itself in the CSMP program, while trying not to lose the best in its old curriculum; Taylor's integration of the computer in the curriculum could make it a belwether for other schools; and, finally, Trinity's teachers have their strong commitment to have everyone involved in problem solving and mathematics contests, and their determination to use general mathematics as an entryway into further mathematical study and success. Summit and Jackson are innovative programs for teaching mathematics to talented students. In contrast to all these schools that are relatively new to excellence, East High and Silver Valley High are models of consistency in their long traditions of excellence.

Finally, we chose these programs for case studies because each of our hypotheses about factors and conditions associated with excellence in mathematics is well illustrated in at least one of the narratives. Those hypotheses are:

Background

1. The community values mathematics achievement and these values are effectively communicated to students -- the students want to learn.

Curriculum and Implementation

2. Homework plays an important role -- in amount and frequency, in the feedback given, and in its connection to classroom practice.

3. The whole program is structured, and understood by staff and students, so that students can and do move flexibly within an array of courses and levels to maximize success.

4. The curriculum has the blessings of the mathematics staff. If they have not had a hand in developing the curriculum, they have at least adapted to it and developed a sense of ownership of it.

Teaching and Staffing

5. High expectations for success in mathematics are consistently and effectively communicated to students.

6. There is a consistently supportive environment for learning in the classroom that accommodates risk-taking.

7. Class time is used efficiently by both teachers and students.

8. Mathematics teachers spend considerable extra time working with students and/or preparing materials.

9. Staff are dedicated and function as a cohesive, sharing, and mutually supportive unit.

Leadership

10 Exemplary programs are characterized by the kind of leadership that results in a well-run, well-organized department that frees teachers from non-instructional distractions.

11. Exemplary programs are characterized by leadership that makes it possible for teachers to feel and act as professionals, and that stimulates questionning, sharing, and taking part in ongoing professional interactions.

The school names and the names of the people in the case studies are pseudonyms. By agreement with the National Institute of Education, we have guaranteed anonymity to the participating programs during the course of the study. All other facts about the programs -- geographical region, size, etc. -- are real. Indeed, we expect that many readers who are mathematics educators will be able to infer the identity of several of the programs from their distinctive characteristics. In any event, it is our hope that readers will draw both insight and inspiration from the ten stories that follow.

DAWSON ELEMENTARY SCHOOL

"The teachers here have high standards. No one is marking time."
Dawson teacher, a veteran of four other schools in the district.

"Dawson never does anything on a minimal basis."
Parent of a Dawson student.

Most elementary school mathematics programs are cut from the same mold. Textbooks do vary and, occasionally, so do the sequences in which topics are covered, but the general character of what students experience in the classroom stays the same from school to school. Dawson Elementary School is a refreshing exception to this rule, not only because the teachers and administrators experiment with new classroom experiences, but also because they have gained excellent results in the process.

Before students finish the sixth and final grade at Dawson, they have been immersed in mathematical problem-solving, been exposed in more than a passing way to logic and mathematical applications, and been challenged repeatedly to take responsibility for their mathematical learning. Several factors converge to make all of this possible. The curriculum -- partly prepackaged and partly homegrown -- invites enthusiastic participation by the students; furthermore, the people behind the program are outstanding in their thoughtful dedication. The teachers reflect deeply and broadly about mathematical learning and they work exceptionally hard to make their vision come to life; the administration shares their vision and supports them in it.

Background

Dawson is a K-6 school located in the residential section of a small city (population circa 105,000), the home of a large Midwestern state university. The school population numbers 365 students and 13 teachers. Because it serves as the school for children of the university's foreign graduate students, Dawson has about 50 children from 25 different countries.

We were attracted to Dawson because of its test results, the involvement of students and staff in problem-solving and mathematical applications outside of class, and because of the variety of classroom problem-solving and computer activities. In particular, fifth-graders last year averaged 7.1 on the computation section and 8.2 on the mathematical concepts section of the California Achievement Test. In a district-wide test, sixth-graders at Dawson were at the top in both computation and problem-solving in a comparision with the 25 other elementary schools in the district. Students can take part in a math club, use a microcomputer laboratory before school begins, work on LOGO and BASIC in class, and

engage in "Problem of the Week" sessions which stress nontraditional problems. Dawson has taken its mathematics program well beyond the boundaries that typically limit elementary school programs, yet has managed to maintain a successful record in test scores.

Within the past few years, Dawson's school district has adopted the Comprehensive School Mathematics Program (CSMP) as its mathematics curriculum at the K-3 level in all schools. Primarily because of the enthusiasm of the principal and several teachers for the program, Dawson Elementary School has adopted the entire CSMP K-6 curriculum. That move occurred in the 1982-83 school year, and the transition demanded even more time and energy from an already generous staff. In 1983-84, adaptation to the change was complicated by a fairly bitter teacher strike in the district, which delayed the opening of school for three weeks. The dust from the strike had barely settled when we visited in late October.

Two site visitors spent three days at Dawson Elementary School. It was our first visit to an exemplary elementary school in the study and, as we entered the school for the first time, we were reminded that elementary schools can be a bit more experimental in creating atmospheres than schools for older students. In the school's foyer was a giant display case highlighting several mathematics books and problems from CSMP and from the Oregon Problem Solving Project. It was the only display in the main entryway, and it used some pleasant graphics to challenge viewers to take a crack at the "Problem of the Month", an exercise in uncovering a number theory pattern. The display was derived from a mathematics newsletter which one of the teachers sends throughout the summer to his students, challenging them to solve problems like:

"What does each set of numbers have in common?
A. 35, 56, 91, 112, 168, 2247
B. 59, 68, 77, 95, 86, 1094"

The display was typical of the efforts we observed during our visit to keep mathematics visible and perceived by students and parents as both valuable and entertaining. Many schools stress the value of mathematics but they often work from a limited view of mathematics; Dawson excels in that it transcends the usual tendency in elementary schools to locate the primary value of mathematics in mastering basic algorithms.

In many communities, the combination of a new and nontraditional curriculum with a divisive teachers' strike could be devastating to school-parent relations. Though not unscathed (several mothers approached the head of the school PTO with: "After that strike, don't expect me to be baking any cookies for the school this year..."), Dawson's mathematics staff seems generally to have retained the trust and support of parents. When CSMP was adopted, the district ran a series of meetings for parents to explain the program and to assuage fears about children's losing out on the basics. It was not clear to us how well the

communication was working elsewhere in the district, but Dawson appeared able to capitalize on the trust in the staff already established among parents, even though the Dawson task was compounded by their K-6 adoption. A fear about CSMP's coverage of the basics, such as the long-division algorithm and algorithms for manipulating fractions, arose among Dawson parents as it did throughout the district, but those parents we spoke with remarked how willing the teachers were to supplement and to send home tailor-made basics work with children on request. (One parent expressed her trust this way: "We recognize that the Dawson teachers' commitment extends beyond 9 to 4.") And many of the parents are reflective enough to recognize the value of CSMP, which seems to one parent we spoke with to be "a way of thinking about why you are doing what you are doing, and why it works."

Several mothers described their confidence in the mathematics program with strikingly similar stories: "My daughter is no whiz in mathematics, yet she's doing all right, and though she might complain about other subjects, she never complains about her math. Also, I see she can apply it in her everyday life -- in measuring and shopping, for instance."

Unlike a few of the programs we visited, which thrive almost in spite of their surroundings, Dawson's mathematics program obviously benefits from several environmental factors. For example, the proximity of the state university has its indirect salutary effects through courses taken by Dawson teachers and through the teachers' contact with university faculty. But the outstanding background feature is undoubtedly the tightly joined commitment to excellence, expressed in the open community trust in the teachers' hard work, availability, and cooperation.

Leadership

While the mathematics program at Dawson thrives in an environment that supports its rare, dual impetus toward success and innovation, that supportive environment hasn't developed on its own. The large and excellent university influences the culture of the city and the values of its residents. And Dawson Elementary School serves families that are primarily middle class and educated. (It does not, however, have the community's wealthiest parents. Several elementary schools are better off on that score.) But such conditions exist in many other American communities as well, and they do not often translate into the enthusiastic and wide-ranging support we observed around Dawson, the kind of support exemplified in a passing remark made to us by the head of the school PTO: "To apply math, you can't stick with the text." Support of that kind is born of trust in the teachers, but it is nurtured through the enthusiasm for the program of the administrators, from the principal to the district office.

The principal supports the program in several ways. A former district mathematics specialist before he became a principal twelve years ago, he is very strong on K-6 articulation. Indeed, despite our focus in the study on grades 4 and above, he insisted we visit a second-grade class to observe how the primary level children are prepared, and he accompanied us there to make sure we enjoyed it as much as he does. He is a strong advocate of CSMP and is enthusiastic about some of the effects he has observed during its implementation. ("It is not uncommon to hear applause coming from CSMP classes.") At the same time, he is proud of the supplementary activities such as the math newsletter, the math club, and the mutual relationship developed between Dawson and a mathematics/science education professor from a college in a neighboring community. There are occasional visits of the professor to do electronics and logic work with the fifth grade, and occasional visits of the fifth-graders to the professor's education classes to model their CSMP classroom activities.

The principal's stamp of leadership is on the program in several ways. He led the way to the K-6 CSMP adoption in Dawson. Partly in coordination with a district move toward subject specialization in the intermediate grades, he has moved one fourth-grade teacher (strong point: reading) away from teaching mathematics and one fourth-fifth grade teacher (strong point: mathematics) into teaching only mathematics. Finally, he has shown his trust and confidence in the teachers by minimizing his interference. They are, as we describe later, a very proud and professional group of teachers, and he treats them that way, in particular allowing several of the strong individuals on the staff to be themselves.

If the principal's role has been to allow the innovations to happen, the real impetus to ensure that they do happen has come from the district office, in the persons of the Mathematics Specialist and the Coordinator of Secondary Education, formerly the Mathematics Specialist. Both women are strong advocates of CSMP and have been responsible for its implementation. This has been a complex and challenging task in that it involved first winning over the administration, teachers, and parents, then providing each teacher with the training and support necessary to use the CSMP materials, which demand consistent nondirective questioning in the classroom and hence a special brand of teacher training. One or the other of the women visits each CSMP teacher in the district at least twice a year to extend this training and to smooth the CSMP adoption. (A second-year CSMP teacher at Dawson said she was visited by them once a month.)

Like CSMP, subject specialization has been the occasion for increased teacher training. As the district moves toward specialization at the intermediate level (currently, about 20 percent of the elementary school children in the district are taught mathematics by specialists), the two administrators have designed seven fifteen-hour courses for district

teachers. The program, dubbed the "Mathematics Endorsement Program," will be integrated into a requirement for specialization at the intermediate level. Topics for the courses are problem-solving, geometry, probability and statistics, and computers. (All of the district teachers of mathematics in grades 4, 5, and 6 have taken the computer course.) Furthermore, through these two administrators, the district encourages teachers to attend professional meetings, providing release time and substitute teachers, as well as some travel and expense money. In short, training and professional development have become essential components in the district's mathematics program.

While she was the Mathematics Specialist, the Secondary Coordinator earned a statewide reputation for her vision and for her effectiveness. She not only engineered the district adoption of CSMP, but cleared the way for teachers in the district -- and especially at Dawson where some of the best are congregated -- to push past the usual limits on elementary school mathematics and to challenge their students to be young mathematicians. Her ambition and pride have been extremely influential in the district's experiment with elementary level mathematics, and she has played a central role in fashioning Dawson as the centerpiece of that experiment.

Like other visionary leaders we met in this study, she is an opportunist and a publicist, eager to aggrandize the efforts of her mathematics teachers. On our arrival at 8:00 a.m. for a second day at Dawson, we were greeted by a reporter for the city newspaper, invited there by the Secondary Coordinator to talk with us and her about the nature of our visit, and to watch the exemplary teachers in action.

Curriculum and Implementation

The CSMP curriculum is distinctive in its nontraditional approach to teaching mathematics. Concepts are developed through the use of three visual "languages": the language of strings (Venn diagrams used to develop number concepts and a facility with sets), the language of arrows (a functional approach to operations), and the CSMP "minicomputer" (a pictorial abacus used to develop place value and other concepts). Probability, statistics, and transformational geometry also are threaded into this spiral curriculum, which places a heavy stress on mental arithmetic, pattern-finding, and analytical thinking.

Because it is so nontraditional, the curriculum could intimidate teachers and alienate parents. As noted above, however, the Dawson parents appear to trust the wisdom and commitment of their principal and teachers and, partly through the CSMP orientation sessions provided by the district, also appear to have developed their own cautious enthusiasm for the program.

For their part, the staff were well geared for CSMP when it came along. Three of the veterans had already established their own nontraditional approaches to teaching mathematics -- incorporating logic, programming, and mathematical applications such as electricity and banking into their content, along with some special attention to the student interactions that ensue when such mathematics is encountered. And, once the CSMP curriculum was adopted, none of the teachers allowed themselves to become tied to it totally. We saw a fourth-grade teacher, new to CSMP and in her second year at Dawson, who spiced a CSMP lesson with her own improvised "Facts of Five" drill. She interrupted the drill several times to ask the class what patterns they saw in the growing table of multiples of five, and the children enthusiastically bounced up and down as they recognized and pointed out patterns. When we commented to her how exciting it was for us to sit through such an innovative drill, she observed: "I couldn't have done that before CSMP. Did you see how well they do mental arithmetic and even handle negative numbers? That's CSMP."

Her attitude is typical of the staff: make use of CSMP, but don't abandon supplements deemed important. We saw a teacher of the fourth and fifth grades using activities drawn from the Oregon Problem Solving Project and Creative Publications, from the LOGO programming language, and from application activities developed by the professor from the nearby college. Two other teachers have developed their own banking and merchandising activities for the sixth grade. The widespread willingness to complement CSMP with other valuable activities gave much of the life to the vibrant program we observed at Dawson Elementary School.

Given the teachers' zeal, it is easy to miss another strong point in the program, one that is tied directly to the CSMP adoption. The individual lessons and the sequencing of lessons are such that a consistently full 55 minutes of mathematics are required every day. Coupled with the existence of a separate "Problem of the Week" session run for twenty or so students by the teacher who handles the fifth grade and half of the fourth grade, this means that Dawson students do a healthy amount of mathematics.

The introduction to CSMP, however, apparently was rough for several teachers, for several reasons. They felt that the time spent with them in training was inadequate, especially with regard to supplementing. As we described above, the job of supplementing CSMP is proceeding smoothly enough, but it has cost the teachers in terms of time and strain. One teacher told us how she had realized during the administering of an assessment test, to her grief, that her students were unfamiliar with the long-division algorithm, so she called a halt to the test-taking long enough to give them a brief lesson on the algorithm. Another teacher, though a strong CSMP advocate, described himself as "buried in work" due to his supplementing. The CSMP program has obviously engendered a mixed reaction from the teachers. By dint of its focus on open-ended and critical thinking, it invites creative supplementing by the teachers, and

they seem to welcome that. On the other hand, some of them chafe when they find themselves expending energy to fill in gaps in the program that they refuse to gloss over. Dawson is in a curriculum quandary that will not disappear quickly, but it is testimony to the dedication of the teachers that excellence continues unabated.

Teachers and Teaching

The mathematics teachers at Dawson devote themselves to their craft in ways that seemed classic by the time we completed our site visits to exemplary programs. Like their counterparts elsewhere, they use time superbly, go to pains to minimize failure and to maximize expectations for success for their students, and maintain a staunchly professional posture.

In the seven mathematics classes we observed, we saw precious little time wasted. The non-mathematical items that were dealt with were dispatched quickly. ("I know you have Halloween candy from your Trick or Treating last night. I don't want to see or hear it"). Furthermore, every teacher used a variety of questions and used them frequently. ("Can someone give me some other names for 3/4?"; "How did you get that?"; "Is 56 a multiple of 10?"; "Who can give me a number less than -10?"). Even the fourth-grade "Facts of Five" drill was elevated from the mundane task it usually is to a dynamic give-and-take through the teacher's questions and her stress of patterns.

Ironically, the strong pedagogical skills of the staff have grown from what one sixth-grade teacher described to us as two different educational philosophies. In his opinion (and in ours, too, on the basis of our brief visit), the fourth and fifth-grade teachers built their style around the mathematics and mathematical problem-solving strategies derived from CSMP, LOGO, the Oregon Problem Solving materials, and so on, while he and the other sixth-grade teacher placed a heavy emphasis on the role of "affective education in cognitive learning." They come by their focus on affective learning naturally: one is a former clinical social worker, the other a former staff member of a hospital for emotional disorders. One result of their emphasis on affect is open attention in the classroom to the issue of student responsibility, as in the following comments and questions we noted in one class:

> "I see the same hands up. Some people aren't working."
> "How many of you are uncertain whether this is a review?"
> "These are the kinds of side issues about fractions which you need to consider."

The second sixth-grade teacher, on leave this year to develop computer materials for the district, gave her own assessment of the philosophical underpinnings: "We are very success-oriented. We want the kids to feel successful." She described for us their efforts to "take the challenge posed by students coming into the sixth-grade with their preconceptions

about who is good and who is not," in particular, seizing opportunities to highlight the good test results of those who are seen as low on the totem pole.

The sixth-grade teachers also employ an imaginative technique they call "the 100 percent clue." If a student turns in a paper containing a mistake, one or the other of the teachers says something like, "You have one mistake; I'll give you 3 1/2 minutes in which to find it, correct it, and earn 100%." "Sooner or later," they told us, "that student is turning in a 100% paper." The teacher on leave went on to tell us: "We try to assess student needs every six weeks or so, and make changes accordingly. We will ask in class, 'Who wants a review'?, then split the students up between us. One of us will take the review students, the other will take the rest for a day or more of enrichment. We trade the review and enrichment groups occasionally and, when we do that, we renew ourselves as teachers."

This conscious effort to take care of themselves while they take care of their students is typical of the professional posture and cooperative attitude of the Dawson teachers. Theirs is not a unified sense of collegiality, as it is in many of the programs we visited. The two different "philosophies" legislate against total unity. Yet there are sharing and cooperation, nonetheless. The fourth-grade "Facts of Five" teacher, who is in her second year at Dawson and who has taught in four other schools in the district, proudly told us how teaching magazines are circulated around the staff, and that they are read and discussed. She remarked how freely materials, ideas, and ditto sheets are shared among staff members, a significant change, she said, from the jealousy she experienced in other schools. Nor does this strong professional stance stop with the mathematics people. A fourth-grade teacher who teaches no mathematics is a former language arts specialist and program planner for a professional reading organization.

The staff commitment to professionalism had one manifestation we found especially touching. Because he has become convinced of the value of LOGO, the fifth-grade mathematics teacher purchased two Texas Instruments microcomputers and the LOGO software with his own money and placed them in his classroom. (The school makes available a lab with six Commodore Pets, under the librarian's supervision, for use before and after school.)

Despite the sharing of ideas and materials among teachers, the communication patterns need honing. The sixth-grade teachers feel very independent and self-reliant in the implementation of their affective educational goals; the fifth-grade mathematics teacher is intently focused on his use of CSMP and his supplementary computational, problem-solving, and LOGO activities. There is, however, little talking across the two grade levels. Consequently, two "educational philosophies" that needn't be in conflict are left to appear that way. The rift is not great and does not threaten the program, but we were left wishing it weren't there and wishing that the principal would take a hand in improving the staff communication.

Despite the lack of coordination between the two "philosophies," Dawson students seem to thrive through the double challenge. Before they reach the sixth grade, mathematics classes are full of mathematical challenges. During our visit, for example, the fifth-grade teacher challenged them with materials on the logic of and/or gates, using a calculator as a model, and on set concepts from the rather sophisticated Elements of Mathematics Program from CEMREL. His high expectations and enthusiasm for such activities have been contagious enough so that a handful of students now subscribe to the magazine, Oregon Mathematics Teacher, and maintain a watchful lookout for good problems.

In the sixth grade, the mathematical challenge is still alive for the students, but it takes on a flavor of self-knowledge. Classroom interactions now guide them toward recognizing the extent of their responsibility in learning mathematics -- when to ask for review, how to eliminate carelessness, and so on. Although the staff and program would benefit from weaving the two approaches together, the present situation suffices to give the Dawson students far more than is the lot of their peers in other schools.

The trend toward subject specialization has brought several new tensions to the Dawson program. Only one of the teachers specializes in mathematics; he teaches mathematics to all of the fifth-graders, as well as half of the fourth-graders. But two fifth-grade teachers teach no mathematics at all, and the school was unable to go after a replacement for the sixth-grade teacher on sabbatical because, as is the case every year, the final number of students was not settled until the foreign graduate students moved to the state university in late August.

Consequently, we saw mathematics classes as large as 42 and 45 students (as well as a few in the low 20s). The teachers of the large classes we observed did a remarkable job of keeping students on task, of maintaining a continuous flow of work, and of involving students with open-ended, as well as single-answer, questions. Even so, in each of the two largest classes we visited, we estimated at least 20 students who gave no indication during the hour whether they understood or were totally confused. Furthermore, a few occasional student comments, indicating either misunderstandings or good insights, were ignored. The return next year of a second sixth-grade teacher should mitigate some of the problems of class size, but neither the principal nor the teachers expressed concern when asked about the effects of size. Such is the confidence in their teaching skills, yet we thought their lack of concern short-sighted.

Nor does the specialization sit well with those who no longer teach mathematics. One of them remarked that she missed the flexibility allowed in the self-contained classroom, the freedom to expand or contract the amount of time devoted to a particular subject depending on need. She also remarked that she missed teaching mathematics, though her shaky and frustrating introduction to CSMP, with what she saw as inadequate training and several materials foul-ups, had convinced her to step aside.

So, all is not smooth in the Dawson mathematics program. With the CSMP adoption and the trend toward subject specialization in the district, together with the stress brought on by this year's strike, the program's flow has run into a few rough spots. Yet there is no threat to the program: the talent, energy, and integrity of the teachers are too strong, as are the support and trust all around them. Their challenge is not to survive, but to fashion their experiments with CSMP, with specialization, and with supplementary activities into a program that is even more exemplary than the one we visited.

Summary

In The Good High School, Sarah Lightfoot makes the point that conscious change is a hallmark of good schools. In order to improve, a school must choose its goals, choose its methods, and attend carefully to both. Like the other programs we visited in our study, Dawson Elementary School exemplifies such conscious change, yet in its ambition and innovation, it far exceeds the standards for conscious change set by most good mathematics programs.

The teachers who make the program thrive are webbed in support from all sides -- from the nearby college and university with their intellectual support, from the parents with their trust, from the principal with his pride and moral support, and especially from the two district administrators with their respect, encouragement, and material support.

Without any doubt, however, the strengths of Dawson's mathematics program flow from the strengths of the teachers -- their hard work, their reflectiveness and expansive thinking, their high expectations for themselves and their students. They have an image of themselves that is far grander and more professional than is typical for elementary school mathematics teachers. And they picture the young people they teach as much more than mere repositories of information; to them, they are young explorers who can be challenged to their limits in both mathematics and self-knowledge.

SAMPSON MIDDLE SCHOOL

"We believed in the idea that what was wrong with much of public education was the failure of responsible people to make tough judgments."

Superintendent, Sampson Public Schools

The tough judgments in Sampson were made by the school board and the superintendent, but when it came time for action, they brought in participants from every group that had decried Sampson's educational mediocrity. Teachers and administrators were enlisted to transform the curriculum, and citizens with a penchant for tutoring or for running supplementary programs were invited to become part of the new order. The editor of the local newspaper became an active ally, as well as monitor, in the process of change, and through his efforts public interest swelled and support was sustained at the polls. The results have been phenomenal. In seven years, the system, and the middle school's mathematics program in particular, have been propelled to excellence.

Two site visitors spent two full days at Sampson Middle School. We observed classes, interviewed all of the seven mathematics teachers, a few of their students, the superintendent, the principal, the assistant principal, the two school guidance counselors, and the district coordinator of gifted education. The picture of Sampson's success described by all of these individuals was consistent and it was simple: a fully cooperative effort to design and carry out changes mandated by the school board at the superintendent's request, has led to a deep sense of ownership of the program on the part of teachers and other staff, and high expectations for success among the whole community, including students.

Background

Sampson (population 35,000) is a suburb of a large Northeastern metropolis and contains an even mix of blue-collar middle class residents with white-collar middle to upper middle class residents. It is a slight anomaly among communities along the Bo-Wash Corridor, in that it is a very stable community ("People live and die in Sampson," we were told by one of the school's guidance counselors), with two-thirds of its population married couples with children, and fully 80 percent of the high school's graduating seniors composed of students who attended kindergarten in Sampson. There are some blacks, Asians, and Hispanics in the town, but Sampson is predominantly white and has a large and well-established Italian-American community.

Sampson Middle School comprises grades seven and eight, and is the only junior high school in the town, taking students from five public and two parochial elementary schools. There are 635 students and 48 fulltime teachers in the school, with 7 teachers specializing in mathematics. The school has a distinctly safe and orderly aspect, enhanced by its age and

grace. It was built in 1927 and retains that substantial look and feel of buildings from that era, sporting carefully maintained WPA murals in its spacious auditorium, large new windows throughout, and hallways which are immaculate and very, very quiet. It is an environment that invites visitors; parent groups and civic groups reportedly use the auditorium frequently. It is also an environment that encourages serious and businesslike attitudes in students and teachers. As one mathematics teacher who has taught in other schools told us, "It is a joy to teach in a school where students know they are expected to work."

The Sampson community attends to its schools as much and as carefully as any of the communities we visited. Its concern as well as its stability are reflected in the nine-member school board, whose members tend to stay in office for two terms or more. The current president has been on the Board for 10 years; the man who had been president until two years ago was on the Board for 29 years. More important than members' longevity, perhaps, is their rejection of the aloofness that so often defines school boards' relationships with schools, exemplified by their invitation to students who score 100 on the district mastery test to each June's board meeting for recognition and praise. The newspaper editor, Tom Larsen, provided some special insight into the Board's interest and commitment. He has covered every school board meeting in the town for years and can contrast what he has witnessed there with what he knows is the norm in board meetings in similar towns. "Other school boards are likely to take up entire meetings arguing about who let whose brother get the plumbing contract in a particular school, or something similar. In Sampson, the meetings are almost always focused on education. Just last week I went to a meeting where they were discussing the possible adoption of a new science textbook. It appeared that every board member had read the book!" Larsen provided another insight into the background of the mathematics program we were studying. In a state where political corruption is not rare, Sampson has not had an incident of corruption in the municipal government in over 50 years.

School support flows from the community in other ways besides the school board's attention, some invisible, others visible and serving to perpetuate the aura of excellence. A cadre of 35 senior citizens present one quiet, if not invisible, line of support with their tutoring program in the elementary schools. The local newspaper editor provides a more visible means of support through his paper, a vehicle that he has used as a staunch supporter of the schools (and especially of the superintendent) in their recent rise to excellence. He ran one editorial and two front-page articles hailing our visit to Sampson Middle School, and in the second article he announced that his paper would sponsor a "Pride Day Banquet" for the seven mathematics teachers at the school and coupled the announcement with a picture of the teachers. Since our visit, and mostly in response to it, an Academic Boosters Club has been formed in the town, composed of prominent citizens who want to highlight excellence in their schools. In post-visit communications with me, the superintendent proudly opined, "We are probably the only town in the state with an Academic Boosters Club."

In a way, the state's governmental structure has made it possible for the entire town to show its support. Every municipality in the state votes on its school budget, and in Sampson that has meant deciding on how important class size is and how valued individual teachers are. The principal of Sampson Middle School acknowledged the astounding support of the community and Board when he told us: "In my seven years, I haven't had to "rif" any mathematics teachers, even though the school has shrunk from 810 students to 635 students." As a result, mathematics class size in Sampson Middle School averages around 20 students, a luxury everyone seems committed to defend.

As in all the communities we visited, we concerned ourselves with the intensity of parent involvment in the Sampson mathematics program, wondering how strong a factor it might be in the excellence of the program. Parents do involve themselves in the Sampson Middle School mathematics program, but the intensity of the involvement seems proportional to the level of the students: the lower a student is tracked, teachers told us, the less responsive are his or her parents to progress reports and other feelers sent home.

This news seemed only a slight bit of tarnish on an exhilarating picture of community support, yet the support, like the rise to excellence, has been a recent phenomenon in Sampson. Seven years ago, the town was forced by its new superintendent to look at its relatively low standing in test scores, in both local and state comparisons, and the shock and shame that was generated led to calls for change and, in the superintendent's words, "tough judgments." Of particular concern were the following statistics: sixth-grade students were testing at about the 67th percentile in the state basic skills test in mathematics; seventh graders were testing at the 41st percentile in total mathematics in the Iowa Test of Basic Skills (ITBS); and eighth graders were testing at the 39th percentile in ITBS total mathematics. At that point, the current superintendent was given the fiat to make changes, and changes began to take place.

Seven years later, the transformation has been amazing. Sixth graders now test at the 99th percentile in the state basic skills test and the seventh and eighth graders test, respectively, at the 99th and 97th percentiles in ITBS total mathematics. (Note: While this case study was being prepared, the 1984 ITBS scores arrived, and both seventh and eighth graders are now scoring at the 99th percentile.) Also, while 25 students took eighth-grade algebra in 1978, the number has now climbed to 69. Furthermore, in the words of the Sampson Middle School principal in his application for selection in our study: "In addition to testing, ninth-grade course selections are another indicator. The last two years have seen an increase in the number of eligible eighth-grade algebra I students who select accelerated algebra in grade nine (an increase from one-third to one-half), and this year, the first year of prealgebra in grade eight, almost all prealgebra students have enrolled in ninth-grade algebra I." During the same period, the numbers of students in the lowest, remedial track have been reduced by half, important testimony to the universal nature of the rise to excellence.

Leadership

At Sampson, as at every site we visited, we looked for the stamps of leaders -- behaviors and decisions that have had an annealing, nurturing, or guiding effect on those who have made the mathematics program as good as it is. Given the evident and carefully planned nature of Sampson's rise to excellence, the groundswell rising from the "tough judgments" at the top of the administration, it was clear to us that leadership would be a prevalent theme in our interviews and observations. Though the primary decisions were made at the top, others in the district have shown the force and influence on the program of their own behavior and decisions. The principal, Anthony Parente, maintains such a low profile in Sampson Middle School that a third-year mathematics teacher told us: "He sat in on one of my classes last year, and I didn't know who he was." And yet it was clear to us, as it was to that teacher, that the comfort and safety in the school environment and the very businesslike expectations, were the direct results of Parente's firm control. He has also assumed the role of a middle-level officer -- a captain or major -- in the superintendent's campaign for excellence, participating with his teachers in Saturday planning sessions, even though administrators, until recently, have been unpaid for those efforts.

At another level of leadership, the two guidance counselors in the middle school have taken steps to ease the burden on the mathematics teachers. They meticulously nurture the articulation of the mathematics program with the elementary schools, and they are assiduous in defining a role for themselves as a buffer between parents and teachers. (Every concerned or complaining parent is routed through the guidance office before talking with teachers.) In so doing, they have earned the deep trust and gratitude of the staff.

The mathematics chairman, who is a lawyer and is also the union representative in the school, helped to lead the district teachers in a spirited, though relatively rancor-free, struggle for a 19 percent raise and "the best contract in the county" several years ago. He receives no additional pay as chairman, and his leadership is not as pronounced as at some other schools we visited, though his presence seems solid and his influence real.

Of course the preeminent leader behind the rise to excellence of Sampson's mathematics program has been the superintendent, Martin Langone. When he began his tenure, he decided to focus the district's attention on changes in the K-8 mathematics curriculum, and to fashion those changes after a "top-down philosophy" -- that is, the belief that a concentrated effort to improve expectations and achievement among top level students would eventually filter down and improve expectations and achievement among all students. At this point a decision was made that Langone, Parente, and the teachers all agree was crucial to the Sampson turnaround. Offered $40,000 by the school board either to hire a curriculum coordinator for the district or to find a workable way to use

existing personnel to revamp the curriculum, Langone chose the latter. In so doing, he set two pillars for support of the excellent mathematics program that emerged several years later: he began the building of a committed team and he gave them a clearly defined goal -- to revise the curriculum, piece by piece, so that test scores would rise. "I showed the teachers the test scores from some of the surrounding districts -- all higher than our scores -- and they got fired up to make the necessary changes."

Curriculum and Implementation

To capitalize on their eagerness to improve the scores, he commissioned a committee of K-6 teachers to meet on Saturday mornings to recommend mathematics curriculum and textbook changes. Various texts were scrutinized and textbook sales people were invited in to make presentations; when the candidates were reduced to four, every district teacher tried out all four. A poll led to the final choices. Next, the district paid teachers from grades one through eight $15 an hour to meet on ten Saturdays to revise the curriculum and to develop tests that reflected those changes in the curriculum. Parente met along with his mathematics teachers, and the tests they designed were deliberately designed to be tougher than the state skills test. According to Parente: "When the staff had a chance to make the tests easier, they chose not to." To add fiber to the resolve emerging in the district, the superintendent mandated a district-wide policy of a minimum of one half hour of homework a night.

The mathematics program at Sampson Middle School has five levels. The top level comprises students who have been identified as especially talented at the end of grade four and who then take part, in grades five and six, in a Saturday enrichment program called the Cultivating Academic Talent Program, a program whose first teacher, sleeves rolled up and acting like the former mathematics teacher he is, was the superintendent. ("I wanted to show the teachers that these talented kids could handle more sophisticated topics like algebra.") At the lowest level, the school and the district are proving that their commitment to improvement is universal. There are 4 teachers and 1 supplemental teacher for 57 students and, as we noted above, the numbers of students at this level keep diminishing.

Is the "top-down" approach working? All of the people we talked with are convinced it is working very well. They point to the halving of the number of students in the bottom mathematics level. They also point to the fact that the third level of the eighth grade now uses the textbook used by the the second level until last year. A seventh-grade teacher told us that her incoming students now seem better prepared in computation, so she has the luxury of doing more geometry with them. The department chairman, who teaches the top-level eighth-grade (algebra) class, acknowledged that the kinds of word problems being covered by the teacher of the top-level seventh grade (prealgebra) are not very

different from what he customarily uses with his group. Thus, he says, he will have to look for ways to supplement and enrich his algebra curriculum, because the students coming through the program are better prepared. "Also," he added, "there is no way that we could have devoted two weeks to computer literacy several years ago," referring to this year's decision to give every seventh grader a two-week computer literacy mini-course as part of the regular mathematics courses.

Articulation of the curriculum across grade levels has been a natural outgrowth of the planned improvement in Sampson. The cooperative across-grades spirit begun by Langone in the Saturday meetings has been continued by Parente, the middle school principal, who involves high school department heads in the middle school curriculum development -- again on Saturday mornings. Despite her primary focus at the fifth and sixth-grade levels, the district coordinator for the gifted has conducted two-week training programs with all of the middle school teachers to prepare them for teaching gifted students. The two middle school guidance counselors consult with every sixth-grade teacher in the district, discussing test results with them and listening to their recommendations for placement. Furthermore, as the guidance counselors pointed out to us, the improved record of success at the elementary level (test scores have been rising there, as well), along with the four-year-old homework mandate throughout the district, has instilled a set of higher expectations in incoming seventh graders.

The guidance counselors seemed an especially important part of the maintenance of success at Sampson Middle School, more important than their counterparts at any other school we visited. At the beginning of each year both guidance people sit down with teachers and talk about incoming students -- what to expect from the group of incoming seventh graders, which students have family problems, which students have special needs, and so on. Both are veterans, former teachers who have been working in Sampson district schools for at least a dozen years, and they defy the popular image of guidance counselors as feckless and bored -- they obviously enjoy their work and enjoy working together; indeed, each talked of drawing inspiration from the other. They are strong advocates of the teachers and, whenever they can, they act as buffers and interlocutors between parents and teachers. ("The average amount of time we spend each day talking with parents is greater than the average time we spend talking with students.") Mathematics is a primary focus for them: "We spend more time on mathematics than on other subject areas because the students are so homogeneously grouped in the five levels, and so are more difficult to place." The attention to mathematics apparently has spread beyond course placement, as the two counselors indicated they seek out the mathematics people for lunchtime company. It was clear that they are appreciated by the mathematics teachers, one of whom said she doesn't hesitate to go to them for help, describing them as "very efficient in calling parents and backing us up."

The mathematics curriculum in Sampson Middle School is typical of most schools in its dependence on textbooks, especially typical in its dependence on those American standards, the Houghton-Mifflin series. The lowest level is somewhat exceptional in that the students we observed used worksheets in their classroom work. Another exception is the two-week computer literacy subcourses each seventh grader takes, using the four Apples and the handful of terminals owned by the school. Unfortunately, however, we saw very little in the way of enriching content in the mathematics courses, even at the top level. Perhaps it is a result of the intense focus on test-score improvement, and in that case, understandable, but we were saddened to watch such motivated students carefully toeing the line of textbook learning. Apparently, however, the opportunities for enrichment are growing, as the department chairman indicated to us in his portrayal of the improved mathematical background of his incoming eighth-grade algebra students. Other teachers remarked on their increased confidence in introducing algebraic concepts to middle level students. If the superintendent, the principal, and the teachers follow through completely on their commitment to the "top-down philosophy," they will let the spirit of the Saturday program for gifted fifth and sixth graders filter through the five middle school levels of mathematics. The Saturday program is now taught to 48 students by a local resident who teaches at a nearby university and who is introducing innovative topics on Saturdays in a "risk-free environment." The same opportunity ought to be available to all students.

Extracurricular mathematical activity has been modest at Sampson Middle School. About 20 students ("the whizzes", as one teacher described them) constitute an after-school club that does fairly well in county competitions. But, at the time of our visit, Parente and his staff were eyeing a more active role for the school in mathematics competitions and, indeed, we were informed several months after our visit that a Sampson Middle School team had made its way to the state finals in the Math Counts competition. Principal Parente, who passed on the information to us, was delighted with this new arena in which to strive for excellence.

Teachers and Teaching

Tough decisions, careful planning, and strict adherence to goals have propelled Sampson's mathematics program upward. Another very important factor has been the quality of the mathematics staff at Sampson Middle School. About half of them are certified K-8 and the others are certified 7-12; two have taught in high school. As one of the teachers pointed out to us, this balance of perspective adds strength to the department. There is another facet of the department, however, which seemed especially important to the success of the mathematics program. Not only did the teachers make good use of class time, reviewing homework and engaging students in mathematical activity from start to finish in each class period we observed, but they also were consistently among the most empathic teachers we observed in our site visits. The quote that best capsulized the empathy for us was spoken by a third-year teacher at

Sampson, a candidate for a master's degree in computer science, who apparently thrives on her teaching of the lower level students: "I know what it's like to be freaked by tests." We watched her, with arm around their shoulders, cajoling these students, especially the girls, to sit down and introduce themselves to the very basics of computer use.

Another teacher, who teaches the lowest level of all, and who managed in a lesson on metric measurements to engage a group of eighth graders in a fairly active discussion, impressed us with his respectful and supportive behavior with the students. He told us, "There are days driving to work when I find the prospect of reaching this lowest level class pretty gloomy, but then I picture my own children. I treat these kids as I would want my own kids to be treated." In the class we observed, he was true to his ideal, reviewing homework exercises with the ten students in the class, moving about enthusiastically, appealing to a chart of conversions on the blackboard, prodding with hints ("What's 3/10 of 100?"), all the while making it clear that he would not deviate from minimum standards ("Stay with us, Ben."). In the last part of the class he told them to try a set of conversions on their own. We were impressed with the diligence all ten students showed in attempting the exercise, again with the teacher moving about, helping, but we were even more impressed when he asked, "How many got them all right?", and only one girl raised her hand. No disappointment crossed his face; no disapproval entered his voice. Their effort obviously sustained him and he showed them respect; they, in turn, repaid him with their trust and honesty. In other teachers' classes, we could infer the consistency of their respectful and empathic behavior by the willingness of the students to pipe up with comments like, "That's where I made my mistake," and "I don't know how to set up this equation." It was clear to us, after our visits to all the teachers' classrooms, that they have set up a consistently risk-free environment for mathematics students at Sampson Middle School. They make clear their expectations that the students will try, and when they do, they are rewarded with respect and approval.

Although we were impressed with the lack of wasted class time in mathematics and very impressed with teachers' empathy and their respectful and supportive tone in the classroom, the teaching strategies we observed were generally uninspired. Questioning usually consisted of one-word answers and there was little engagement of students in discussions about their mathematical understanding. More typical were questions that mirrored the flow of textbook prescriptions, such as: "Chris, why did you label the car first?" . . . "Because it had the least information." Textbook prescriptions are not harmful in themselves, but they can be wasteful and misleading when they totally replace questions that probe students' thinking. Consequently, we were left wondering how much students really understood of what transpired in the classes we observed, and we were left wishing that the staff at Sampson Middle School didn't rely on tests as much as they do for their gauge of student understanding. They and others in the community have asked the question, "what is excellence?", have answered it, pursued it, and achieved it. Now it is time for them to broaden their answer.

Summary

On the whole, a multitude of positive factors far outweighed the drawbacks of the mathematics program at Sampson Middle School. The superintendent has parlayed a stable and supportive community, a bright and committed staff, and a universal willingness among school people to engage in cooperative improvement, into a successful program in which almost everyone can feel some ownership. It has been a solid accomplishment. As one of the newspaper editorials, addressing education in Sampson, put it in its headline: "Tradition of Excellence Going to Stay."

DEER RUN

"Results follow perceptions. The way to improve a program is to change people's perceptions first. Then good results will follow."
Former principal, Deer Run High School

"Mary works very, very hard for the program. American education is heavily subsidized by underpaid women like her."
Present principal, Deer Run High School

By standards set at many urban and suburban schools, Deer Run's high school mathematics program might not be considered exemplary at all. Relatively few courses are offered and, while test scores are good, they do not shine very brightly when taken out of context. Context was important in our study, however, along with absolute standards for excellence; we sought out programs that far exceed expectations for success in their particular settings and with their particular students, as well as programs that would meet anyone's criteria for success.

By this standard, Deer Run was a welcome addition to our study, an exemplar of an important yet fragile commodity in this country -- successful mathematics programs at tiny rural high schools. Like the small farms that surround them, these programs usually have meager financial resources, and they struggle. With the spreading teacher shortages in mathematics, their struggle has become especially acute: often, the well-being and even survival of a program revolves around one person. Should that person leave the program or become ill, the students must do without all but the most basic of mathematics courses until a substitute can be found, someone who has the appropriate background and is willing to work in a small town for light pay.

Deer Run has shown that one way -- perhaps the only way -- out of mediocrity for such programs is a combination of enlightened leadership and dedicated teaching that, together, squeeze the most out of available resources. The leadership found a mechanism -- team competitions -- to convince the school and even the Deer Run community that there was more potential for success in mathematics than they believed, and the teaching took a bit of newfound success and worked it into an expected pattern. Now test scores and course enrollments are up, spurred upward by the general enthusiasm for mathematics competitions. The drive to overcome mediocrity in Deer Run's mathematics program is by no means complete. There were rough spots -- for example, some of the teaching behavior we observed -- that cut down on the program's glitter for us. Even so, all of the problems we noted are surmountable, if conditions continue to invite the staff to experiment with improvements. Those conditions are anything but assured. The fragility that haunts much of rural education continues to hover over their established pattern of success and makes Deer Run's struggle to sustain their success an especially heroic American educational story.

Background

Deer Run is a small Midwestern town of 1,100 people, set in the middle of corn and soybean fields. No building in the town exceeds three stories except for the grain elevator and that, in classic fashion, looms for miles from its perch next to the railroad tracks. The houses along the main street, all freshly painted white in celebration of the town's 150th anniversery, add to the town's special, simple appeal.

Mr. Atkinson, the high school principal, described Deer Run as filled with "a strong Protestant ethic and Dutch blue-eyed conservative families." It is a stable community, as well -- 75 percent of last year's high school graduating class were schooled in Deer Run since kindergarten. Most of the high school's 18 teachers are also from the immediate area. Familiarity and roots are about the only attractions that can offset the town's low teacher salaries.

Though Deer Run is small, its school district covers a 62.5 square mile area. The high school contains 190 students in grades 9 through 12, most of whom live on farms in the area. The demands of farm life, coupled with the distances traveled to and from school, understandably cut into students' attachments to school. In addition, the common practice of passing farms from parents to children has traditionally cut into school ties even more, especially as those ties were linked to postsecondary education. But lately there has been a turnaround in Deer Run. When Sam Walker, Deer Run's former high school principal and superintendent (and now superintendent in a larger, neighboring town), took over the high school 9 years ago, only 4 of 45 graduating seniors were going to college. In 1982-83, 18 of 39 chose to continue their education beyond high school.

In a community like Deer Run, which has few college graduates besides its teachers, such a change is revolutionary. In part, as a November 1984 series in the Wall Street Journal made clear, the change can be explained by the social fabric changes in farm communities in the past decade. Farming remains a viable life for fewer and fewer young people, and they are obliged to look to other careers. Even so, an hour's conversation with Sam Walker is enough to convince a visitor that social forces alone have not made the difference in Deer Run. His pursuit of change has been vigorous and intense, and the pursuit has touched mathematics more than any other subject.

The mathematics department has 1.5 teachers: the fulltime person, Mary Vandenburg, teaches general math, algebra I, algebra II, precalculus, and a double session of computer science (BASIC); the half-time teacher teaches business math, algebra I, and geometry; a course in Fortran is taught by one of the science teachers. Two aspects of the mathematics program made it particularly attractive for a site visit. First of all, nearly 80 percent of the students were enrolled in at least one mathematics course. Second, in state and local competitions, the school has fared well, despite the fact that, as Principal Atkinson told us, "In every math, computer, or biology tournament we enter, we're the smallest school." Like the increase in college-bound students, these two changes have been relatively recent.

Mathematics competitions have become Deer Run's ? ver to success primarily because of Walker's zeal and Vanderburg's hard work, but another factor has also helped. The state mathematics teachers' association is one of the most active in the country in organizing competitions on all levels -- local, regional, and statewide -- and they do a remarkable job of publicizing and generating enthusiasm for them. "They get the maximum out of what has to be a meager budget," Walker said. "But it works. People are generally aware of the competitions. Around this area, if you win math competitions, they think you have an excellent program."

Leadership

Walker mused about the value of perceptions as he sat with us in his office in a nearby town, where he had recently begun as superintendent of schools. It is a larger town than Deer Run, with a more diverse population, a wider range of interests, and more complex problems, yet he is already priming his high school's mathematics team to win. With a mixture of pride and disappointment, born of his old and new ties, he reported that the team had just placed second to Deer Run in a county competition.

He is confident, however, that history will repeat itself, that once again his intuition is correct: if visible improvements occur (in this case, a steady climb in competitions), then he, as leader, can change the school's and community's perceptions of their mathematics program. At that point, he will be able to spring from their changed perceptions into demands for more improvements. "I am more sure than ever," he told us. "Results follow perceptions."

On the scale that Walker experiments with his "Results Follow Perceptions" notion, only small towns would seem to qualify as laboratories. Larger settings carry too many variables, too many people to allow his kind of frontal assault. But we did see the phenomenon at larger schools, expressed however, in more subtle forms: mathematics staffs that make themselves more visible in their schools and communities than other departments by their extraordinary availability to students, by their exceptional efforts to work with feeder schools to unify programs, as well as by their well-publicized successes in competitions. In various settings, principals and superintendents told us such things as: "They're our stalwarts." "They're my hardest working department." "I try to give them what they ask for. They earn every bit of it." For their parts, the exemplary mathematics programs do ask more, and also demand more of themselves. It is not their nature to rest on laurels, and it is generally not in the nature of their leaders to let them rest on laurels. Walker was principal and superintendent, not department head, but his leadership toward visibility and affecting perceptions has its manifestations in other exemplary programs, usually, in high schools, through department heads.

The program at Deer Run apparently lacked any lustre until seven years ago, when Walker had an idea and took some initiative on it. His idea was as

simple as it was forceful: first, he would guide the program to some gains; then he would turn the community's favorable impressions of the gains into fodder for further gains. The particular route he chose was through mathematics competitions, because it was relatively inexpensive and because it lent itself to visibility quite readily.

At the beginning, he worked with a teacher at a local junior college to locate as many collections of mathematics contest problems as they could lay their hands on. He then engaged Mary Vandenburg, the fulltime mathematics teacher then relatively new in the school and new to teaching, to work on developing a math team by using the contest problems in her courses. They expected a modest, if not humbling, beginning to their contest results. But Walker told Ms. Vandenburg to aim to move up one place per year, on the average, in local and state competitions. After a few years, when that had begun to happen, he went to the school board, improved results in hand, and persuaded them to raise the mathematics requirement at Deer Run High School to two years. In the meantime, he acted, in his own words, "like an athletic coach." He and Vandenburg identified 10 or 15 talented students in each grade of the high school and began to groom them for the team, even in some cases, asking athletic coaches to release students early for mathematics competitions.

In 1983-84, 33 of the 190 students were involved in mathematics competitions. In previous years, the number has been as large as 50. Enthusiasm for the competitions is so keen that students who aren't even enrolled in a math course come to Ms. Vandenburg to ask if they can be on the team. The new principal, Mr. Atkinson, a former engineer and mathematics teacher, has been bitten by the contest bug and so continues to support the school's involvement in mathematics competitions. (As we arrived the first day of our visit, he was in the hallway posting the results of the most recent contest, in which Deer Run nosed Walker's team for first place.)

With Sam Walker gone, and Ms. Vandenburg comfortably settled into the mathematics program after eight years, Atkinson's role in the continued success of the program is somewhat secondary, but his enthusiam and support are important. And he too is getting ambitious. "Pretty regularly, we have a small handful of students who can handle all the mathematics we throw at them. We need something to offer them. I've asked Mary to look into the Elements of Mathematics program for them." This program, called EM for short in the mathematics education community, is a program that has been adopted for use with gifted students in St. Louis County in Missouri, and elsewhere. To us, it seemed a surprisingly ambitious choice, but it fit nonetheless into the fervor for mathematics that has bitten the Deer Run community.

One other note on Atkinson: his wife and home are fifty miles from Deer Run in the suburbs of the nearest major city, where his wife is a school administrator. He rents an apartment near Deer Run during the school week and returns home for weekends. "I left engineering for education in middle age and got involved in a doctoral dissertation on school climate and school improvements. When the job opened in Deer Run, I took it because of the real

school improvement that has been going on here." Obviously his interest in the program is no longer clinical, and his chosen life in education, with its hardships and sacrifice, makes a heartwarming story, one that fits nicely into the broader Deer Run picture that unfolded for us.

The school community and, indeed, the entire Deer Run community, now share in the pride and support of the program. The school librarian, a former mathematics major in college, makes herself available to students for math tutoring in the library. The woman who until last year was the school guidance counselor had a reputation for careful attention to placing students in mathematics. She occasionally used the results from the Differential Aptitude Test to have selected students reverse the usual order and take algebra II before geometry, if they seemed from their test results to be unprepared for geometrical thinking. She also established a reputation for encouraging girls in the middle school and the high school to think beyond nursing and school-teaching as possible careers. (A parent: "My daughter used to think about nursing. Conversations with Jean directed her toward engineering. Now she wants to be an engineer.")

The middle school now has its own math team. Through its carefully designed set of objectives for its mathematics curriculum (really an unofficial mastery learning program) and through its sharing of a teacher on a half-time basis with the high school, the middle school has established some continuity with the high school program.

The town is well aware of the math team. When Mary Vandenburg wanted to send an especially talented student to a competition in the East last year, she garnered some financial support from the Lioness Club in Deer Run, additional support from a town merchant, and the rest from school funds. The student was able to go to the competition. (By all accounts, it appears he was an exceptional student and a source of local pride. He is now at MIT, and three or four of the school's teachers avidly shared anecdotes about his experiences at MIT with us over lunch.)

One further anecdote caps the story of the math team in this tiny community. The district's new superintendent told us how, on the evening of the most recent competition, he was roused from supper by automobile horn-blaring and the ringing of his doorbell. "I really didn't know what was going on. When I opened the front door, there were Mary and the team waving and flashing their first-place ribbon."

Curriculum and Implementation

Not surprisingly, competitions are on Mary Vandenburg's mind as she manages the Deer Run mathematics curriculum and implements it from day to day. (The curriculum is really her responsibility alone -- the half-time teacher from the middle school has little to say about the curriculum.) They are on her mind as she begins teaching algebra I each September: "I look for candidates in that group and I start recruiting." They are also on her mind as she makes herself available to students "before school, after school, during lunch, during breaks, and during my planning periods."

During these times, when she is not providing remedial and general help, she is working with her team members. Occasionally -- as, for example, during our visit -- she will have team members give presentations during class on their contest work. Contest activities are not restricted to the math team. Approximately 80 students a year (more than a third of the school) take the American High School Mathematics Examination (AHSME) of the Mathematics Association of America. A small group are involved in the contests in mathematics and science called Test of Engineering Aptitude in Math and Science (TEAMS). Last year Deer Run won their district and regional competitions, and then placed fourth at the state level. Typically, they were the smallest school represented at the state level.

The value of mathematics competitions to a school's program -- especially when they are as pervasive as at Deer Run -- is open to debate. One department head we visited in our study told us that he avoided them "because they mainly teach tricks" and are not conducive to a thoughtful approach to mathematics.

Other department heads we visited allow competitions to play but a minimal role in their programs. And, of course, there are the schools we described in case studies like East High School and Trinity High School, where contest victories are considered a valuable measure of success. Their value to Deer Run in this regard is clear, but we happened across what seems another good reason for their prominence in the school when we interviewed Glenn, a senior year student in precalculus: "I like being involved in the competitions because, in preparing for them, you learn things like inverting matrices that you wouldn't ordinarily learn in class." It is difficult to gauge how many such topics enter the curriculum through competitions, but the pace of precalculus seemed slower at Deer Run than at other programs we visited, so it is believable that Glenn was on target.

The pace of the curriculum was one factor that set Deer Run apart from the vast majority of the exemplary programs we visited. Another was the use of homework. In some of the Deer Run courses, students are permitted to do their homework in class, and teachers make themselves available for help. While this runs counter to the practices in the other programs we visited, and so is of questionable value, the practice was singled out by a couple of students from farms as valuable to their learning, because "it's hard if you get stuck at home on an assignment."

Given its small size, the mathematics program at Deer Run presents no complicated student placement challenges, and yet Mr. Atkinson was strong in his praise of the guidance counselor who had left at the end of the previous year, and equally strong in his disappointment in the performance of her successor. Apparently the former counselor had been a strong influence on the students, especially the girls; her departure, seen in the light of the recent turnovers in superintendent and high school principal, made the mathematics program seem a bit more vulnerable to us.

Because she teaches most of the courses, and because she is keen to meet all students' needs, Ms. Vandenburg risks overextending herself. On the one end of the curriculum, she has seen the need to introduce calculus to the several students who exhaust the course offerings by senior year; she was planning to incorporate it as a semester course, combined with a semester of number theory. On the other end, she has decided to introduce a prealgebra course for those ninth-graders who are not fully prepared for algebra, but who need something more challenging than general mathematics. While he was in charge, Sam Walker refused to allow her to teach prealgebra because of the time taken from planning. The new principal and superintendent have given their blessings, however, and Vandenburg was eager to get the course up and running.

Teachers and Teaching

After the careful planning of Sam Walker, Mary Vandenburg's dedication and hard work constitute the second major factor behind the progress of the mathematics program. She is the mother of two small children, with all the concomitant responsibilities and constraints that come from leading a double life. For example, our first morning in her class was interrupted by a call from her nursery school, whose staff had temporarily misplaced her younger child. Vandenburg seemed slightly envious that other math team coaches whom she knows are able to use after-school time to prepare their students for competitions. She cannot, because of her family responsibilities and because the majority of her students are dispersed at the end of the school day across the wide expanse of the school district, many to farm chores that will not wait. In any case, this dedicated teacher finds the time, during class, during lunch, during homerooms and preparation periods, to prepare students for the contests.

During her eight years at Deer Run, Vandenburg has been the only full-time mathematics teacher and, although she lunches once a week with the part-time teacher so that they might coordinate their algebra teaching, she really is a department unto herself. In so many of the programs we visited, continued success appears to be tied to the collegiality of staff and the strength they draw from each other. In that light, the professional loneliness of Mary Vandenburg seems all the more poignant, and her sustained enthusiasm and commitment all the more laudatory.

Her dedication, and the dedication of many of her rural teacher colleagues, has a special quality to it because of the relatively limited opportunities for young people growing up in an isolated community the size of Deer Run. There is a strong commitment on the part of these teachers to expose their students to as much as possible of what is new and different and to push them to open their eyes to it. Thus, the special appeal of regional and state competitions as vehicles for program improvement and Mary Vandenburg's commitment to involve as many students as possible in them: "When freshmen come into our school they want to be part of that winning team. I have had students who are not taking math in their senior year ask if they could still go to math contests. I try to encourage all of them." Glenn, the senior quoted earlier, put it in a slightly homier way: "If the dumbest person came up to Ms. Vandenburg and asked to be on the math team, she'd find a place for him."

Money is an issue remarkably removed from the issue of teacher dedication in Deer Run (and, it is reasonable to assume, in communities like it). It is a sad corollary to the perpetual dearth of money for education. Generally in this school and community, there is a sense of pride in making it on very little. In the metropolis 50 miles away, a newspaper article appeared on the Deer Run schools under the headline "Excellence for Peanuts."

In any case, money has little bearing on Mary Vandenburg's dedication to the mathematics program. When we asked whether the master's degree she hopes to earn would increase her salary significantly, she looked surprised, even a bit annoyed by the question: "I don't know. That's not why I'd get it. I don't care what they pay me. I'd get it to help me teach better."

Money could definitely help the Deer Run High School mathematics program, however. There are spots where it evidently suffers from the district's skimpy financial resources -- for example, in training for broader teaching skills. We observed five classes and were struck by several aspects of theclassroom interactions. For one, we were struck by the occasional impatience expressed -- by both mathematics teachers -- in the lower-level courses like general mathematics. Furthermore, the part-time teacher was often sarcastic in addressing her students, a behavior notably absent in the vast majority of classrooms visited in our study.

A second disappointment was the lack of much development of student questions into further learning for the students. Ms. Vandenburg took the time to answer questions, but several of the answers we witnessed seemed to leave the questioners hanging. For example, as she drew a circle on the blackboard in her precalculus course, with radian and degree measures listed for angles, a student asked, "Is that a function?" The answer: "Sine and cosine are functions, but we haven't covered them yet." Then she went on with what she had begun. This was not only a confusing answer which did not satisfy the student, but it was a missed opportunity to spring from the question to a discussion of functions and trigonometric functions, in particular, and to get the students to voice their understandings and misunderstandings about the concepts. Later in the class, the same student came back with another question, during a discussion of odd and even functions: "Are parabolas and hyperbolas even functions?" The quick and unsatisfying answer from Ms. Vandenburg was, "Hyperbolas are not functions." Again, a missed opportunity to probe the students' thinking and to get them involved in a meaty discussion.

Mary Vandenburg's deep dedication to her students makes it clear that the missed opportunities and occasional careless behavior (such as inappropriate expressions of impatience) do not derive from a lack of concern. Rather, they derive from her professional loneliness as a department unto herself, and from the financial inability of the school district to provide much professional development. As it is, the principal stretches the budget to send her to state mathematics teacher meetings and to the competitions.

Isolation and a lack of funds are also hampering Deer Run's attempts to expand its curriculum wisely. The grant proposal Mr. Wilkinson has written to fund the purchase of the Elements of Mathematics materials for the high school's talented students, however nobly motivated, may be shortsighted. The materials are very sophisticated mathematically, and the program at Deer Run is not. Again, the geographic and financial isolation of the program has limited its options for finding appropriate curricular changes.

Conclusion

Sam Walker told us, from his new vantage point as another district's superintendent, "Deer Run High School has done more with what they have than any other school in the state." A biased and subjective assessment, no doubt, but it does reflect the truth about the school's valiant and fragile efforts in mathematics.

In studying exemplary programs, our researchers have travelled from inner city schools to suburban schools to rural schools. Each type has its own set of special challenges, and each has designed its own set of responses. In Deer Run's case, the challenges were a low budget and a traditional set of values that kept educational success on a rather low plane. Their response, through forceful and imaginative leadership and dedicated teaching, was to use a steady improvement in mathematics competitions as both a motivator for students and citizens, and their standard for setting the tone of the entire mathematics program.

Success in mathematics continues to develop at Deer Run High School, yet it also continues to be a fragile sort of success. Funds are and always will be low; administrative turnover has been high, and the program relies on the deep dedication of one woman. Indeed, it is reasonable to say that, when compared with the other 27 programs we visited, Deer Run will have the hardest time sustaining its recent record of excellence.

TRINITY HIGH SCHOOL

"Trinity is a hypercritical community."
Principal, Trinity High School

"To those of you sending students to Trinity High School for the first time, you need to know that Trinity High School teachers are demanding in many ways, and your student may have to study harder to achieve worthwhile grades compared to the previous school."
From a letter sent to parents from the Trinity mathematics department.

Trinity was one of our diamonds in the rough, one of the schools we visited that exceeded the expectations set by their written applications. Certainly, Trinity was highly rated by our panel of program raters, but not as highly rated as some others we chose not to visit. We chose Trinity to enrich the variety in our study: it is a West Coast high school and so, geographically, it was different from most of our other candidate programs; furthermore, unlike most of our other candidates, Trinity submitted evidence that they paid careful attention to enriching general mathematics and to guiding general mathematics students into algebra. In addition, the school boasted a high SAT average (consistently about 100 points higher in mathematics than in the verbal exam) and a relatively high level of extracurricular activity in mathematics.

Trinity turned out to be impressive in several ways. The sense of appreciation for and excitement about mathematics -- and problem-solving, in particular -- which the staff have generated among all levels of Trinity students, far exceeded what we expected. The teachers used some of the more innovative in class challenges and questions witnessed in our study, and they have several mechanisms in place which enrich the program from top to bottom -- a math team which involves students at all levels; several supplementary programs which not only provide content help, but also stress attitude and process; and a continuous, out-of-class problem-solving program which involves the majority of the students. Mathematics is a lively and influential enterprise at Trinity High School, and students pay attention to it outside the classroom.

At the same time, however, there is something almost paradoxical about Trinity's Mathematics program, for it proved to be complex as well as exciting to study, a continuous challenge to the listening and observational skills of the two site visitors who spent three days there. Personalities, politics, and philosophies are so enmeshed in this "hypercritical community," to use the principal's phrase, that it was impossible to look at any of the strong aspects of the mathematics program without hearing undercurrents of doubt and, occasionally, complaints and criticism. On the other hand, the energy level displayed among staff and students, the atmosphere of intense self-examination, the willingness to risk and challenge, all constitute an intriguing counterforce to the doubt and criticism.

Background

Trinity is a small suburb of one of the West Coast's largest cities, a middle class town about a mile square with a mixture of what one administrator described as "working class and a growing number of university types," and a town in which almost all the housing is composed of single-family dwellings. There are three elementary schools, one middle school, and one regular high school (Trinity High School), and one small alternative high school in the district. Trinity High School, which comprises grades 9-12, contains 760 students and reflects the ethnic mix of the entire district: 40 percent minority, consisting of 15 percent Asian, 15 percent black, and 10 percent Hispanic.

The community appears to pay close attention to education. A casual survey of impressions of the mathematics program depicted a group of teachers who are firm, demanding, and hard-working.:

- The Superintendent of Trinity Schools: "More demands are made on mathematics students at Trinity than by other departments."
- The Assistant Superintendent: "The mathematics department held the students more consistently to high standards during the 60s and 70s than did other departments."
- A second-year teacher, who has taught in several other high schools in towns around Trinity: "In every school I've been in, the mathematics staff have taken far fewer absences than other departments. That holds true at Trinity."
- A senior student: "The math department is really organized. They meet in the beginning of the year and divide up responsibilities -- who will be in charge of math league activities, lunchtime contests, and so on."

What some in the community see as firmness and high standards, however, others see as shortsighted rigidity. Even the administrators, despite their words, seemed muted in their praise of the mathematics program because they quickly followed their praise by mentioning the criticism in the community that the program is weighted in its attention toward the upper and lower courses, thus leaving middle-level students with insufficient guidance. The superintendent and assistant superintendent spoke with us more with an aspect of curiosity than pride when they related how Trinity SAT scores in mathematics are consistently about 100 points higher than the verbal scores, and what pride they have been able to foster in the community seemed to them offset by their and the community's frustration over the early disappearance of minority students from the top sequence of courses. (Last year, blacks represented fewer than 5% of the students in algebra II and precalculus.)

As with all the sites we visited in the study, we sought out general perceptions in the community of the mathematics program at Trinity High School. What we heard was extraordinary, both in its intensity and, especially, in its variety. The intensity signalled a community committed to educational concern and examination, but the variety of conflicting views of the mathematics program signalled a process of examination carried out with insufficient care, where criticism has given way to blame much too quickly, often on too little evidence. One example, which concerns the entire school and not just the mathematics program, is the issue of students who don't live in the district. Because of its reputation for success in education, Trinity High School attracts students, mostly black, from outside the district. There are about 150 on record and, the principal advised us, probably another 150 who have managed to pose as Trinity residents. Somehow -- no one seemed sure of the origins -- the impression grew in the community that these students were a disruptive influence. The school board responded by approving a small study of the effects of outside students' presence in the program and the results, the principal proudly reported to us, pointed to the "safe and stimulating environment" fostered by the presence and participation of the students from outside the district.

There are pockets of dissatisfaction and distrust in the school community, as well. The mathematics teachers at the high school don't fully trust the middle school to teach algebra, now that eighth-grade algebra has become a reality in the district. (The department head: "The students who take eighth-grade algebra don't understand enough of the 'whys' of algebra to do well in our algebra II.")

From their side, the Middle School teachers are equally dissatisfied with a relationship they see as lopsided and laced with prejudgment. "Their way is always better . . . they find fault with us." It is their perception that no credit is given to the Middle School for the mathematics preparation they provide, that after what they see as careful placement of eighth-graders in ninth-grade mathematics programs, the only report the Middle School gets is a printout of each student's high school grades, a meaningless gesture to them. Furthermore, they chafe at having received no credit for the concept of the general mathematics program when it was implemented with acclaim several years ago. The high school mathematics teachers also have a rather cool alliance with the school guidance counselors. (The department head: "They cooperate with us on student placement, but generally they think we're arrogant.")

Finally, the mathematics teachers feel a lack of support from the central administration and the community. The department head told us that all of the academic course enrollments are over the maximum allowed by contract -- 30 students -- yet financial support to alleviate the situation is missing. A state proposition has severely limited tax money available to schools; the community has failed to pass several bond issues which would have made more money available for hiring staff; finally, a proposal to a local corporation for money to support the search for and hiring of a minority mathematics teacher has been languishing at the corporation's end.

Even the students at Trinity High School seemed to inject an air of distrust into their academic lives. Their whispers and glances showed how suspicious they were of us during our classroom visits, and staff members described their surprising wariness about enrolling in untried courses like the PASCAL computer course and courses taught by untried teachers. As one teacher remarked to us, "Kids at Trinity shop for courses on the basis of hearsay." Distrust is always a better base to build on than indifference, however, and when we passed the litmus test for these students, we found them in interviews to be among the most energetic, enthusiastic, and humorous group of students we encountered.

A similar bright side exists for the entire mathematics program, for while there are important avenues of support that have been closed off, several exciting avenues have been developed. For one, the local newspaper reportedly gives ample coverage to the school's successful mathematics teams; for another, an exciting and innovative supplementary program -- described below -- has been developed in conjunction with the nearby state university, a program which gives minority students a better chance to succeed.

Curriculum and Implementation

The academic track at Trinity High School includes algebra I, geometry, algebra II, and precalculus. Because the district maintains a minimum cutoff of 15 students per course, calculus is not taught at Trinity; students eligible for calculus may take it either at the high school in the town next to Trinity or at the nearby state university.

As small as it is, Trinity has no honors program as such, but the academic track is very demanding. Students not likely to succeed in it may enroll in the sequence of courses that includes general mathematics, algebra IA and IB (algebra I spread over 2 years), and applied geometry. The school also offers a SAT math course for students who might not succeed in algebra II but who intend to take the SAT exam.

Several years ago the staff designed a general mathematics curriculum, of which they are clearly and understandably proud. In the words of the district's Director of Special Services, who composed the application to be in our study, the course begins with a one-month focus on basic skills, and then:

> "From the end of that time until June, the students see a variety of practical problems with a prealgebra orientation: area/perimeter/volume, percent/interest/sales tax, measurement of lengths and angles, consumer problems, equations. A cycling approach is used where new techniques are introduced periodically, used for a few days, then left for some time. They are seen again later in other types of problems.
>
> "Teachers have prepared a curriculum of 180 work sheets, one for each day of the year. Students receive a new sheet every day. A test is given every Friday."

The general mathematics program is given an added boost through the use of student tutors, who are either paid (through a state-financed School Improvement Program) or are given course credit for their tutoring. The philosophy that guided the staff in the development of their general mathematics curriculum was summed up by the department head as, "Give the students enough to succeed in algebra IA." There has been a strong commitment, expressed in a tremendous amount of time and effort devoted by the teachers, not to have general mathematics be the terminal course it so often is in other schools.

At the time we visited, the department's core which comprises five teachers, had begun to express both concern and resentment about the general mathematics program, which they believe has been taken away from their control. In the past few years, as the district moved to a two mathematics course minimum requirement, the academic courses have swollen in enrollments, and the general mathematics program has grown from one section to four sections in the past ten years. No money has been made available to hire more mathematics teachers and the academic course duties of the core teachers have grown, so general mathematics has been turned over to a new combined science-mathematics teacher and two vocational education teachers. They are using the curriculum developed by the Trinity veterans, but those same veterans fear that the philosophy upon which they based their development is endangered. That fear gained stature for us in the rather stark admission of one of the new general mathematics/vocational education teachers to one of us after a class visit: "I don't know what I'm doing in there."

Peter Robbins, the 15-year veteran of the department, is in charge of a supplementary program (we'll call it the Development Program), arranged with the state university, an after-school program of tutoring and small-group work, set up primarily to support the mathematical growth of minority students. He supervises 4 graduate students and university seniors who work with 65 Trinity students in the Development Program. We observed one very impressive session in which the graduate student/teacher worked with a group of 16 on questions pertaining to an upcoming geometry test, had them break up and work in pairs on some problems, and throughout the session, worked in some appropriate coaching. In a reaction to a side conversation of several students, "You can't expect to do well on the test if you continue to act that way." "Let's look at the types of question you can expect to see on the test, and discuss what's difficult about them." "What can you say about the third sides of 2 triangles if 2 sets of corresponding sides are equal?"

The effectiveness of the student teacher was one of the heartening aspects of the session we observed; it was clear that Robbins was an effective mentor for this university mathematics student, and when we watched her interact with the students so effectively, we began to see this program as a potential model for attracting content-area specialists into mathematics and science teaching. Another heartening aspect of the program was partly accidental, namely the variety in the student group

that was working so energetically after school: there were four whites, four Hispanics, four blacks, and four Asians in the group, and it was tempting to see that afternoon session as only possible in America, as some modest, though still inspiring, fruit of several decades of concentrated effort.

Articulation with the middle school is, as we mentioned above, a sore point with the mathematics staff. Nancy Bernstein, the department head, also spoke of her desire to have some effect on the mathematics taught at the elementary level, especially in making more variety in problem-solving available to students, yet spoke also of her frustration at not having the time to do it. (Bernstein, by the way, receives only $250 extra in compensation, with no time freed from teaching for administrative duties.) She and her staff do meet once a year with the middle school mathematics people, but they have had little satisfaction in their attempts to change the quality of the algebraic understanding of eighth-graders.

Curriculum development and textbook use in the Trinity mathematics department mirror the development of the general mathematics program, in that the teachers use home grown ditto sheets (their "ditto-a-day" concept described in a later section), and, when they use texts, they are very flexible. For example, Bernstein uses the Houghton-Mifflin Dolciani algebra II text, yet covers the matrices section first. Another teacher uses one series for class development, another for homework exercises.

Leadership

Several circumstances combine to give leadership a special flavor at Trinity High School and in the mathematics department, in particular. Those in positions from which leadership usually emanates have little established foothold: the superintendent is in his first year; the principal is in his second year; and the department head returned last year after a five-year break to raise a family. In contrast, the vast majority of Trinity teachers have taught only at Trinity High School and have taught there for a long time. They are also one of the most energetic and feisty groups of individuals we met in our school visits, and they evidently provide for themselves much that established leaders elsewhere provide their staffs: ongoing professional interactions, the sharing of materials and responsibilities, and that tenor of self-examination and criticism we have already discussed. (Of course, there is a grey side to the feistiness, the occasional propensity to complain in isolation to which we alluded earlier).

Despite the self-sufficiency that sustains the staff in their teaching and professional interactions, both the principal and department head do provide some vital aspects of leadership. The principal uses a mechanism that was as refreshing to watch as it promises to be cohesive for the staff and conducive to staff communication. Every morning, at a time when the entire school takes a break from classes, he meets with all the

teachers in their lounge. Serious announcements, humorous repartee, the sharing of home cooking, and slightly abrasive questioning all fill the twenty-minute get-together and, despite the occasional grumbling we heard from teachers, the meeting can serve to draw the staff together in purpose. An example that occurred during our visit shows how the mechanism facilitates staff communication during a crisis: the principal announced that a student had been seen with a gun the previous day and, immediately, the teachers pulled together to describe the student and her daily schedule and habits, and, in a few minutes, had designed a plan by which they could detain her, should she show up, long enough to get the assistant principal to her.

Bernstein, the department head, also leads in clearly defined ways. In particular, at the time we were visiting, she had measured the severity of her own and her teachers' complaints, had collected them in a memo, and was preparing to bring it to the central administration and school board. The list included dissatisfaction about a recent hiring of a mathematics teacher, a continuing sense of estrangement from the elementary and middle school programs, and a lack of financial support that had, in the eyes of the teachers, diluted the effectiveness of the general mathematics program they had so carefully built, by making it necessary to pass it on to teachers from outside the department with little attachment to and ownership of the program.

In one other aspect Bernstein resembled the best of the leaders we observed in the study: she works very hard and very long. As in some of the other programs we visited, the hard work is a mixed blessing in that it often approaches overwork and makes "burnout" a very real possibility. She told us she starts her day at 5:00 a.m. and goes to bed at midnight. In between, there are family matters and child care, but most of the time is devoted to the Trinity mathematics program. Weekends also, at least in part, are devoted to the program. Other teachers match the effort. As one veteran of 15 years at Trinity told us very matter-of-factly: "Sometimes Nancy (the department head) calls me at 11:00 at night and we plan for the next few weeks of algebra." The mutual respect on the staff and the teachers' obvious concern for Ms. Bernstein's treading near burnout were very moving to hear about and observe.

Teachers and Teaching

Although eight people teach mathematics at Trinity High School, only Nancy Bernstein is a full-time mathematics teacher. Another woman, in her second year, teaches only mathematics and computers but does it on four-fifths time. The other three core mathematics teachers, who have taught mathematics at Trinity for more than ten years, also teach science. The remaining three teachers double as either science or vocational education teachers.

The development of the general mathematics course typifies two qualities of the mathematics teachers at Trinity that seem essential to the strength of the entire program: the willingness to work very hard for their ideals, no matter the cost in time, and their resourcefulness in making that work count. In other words, despite the occasional complaining, the teachers find ways to get done what they feel must get done.

Much of the time is spent by teachers implementing what they refer to as their "ditto-a-day" approach to courses. Among the five teachers at the core of the department, we sensed a general dislike for straight textbook approaches to teaching. In particular, they don't like the sequencing of many topics and they especially do not like the lack of variety in problems. Consequently, they produce daily ditto sheets of mixtures of problems for homework. If two people happen to be teaching the same course, say algebra, they split the duties, two weeks of dittoing by one person, then two weeks of dittoing by the other. In the case of the precalculus teacher, in her second year at Trinity, the responsibility is hers alone. She uses the Harcourt Advanced Mathematics text for explication but likes the Houghton-Mifflin text better for problems, and so she hands out daily sheets of mixed problems, review as well as current.

This same woman showed her resourcefulness in other ways. It was she who arranged the calculus option for Trinity students at the neighboring high school. She also teaches the AP PASCAL computer course from her own notes, and when only a handful of students enrolled, she scoured the hallways, library, and cafeteria and enlisted students until the minimum of 15 was met. (As we have noted, Trinity students are notoriously suspicious and wary of new courses and new teachers.)

The dedication and resourcefulness of Trinity math teachers are evident in one other established practice, the Friday problem sheets, collections of challenging problems traditionally handed out by teachers in all of the academic courses. Teachers varied in the amount of credit they attached to solutions and the amount of time they gave students to complete the sheets. (A week was the minimum). At the very least, however, teachers give credit for attempts at solution, and they do not penalize for unsuccessful attempts. Before the due dates for the Friday sheets, teachers and students may discuss difficult problems in class, with, as we observed in one class, the teacher giving suggestions for new attempts to solve the more difficult problems. The effect on many students is galvanizing. Two seniors told us they estimated that at least half of the students in algebra II and precalculus have a go at the problems, and that it is not uncommon to hear them discussed in the student cafeteria. They also claimed that regular attention to the Friday problem sheets facilitates a smooth flow through the curriculum, that it is easier for students to see connections among concepts. As an example, they recalled a teacher who reinterpreted several geometry problems from the Friday sheets algebraically, thus giving the students a previously unseen bridge to the mathematics of another course.

At some of the exemplary programs we visited, we observed teachers who attempted to teach students how to learn mathematics as well as merely teaching students mathematics. We saw examples of this kind of teaching at Trinity. Just as the mathematics teachers refused to be limited in content and sequence by course textbooks, so they also refused to be limited in their classroom strategies by the canonical model of teacher talking at students. They often coached, cajoled, guided, and chided. Here are three examples:

- Peter Robbins, the Development Program coordinator, gave a problem in his algebra I class and had the students work on the problems in small groups. ("Don't offer your answer until you get three people in your group to agree on the answer.") The ensuing discussion was lively and fruitful. (The teacher to us, later: "I couldn't have done that before the Development Program. It showed me what a useful and powerful tool student peer interactions can be.") Later in the same class: "There is a special relationship between the slopes of perpendicular lines, and the book doesn't say it explicitly. What is it? Don't shout out your answer until you check it out with someone near you."

- In her algebra II class, Nancy Bernstein asked for an explanation about the convergence of a particular series. When the original student's explanation drew blank expressions from the rest of the class, the explanation was bandied about and refined until it was more understandable. To the first student: "I know that your explanation was correct, but you didn't say it so others could understand it." This was only one of several examples we witnessed of urging students to refine their mathematical reasoning and explanations.

- The second year teacher of precalculus polled her students on the problems from the previous night's homework sheet that caused particular difficulty, then told them to work on them in small groups for 15 minutes with the direction: "Choose your groups carefully. Pick someone to work with who knows what he or she is doing in the area where you need help." The groups were lively, on task, and in our view, fairly successful at covering the troublesome problems.

By their own assessment, the work load of the mathematics teachers has kept them from helping each other as much as they would like, and has kept them from attending to the newer teachers, in particular. It thus threatens to dilute their well-conceived general mathematics program. In our view, it also threatens to waste some of the refreshing classroom dynamics we witnessed. To amplify on a previous example, there was little follow-through on Bernstein's "you didn't say it clearly enough so others could understand it" interjection. The student to whom the comment was directed was left to sit silently and apparently confused by the advice. But there were 33 students to attend to in the class -- with a range of abilities, since there is no honors level -- so the lack of follow-through, while unfortunate, seemed inevitable.

The Friday sheets dovetail nicely with Trinity's approach to mathematics competitions. Together, they constituted one of the best efforts we witnessed in our study to generate enthusiasm for mathematics outside of the classroom. We saw a variety of approaches to competitions in our site visits, but none that was as broad in scope as Trinity's. The teachers want to see all students -- not just the top students -- involved. As Robbins recalled: "We thought through competitions very carefully 15 years ago. First of all, we instituted weekly in-school competitions, then began taking students to local competitions. They did badly at first, but we began to note an improvement in achievement on the national exam of the Mathematical Association of America, even among average students. We also noticed that, through the competitions, we were asking the students to integrate their classroom mathematics learning." At that point, the teachers began the Friday sheets to feed this trend toward integration and improvement.

Now Trinity excels in their league competitions, yet their commitment is still toward all the students. More than 50 students gather with teachers for lunchtime versions of the Atlantic-Pacific Mathematics Competitions. Shortly before we arrived, Trinity brought six five-person teams to a league competition. The veteran teams scored high enough for Trinity to win the competition, but what impressed us was the account by the assistant principal, who drove students to and from the competition, that the older students were debriefing, consoling, and coaching the younger competitors all the way home. Again, these younger competitors were not all stellar students. Indeed, in one class we heard one of the teachers urging students from the Development Program to take part in the next competition. When we began to think of Trinity as a diamond in the rough, we had in mind this consistent and supportive mechanism for prodding the widest range of students toward excellence in mathematics.

The students seem to be responding to the mechanism. As one student responded to our question about what makes Trinity's mathematics program so successful: "Easy, here kids help each other learn, and the teachers help kids. If I were a student in the high school that we compete against, and if I asked another student for help, he'd be likely to cover his paper with his hands and tell me to figure it out myself. Here at Trinity we cooperate with each other."

Summary

With their extraordinary efforts to enrich the content and sequence of courses as well as classroom dynamics, with their nurturing of institutions such as peer tutoring, the Development Program, the Friday problem sheets, and the mathematics competitions, the mathematics teachers have created a dynamic as well as exemplary program. And yet, as we mentioned at the start, tension shows through the fabric of the program almost constantly.

As the principal told us, Trinity is a "hypercritical community": parents/voters criticize the scope of the mathematics program and withhold their support at the polls; students respond to rumors and stay away from anything unfamiliar, such as a new computer course or a precalculus course taught by a relatively new teacher; the high school mathematics teachers criticize the middle school mathematics teachers and vice versa; the high school mathematics teachers are very wary of administrators and critical of their lack of support; and despite their words of support for the mathematics program voiced to us, the administrators seem somewhat muted in that support and appear caught between community criticism and their own admiration for the breadth of the mathematics teachers' efforts and success.

When a group of teachers such as the Trinity High School Mathematics Department struggle and succeed, in general, despite pockets of failure, it seems essential that the surrounding community of administrators, parents, voters, and so on, focus primarily on the success and effectively communicate their support for the efforts and their appreciation of the success. That communication of support is regrettably missing in Trinity; blame is resorted to much too quickly, and the struggles of the department will probably continue. For our part, we believe we saw at Trinity several program facets -- the well-defined approach to problem-solving and competitions, the well-organized approach to supplemental help, the well-conceived approach to general mathematics -- that can stand as exemplary models for many other schools.

SILVER VALLEY HIGH SCHOOL

"What makes our program successful? Well, for one thing, we stay on top of every student."

Mathematics Department Head, Silver Valley High School

A striking feature of exemplary mathematics programs is their insistence on getting the most out of their resources, both material and human. They identify goals, plan how they will reach them, and then stoke whatever fires are available to them. The better ones take absolutely nothing for granted in this process -- not past laurels, nor the professional backgrounds of their teachers, nor the family or school backgrounds of their students.

One of the best of these is Silver Valley High School. Seemingly oblivious to its comfortable suburban setting, the school has put together an extraordinarily comprehensive mathematics program, which grasps in all directions in its pursuit of excellence. In a professional community where parent interest in mathematics education might safely be assumed, the mathematics department has one of the most persistent programs of parent communication that we observed in our study. In addition, they have established an elaborate program of student placement and monitoring, and a carefully planned system of teacher training and evaluation. As a result, expectations are high on all sides and attention to accountability -- for both staff and students -- seems everpresent. The program has set out to keep all participants on their toes, and it has succeeded admirably. If teaching mathematics is part art and part science -- with the blending dependent on individual situations -- then Silver Valley leans heavily on the science end of the formula.

Background

Silver Valley High School serves four small, modern, middle-class suburbs of a large Midwestern city. Its single-level, sprawling campus sits close to an interstate highway that is a straight ten-mile shot to the central core of the city. Because of its convenient location and record of excellence, and because it was amenable to the challenge, Silver Valley became the first school in its state, in 1976, to take part in an interdistrict busing-for-integration program. Since then, the school has admitted about 25 black students from the city each year.

Like many middle-class suburban schools, the school has a rapidly declining enrollment. In 1976-77, it served 2,100 students; in 1983-84, there were only 1,660 students; and projections for 1990 picture a further decline by several hundred. Unlike some other victims of a similar decline, however, Silver

Valley shows none of the wear on staff morale or tear on its curriculum. It was not the wealthiest school we visited, but it is evidently comfortable enough to hold steady on its course. The district ranks among the highest in its state in value per student. At the time of our visit, its annual expenditures per student were $3,225 for educational purposes and $550 per student for transportation, construction, and debt service. The high school has managed to retain a teaching staff in which 80 percent have master's degrees or higher, and an average student-teacher ratio of 15:1. The academic stamp on the school is clear: about 85 percent of its graduates go on to college -- more than 75 percent to four-year colleges.

While the school as a whole has been shrinking, the mathematics program has been thriving, with a rise in the past six years in the percentage of students enrolled in mathematics courses. In a school that requires only one year of mathematics, the figures are impressive: 16 percent of the students who graduate have taken at least one semester of calculus; 90 percent of the students take both algebra and geometry courses. Most impressively of all, perhaps, more than 90 percent of the students in the ninth-grade arithmetic skills course go on to take a full four years of mathematics. In addition, the school has maintained an average SAT score in mathematics (539 in 1982-83) well above the national average (467), despite the relatively large number of students taking the exam (more than 220 in 1982-83 out of a graduating class of 420 students).

These statistics attracted two site visitors in Silver Valley for a three-day visit, as did the school's sound record in mathematics competitions and the extraordinarily high level of student involvement in computer programming and in using commercial software to supplement their mathematics courses. (The school was the first in its state to use computers in instruction, in 1967.)

We had selected some other programs to study that were relatively new to excellence in mathematics, some even where change and experiment seemed central to their excellence. Here, in Silver Valley, was a program with an extended acquaintance with excellence, yet with the sustained impetus to keep improving. Like the interstate highway the school abuts, like its campus, and like the communities it serves, all of which are modern but not brand new, the mathematics program has reached a level of maturity that is still young and fresh. It combines maturity with a vision for improvement, and it was explaining this combination that challenged us as site visitors.

One manifestation of maturity in Silver Valley's mathematics program is the staff, which has enjoyed a remarkable longevity. In describing their role within the school, the principal referred to them as "our stalwarts, our watchdogs on excellence," and talked of their dependability during the shaky days of the early seventies, when experimentation in education -- often shallow -- was the national rage. Of the 16 teachers in the department, 10 have been part of the program since the 1960s. Along the way, several others have been lost to industry and to other schools, but the core has stayed together since the early days of the program. In part, but only in part, this record is explained by the ability of the district to pay well. The principal estimated the school's salaries to be the highest in the state for teachers with master's degrees plus 30 hours credit (top salary: $36,000).

Not that money flows freely for the mathematics program. The five-member School Board (selected from the four communities) that oversees the high school has proved it can maintain a tight grip on its purse strings. The school's computer coordinator, a mathematics teacher, had to make eight presentations to the Board before they would release the money to buy the 32 Apple computers he was requesting. Granted this was a considerable investment, but with the school's remarkable track record for computer use, the safety of the investment might have seemed assured. In any case, there are two telling comments about the mathematics program in this story. First, they have been well supported in material resources (24 of the computers went to them), albeit with occasional struggles. Second, and perhaps more telling for an analysis of the program's success, they were willing to persist, to go back before the Board that eighth time, to get what they felt they needed.

The Board oversees only the high school. Each community has its own elementary and middle schools, and its town boards governing them. Because of the solitary focus of the Board, the principal is really a district administrator and deals directly with them. In that sense, the communities are closely connected to the school and thus to the mathematics program.

Beyond that, we saw no evidence of direct parent involvement in the program. It seemed, however, an absence born of trust and satisfaction, because the department is assiduous about communicating with parents. "It is the chairman's responsibility to deal with the public," we were told by John Young, Silver Valley's mathematics department head, and he has instituted some practices to make it happen. There are mailings that explain the course offerings, the homework policy, the placement and monitoring policy, and the advanced placement program. There is also a parent guide to good home study skills. Eight student reports go home, four in the form of quarterly grades and four in the form of mid-quarter progress reports. Parents are involved in student course changes or when a student moves from one curriculum track to another. And the department keeps a record of every parent phone call on student placement: who called, the nature of their message, and the resolution of their conversation.

Leadership

Both Silver Valley High School and its mathematics department have been shaped from long and deep convictions about the role of leadership in education, primarily in the thinking of Mr. Cabot, the principal, and John Young, the mathematics department head. Each man seems to recognize the incontrovertible yet too rarely accepted fact that educational leadership fails if it does not both exalt teachers and genuinely challenge them to grow as professionals.

"I have always maintained that teachers are managers," Cabot said, "and should be treated and trained as such." With that conviction as a guide, he pursued several basic changes when he became principal over a decade ago. He eliminated lavatory and lunch duties for teachers, reorganized the physical space within each department so that every teacher has space of his or her own in which to work, and began a systematic program of professional development. He "talked the Board out of a top management model" and sold them on his

model, one in which department heads assume a larger share of managing their departments. Each department head is responsible for his or her departmental budget, curriculum development, and hiring, and shares the responsibility for teacher evaluation with another department head. Thus, John Young and the head of the science department share the responsibility for evaluating the mathematics teachers. Other departments have similar arrangements. It seemed a clever mechanism that allows evaluation by people close to the material being covered in the classroom, while guaranteeing that the evaluation includes the perspective of someone who is not too close to the people being evaluated. When the mechanism was set in place, Cabot sent all the department heads to be trained together in supervision. Department heads are officially administrators at Silver Valley. Each teaches two courses, and each is through teaching by 10:30 in the morning, so that departmental administration can flow unimpeded throughout the remainder of the school day.

Cabot's delegation of authority applies to parent relations as well. "I don't deal directly with parents. We urge the parents to deal with the teacher directly, or if not the teacher, the department head."

Evidently, Cabot's delegation of authority is extensive, so extensive that his management structure dominated our conversation with this mild-mannered but strongly opinioned man and made his rare comments about pedagogy seem almost out of place. On the surface, his brand of leadership seems to fly in the face of the bevy of recent recommendations about effective school leadership, which generally include some variation of the rule that effectiveness suffers in proportion to the distance of the school leader from the classroom. But the surface impression ignores the fact that Cabot has created a team of active school leaders within his school, whose representative in the mathematics department, at least, is an exemplar of the recommendations from the effective schools literature.

John Young is as mild-mannered as Cabot, and so appeared to us quite different from the many intense, emotional, even volatile department heads we met in our visits to exemplary programs. After several days of observing his controlled and patient demeanor, it came as no surprise to us to learn that he is a talented magician by hobby and produces an annual magic show for the school. Just as with Cabot, however, Young's mild manner belies a store of strong opinions about education, opinions that have set the tone and shape of the mathematics program in the 13 years in which he has been department head. During that period, he has earned the respect of colleagues throughout his state for the evident success of his program, and has gained national recognition from his book on effective teaching techniques in mathematics, published by the National Council of Teachers of Mathematics. Furthermore, when we visited he had just returned from the White House, where he had received his state's Presidential Award for mathematics teaching.

Thus the cachet of Young's opinions is unquestioned, yet we found his expression of them, while firm and confident, to be refreshingly free of pontificating:

- on teacher growth -- "It takes three years before a teacher contributes more than the text."

- on homework -- "It is essential. When I supervise, I specifically watch how teachers handle students who don't do homework."
- on his program's success -- "If I were to try to reproduce the program's success elsewhere, I know two things I would stress: K-12 coordination, and staff involvement in professional meetings -- at least one a year. If you come back with two ideas, it's worth the expense and effort. Just to talk and meet with other people makes it worth it."

Young's supervision of his teachers, shared with the science department head, is extensive. New teachers are observed in class ten to twelve times per year, sometimes without prior warning, and the supervisors follow their visits with criticism and some training, often based on Young's book. Veteran teachers are observed in class two or three times per year.

Coordinating curricula is very important to Young. He meets with the head of the science department periodically to review how well the two departments are nourishing each other. (Young gave us an example of an issue that might highlight such a meeting: "Is the mathematics in the science courses too tough?") He meets once a month with the staffs of the elementary and middle schools whence his students come. Together they discuss curriculum issues and student placement, which is based not only on standardized tests, but also on eighth-grade teachers' ratings of study skills and the recommendations of a committee of mathematics teachers. Young also has worked with the middle school staffs to develop a test to be used for eighth-grade placement. The head of guidance at Silver Valley told us: "The mathematics department has done more than other departments in K-12 coordination. They have, for example, held inservice sessions with the middle schools in content areas that needed stressing."

There is one facet of the middle school curriculum where Young's opinion and influence have been unbending. He and his staff are adamant about there being no eighth-grade algebra in the district. Instead, to accommodate the brightest eighth-graders, Young is developing, with the middle school teachers, a course that comprises some prealgebra, statistics, logic, and nontraditional problem-solving.

Within his own department, Young has delegated some of the responsibility for curriculum coordination to faculty committees within subject areas. Thus, algebra 1 teachers form a committee, as do the geometry teachers, and so on.

Generally, the expression "tight ship" applies to the system Young has set up. He does not like to see any leaks or weak links and, when he spots one, he moves to shore up the system. During the course of our several conversations, he had remarked that student respect for and attention to homework have recently been (in his eyes) unsatisfactory at Silver Valley. The department's homework policy is exceptionally firm -- offenders are required to stay after school to make up neglected work -- and it is routinely enforced, yet Young still perceives a problem to be overcome. As we parted, shaking hands, at the end of our visit, he briefly summarized the program's future for us and then added, "We're not going to give up on homework!"

Curriculum and Implementation

Not giving up also describes the history of the mathematics curriculum at Silver Valley, but with a slightly different twist. Unlike many of their colleagues around the country, the staff veterans who began teaching in the sixties liked much about the School Mathematics Study Group (SMSG) "New Math" materials, latched onto them, and have not let go since. One of the teachers has even invested in hard covers for SMSG materials in order to preserve them for the precalculus he teaches. John Young has adopted the SMSG logic materials and problem sets for his honors algebra I. The materials have survived only in a few courses but, nonetheless, as my site visitor partner exclaimed after one class visit: "The new math is alive and well at Silver Valley!"

It is alive and well also in the way it informs textbook decisions. When we interviewed both Young and several of his geometry teachers, they were pleased with their choice of a new geometry textbook (published by McDougal/Littell Press) that uses algebra as a primary vehicle for approaching geometry. (A typical procedure might deduce information about a triangle through the use of simultaneous equations.) The integrated approach obviously appeals to their SMSG-rooted sensibilities.

This text is used in the two middle tracks (of the four tracks) of geometry. An informal geometry text is used in the lowest track, and two texts -- one on integrated geometry, the other on analytic geometry -- are used in the honors course. More generally, the four tracks or levels of the curriculum are Honors (accelerated and enriched calculus), A-level (enriched calculus), B-level (precalculus), and C-level (non-precalculus). Students are placed in the different levels through a procedure described in the following brochures for parents:

> "A student's initial placement in a particular subject is based on the level of performance as assessed at the end of the eighth grade. The initial recommendation for placement is made by departments after careful study of the following criteria: seventh/eighth grade achievement, reasoning ability, interest, Silver Valley Achievement Entrance Examinations, national standardized achievement tests and aptitude tests, and eighth-grade teacher recommendations.
>
> "Flexibility in course placement is a continuing practice in each department each school year. Recommendations for course changes are based upon achievement and interest, in addition to parent approval. Course changes may occur at any time. A student and/or parent may request a review of placement any time during the four years. Such requests are directed to department chairpersons."

The commitment to appropriate and flexible placement continues well into the school year. For instance, there is a course called A/B algebra, for students whom the staff have identified as having the potential for doing A-level work, but who lack the appropriate study skills. During the first semester of the

A/B course, the teacher puts special stress on study skills, through careful attention to correcting test problems and through individual attention to students in class. At the end of the semester, those who seem to have realized their potential move to the A-level course; the rest of the students remain together and the course becomes a B-level course.

Complementing Silver Valley's placement system is their monitoring system. Some of it, such as the nurturing and observing in A/B algebra, is relatively informal. But the department has also formalized monitoring to an extent, in part at the behest of Mr. Cabot, the principal. As he told it, around five years ago they discovered that approximately 120 of their students did not have the skills to survive the eighth grade, never mind the rigors of high school. The discovery served to prod the Board into funding a clinic with a full-time aide. The clinic, which costs about $8,000 a year to maintain, has several uses. First of all, it supports the efforts of the mathematics department in guiding students safely through the minimum competency test all students take in their junior year. A screening exam in freshman year alerts teachers to the students who will find it tough to pass the competency test two years later, and those students are urged to take advantage of the clinic in their free time. Once a student has failed the competency test in the junior year, however, he or she is obliged to visit the clinic during free time. (This illustrates the tone and level of control in the program, since passing the test is not required for graduation.) The clinic is thoughtfully hidden away to make visits more palatable. Even so, Young told us, "The aide is prepared to drag the students in from the hallway". A second use derives from the departmental homework requirement: students who are delinquent in doing homework must spend time in the clinic after school.

Cabot and Young instituted one other mechanism to buttress students' chances to pass the minimum competency test: the so-called skills maintenance worksheets. These brief basic skills quizzes are administered each Thursday at the beginning of class. Typically, there are four or five exercises built around one topic. An example of an exercise from the percent worksheet is: "Sara wants to enter 12 3/4% on a calculator without a '%' key. What decimal number should she enter instead?"

To sum the curriculum story so far, the Silver Valley mathematics curriculum is divided into four levels. There is some traditional textbook use, as well as several courses in both the high and low levels where teacher-developed materials are used instead of texts. Some of these materials contain vestiges of the SMSG materials of the 1960s. A comprehensive placement and monitoring system supports the curriculum.

No curriculum implementation is ever perfect, and some tarnish shows up at Silver Valley when students talk about the differences between the honors H-level and the other levels. Several students told us that it was not uncommon for students to be eased out of the H-level because of their unsatisfactory work, and then for them to "coast" through A-level courses with A's. Whatever the real facts are, it was clear that the students perceive the four levels to be two levels, with a wide gap in between.

The one other notable component of the curriculum is the computer curriculum, one of the best that we saw in our site visits. In fact, it represented the best combined use of programming, course-related tool software, and general software of any school we visited. Of the school's 48 Apples, 24 belong to the mathematics department; they are divided evenly between two labs, one of which is reserved for use within mathematics courses, the other available for individual student use during free time (between 7:00 and 4:00). The two labs are separated by a glass partition, and both are observable from the office of one of the mathematics teachers, Mr. Cosgrove, who can both monitor use and assist classes who are using the computers. Apparently, not much monitoring is necessary, as Cosgrove reported to us: "We've told them that we'll close it down if they abuse their privileges. They police it pretty carefully."

All programming courses are elective and, at the time of our visit, there were 320 students "actively involved" in them. The courses were being replanned during our visit. Programming I and II have been semester courses in algorithm construction using BASIC, and advanced programming a course involving projects, which students could repeat as often as they liked. In the new design, programming II would concentrate on LOGO, and advanced programming would include machine language. In addition, the staff (the four who teach computers) planned to institute a less formal version of programming I for Level C students. Cosgrove talked with us about one engaging as well as ambitious idea he has embarked on: to work with the school's industrial arts department to build a robot -- programming students doing the programming and shop students doing the assembly.

Silver Valley seemed like most other schools in their experimentation with programming, confronting questions about which languages to teach, how to guarantee wide access, and so on. And a few of the more common problems have cropped up in the program. For example, female enrollments drop way off after programming I (15 out of 16 in programming II were male).

In one aspect of their computer curriculum, however -- using the computer to support course work -- Silver Valley seems much more settled and mature than its counterparts around the country, a phenomenon no doubt derived from the mathematics department's long association with computers in instruction. Geometry courses have built-in programming components, and Cosgrove described how, when he works with Level C students in programming I, he takes time to teach the working of such things as the slope and quadratic formulas. When other teachers reach certain topics in algebra, trigonometry, and analytic geometry, they are welcome to bring their classes for a computer session with Cosgrove's help and the help of the department's bank of tool software. The bank includes some of the graphing software of MECC and Scholastic, Inc., Addison-Wesley's conic sections and trigonometric functions software, and Math Software's Super/Math Package.

To place it in perspective, the well-organized computer use is typical of the entire mathematics curriculum and its implementation. All tests are computerized and all courses are designed by objectives. So when Young, the department head, sets out to search for new textbooks, he takes his cues from the course objectives.

When the teachers want to take the pulse of their placement program, they can juxtapose computerized test results with computerized placement records (complete with records of parent involvement). The program stands out as an exemplar of superb management, with very few blind spots. One possible blind spot is female involvement in advanced courses; we heard little concern expressed about the male dominance in a few of the courses (15 out of 16 in programming II; 18 out of 24 in honors precalculus; 12 out of 19 in advanced placement calculus AB). Another weak point has been representation of black students in upper levels, but Mr. Cabot, the principal, was optimistic: "I sense an upward movement of the black students. When busing began, they were all C-level students. Now there are some at the A and B levels, as well." Whether the optimism is warranted remains to be seen. As noted above, many students, both black and white, perceive a sizable gap between the honors and non-honors levels, and the staff will have its work cut out to eliminate this perception of a program divided into two classes -- the select and the non-select.

Teachers and Teaching

As might be expected in a department where 10 teachers have been together nearly 25 years in a school whose principal actively cultivates professionalism among his staff, the 8 Silver Valley teachers we observed were, for the most part, models of effective teaching behavior. To our eyes, they obviously planned well, stayed on their planned courses, used class time to its fullest, engaged their students in active discussion, and so on; in short, they were living manifestations of the recommendations of the effective teaching literature. We could fault them on only one ground, and it is one that plagued most of the programs we studied. When a crisp pace to classwork is prized, then many students are left to sit silently in a state where neither teacher nor class observers can be sure they are understanding what is going on. For the most part, however, the approach to instruction is right in line with the literature.

Of course, their disciplined approach to teaching is understandable, since Young's book has played such a central role in staff training and evaluation at Silver Valley. But their commitment to perfecting their craft predates the writing of the book. The older teachers are almost all veterans of the National Science Foundation summer training of the 1960s. The grand prizewinner in that category is Mr. Cosgrove, who counted off nine in which he had participated, in a variety of settings around the country.

What was less expected were the range of teaching approaches in the mathematics courses and the dynamism of most of the veteran teachers. The latter was impressive in light of the long experience of the majority of the teachers, decades in the classroom that would have dulled the edge on many. As for the teaching approaches, we saw combinations of whole-group discussions, small-group work, team boardwork, individual seatwork and boardwork, and individual student recitations and explanations at the board. Different teachers used different combinations; those who aim for variety talked about their reasons for using the techniques they chose, usually to have some effect on the students' expectations or to improve study skills.

Mr. Bardak, who teaches honors precalculus: "Right now, at this point of the year, I have started them off with small-group problem-solving. When I call on a group, they choose one of their group to report on their work. Pretty soon, I'll move toward requiring them all to be prepared, so that I can call on anyone."

Throughout the program, there were manifestations of one of the most universally powerful factors we encountered in our site visits -- the communication of high expectations. Much of what has been reported so far in this case study reflects the strength of the factor at Silver Valley. A conversation with several students -- black students bused in from the city -- made it especially memorable for us. One of the students remarked that the program had been good for him. Asked why, he said, "Mr Young makes you do all this homework, and you do it." "Or," another added laughingly, "you don't take math."

Young's book recommends the use of overhead projectors in class discussions -- both to present new material and to pose problems. We saw the projector used in more than half the classes that we visited. The book also recommends seating students in a U-shape to facilitate discussion. That, too, we observed in several classes, although traditional seating was more the rule.

The quality of teachers' classroom interactions was high in most of the classes we visited . (One exception was the AB advanced placement calculus, where the demands of the material, particularly the amount, seem to legislate against much thoughtful interaction or time for student interpretations. This, by the way, was typical of most of the AP courses we visited in programs around the country; a fast pace seems to supersede other values.) In the Paideia Proposal, Adler wrote about the three roles of teachers: to deliver information, to coach, and to stimulate thinking. We saw examples of all three in the Silver Valley program:

Mr. Young's honors algebra I:

- "Put this in your notes."
- "What's wrong with $-3 \geq x > 7$?"
- "Those are not the right words, but that's the right idea."
- "What do you observe about these statements?"
- (to a student who suggested a solution to an inequality, then discovered it didn't work.) "That's good. It gives us information about something that doesn't work."

Mr. Tadisch's B-level geometry:

- "What can you say once you know these 2 angles are equal?"
- "Everyone stand. When you see the error in Judy's proof, sit down -- that's good! Five people were left standing. That means they were saying they didn't understand. They gained something."
- "Nobody has a solution? Okay, pull together in small groups with your neighbors and share your ideas."
- "That approach looks promising. Get on that horse and ride it!"

Tadisch, who coaches baseball, appeared to have a welter of strategies up his sleeve. A few are definitely of the corny variety, but they seemed to appeal to his students. One is called "The Top Ten Hustle." Tadisch puts a problem on the overhead projector, and as students complete it, they rush up silently to show him their answers. The first ten who are correct are awarded numbers, somewhat in the fashion of the finishes of a cross-country race.

We asked David, one of the students in this course, to describe its outstanding features: "I like the different techniques -- the overhead projector, the problem work in small groups, the board work. They help me get the stuff down better. I also like the different ways Mr. Tadisch finds to give all the students a chance to do well. Like his 'Mulligans' -- surprise quizzes that only count toward the grade if you do well." About what might make the entire program work so well: "I can always get help anytime after 7:30 in the morning. I may not get to work with a particular teacher, but I know that someone will help me."

Of course, teacher availability is a built-in feature of Cabot's grand design for a school where teachers can concentrate on managing students' learning and their professional growth. Eliminating lavatory and cafeteria duty did not necessarily make life easier for the teachers. Their typical course load has grown from four classes a day to five, and the district requires that they be available to students from 2:30 to 3:45 every day. As David indicated, however, teachers typically go beyond what is required of them. During the school day, students needing help can check in with the aide in the clinic or catch a free teacher at her or his work space in Young's outer office. Ms. Brodski, a second-year teacher, uses her two planning periods during the day to call parents, alerting them to any coursework trouble that might loom for their children. She teaches primarily at Level C and bemoaned the lack of concerned parent response that she saw as typical of that level.

If there is gray side to this exemplary program, an area where the efforts are not quite so sharp as they are elsewhere, it is Level C. To be sure, if 90 percent of the students at that level take 4 years of mathematics, the problem cannot be severe, but the classroom interactions seemed less sharp there and the teacher behavior less dynamic. Teachers of the A-and H-levels hardly ever teach B or C courses, and the same is true of B- and C-level teachers teaching A and H levels. (The arithmetic skills course has been taught by the same man for 17 years, and he requests it each year.)

Interestingly, while the staff showed little concern about this situation and, indeed, seemed satisfied with it, some of the students cited it as a shortcoming. Without doubt it contributes to the widespread student perception of the gap between the upper and lower levels. In a touching show of care for their peers, a gesture that was reproduced at other exemplary sites with a similar situation, Silver Valley honors students gave us one or another variation of: "The best teachers teach the upper level courses. I wish the lower level students could have them as teachers, too." No matter how accurate their assessment of the teachers, the students' lament serves as a warning that the program's unquestioned excellence is tainted with perceived inequity, at the very least. Staff decisions about course preferences have done little to mitigate the perception.

There is one other aspect of teaching and staffing that was important at many mathematics programs we visited, namely, the collegiality, teamwork, and sharing among the staff. At Silver Valley its influence seemed muted, though we were told that it does take place informally. Mr. Cosgrove mentioned the importance to him, through the years, of teachers' mutual support in identifying critical subtopics in the various courses. Another opportunity is provided by the math team, for which seven teachers, without pay, serve as coordinators and advisors. And finally, professional meetings provide this staff a stimulus for interacting. As noted above, Young, in particular, and Cabot stress the value of such meetings and 80 percent of the mathematics department respond by attending at least the state-level mathematics meetings each year.

Conclusion

Silver Valley is rich in factors contributing to the success of its mathematics program. The dominant one is leadership, in the persons of the principal and, especially, the department head. Their careful planning and management have produced an environment which both exalts and challenges the teachers. The teachers themselves constitute a second influential factor, through their knowledge, dedication, flexibility, classroom control, and enthusiasm. A third factor is the curriculum, carefully sculpted through the years and supported by an exemplary system of placement and monitoring. The resulting program is steeped in high expectations and a constant attention to accountability.

The long acquaintance with excellence is also a contributing factor of a sort -- the so-called "halo effect" -- which signifies that a tradition of success breeds pride, high expectations, and so more success. But for schools who want to learn from Silver Valley's success, citing the halo effect begs the issue. It is much more instructive to look at the quality that ties all of the above factors together and drives the tradition of excellence. That quality is consistency. It is a subtle quality that informs the entire program. For example, it leads parents to expect to be well-informed; it allows David, the student, to expect Mr. Tadisch always to make it possible for him to do well in class; it allows the teachers to expect a challenging review each time they are evaluated. That kind of consistency does not develop easily. It is the product of comprehensive planning and monitoring, and demands a constant commitment to honest self-criticism. Silver Valley exemplified it as well as any program we visited.

TAYLOR HIGH SCHOOL

> "Most of the teachers in this school pull and gnaw and are fiercely independent. But even in that group, the math people stand out because they have a lot of pride, and they work exceptionally hard. I know of at least 3 who work 70 hours a week . . . There is a negative side, though, because burnout poses a real threat to our mathematics department."
>
> The principal, Taylor High School.

As we moved from school to school in our study, we mapped a variety of routes to excellence in mathematics. We saw no easy routes, of course, but we did mark some safe ones -- stick to the text, watch test results carefully, do what others do, but do it better. A second group of exemplary programs challenge their top students with the nontraditional, but keep to a traditional, though still demanding course with average and below average students. A few others are innovative with all their students, controlling risk with a basic reliance on traditional textbooks but incorporating the nontraditional where they see the need and can grab the opportunity.

Taylor High School fits into this last category. The teachers have committed themselves to frequent and meaningful computer use in every course; they have bolstered their committment to excellence with an innovative extracurricular program for minority students; and they have made a conscious effort to keep girls from dropping out of mathematics courses. As Taylor's principal notes, the demands of innovation in the program have been severe. The strain of the staff's hard work shows through the gleam in the program, yet it is impossible to imagine the gleam without just that kind of effort. It is also difficult to imagine the program as imaginative and successful as it is without the support the Taylor mathematics teachers have drawn from the school and district administrators. In her letter of application to our study, the department head cited the support of "our mathematics coordinator, principal, director of secondary education, associate superintendent for curriculum and instruction, and school board" in securing funds for an expanded program in computer use. Her example not only outlines the chain of support for the mathematics program but also indicates the breadth of attention it has earned.

Background

Taylor High School is one of three high schools serving a Midwestern city (population 105,000) much of whose character is molded by the large state university located there. Taylor comprises grades 10-12, and its 1,700 students represent a cross-section of the city's population -- many children of university staff, but many others with no univeristy affiliation at all. Twenty percent of the students are black; another ten percent are from other minority groups.

The physical design of the school is distinctive. Set on an open rolling expanse next to a small river, the round school buildings blend nicely into their surroundings. They were also given the round shape, I was told, so that students and teachers emerging from class would be spared the sight of waves of bodies surging toward them. As the student population grew, however, aesthetic concerns were set aside, and several mobile units -- so-called portable classrooms -- were installed on the grounds. They are still used, complete with portable heaters and leaky acoustics, yet in the advanced placement calculus course I observed, the close environment added an air of intimacy to an already congenial group of learners.

Congeniality abounded in the mathematics program at Taylor High School. The staff -- principal, assistant principal, and teachers -- were remarkably cooperative, thoughtful, and informative. And, when I asked to talk with a couple of students -- meaning exactly two -- the department head sent out the word and twenty appeared in the appointed room during their free period, eager to express their opinions about the program.

The attitudes of Taylor's staff and students reflect those of the surrounding community. The imposing proximity of a large and very good university puts education -- and mathematics education in particular -- on the front burner of interest for many residents of the city. Parents were termed "very interested and very aggressive" by the department head, Mrs. Schmidt, who also characterized the community as: "very supportive: they have never turned town a tax millage." It would be a mistake, however, to write off Taylor's success in mathematics to its sophisticated setting and the interest of it constituents. The other large high school in the city has a student population similar to Taylor's, yet their mathematics results are not on a par with Taylor's, and their drive to be innovative lags far behind. As one of the district administrators told me: "The staff at Taylor pushed <u>us</u> on computers. We've had to push the other staff."

All the same, while the community's interest in education hasn't assured Taylor's success in mathematics, it hasn't hurt, either. And while it seems evident that the mathematics department succeeds in good measure because "they pull and they gnaw," to use the principal's phrase, it is also evident that they find it inviting to pull and gnaw in a community where education is a commodity large and visible enough to grab onto. During my visit, there was circulating in the community a 78-page document called "Proposals for High School Improvement" which, among many recommendations, calls for raising the mathematics course requirement from 1 credit to 3 credits.

The debate in the community over the document has been intense and, at times stormy, as group after group have offered their opinions. "We have to ask for input from every community group," the director of secondary

education told me, and so Cluster Meetings have been held with various parent groups, the Rotary Club, the NAACP, and so on. Adding spice to the debate has been the community's unsympathetic response to the teachers' strike that delayed this year's opening of school by three weeks.

There is another, somewhat conflicting side to the community, as well. In spite of signs of community interest in education, the group of seven girls from AP calculus whom I interviewed complained that there is too little attention paid to academic excellence among Taylor students. They felt scorned for their AP ties and resented the annual "Geek Week" in which participating Taylor students don glasses and carry armsful of books around the school. And in spite of the presence and influence of the university, the mathematics department head told me that the department doesn't use or interact with the university "nearly as much as we should." Indeed, except for the engineering program for minority students described in a later section, I saw no evidence that contradicted her.

The apparent conflict here -- community intensity about education versus some insouciance at the school -- resolved itself for me as I got to know the students and teachers better. The former -- in particular, the AP girls -- are very serious and their standards are high; the latter are exceptionally confident and independent.

When we chose our exemplary sites to visit, we were attracted to Taylor for several reasons. Certainly the efforts to attend to equity in mathematics education were attractive, and the moderate success of those efforts made the school even more attractive. Although girls represented less than a third of the advanced placement calculus class I observed, they represented half of the students in the non-AP honors calculus. We were also impressed that, despite the current minimum requirement of only 1 course, the staff has been able to enroll 75 to 80 percent of the students in mathematics courses each semester. Furthermore, AP calculus test scores and the percentage of students taking them have been well above national averages. And finally, we found Taylor's extensive and innovative use of computers very appealing.

The support that underlies the computer use at Taylor is worth mentioning here because it again illustrates how much and how widely the community -- in this case, the school board -- thinks about education. The Board has supported computer inservice for teachers, the summer development of computer materials by staff, and the purchase of a relatively large collection of hardware -- a few TRS-80's, 6 Itel time-sharing units, 22 Apples in the mathematics department, and another 24 Apples for word processing. In a community as complex as Taylor's, however, no such arrangement can be without its drawbacks and criticism. Indeed, the school's computer coordinator is of the strong opinion that the Board limited its generosity to hardware and has gone stingy with software and support needs. Consequently, he worries that the mathematics teachers, who bear most of the computer responsibility in the school, will get swamped and demoralized by their growing computer demands.

Leadership

It would be a mistake to discount the computer coordinator's concern about demoralization. It would also be a mistake, however, to discountthe enthusiasm that drives the mathematics teachers' sense of adventure and exploration as they set about changing the curriculum in some innovative ways. In a structure as rigid as the American public high school, a sustained spirit of exploration requires the support of enlightened leadership, which exists for the mathematics teachers at Taylor on three levels: the department head, the principal, and the district's director of secondary education.

The department head, Mrs. Schmidt, has been teaching mathematics at Taylor High since the school began in 1969, and she has chaired the department for ten years. Compared with department structures at other schools we visited, the arrangement at Taylor seems better than average in its compensation of the department head. For example, Mrs. Schmidt has a reduced teaching load of four courses instead of five, and earns ten percent over what her salary would be as a fulltime teacher. Her authority to evaluate teachers is minimal -- by design, since at Taylor that responsibility belongs to the counselors, the three assistant principals, and the principal. Even so, as has been the case with most of the good leaders we observed in this study, Mrs. Schmidt's influence over her teachers seems in no way diminished by a lack of official authority.

The computer coordinator, a physics teacher and so a close, but still outside observer of the mathematics program, spoke admiringly of Mrs. Schmidt's abilities to "rein in the divergent personalities in the department" and "to use what power she has as a lever to control the department." The image he offered was one of firmness, not rigidity, a critical distinction for those who would foster growth among those they lead. That Mrs. Schmidt has kept this distinction sharp was confirmed by two mathematics teachers who characterized her sharing of materials as "a model for the rest of the department," and her willingness to "explain difficult things to the staff in several different ways," as a model in communicating.

Modeling of successful teaching behaviors is a characteristic of mathematics leaders we have observed in this study, and so is the ability to engender trust. I heard evidence of the latter from several teachers regarding Mrs. Schmidt, but the most poignant example came from the seven girls in AP caculus. Almost all of them were enrolled in other AP courses as well, and they spoke fervidly of the pressure of their work loads. "Mrs. Schmidt," they told me, "is the only AP teacher who doesn't act as if her course is the only one in the school. We can trust her to change test dates if our other courses get too demanding."

I observed one incident that illustrated another aspect of Mrs. Schmidt's qualities of leadership -- her willingness to listen. As I was chatting with her in the central area of the mathematics department, a teacher -- an exchange teacher from England -- walked in, glowering. Apparently he had endured nothing but trouble for the previous hour from one of his classes. As he fumed to us about their lack of respect and their lack of motivation, Mrs. Schmidt listened, showed she understood how he felt, and when he was ready to discuss options for dealing with the troublemakers the next time they acted badly, she helped him to talk through some options.

At the next level of leadership influencing the success of Taylor's mathematics program is the principal. His influence is primarily indirect, in that he pays close attention to the needs of the staff, worries about their morale, has taken some steps to alleviate their worries, and has taken other steps to continue from Mrs. Schmidt the line of trust that begins with the link from the staff to her. For example, when he saw the computer responsibilities of the mathematics staff growing to worrisome proportions, he gave the position of computer coordinator to a physics teacher. He told me that he takes pains to involve Mrs. Schmidt and the other department heads as much as possible in the interviewing of prospective teachers. When he recently became convinced that the district administration was giving short shrift to his staff in the development of the Proposals for High School Improvement, he, in his own words, "put my job on the line" to induce the administration to bring Taylor's department heads into the process of developing the proposals.

Despite some differences of opinion and strained feelings between Taylor High School and the district administration over the Proposals for High School Improvement, there is a third and very important level of leadership that influences Taylor's mathematics program, and it emanates from the central office in the person of the director of secondary education, Ms. Falco.

Until the past year, she was the district's mathematics coordinator, and her stamp of personal interest and enthusiastic support has been on Taylor's exploration with computers from the start. More than that, she has explored with Taylor's staff some of the far-reaching implications of their commitment to integrate computer use into all courses. For example, she is intrigued by the prospect that the strategy might serve to ease girls into computer use, thus avoiding some of the male-dominated patterns that have emerged when other schools have begun computer courses.

Falco's commitment to sex equity runs even deeper. She has brought nationally recognized experts like Judith Jacobs to the community to speak with the teachers about women and mathematics, and she was instrumental in including in the Proposals for High School Improvement a provision that teachers will be evaluated on their effectiveness with women and minorities. Success with young women in mathematics has been

real at Taylor High School and it is growing, yet the school, and the whole district, has so far failed to equal that success with minorities. The failure is clearly a sore point and source of frustration for Falco and, though she intends to target some efforts at the lower grades since many of the minority students have already fallen way behind by the time they reach high school, her sense of frustration continues.

Yet her frustration, like the principal's concern for the stake his teachers have in the future of Taylor, is a powerful and potentially creative emotion, and it promises changes for the better. The power in such feelings exemplifies the intensity of vision which guides the leadership -- at all three levels -- behind the excellence in mathematics at Taylor High School. Rarely in my travels to exemplary programs did I witness the quality of visionary leadership that I saw in the mathematics department at Taylor High School.

Curriculum and Implementation

Of course, visionary leadership in mathematics is worth little unless the teachers also buy into the vision and apply it to their teaching. That Taylor's mathematics teachers share in the vision and associated commitment is evident in their pride and penchant for hard work. In particular, they are committed to weaving computer use into the entire curriculum, to adjusting curriculum materials to meet student needs at all levels, and to attending to the success of females and minorities. It was not the case that every teacher I interviewed is driven by each of these, but each goal has its own group of passionate advocates among the staff, and the aggegrate of harmonious passions defines a unified staff commitment. Furthermore, all of the teachers are determined to look beyond the text to meet their goals. There is a deep-rooted tradition in the department of developing supplementary materials and, as one veteran teacher described it, "Whenever a new text comes, we adapt our materials."

This veteran, Mr. Weston, has been supplementing the geometry curriculum with logic activities since the school began in 1969. With district support during the summer, he has developed computer-related proofs to supplement the geometry text, and he and several colleagues have been honing the computer materials into a five-day component for each of the geometry courses. The activities are well-conceived in their use of the computer. For example, one of them challenges students to induce a formula for the circumference of a circle by letting the computer crunch out the computations for the perimeters of a sequence of polygons, the numbers of whose sides increase so they approximate the shape of a circle. Weston sees the computer as "a way to weave geometry, algebra, and logic throughout the curriculum," and he is clearly inspired by that prospect.

I saw the computer being used in other contexts: in the math lab, where 16 low-level students worked individually with the Milliken Company's basic skills software; in a precalculus course in which several students

stepped to the microcomputer at the side of the room to write a brief BASIC program to help compute some limits of numerical sequences. In career math, which is a course many of the math lab students move into in eleventh or twelfth grade, the teacher assigns her students several very simple BASIC programs -- e.g., to change units of measure. (She also uses calculators with them for some problem-solving activities). Each of these uses came from the teacher's own initiative. Indeed, all of Taylor's computer materials are written by the mathematics teachers.

Though textbooks are chosen by a district-wide committee, Taylor teachers have something to say about their use. For example, they insist on using the same texts for different levels of the same course. Thus, all levels of geometry -- from honors down to the lowest level -- use the same text, with the demands of the courses differing in the amount of material covered and, to some extent, in the depth in which it is covered. Tests, too, are fairly standardized across levels and are developed by the teams of teachers assigned to a particular course. I was told that the staff avoided curving for grades and aimed as much as possible to grade on the basis of ideas understood, even if it means that no A's are awarded for a particular test.

During our visits to schools in this study, we watched for any direct or indirect expressions of high expectations to students that might bear on the success of the programs. The firmness in the standards of Taylor's staff, permeating all levels of courses, was one of the broadest indirect expressions we saw in our study. In order for such firmness to work, however, it must be balanced by careful attention to student placement, and then to meeting the needs of students, once placed. With some slight wavering, the balance appears to be in place and holding in Taylor's program. In the tenth grade there is one honors level, which thereafter splits in two -- one being an AP track. There is a regular college track and, for the incoming tenth graders with the lowest skills (and some eleventh graders), two courses are available: essential math and math lab. I was impressed with the care and thoughtfulness of the young teacher who teaches both of these courses. The essential math students make use of a text, while the math lab students don't, so she is developing her own diagnostic test to assist her in placing the students with low reading skills in the math lab course.

There is wavering in the balance, however, and it comes from the preponderance of black students in this lowest level -- nearly 60 percent of black students are in those courses. Two of the black teachers I interviewed see the problem's roots in the junior high: "At least one junior high in the city begins tracking in the seventh grade, and many black students are eliminated long before we get them." For the black students who do survive, these two teachers have begun a cooperative program with the local university's engineering school. Once a week, about 20 black juniors and seniors meet during their lunch hour to work on projects such as building a microcomputer, to go on field trips, or to listen to invited speakers -- usually black engineers. In addition, during the summer, the university arranges summer jobs for the students with support from one of the state's largest companies.

To make the program work, both teachers actively recruit when the school year begins, taking time in staff meetings to canvass other mathematics teachers for sophomore candidates. They then approach the recommended students with blandishments like, "You're doing well. Why don't you come to our next meeting." The effort is simple and persuasive, and it evidently pays off. All of the students who have stayed with the club through their senior year have gone on to four-year colleges.

As successful as the club has been in motivating black students who show potential, there were no blacks in the AP calculus course I observed, and the majority still progress no higher than the lowest track. If the present Proposals for High School Improvement hold up, all teachers will be evaluated on "success with females and minorities." This should keep the efforts at improvement alive, but those efforts will have to be considerable.

Teachers and Teaching

The influence of the surrounding community, the firm and supportive chain of leadership, and the imaginative curriculum all lend strength to the mathematics program at Taylor High School, but it is the quality of teaching in the program that makes it vibrate with excitement. And it vibrates, rather than merely hums, because the quality has several layers to it. The teachers are bright, with the irbrightness revealing itself in planning, organization, and follow-through. The teachers are enthusiastic, and they feed that enthusiasm to each other. And, lastly, the teachers are guided by a deep sense of responsibility -- to their students and to their own ideals -- and they reveal that quality by the long hours they put in.

There are 13 mathematics teachers in the department (2 part-time), 5 of whom have been on the staff for more than 10 years, 5 of whom have been on the staff between 5 and 10 years, and 3 who joined in the past few years. (One is a Fulbright Exchange Teacher from England.) Their offices, which they share in pairs, all open into a central meeting area which is decked out with bulletin boards, blackboards, shelves of books and journals, and tables. Students are free to come to this area, and during the two days of my visit, there seemed always to be something going on in the area -- usually students meeting with each other or with teachers. When I remarked on the constant use of the meeting area to Mrs. Schmidt, the department head, she beamed at my having recognized something very important to her: "Oh, yes. We are a staff working together toward a goal." The goal, of course, is the continued excellence of the program, from the lowest level to the highest level, and the meeting area helps to keep the striving alive by making teachers more available to students. It also allows them to nurture the spirited collegiality I found so attractive about this group of teachers. The area often resounded with laughter and spirited discussion, and its bulletin board, which contained announcements, short articles, and puzzles (put there by teachers to challenge their colleagues) seemed a useful and well-used mechanism for communication.

The collegiality extends beyond the meeting area as well: all teachers within the same course work together to develop final exams. One teacher told me: "The teachers in this department automatically put copies of tests they use in each other's mailboxes." And the physics teacher/computer coordinator told me that mathematics is the only department in Taylor High School "where, within courses, things are tightly coordinated. Each teacher is insistent that the topics he or she thinks are important are covered by the other teachers."

The computer has also become a vehicle for nurturing collegiality, with the exchange of opinions, ideas, and materials it demands, but the cost has been dear. Mrs. Schmidt acknowledged that her teachers "have invested many additional hours preparing computer materials, grading projects, and keeping the computer lab open for students' use after school and at other times." The former computer coordinator, Mr. Elkins, who pioneered the use of computers at Taylor and still teaches the advanced computer courses, told me he spends at least two hours a night grading programs. Mr. Weston was paid for two weeks' work during the summer to develop his geometry computer materials; yet he estimates he spent more than 200 hours on the project. Although the principal has tried to alleviate some of the computer burden of the mathematics staff by involving the physicss teacher as a coordinator, the burden and strain remain, and they will continue to test the mettle of the mathematics staff for some time.

The characterization of the mathematics teachers as organized and consistent in their follow-through comes from perhaps the best source of all on the subject -- the students. When I met with a group of them and asked what made the math program special, they agreed unanimously that the mathematics staff was the most organized of all in the school. A transfer student then spoke up to contrast the Taylor teachers with the mathematics teachers in his former high school: "Where I used to go to school, we just went over our homework in class, then moved on to new homework assignments. Here at Taylor, teachers lay things out so we can understand them."

They can "lay things out" as well as they do because they approach teaching very thoughtfully. The woman who teaches math lab, essential math, and career math -- the lowest level courses -- impressed me with her dedication, determination, but especially her resourcefulness, taking frequent opportunities to supplement text work with calculator, problem-solving, and computer work. The two teachers who coordinate the extracurricular engineering program think carefully about involving black students in mathematics. The quality in Mrs. Schmidt's teaching was recently acknowledged offically when she was named her state's winner of the Presidential Award as outstanding mathematics teacher. But the story that sold me on the teachers' reflective approach to mathematics teaching was related by Mr. Weston. One of his students showed his father the logic materials developed by Weston and the other geometry teachers to

supplement the geometry textbook. The father, a teacher of logic at the university, found fault with the lessons and passed on his criticisms to Weston. I asked Weston if the criticisms had been difficult to hear, if he had wished that the father had minded his own business. He seemed honestly put off by the question: "Oh, no. We took the criticism very seriously and analyzed our materials to see if the criticism was valid. It was, and we made changes. We actually were grateful for the help." Here, I realized, is the essence of confident and reflective teaching: the ability to listen to, analyze, and use a critic's suggestions.

The enthusiastic teaching and the preparation, organization and thoughtfulness I observed among Taylor's mathematics teachers were all first rate, but there was one gap, one level of excellence they have yet to reach. I saw little of the kind of higher order classroom interactions we observed at such schools as Trinity High School and East High School -- the approach to teaching that aspires to developing mathematical thinking as well as inspiring the learning of mathematics; the classroom questioning that challenges students to analyze their own thinking, refine their explanations, and ask good questions. These were generally missing at Taylor, but they constitute a perspective and a set of skills that are easily within the reach of the Taylor teachers I met. Perhaps they lie on the next plateau of excellence toward which they will push the program.

Summary

Taylor High School is proving that innovation and success can proceed hand in hand. Their success in mathematics has a bit of the traditional in it -- namely, high AP Calculus test scores and a high percentage of students in mathematic courses; it has a bit of the nontraditional in it as well -- an innovative plan for computer use and a supplementary program to attract black students to technological majors in college. Underlying the program's excellence are a staff that is extraordinarily reflective in its approaches to teaching and curriculum design, and a chain of leadership that makes excellent use of the conscientious and energetic staff, taking pains that they be involved in decisions about the future course of mathematics education in the school and district. Given the vision and energy that drive Taylor's program, even that higher plateaus of future course should reach excellence.

GREELEY HIGH SCHOOL

"What makes the mathematics program so strong? The teachers -- they have a sense of mission."
former Greeley principal, now Assistant Superintendent

In one form or another, a sense of mission seems to inspire many successful mathematics programs. It certainly was not uncommon among the 28 schools we visited in our study. It would be difficult, however, to point to a program whose sense of mission is more idealistic and intense than at Greeley High School.

Greeley has been designed to provide excellence with equity, not just in the hollow, hopeful tones of most program designs, but with clearly delineated standards. In the duality of the goal, it seems an especially American experiment; at least it is difficult to imagine another country's educational system supporting the struggles and risks that have shaped the first few years of Greeley's existence.

Background

Greeley is located in a large Midwestern city (population approximately 600,000). Six years ago, the courts ordered the city to make efforts toward school desegregation. In response, the district decided to set up a series of magnet schools -- including Greeley High School as the designated "high school for the college bound." Before the transformation, Greeley had been almost entirely a minority school, with the worst reputation in the district for crime, drugs, and disruption. As a special school, Greeley was completely transformed. The staff and students were transferred out, unless they qualified for the new Greeley and wanted to stay. For staff, the requirement for staying was a master's degree in the subject area being taught or 15 hours beyond a bachelor's degree, including a subject area research course. Students were required to have a C average, and the racial mixture of the student population was set to match the city's -- approximately 60% white, 40% black.

With the luxury of a clean slate, the designs of the new Greeley High School were ambitious in laying down their expectations and standards, and they have been tenacious in holding onto them. From the start, the staff has aimed to qualify 90 percent of the school's graduates for college, and they continue to meet their goal. Attendance, carefully monitored, has been an ongoing measure of success, and the average daily attendance is 95 percent. Academic standards were raised above those of other high schools in Greeley's district. For example, students are required to take a minimum of two years of mathematics, and are required to begin with algebra, unless they have had it before they enter Greeley.

The commitment to the city has been strong; as Greeley has become popular, the suburbs have been allowed to account for no more than 10 percent of the students accepted. No such limit on students was necessary in the first year, however, when both city and suburbs were chary of the new special school and its sense of mission. The first principal -- now assistant superintendent -- advertised, hustled, and cajoled, spending evenings, along with his staff members, at neighborhood meetings throughout the city to convince wary parents that enrolling their children in Greeley was worth the risk. The school started small; since then, the growth has been rapid. From a first group which numbered just under 300, the school has grown yearly to 530, then 700, 830, 900, and finally to 1,100. The original goal for the school was 1,000; so size, with all of its challenges to teachers and administrators, has suddenly become an issue at Greeley High School.

Early on, when the agenda for change was still taking shape, the school decided to adopt the Geneva-based International Baccalaureate (IB) program, which allows juniors and seniors to earn credentials for college course credit or advanced placement at universities. Greeley's mathematics department has designed its precalculus, calculus, and advanced topics courses according to IB standards. There are three levels of IB exams, and the numbers of Greeley students taking one of the mathematics exams have been increasing. In 1983, 25 took one of the mathematics exams; 30 took a computer studies exam. This year, the staff expects 50 students to take one of the mathematics exams and about 25 or 30 to take the computer exam. Adoption of the IB program was but one manifestation of the daring that inspired the transformation of Greeley High School. In mathematics, at least, the adoption has not been without problems as we shall see, but the increasing enthusiasm of the students for advanced college placement speaks well for risks taken.

We were attracted to Greeley by the daring in their experiment as well as by their accomplishments. On the so-called Subsidiary Level of the IB mathematics exams, the exam most frequently taken by Greeley students, the Greeley average in the past two years was about 4.7 (out of a possible 7); the international average was about 4.2. Furthermore, the 1983 average of the 8 Greeley students who took exams at the other 2 levels was 6.0, well above the international average. In addition Greeley's student interest in extracurricular mathematics activities has been high, and Greeley's contest achievements have been impressive.

Two site visitors spent two and one half days at Greeley, and this penchant for forging ahead, taking some risks, and aiming for ideals seemed to us the most exciting aspect of the mathematics program, and indeed, of the entire school program. The commitment to equity, the endorsement of a "nothing lower than algebra" curriculum, the embracing of the IB program, the plunge into new computer competitions and a welter of mathematics competitions, all seemed very exciting, especially in light of the record of success.

A specialized school like Greeley is bound to have several strong departments, but the mathematics department there seems to stand out. The principal noted that, in what he described as a "very strong teachers' union town," the mathematics people seem to stay later than others to help students. ("I never see a math person leave at 2:45, the time beyond which we can't make them stay.") The coordinator of the IB program told us, "Of all the departments, mathematics has come the closest to meeting the needs of the gifted." The assistant principal, who handles scheduling, reported that "the requests for increased mathematics courses and staff members have been one quarter higher than in other departments."

From the first years of trying to sell the school idea to the community, the mathematics department and, indeed the whole school, have cultivated parent contact carefully. A Parent Day took place during our visit and we were able to observe interactions and to interview parents. The school uses a clever strategy -- having parents come in to pick up report cards. Artificial though the strategy is, the school makes full use of it to build parent-teacher communication. The entire staff -- teachers, guidance staff, and administrators -- seat themselves throughout the cafeteria and a steady stream of parents sit and talk with them. Despite the daytime scheduling, the turnout is very impressive and, as we watched them, the conversations seemed long and substantial. Last year, with just over 900 students in the school, 800 parents showed up for at least one Parent Day including many with children in trouble with grades, a noteworthy accomplishment in our eyes since we were chagrined to see parent contact at many schools in our study weighted heavily at the sucessful end of the student spectrum. At Greeley, if any special contact is needed later on, the bridge has been established. For example, when asked about any efforts toward ensuring minority success in the IB courses, the principal described how he had recently been on the phone with the mother of one minority student who was late in submitting an IB essay. He and the mother established guidelines for seeing the student through the task -- the principal to watch the guidelines at school, the mother to watch them at home.

Despite its special history and the care taken in its development, Greeley High School was for us another example of a successful school struggling for support within a large urban school system. We had noted in other city programs in our study that success can seem a liability in a system where large-scale politics control decisions, and where politically savvy administrators are disinclined to favor one school or program over another. In that kind of environment, successful schools and programs often earn little more than benign neglect; compliments flow freely, but real support flows to the schools and programs that need shoring up. The situation in Greeley's district is not quite so dire, but administrative support for the school, and the mathematics program in particular, is mixed. As described above, the school could not have gotten off the ground without the salesmanship and leadership of the

original principal, who now supports the program from his position as assistant superintendent. Also, after the district conducted a recent survey of mathematics teachers throughout the city, a set of recommendations was made, several of which are consistent with the goals of Greeley's mathematics program -- in particular, training in effective teaching models, such as the Missouri Mathematics Effectiveness Project, and allocations of overtime pay for teacher-sponsors of student participation in mathematics extracurricular activities.

Real financial support, however, lags behind ideals and recommendations. Although a concession was made by the district in allowing small IB classes, there is a strong commitment not to treat Greeley differently from other schools. That means, in particular, that the mathematics department proceeds on a very skimpy budget. (Little money is available for materials, and students buy their own textbooks.) The department head reported having to do some arm-twisting with the principal during this year's budgetary wrangle to make sure that computer supplies were not drawn from her budget. The school itself seems to have done little courting of support beyond the district office. Though several administrators and teachers agreed with us that two large nearby universities could be easily tapped for tutorial help and supplementary programs, especially now that Greeley has expanded beyond the original goal of 1,000 students, we sensed no real desire to use the universities in this way. In light of the growing alarm among the mathematics teachers that many incoming students are being poorly served in large algebra I classes, we found the hesitation curious, if not a bit unsettling.

Leadership

In the context of our study, there are two kinds of leadership: the leadership that defines the standards of excellence in mathematics education and charts the course for attaining it, and the leadership that holds the course and cultivates the team effort that is essential for continued excellence and improvement. Often, as is the case at Greeley High School, the leader or leaders of the second type are different from the leader in the first type. In Greeley's case, Mr. Atkins, the former principal and now Assistant Superintendent, took complete charge of the school's destiny in the first few years. By his own description, he left a deep impression all the way down to the classroom: "I was so damned autocratic, I gave teachers a format for class instruction and told them this was the way I expected them to teach. First thing every day, they were to review what was done the previous day. Next, I wanted them to outline for the class what was going to be done that day. Then they were to teach the lesson, summarize, and give a homework assignment. I wanted them to allow plenty of time to talk about the assignment, but absolutely no homework was to be done in class. I required each teacher to have a lesson plan and bring it to me when I visited his or her classroom. I came on very strong to teachers, but we were under presure to make the school a success."

Now that the school is perceived as a success, and the individual departments have been able to mature in that success, the current principal, Mr. Jackson, is inclined to trust the departments to maintain their own standards of success. His own involvement in Greeley's classroom activities is embodied in good part in his commitment to building student questioning skills: "It takes time for some teachers who transfer to Greeley not to interpret student questions as disrespectful. However, I keep telling kids that there is no question too stupid to ask." --Much of Jackson's attention goes to cultivating the image of the school in the community, for despite its record of excellence, the school continues to be scrutinized for its efforts at equity. "I tell my staff to be very careful about bringing non-integrated groups outside of school. I took a lot of flak recently for a non-integrated math team that represented us in a tournament".

At first glance, the stamp of leadership within the mathematics department is not evident. Indeed, after a few interviews it seemed to us the department was run as a cohesive group effort. Eight teachers are involved in mathematics team activities; they discuss courses together, and they even socialize together. And yet, as our visit progressed it became apparent that the cohesiveness and vibrance we noted in the mathematics department are due in good part to the efforts of Mrs. Wallace, the woman who has been department head since the year after the school's transformation. There are some direct measures such as the monthly meetings and her ensuring that honors courses are rotated amoung staff members, but her leadership can be best characterized by a subtle fostering of trust and mutual respect among the members of the department.

Mrs. Wallace has become an enthusiastic proponent of the IB program, sharing the teaching of the IB precalculus, calculus, and advanced topics with another woman in the department, Mrs. Ramirez. By their own testimony, both have had to work very hard to prepare themselves for the IB curriculum, especially advanced topics. "For awhile, we were learning along with the students," says Mrs. Ramirez. Both women have also stayed tuned to the issues of mathematics avoidance and anxiety, with one or the other teaching honors algebra each year as a means of identifying and encouraging mathematically talented young women. In addition, Mrs. Wallace completed a mathematics anxiety and avoidance project for the district, resulting in a set of guidelines for classroom mathematics instruction.

We have noticed that teamwork, a partnership of professionals working together, seems to be an essential part of many exemplary mathematics programs. Often hidden in the team process are the quiet efforts of the department head to create and maintain an environment in which teachers are both challenged and able to act in a professional manner. In her conversations with us and in the interactions in which we observed her, Mrs. Wallace showed warm regard and genuine respect for her staff members, and she obviously valued their opinions in both formal and informal departmental meetings.

Curriculum and Implementation

Given his looming presence in the design of Greeley, Mr. Atkins obviously left his stamp on the curriculum adopted for the school, yet he credits the staff with the bulk of its formation: "We gave the staff members no free time to develop the curriculum, but they did it." We noticed elsewhere that staff members' sense of ownership of curricula often goes hand in hand with excellence, and that process apparently helped to bring Greeley quickly to success.

At the upper end of the curriculum, as we've noted, the staff chose to design courses according to the International Baccalaureate model. In mathematics that model begins with precalculus, but the department staff members have committed themselves to the goal of informing the entire curriculum with the IB spirit, which takes shape in the following goals:

- to develop in students an understanding of mathematics as a discipline
- to develop in students attitudes favorable to later use of mathematics
- to develop in students the ability to learn mathematics on their own
- to encourage students lacking confidence in their own knowledge.

Greeley's record in attracting students to higher mathematics courses has not been as numerically impressive as the records of some other schools, but in light of its commitment to keeping a 40 percent minority enrollment, and in light of the 2 to 1 female to male enrollment in the schools, the record is impressive enough. Eighty percent of Greeley students take a third year of mathematics and nearly seventy percent take a fourth year. There are no non-academic mathematics courses in the curriculum, so the courses represented in these numbers are advanced algebra, precalculus, calculus, and advanced topics.

As surely as Greeley thrives because of its ideals and sense of mission, it also faces problems because of them. For example, the rapid growth of the school, combined with the commitment to the 60-40 racial mix, have led to a mild crisis in algebra I. With over 50 feeder schools, about one third of them private schools, Greeley has little control over the quality of prealgebra training. In another manifestation of the plight of urban programs caught in the politics as well as the large size of city systems, the guidance staff conceded that they know which feeder schools have the highest success rate for their graduates in Greeley's algebra I course, but they feel powerless to capitalize on the information. Instead, they are left with only one option, to recommend to incoming freshmen that they take a summer school prealgebra course. Compounding the problem further is the district's procedure for admitting students. If an applicant has a C average or better, he or she is placed in a pool according to race. There follows a lottery -- actually two, one black, one white -- by which students are selected according to the

appropriate racial ratio. As the school grows, this procedure makes the mathematics department's task increasingly tougher, for while the large number of feeder schools make diagnosis for course placement in algebra I impossible, the school's commitment to high standards seems to have legislated against having a very active remediation program. High standards and remediation needn't be in conflict, but we didn't note any strong efforts to start such a program. Teachers regretted the termination of a federally-funded remedial resource center and wished that district funding could revive it. The assistant superintendent saw little chance of such funding, and remarked that it was his impression that Greeley was not doing enough to engage the help of local university students or to create a workable peer tutoring program. In the meantime, approximately 30 percent of Greeley students fail to pass alegebra I on their first try. No matter what form it takes, it was our impression that Greeley's mathematics department eventually will have to face the task of designing some kind of organized remediation if they are to keep their standards high.

Another detrimental consequence of rapid growth has been what teachers described as the "growing gap" between the honors and regular tracks, that it has become, for example, very difficult for regular track students to succeed in precalculus, which is taught as an IB course. Since only about 30 percent of the students are in honors courses, the majority of Greeley students are left, despite the school ideals about excelling, with few real options for advancement. Both the department head and the principal brought the problem to our attention, each identifying the move from advanced mathematics to precalculus as the weak link, so the option for Greeley's non-honors students may increase soon.

The school and mathematics department have employed several other strategies to ensure that the program moves ahead. Risk-taking is one of them. Despite its unexceptional computer setup (11 Apples in a room supervised by an aide, a computer concepts course and an IB computer course in Pascal), Greeley has forged ahead in computer competitions as it has forged ahead in other endeavors. Last year the school placed first in the Future Problem Solving Contest on Computers and entered 30 students in the first IB Computer Exam. (A total of 70 students took the exam internationally.)

Another strategy is to stay firm with students (and staff) on expectations. At least a half hour of mathematics homework per night is expected. And no student is allowed to drop from honors until he or she spends at least a half hour twice a week with a teacher outside of class to shore up whatever weak spots exist in the student's struggle with the honors curriculum.

Teachers and Teaching

Staff qualifications comprise an obvious strength of the Greeley mathematics department. There are 10 fulltime mathematics teachers and 1 combined science-mathematics teacher. Although they are a relatively

young group (average age in the 30s), the minimum amount of teaching experience is 12 years. Three have taught at the junior high level and all but one of the eleven have taught at the college level (in the evenings).

In our staff interviews we were struck by how much the teachers all relished being at Greeley where, in the words of one, "we can concentrate on pedagogy and content, not discipline." Those who were among the original staff members when Greeley was transformed five years ago told of the ridicule they faced from colleagues throughout the district for taking part in such a risky venture. All of the mathematics teachers talked of the open envy of those same colleagues now that Greeley has become a success.

They are a proud group of teachers, and they seem to have turned that pride into a healthy tool for maintaining good communication among themselves and for holding high standards in the program. The staff meets at least once a month with the department head; they socialize quite a bit outside of school (conversations during a couple of our lunches with them were testimony to this); those who teach different sections of the same course plan together informally; and all take part in student mathematics extracurricular activities. Together they are facing the problems related to the school's rapid growth, and shortly before we arrived they had voted as a group not to "water down" their advanced algebra-trigonometry course, despite the difficulties experienced by a growing number of students. Refusing to bend will create its own set of problems for the department, but in making their decision the staff took two steps that enriched their own investment in the excellence of their program; they reanalyzed and redefined their standards, and they did it together. Careful evaluation and teachers' ownership are cement for exemplary programs.

Both the principal and the staff members seem to have defined carefully how mathematics ought to be taught at Greeley High School. The idea about teaching style and classroom questions seemed a bit tarnished, despite the principal's advocacy and the teachers' intentions. In all the classes we observed, teachers made full use of the time available and kept students on task. As in other exemplary programs we visited, the teachers maintained a giving attitude and risk-free environment in their classrooms. But only in several of the IB classes did we see much student questioning and prolonged student-teacher interactions. Even in an honors algebra I class, students quietly took notes and spoke only when spoken to. Furthermore, though this may be a luxury unreasonable to expect in a school struggling with change as Greeley is, we saw little of the in-class coaching and open expression of high expectations in teacher-student interactions that we saw in other schools.

The involvement of Greeley staff and students in mathematical activities outside of the classroom is impressive. All of the ten fulltime mathematics teachers participate in contest preparation and activities.

During the 1982-83 school year, there were 82 students in the Math Track Club (whose name arises from the criteria used to award letters, similar to the criteria used by track clubs), and they participated in 25 mathematics contests during the year.

Summary

Among the joys we derived from visiting exemplary mathematics programs are the touching visual memories and tales of heroic endeavors which, while not bearing directly on the mathematics programs, help to define the environments in which they thrive. At Greeley, we watched the principal beam as he unfurled the Banner of Excellence just awarded to the school by Secretary of Education Terrel Bell. Moved deeply, we listened to him relate the story of the anonymous staff member who donated $300 to cover college tuition costs for a gifted student who had exhausted Greeley's mathematics courses. We shared in the genuine enthusiam of the guidance counselor we interviewed, a veteran Greeley staff member who had coached wrestling and football before the transformation, as he informed us that never had participation and interest in athletics at Greeley been so high as now, and that he and other staff members found themselves forcing students to leave the building in the evening, so eager are they to spend time with each other.

Greeley High School was born from ideals and thrives on innovations and a sense of mission. Partly because the school has been successful and is growing so quickly, reality is rapidly catching up to the ideals. Despite the sense of mission, the school remains a big city school with all the attendant problems -- tight budget, a sense of distance from the top levels of the district administration, and the intrusion of politics into education. Through it all, the mathematics department has an enthusiastic, engaging, talented, and industrious group of teachers, and for us it was one of the most exciting programs we visited.

JACKSON HIGH SCHOOL

"Every community has a considerable number of gifted students, and very few communities have any honest programs for these gifted students. We are addressing an important national need."
-- Mathematics department head, Jackson High School

Background

Jackson High School is a small school for talented students with a tradition of excellence reflected in its alumni rolls, a list which boasts a couple of Nobel Prize winners and several famous authors. It is also a school in transition, and the strain of transition could undermine some of the qualities that have made it shine -- in particular, the exemplary mathematics program which drew us there for a visit.

Originally designed to be part of the college of education of a large Midwestern state university -- a laboratory gifted school for the training of teachers and the implementation of new ideas and new methods -- Jackson became semi-detached from the university several years ago. It is no longer part of the college of education, yet the university still maintains some control over the school. Indeed, a university faculty committee has spearheaded the program to give the school a new footing and new direction. A university mathematics professor has been named to be interim director on a half-time basis. Now financially independent from the university, the school has been able to pick up sixty percent of its operating budget from the state (a set-aside fund for laboratory schools). There is no tuition, so many parents have chipped in with donations (the norm is $1000 per family) and thirty percent of the operating budget has been covered in this way. The remaining ten percent is "scraped together," in the words of a parent, and the university helps with the building overhead. The distribution of these numbers speaks to the sense of some dislocation among its staff and supporters as Jackson restructures itself. It is a time during which staff, parents, and university faculty are asking basic questions about the school: Do we stress acceleration over depth in our curriculum? Are we doing as much as we can to identify those students who require a slower pace and more direction? The nature of the questions is healthy; unfortunately, the processes used to generate and deal with them have not always been as healthy. Some of the university people and parents have been calling for changes and, at least in mathematics (the only program we visited), there are fears that their gains and the philosophy behind the gains will be jeopardized by the calls for change.

The Students

Jackson High School actually begins at the seventh grade and runs through the twelfth grade. The eighth grade is omitted, however, since it is felt that enough is covered in the seventh grade to consider the second year of the school the ninth grade. The students come to Jackson typically three years ahead of their peers throughout the county. Until recently, they have been accepted on the basis of a school-developed entrance exam, but the school has found this unsuitable for non-English speaking applicants, and so is moving to a nationally standardized test.

By one teacher's estimate, about two-thirds of the students come from families where at least one parent is a university faculty member or is of similar professional standing -- doctors, lawyers, and so on. The school itself shows no special privilege, housed as it is in a brick and stone structure that would satisfy anyone's set of criteria for "the typical American school building." In part because the school underplays its role in keeping order and setting discipline, the student body as a whole seems almost undisciplined in its energy -- shouting and wrestling in the hallways between classes, joking in classes, especially in their opening moments. But these first impressions belie the real accomplishments of these youngsters and how seriously they take them. A closer listening in the hallways reveals how competitive many of the students are, reflected in the numerous conversations we picked up which centered on comparisions of test grades. And the mother of two students remarked, "It's a joy to hear so many intellectual conversations in the hallways. My daughters could never get that in the local public high school."

Interviews with a school graduate (now a computer science major in the neighboring university) and with four current students (one of whom was taking an advanced mathematics course in the university) provided a special student portrait of Jackson and, in particular, of its mathematics program. According to them, the school enables them to succeed because of:

- its small classes
- the accessibility of teachers outside of class. (one student: "This is the way we get known by them -- they find out what we know, what we don't know.")
- the opportunities for extra projects beyond the tests and classwork, with the extra credit and attention which these entail
- the fact that the teachers "notice what we say"
- the fact that the teachers "want to teach"

The two students taking university mathematics courses added one factor (in separate interviews) -- the consistent stress of the teachers on understanding the concepts involved and the parallel undervaluing of memorization of mathematical facts. Said one, "We learned how to reconstruct formulas if we forgot them, and I can still do that. I don't like it that in the university courses all that seems to matter is whether you can remember the material on the tests." Later, he identified another feature of the Jackson program that was significant for him: "In the courses at Jackson, there is a lot of tying of mathematics to the real world and a lot of tying together of mathematical concepts -- like in geometry, where we saw some of the same concepts approached through plane geometry and through vectors. Even the tests challenged us to make these connections."

Curriculum and Implementation

This emphasis on understanding mathematics, as opposed to merely being able to use it, is one of the distinctive features of the program. It is a pedagogical principle often preached in this country, but it is hard to imagine a more thorough or consistent attempt to put it into practice than that observed at Jackson. It is the bedrock of the curriculum put together by Bill Brooks, the head and guiding spirit of Jackson's mathematics program. As the students quoted above implied, Brooks and the other teachers place minimal value on students' being able to regurgitate memorized material and they avoid an algorithmic approach to teaching mathematics; instead, they place a premium on students' taking the time to reconstruct formulas and other constructs on the basis of understanding. In the words of Brooks, "We work for a deeper understanding of key concepts, and for more comprehension of the heuristic planning that ought to guide many decisions during the process of analyzing a problem."

The central role given to understanding implies another distinctive feature of this program -- use of time. Again, the words of Brooks: "We have based our notion of use of time on the belief that ordinary curricula squander time on easy topics. We try not to. Instead, at any point a class will take time to review a topic, or to look at it more deeply, or to look at it in more minute detail, if that seems appropriate." As an example, he mentioned that logarithms are typically approached in four different ways in order to heighten understanding. He tells the other teachers to rely on their instincts and to "use your time where you need it."

Though the philosophy of teaching for understanding and of using time as an ally in this process extend throughout the curriculum, it finds its richest manifestation in calculus. The syllabus for calculus has been carefully developed over a nine-year period to take advantage of the fact that many Jackson students take calculus beginning in their junior year (and thus time becomes a luxury for the teacher) and of observations made

over that period of time of strengths and weaknesses evinced by the students in the calculus courses. It is an innovative course, mainly developed by Brooks, which begins, not with the notion of differentiation but with integration -- in particular, as it represents the work done in compressing a spring. From the posing of that initial work problem, students are led into a view and appreciation of calculus that few other students in this country get. It is a challenging regimen, as evidenced by Brooks' statement about the homework policy espoused in the course: "We use small, bite-sized tasks only occasionally -- to avoid allowing students to succeed in doing homework without thinking about it." Instead, students are assigned problems which require time and thought to solve, and which often connect the mathematics to the real world in imaginative and memorable ways. During our interview, the program graduate now in the university was able to recall one such problem, word for word, even though it has been four years since it had been assigned.

Jackson's teachers have found that not all of their students display exceptional proficiency in mathematics. Therefore, they try to maintain a two-track program. Again, the words of Books: "Past experience has demonstrated that those students who are mathematically gifted usually reveal themselves early in the seventh grade. This is not a matter of opinion, but of fact. Consequently, we try to begin the two-track program before the end of the seventh grade.

"For the faster track, the curriculum consists of algebra in grade seven; more advanced algebra, including trigonometry, in grade nine; geometry in grade ten; and calculus in grades eleven and twelve. A few students sometimes take one or more math-related courses in addition to this, such as the course in finite mathematics, university courses in computer science, or university courses in mathematics, physics, or chemistry.

"For the alternative track, the seventh-grade program is also algebra, but -- from the time when a separation is made -- the pace of the course is somewhat slower. The ninth-grade course is again similar, but with a slower pace. Grade ten is devoted to geometry. Grade eleven is a precalculus course that reviews and extends the work in algebra, geometry, and trigonometry. In grade twelve, students may begin calculus (if they appear to be ready), or may take finite mathematics."

Obviously the design of the two-track system has drawn careful and imaginative thinking. Does it work? Unfortunately, no, and therein lies one of the more harmful repercussions of the school's rocky period of transition. The two-tracked system has been thwarted by scheduling conflicts in the past few years ("the tail that wags the dog," complains Brooks), fed in part by the school's ambitious foreign language program, which have forced the department to group the students rather heterogeneously. The process of redirecting the school in the past few years has only served to cloud the tracking system even further. The teachers lavish individual attention on the students outside of class,

but still the disparity between those who are catching on quickly and those who are not is evident to Brooks and the other teachers, and yet they don't see any easy way to enforce the two-track system.

In general, the curriculum with calculus as its centerpiece, is innovative, ambitious, and, to mind, inspiring. Primarily, its development is the work of one man, Brooks, though the other teachers all seemed comfortable working with it. The support of the new administration for the mathematics curriculum, insofar as it is there at all, is muted, and the possibility that changes will be requested (the feasibility of changes in the approach to algebra and the inclusion of a separate course in analytic geometry have been discussed in committee meetings) cast a dark cloud over the program at the time of our visit.

Leadership

Jackson's mathematics program is weathering the school's period of transition, but the turbulence is having a greater effect than it might if the leadership were more focused and forceful. Decisions about the program can emanate from at least five sources. The school's new half-time director controls the academic life of the school; its principal handles scheduling; a university faculty committee has assumed the task of making curriculum recommendations; for the past decade, Brooks has sustained the development of the program with its distinctive emphases on understanding and coaching; and, finally, many of the managerial responsibilities, such as teacher supervision, have been delegated by Brooks to a five-year veteran of the program, Paul McGregor.

In this leadership melange, differences of opinion about the mathematics program have begun to show up. The new director apparently leans toward a more defined, more challenging, and more frequently used testing program. Brooks and McGregor, on the other hand, are chary about being drawn toward a program "whose value is defined by the difficulty of its tests." The director and faculty committee -- distressed at the near breakdown of the two-track system -- have indicated a desire for a separate analytic geometry course in the curriculum which could soften the transition to calculus for the less talented students. For his part, Brooks questions the wisdom in the suggestion, maintaining that no-one is yet sure of the nature of the difficulties being experienced by these students, and that the failure of the two-track system is due in large measure to the school's scheduling problems.

Both Brooks and McGregor are uncomfortable with the task of teacher supervision -- by their own admission -- with McGregor reluctantly assuming the responsibility. The faculty committee promised to help out with class observations, but that promise had not been fulfilled at the time of my visit. And, as far as the training of new teachers goes, money available for summer training has dried up, and there were no signs of any efforts to raise more.

Thus, the mathematics program at Jackson appears to have been made more vulnerable by a rather disjointed leadership structure. If the communication within that structure improves, then the differences of opinion can lead to a healthy annealing of the program within the larger framework of the school. If it doesn't improve, then the program will continue on its fragile course.

There is an irony in this situation that warrants mention. In the sense of visionary leadership -- having an ideal and inducing colleagues to share it and work toward it -- Brooks's leadership is outstanding. Indeed, it is his adherence to his vision that renders him unbending in the face of outside criticism or the suspicion that he will be asked to make substantial changes. His vision is a mathematics curriculum based entirely on student understanding -- both of mathematical content and of problem-solving heuristics. Just as several writing educators (e.g., Nancie Atwell and Tom Newkirk) advocate the creation of "the literate environment," a place where people read, write, and talk about reading and writing, so does Brooks seem to envision a mathematical environment where people think and talk about mathematics, and look for its presence in unanticipated settings.

Teachers and Teaching

At the time of our site visit, there were four teachers in the program: Brooks, who has been there for eleven years; Paul McGregor, who has been there for five years; a three-year member of the department, who was preparing to move back to England; and a teacher who was in his first year in the program. Replacing teachers at Jackson is no simple task. Not only does the demanding curriculum call for bright and committed people to teach it, but the teachers are underpaid, earning about two-thirds of what beginners get in the local public schools. Furthermore, the salary structure, as inherited from the days of being tied to the university, offers no system of seniority -- all master's-degreed teachers make the same salary, no matter how long they have been at the school.

Furthermore, money that used to support summer training for new teachers is no longer available, and the first-year teacher has been left with detailed course syllabi, occasional class visits from McGregor, and the opportunity to observe other teachers teaching. During our site visit, he was quite open about his lack of confidence in teaching a beginning calculus section, but equally clear about the growth of his process skills: "I'm learning that what you need to do to motivate these kids is to keep asking questions like, 'Okay, now what do you think about this?' Get them active and they start learning." The office configuration of the teachers adds to his chance to pick up, however casually, the teaching skills necessary to succeed with this challenging curriculum and with these challenging students. They are all located together on the first floor of a house that abuts the school, with no doors separating one teacher from another.

It is there, as the students noted, that much of the individual attention is gained. McGregor, especially, seemed generous with his office time, letting students linger, singly or in groups, even when the topic of conversation had drifted far from mathematics. Both he and Brooks are not completely comfortable with the looseness and lack of control over the office interactions. As Brooks put it, "Even when the topic of conversation in these office visits is mathematics, it seems wasteful to go over the same things again and again. It's hard to tell whether the need being expressed is cognitive or emotional. If it's emotional, then concentrating on the content would seem to do little good."

Recognizing and responding appropriately to the emotional needs of these gifted and talented students constitute what seems to be a weak feature of this program (and perhaps the school). The affective is not ignored or undervalued -- that is not the problem. Indeed, Brooks has taken pains to make coaching a distinctive feature of the program's teaching. An example from his calculus class: "Those of you who are still having trouble with this -- about half of you -- find someone in the class to work with you on it for the next ten minutes." More generally, the pervasive strategy of expecting students to rederive formulas and to reconstruct their understanding of concepts has an essential component of coaching to it. (The implied message is: "You don't need to memorize that. You can figure it out.")

But even the coaching is tied to cognitive goals. When it comes to responding to the students' emotional needs that are peripheral to their cognitive needs, however, the staff seems to lack conviction or a sense of direction. Admittedly, this is an area in which mathematics teachers have little training or expertise, but the emotional and behavioral needs of gifted youngsters are often closely aligned with their cognitive needs and, just as often, they call for adult intervention. For example, sarcastic comments from students were rampant in several observed mathematics classes at Jackson, some of them seemingly harmless, others potentially hurtful to the students on the receiving end. In some of these observed interactions, the behavior was doubly disturbing because they concerned comparisons of test grades. Neither teachers nor students allowed the interactions to distract much from the business of learning mathematics, but the behavior seemed antisocial enough to warrant adult intervention. Oddly, this phenomenon appeared in observations of upper level courses; the British teacher observed in the seventh-grade class showed a typically British intolerance of such antisocial behavior in the classroom; indeed, she kept all destructive behavior to a minimum.

In the end, however, the words of the students stand as proof of their devotion to the teachers and to the teachers' deep concern for their welfare. They sense that these four people "want to teach" and that they "notice what we say." They also are grateful for the respect for them expressed in the high expectations of them as learners of mathematics through <u>understanding</u>, with test performance a secondary, albeit important, touchstone of success.

THE SUMMIT SCHOOL

"There are ten or fifteen students in this school who ask the questions a teacher lives for."
Mathematics department head, The Summit School

"The pace of work here is intense, but the students make it worthwhile. The other day a student came in to my office, we talked for an hour or so, and I felt recharged for another two months."
Mathematics teacher, The Summit School

"The key to the success of the mathematics program is the dedication and total commitment of the teachers, and their striving to meet the needs of the kids. It is an environment where the teachers are given the freedom to be creative and innovative, but also the freedom to burn themselves out."
Dean, The Summit School

The buildings that now house The Summit School used to house a state hospital. Acres of space and stately oaks still suggest the restfulness of a hospital but, in doing so, they belie the environment within. Whatever peace and tranquility used to reign in the hospital's rooms and hallways are gone, replaced by an intellectual energy that seems both pervasive and neverending. Teachers and students thrive on the energy and on their contact with each other; and because Summit is a boarding school with teachers who log long workdays, that contact is extensive.

In design The Summit School is unlike any other school in the country. Its students are drawn from across the state to spend their eleventh and twelfth grades at Summit. They are talented in mathematics and science, and they are carefully screened for their willingness and ability to work as hard as this school demands.

Because of the special nature of the school, one of our challenges was to uncover anything about the excellence in Summit's mathematics program that might export to other schools. Since the school has existed only for four years, the mathematics staff is unwilling to say that any of their practices or strategies are exportable. Their caution derives from Summit's young age, but there is also the fear that an ivory tower may be closing around them, that they are too isolated from regular public and private schools. We, however, saw some things -- curriculum decisions, teaching strategies, communication patterns -- that we believe can be used by other schools.

The Summit School has received more national attention than perhaps any other secondary school in American history, with articles in such publications as The Christian Science Monitor and The Wall Street Journal. The school is so young and experimental that its teachers and administrators run the danger of wilting in the spotlight or of tripping

over the footlights. The ivory-tower fear is worth tracking in the coming years, as is the trend we noted among the school's administrators to be more outward-looking -- for funding and consultation -- than inward-looking to the needs of their teachers and students.

No matter what course Summit's story might take in future years, for the time being the school pulsates with an intellectual energy that can drown out any fears or criticism. It is also an energy that envelopes anyone drawn near it, witness our experience as site visitors. There were two of us who visited Summit for the study, and when we let it be known that we would like to interview a few students, fifteen of them appeared at 5 o'clock of our first day and kept us riveted to our chairs and notebooks until 7 o'clock. Like the teacher quoted above, we left the school recharged, and feeling that we were witnessing something very special in American mathematical education.

Background

The Summit School began in 1980, with the special support and funding by the state governor's office, as a statewide school for eleventh and twelfth graders deemed talented in mathematics and science. The approximately 400 students -- carefully chosen to represent a cross-sampling of the state's population -- live at the school and are completely subsidized for tuition, room, and board. The program's cost has not been cheap: state coffers provide 3.5 million dollars a year. (Ninety percent of the operating budget is state-financed.) To offset the cost to the state, the school's development office has raised more than 7 million dollars from private sources, many of them companies represented in the technologically fertile area where the school is located. Federal support has been minimal, despite the original intentions of the school's designers that the federal government share equally with the state and private sources in the running of the school.

Because of its cost and because of the considerable public criticism of the school as elitist, The Summit School has -- built into its design -- a mandate to spread the wealth, so to speak, through a series of outreach programs. Summer workshops, equipment loans, and consultation are all made available to districts throughout the state, and the school has served as a test site for the state's new competency examination. In addition, the Babcock Foundation has provided funding which each year enables several teachers of science and mathematics from high schools throughout the state to spend the year teaching at The Summit School.

Administratively, the school seems a blend of the secondary and postsecondary. The hierarchy includes a director, a dean, and a principal, with the last appearing (according to several teachers) to have the strongest day-to-day ties with the school's academic pursuits. There is also a Board of Trustees, a blue-ribbon panel of national experts in mathematics, science, and education. By all accounts, their recommendations have been heeded carefully in setting the tone of the school programs.

The school's leaders recognize that, as it evolves, that tone must be defined by more than curriculum and test scores. It is not enough to offer talented students more challenging courses and a chance to work together. The director of development, who has spearheaded the drive to acquire the 7 million dollars of support, gave his definition of the spirit that drives the school: "We have a strong sense that we are, and should be, preparing our students for leadership. We communicate that to the businesses and foundations we talk with. We make it clear to them that it is in their self-interest to contribute. Self-interest, not charity, should be their motivation for contributing."

At the administrative level, therefore, there appears to be a working sense of mission. The teachers, however, are not so sure that it has filtered through the whole school. At least that was the assessment of one of the mathematics teachers, who lamented that the administrators felt obliged to focus so much of their energy and attention outside of the school. "I hear very little from the administration about what goes on in the school. It's been hard in the past year to get them to define a sense of mission for us. Academically, it's the teachers who pretty much run this school."

Under the leadership of their department head, the mathematics teachers have been honing their own sense of mission, distinguished by a strong and unified sense of what kind of mathematics ought to be offered to Summit students and how it ought to be taught, and by a strong commitment to equal access to the learning of mathematics. In describing other exemplary mathematics programs, in settings more traditional than Summit's, we have noted similar senses of mission among the staffs -- e.g., to attain excellence with equity, to keep all students in mathematics courses for four years of high school, to develop a sense of self-responsibility in all students, or to develop in students a sense of what "good" mathematics is. The visions and sense of mission that have unified these staffs and given their programs energy and life have varied from school to school, but their influence in so many programs marks them as a significant factor. The developing sense of mission in the Summit program was only one echo of other exemplary programs. There are others, as we describe in later sections.

The Students

The students at The Summit School are clearly exceptional, but teachers and administrators were careful to inform us that they are not necessarily the top students in the state. According to the dean, "Less than 50 percent of the student body could be described as gifted." This is a result of the multiple criteria used to select students, which aim for a balance by race, sex, and geographic distribution through the entire state. To bring together these young people is an ambitious-undertaking, especially since the state's profile extends from several large cities to a broad expanse of rural communities, a mixture made even

more complex by the Southern history of racial polarization. Consequently, there is an elaborate selection process that combines nominations, interviews, testing, and then more interviews. Generally there are around 800 applicants for 200 places in an incoming class, and the resulting student population runs the gamut from the confident and gifted to students who, despite their previous records and proven potential for further success in science and mathematics, are conservative, cautious, and even a bit intimidated. In fact, several teachers described the general tenor of the student body as generally conservative. Said one teacher: "They are conservative enough so that we don't always find it easy to incorporate innovations. For example, they put up a fuss when we tried to replace a course in differential equations with one in finite mathematics. They complained to us that they knew differential equations is an established course in colleges and that they didn't want to be left out." One of the many praiseworthy qualities of the teachers is the quiet respect they have developed for this student caution. Rather than fight it, they flow with it and nudge them when the situation warrants it. They succeeded, for example, with some diplomatic persuasion in instituting the course in finite mathematics in place of differential equations.

We sampled some of the students' ingrained caution and conservatism in several classes. For example, in one observed precalculus class, only one student asked a question that was not aimed at clarification, and even his questioning seemed tainted, apparently driven by a desire to show how much he knew. This was an extreme manifestation, but not an aberation. The students' caution was evident in several of the first-year courses we observed. On the other hand, in an early-morning, third-semester calculus course, caution and conservatism were thrown to the wind. Almost all the students kept up a lively banter of exploratory questions and shared observations, both with the teacher and with each other.

Because of the wide variety of student backgrounds and attitudes, the school's planners have cut no corners in preparing to meet their students' emotional needs. All educators who work with gifted students recognize that giftedness often has a price, and the price for gifted young people is usually emotional stress. Here, at Summit, is a school which brings together young people from vastly different social backgrounds -- some gifted, others not, but all with the potential for significant success -- and puts them in a very challenging and, at least to some, an intimidating environment. In light of the evident risks, it would seem essential to give these students as much support in adapting to the environment as possible.

The Summit School has left little to chance in making it safe for its students to take on the risks of immersing themselves in the school. There is an evening study skills course which is required for all new students, a solid tutorial program -- at least in mathematics, our only observed department -- and a counseling program which conducts support

groups for the students. (More importantly, perhaps, the counseling director seemed highly sensitive to the potential risks and danger points for the students, and spoke of the strategies her staff has employed to help students to survive.) To mitigate intense and possibly unhealthy competition among the students, the school has decided against having an honors program and against computing class rank. Furthermore, to apply a little weight to the support programs, the school has established a mandatory two-hour quiet study time for all students, an edict that at least a couple of the mathematics teachers think is too protective and authoritarian. The general attitude of the administration, however, is that they would rather err in the direction of being too protective and not risk negligence.

Curriculum and Implementation

The mathematics department's attention to student placement complements the school's support programs nicely. Precalculus is a required course and other courses have been carefully tailored to make sure that all students are well prepared to take it. In principle, all entering students have taken algebra II in their previous schools. But, as one of the teachers wryly observed, "Some have taken algebra II, but not so you'd notice they have."

When the school first started, the mathematics department used student SAT scores as a placement device but found them to be inadequate for singling out the students with weak algebra II backgrounds. They therefore developed their own placement test and are now confident that they can place students correctly. For the students with the weakest backgrounds, there is a course that covers algebra II and a little bit of extended work in a year; for those with stronger backgrounds, there are courses that move through algebra II and trigonometry, and through algebra II and precalculus in a year. The remaining students, of course, begin with precalculus or even higher courses. (In the third-semester calculus course which we observed, there were a couple of first-year students.) The staff stays carefully tuned to how well students are placed and by their own testimony, "We allow a fairly fluid movement up and down among courses." In fact, the dean of the school cited the mathematics staff's ability and willingness to create new courses, halfway through the year, when they seemed warranted to meet student needs. Courses meet three times a week and the typical teacher load is seven courses. Thus the flexibility that allows students to move fluidly to suitable courses does not come without cost to the teachers.

Precalculus is the acknowledged "center of the curriculum," and the staff's careful thinking about the course has determined their thinking about the rest of the mathematics courses, as well. The precalculus syllabus contains six pages of topics alone, and the staff is united in their notions about approaching those topics. As the department head described it: "We avoid stressing facts, memorization, and the

traditional theorem-proof approach. Instead, we aim for a discovery, think-it-through approach." There is much that unites Summit's mathematics teachers, but their unity on this pedagogical approach is especially rock-solid.

The attention to how students learn in their mathematics courses extends beyond precalculus and, in fact, has influenced staff decisions about what students learn. The prime example is in programming where, under the persuasive influence of the department head, Paul Thompson, courses in BASIC have been replaced by courses in LOGO. The teachers seemed unanimous in their opinion that, with its emphasis on programming structures called procedures, LOGO is superior in inducing students to think about "What do I need to know?" in order to solve a particular problem. As if to underscore the wisdom of their decision during our visit, student reported to one of the teachers, "I'm doing much better in math now that I treat problems as if they were LOGO programs and break them up into pieces."

The student who reported this bit of personal growth is female, as is the teacher in whom she confided -- circumstances which are not at all coincidental. The three fulltime women mathematics teachers have worked to sharpen the lines of communication with female students. Their determination resulted from interviews with several girls a few years ago, which revealed how intimidated they felt in class with so many talented boys, often perceived as aggressive, no matter how talented they themselves were. The resulting patterns would be familiar to teachers in other mathematics programs: boys dominated discussions in the classroom and dominated the use of computers outside of the classroom.

The women teachers convened an after-school session for female students, allowed some airing of feelings, and suggested they meet on a regular basis. They have continued to meet and the group has evolved into a popular club where, according to one of the three women teachers, "We raise their consciousness about the importance of asking questions in class. We discuss and practice some of the tricks the boys have learned in order to succeed, and we have established some problem-solving groups. Several boys have begun to show up for the meetings, and the girls decided to let them take part." One effect of the club, as the student report about LOGO implied, has been a balancing of computer use among male and female students.

Computer use is at a high pitch at Summit. Up and down the hallway of the mathematics department, computers are located wherever they will fit -- a few in this room, a single one in that office -- and wherever they are, they are regularly used. Primarily, they are regularly used for programming. Besides LOGO, we saw signs of "C" and PASCAL. There seemed, however, to be little use of computer software in the mathematics classes. The one noted exception was the use in several courses of graphing software, such as that produced by Conduit.

Leadership

In good part, the absence of much software from Summit's curriculum derives from the healthy skepticism of Thompson, the department head, which is grounded in his high regard for his teachers. As he told us, "Until I see software that does as good a job in the classroom with students as most of the teachers in this department, I'll continue to be skeptical about its usefulness."

Thompson is a man with strong opinions about teaching mathematics who has all the energy and forcefulness needed to act on those opinions. He is, in fact, a fireball of energy who believes strongly in a style of teaching that challenges students to think, observe, and appreciate good mathematics; who believes equally strongly in a program structure based on "teacher as learner," where teachers take it upon themselves always to be learning new things; and who believes in a program supported by a deep commitment to collegiality among the teachers. Thompson supports his strong opinions by being the primary model for all of them, demanding of himself at least as much as he demands of his teachers. ("It's been a long time since I got out of here before 7:00 in the evening.")

He also has been the primary force in all the curricular innovations and has infected the rest of the staff with his enthusiasm and vision. In the formative period when the school was being planned, Thompson was hired to develop the mathematics and computer science programs, and he has made each hiring since then a careful, deliberate, and resolute choice. The resulting staff is a blend of different personalities and backgrounds, different enough to make us curious and lead us to ask several teachers how he managed to get the department he both wanted and needed from such a diverse group. "Magic," said one, who continued, "His instincts are so good, he seems to be able to sniff out applicants' resumes." And he has persisted, said this teacher -- "often in the face of some real heel-dragging from the administration, who are technically supposed to approve the hirings. He's been able to get the people he wants, though."

As we distilled from all our study data the profiles of the exemplary mathematics leaders we met, we noted that they usually combined some of the following: they were able to get things accomplished for their programs, despite administrative hurdles; they championed their teachers whenever they could; they fostered a sense of professionalism among their teachers; they infected all of their colleagues with their visions of even better programs; and they served as the primary models for all they preached. Thompson epitomizes all of these qualities.

Teachers and Teaching

All of the circumstances at The Summit School are ripe for excellence. The money is there; the talented and motivated students are there; and in the glare of intense publicity, the high expectations are also there.

But, as we have noted for other exemplary programs -- old or new, rich or poor -- the excellent results would just not exist if it were not for the qualities, attitudes, and practices the teachers bring to the programs. In his adamance about getting the teachers he wants, Paul Thompson has recognized this. Fortunately, in their willingness to accede to his wishes, however slowly, so have the school's administrators.

One of the strengths of the Summit mathematics teachers has already been mentioned: they do whatever it takes to assure success for their students -- their own placement tests, multiple entry courses for students with different backgrounds, their special attention to guarantee females equal access. They are also extraordinarily generous in their availability to students: one student remarked to us that he could always find a teacher to help him any time between 8:00 in the morning and 10:00 in the evening. Like their counterparts in other exemplary programs we visited, the eight teachers refuse to tolerate any possibility of failure for their students.

They have other powerful attributes, as well. Most noticeable is their careful attention to teaching style, to how they deliver up the mathematics to their students. Thompson, for instance, is charged and flamboyant, committed in his instruction to what he calls "big picture instruction." In a LOGO class, he led a spontaneous discussion of "What makes something mathematical?", a discussion spurred by a binary search problem which, in its passing to the mathematics involved, touched on Mozart's piano concertos and on Finnegan's Wake. In a precalculus class, he used a style resembling that of a law professor. ("That logic is sound, but you didn't explain it very well.") He has been known on several occasions to grab a second-year student from the hallway to recollect in front of a class of first-year students about a concept or problem which was particularly nettlesome.

The other teachers do not try to emulate Thompson's flamboyance -- it is too much of a personal stamp -- but they do try to learn from him. Said one man relatively new to teaching, "I've learned from Paul the value of putting silent pressure on students who don't prepare, letting them squirm a bit while I confront them with questions." From watching this teacher in class, it was evident that he also is picking up Thompson's use of challenging questions and his insistence that students take care in formulating their answers to mathematical questions. The following are quotes from his precalculus class:

- "Very good! That's shorter than the explanation I would have given."
- "How many of you think you can take log base two of both sides of an inequality and preserve the inequality? Why or why not?"
- "I think I understand your question, but others do not. Try and rephrase it."

The emphasis on student responsibility and self-discipline reflected in these comments and questions is one shared by all the teachers, one of whom told us: "We try to impress on the students that they ought to look to themselves first, before they go to blaming teacher, book, or school."

The use of questions intended to make students think a bit before they answer is a hallmark of most of the teachers and classes in the department, though the notable exception was unfortunately the lowest level of algebra II -- in this school's hierarchy of courses, the virtual equivalent of other schools' general mathematics courses. There the concern of the teacher seemed to be the quantity of material covered, and the concern of the students seemed to be what was going to be on the upcoming test.

This exception aside, there is uniformity in much that these teachers do, and that results from an extraordinary sense of collegiality which they have developed in the short time that they have been together. Said one, "We usually look at each other's tests and worksheet questions." Another pointed to the indirect benefits that accrue to students from staff collegiality: "A student told me that he had heard the same suggestion concerning the organization of work from three different mathematics teachers. That happened to be something we had discussed together." When possible (and it usually isn't, given the heavy teaching schedules), the teachers sit in on each other's classes, a practice which can serve to spread the wealth. In the classes of two different teachers, we saw the innovative use of homework discussions to foreshadow and act as advanced organizers for the content of the next day's classes. One teacher had observed the other several times in the preceding months, and we could only infer that the practice had been consciously imitated.

Though they do meet formally as a department for two hours a week, most of the teacher interactions occur in hallway encounters and office visits. They love it and crave even more. "We hardly ever get to talk about pedagogy," said one, "and I would like to have others sit in on more of my classes." To one of the Babcock Fellows, at the school for one year, the experience of being part of this staff was a revelation: "The staff interaction here is so rewarding! I never thought that teachers communicating with each other was so important. When you think about it, however -- and I don't mean to be flip -- teachers in regular schools end up spending 90 percent of their time with people who haven't graduated from high school yet, and they hardly get a chance to learn from each other."

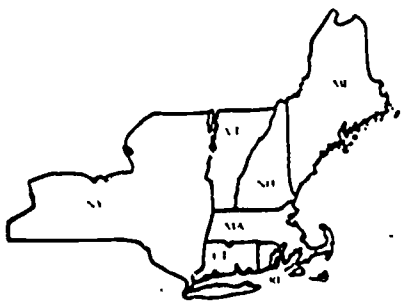
Without doubt, therefore, the primary source of the energy that courses through the mathematics corridor and classrooms at Summit is not the curriculum, nor is it the select student body. It is the cohesive and extremely dedicated group of teachers, who more than live up to Thompson's vision of teacher-as-learner. This is not to ignore the rough spots that do exist. The sad lack of engaging questions in at least a couple of the lowest level classes was mentioned earlier. Though Thompson's classroom challenges to his students are carefully calculated, we wondered how many of the students on the cautious end of the attitude spectrum were internally pulling away from his law professor tactics. And we saw only a few classes in which students did any work at the board, a circumstance we thought odd, given the interest of the teachers in developing opportunities for discussion.

These potential rough spots deserve attention, but to dwell on them would be to distort the superb professional community and mathematics program put together by Paul Thompson and his teachers. Indeed, perhaps the real rough spot facing the Summit mathematics staff in these formative years will be their capacity to sustain the level of energy necessary for the program to continue to thrive. In addition to their considerable devotion of time to their mathematics classes and students, all of the teachers are heavily involved in coaching, clubs, committees, and the Summer Outreach Program, which fulfills the school's obligations to schools in the rest of the state. Burnout for these teachers is a possibility they face all year long.

A Study of Exemplary Mathematics Program

ATTACHMENT 5

Journal articles, correspondence



the resource exchange for educational services

January 21, 1985

Ronald Brandt
Executive Editor
Educational Leadership
225 N. Washington St.
Alexandria, VA 22314

Dear Mr. Brandt:

In an earlier letter to you, I mentioned that I was writing an article about leadership in exemplary school mathematics programs. I have completed the article and it is enclosed. I hope you will decide to publish it in Educational Leadership.

Leaders in the curriculum content areas -- in particular, mathematics -- have been sorely underserved in the areas of training and communication. The research which has inspired the enclosed article has led us to two recommendations concerning leaders' training and communication. Furthermore, there are some clear implications for policy decisions that emerge from our portrayal of the exemplary leadership we witnessed during our site vists.

Gene Hall's research indicates that department heads are generally not catalysts for change. As a result of our research, I firmly believe that this need not be the case. I have attempted to communicate some of this conviction in the article.

Please respond in either the enclosed envelope or by telephoning me at my office -- (617) 256-3987. Thank you for your consideration.

Sincerely,

Mark Driscoll, Ph.D.
Principal Investigator
A Study of Exemplary Mathematics Programs

P.S. Table I, which accompanies the article, gives a sampling of the study's findings on leadership from the 28 programs we visited. I invite you to use it, or part of it, with the article.

Encls.
MD/ac

Leadership in Exemplary Mathematics Programs

by Mark Driscoll, Ph.D.

Northeast Regional Exchange, Inc.

A. Introduction

For the past two years, we at the Northeast Regional Exchange have been engaged in A Study of Exemplary Mathematics Programs. Funded by the National Institute of Education, we have conducted this research project with the express purpose of identifying and describing factors and conditions associated with excellence in precollege mathematics. Toward this end, 8 of us in teams of 1 and 2 have visited 28 exemplary programs (grades 4 through 12) -- of various sizes and in various social settings -- in 16 states and the District of Columbia, and have also studied several dozen other exemplary programs by telephone and mail.

As a result of our research, we believe we have convincing evidence in several categories, described in detail in our final report and in 10 case studies drawn from our site visits. In the present article, I will concentrate on one of those categories -- Leadership.

The majority of the programs we visited were characterized by effective and often dynamic leadership, an especially impressive fact because it flies in the face of what apparently is the norm. In a recent article in this journal, Gene Hall and his colleagues made the following observation about the viability of the high school department as a unit of change (1, p.61):

> All too often, department heads report that their role is basically one of checking books in and out, keeping records, passing on communications from

"above," and ordering supplies. In general, they do not appear to have the time or opportunity to serve as active leaders, nor do they see themselves as having responsibility for initiating or facilitating change. Their selection typically has little to do with leadership ability and training for the role is nonexistent. . . . Further, there frequently is not enough staff unity and identity with the department for it to automatically serve as a unit for the adoption of major changes in high schools."

Because of this stark contrast between the leadership norm and what exists in many exemplary mathematics programs, we have two primary recommendations concerning future attention to mathematics leaders, one pertaining to their training and the other to their communication with one another. I describe these recommendations after an account of some of our findings.

B. Findings

Fineran et al. have categorized problems commonly encountered by mathematics leaders in their work with teachers, and suggest the same six categories for describing critical leadership skills in mathematics (2):

1. communication
2. instructional materials
3. teaching strategies
4. program coordination and articulation
5. curriculum development
6. program assessment

The same categories are appropriate for describing the exemplary leadership we observed, along with a seventh which does not fit easily under any of the above 6

rubrics, yet encompasses some of the more striking features we observed:

7. development of program esprit and vision.

For the present article, I have chosen several of these categories in which program leadership features were especially striking.

Communication

Two kinds of communication challenge leaders at the department level -- communication within the department and communication with individuals and entities outside the department. Communication among the teachers in a program was one of the strongest factors we identified. Collegiality and sharing among teachers appeared to undergird the success of the majority of the programs we visited. A couple of quotes from our site notes can heighten the flavor of this factor's importance:

> "This is the fifth school in the district I've taught in, and it's the first one in which the teachers readily share. We share ideas, problem sheets, magazine articles -- whatever looks like it might help." Fourth-grade teacher in Michigan.

> "Many an evening, we are on the phone with each other at 11:30 at night, putting together worksheets." Teacher, California high school.

There were many other examples. In a New Hampshire high school, the entire mathematics department of six people meet over lunch every day and discuss students -- who is having trouble, who is placed in the wrong course, and so on. On a less

formal basis, this kind of lunchtime conve..ing of teacher groups to discuss professional matters took place at a large handful of the other schools. (Ordinarily, of course, schedules do not cooperate to allow this to happen at midday.)

What role do the leaders play in this fluid communication? It varies in form from program to program, but the effect is usually to facilitate the fluidity. In only a few cases did we hear them talk about the ideal of "communication" as such; if they alluded to communication at all, they expressed it in terms of more concrete goals, like flexible and appropriate student placement in mathematics courses. Recall that these were all successful programs, usually dependent for success on ensuring that their students are suitably placed. Quite often, this requires the teachers to be talking to each other frequently about the students who do not seem to be suitably placed or are otherwise having trouble. Some of the programs have regular -- primarily monthly -- departmental meetings but the role and frequency of these did not seem to be exceptional. Communication happens in more informal settings. For example, about a quarter of these programs have teachers' offices or desks all located in a central area along with the department head's office. Students can visit, resources can be passed back and forth, and blackboards and bulletin boards can serve to communicate ideas.

There are other techniques we saw for nurturing communication among staff. One example is the delegation of authority to teams of teachers for such tasks as test development and curriculum coordination within courses. For example, all of the geometry teachers in a high school might meet weekly to put together tests and to ensure that they are coordinated in coverage of course material. In the end, however, the methods employed are less important than the fact that the teachers find ways to communicate. And their leaders generally help the process along.

The majority of leaders we studied are models of the fluid communication they want to see in their programs. They talk about teaching, they share, they listen.

The other kind of communication -- that with people and entities outside the department -- seems tightly tied to leadership. When we asked the veteran head of an exemplary high school program in Boston to describe how he would reproduce his program's success in another school, he listed several conditions, but stressed, "It would have to be run by someone who could work closely with the principal to get things done for the program." This notion was reinforced for us when a New Hampshire high school principal remarked that, although his mathematics staff were very successful with their students, they fell short on one account because of their desire to keep the department democratic, with a rotating, rather powerless chair. "They don't push or sell their program well enough in the community," he told us. "They're not visible enough." As a result, he concluded, they are far less effective in securing what they want from the school board. At yet another school, the conviction about the importance of visibility was planted firmly for us. When we asked the principal about the reported jealousy toward the mathematics department among the heads of other departments, he waved his hands impatiently and said, "When they are as forceful and convincing as (the mathematics chairman), then they'll get the same sort of support." Exemplary mathematics leaders, we found out, can be exemplary at sales and public relations.

Teaching strategies

Formal training to influence teaching strategies occurred at approximately a quarter of the programs visited. When the training was formal, it occurred most often at the school or district level, and it often took the form of effective teacher training a la the Madeleine Hunter or Good-Grouws models.

At the program level, leaders displayed two primary strategies besides formal training to ensure that the teaching in their programs is done the way they think it should be done -- modeling and open trust. Modeling has limited effectiveness for influencing teaching patterns within departments, since most teacher schedules do not permit teachers to observe one another. (A pity -- when it occurred in the programs we observed, it seemed a powerful tool for learning.) And yet modeling was a factor we could not ignore. In more than a third of the high school programs visited, the department head was the most effective teacher observed. Indeed, three of them were selected as their states' winners of the Presidential Award for most outstanding mathematics teachers (one chosen per state). Because communication within the departments is generally very fluid, they find ways to pass on their suggestions and advice in meetings and informal conversations.

Open trust is a phenonemon that is especially hard to quantify or pin down, but we were struck by the relatively large number of teachers who, when questioned by us about their programs' strengths, told us, "For one thing, I am treated like a professional here." Generally, this meant two things: that their opinions counted for something in the course of the program's development and that they were trusted to do well in the classroom. For us, however, this apparent strength is confounded with a glaring weakness in many of the programs we visited -- a lack of anything but the most traditional and textbound goals for class discussion. There were some wonderful exceptions to this, classes where teachers cleverly contrived to get students to discuss problem-solving and to ponder such issues as, "Why should we be concerned about ratios in geometry?" But generally we were disappointed by the narrow definitions of classroom discourse and the lack of initiative on the part of the leaders to effect some change.

Program Assessment

One of the abiding thrills for us as we traveled from exemplary program to exemplary program was witnessing the extraordinary intolerance of student failure among the teachers. This was nearly universal, and for many of them it extended to an intolerance of disinterest for mathematics among their students. By this I mean they labored not only to render the students successful in their current courses, but also to keep them enrolling in mathematics courses. A memorable example was a California high school in which the teachers, in the words of the department head, "were determined that general mathematics not be the terminal course it usually is in high schools." Toward this end, they developed over 150 worksheets as the backbone of the course; they then completed a similar task for a course which spreads algebra I over two years, and developed a non-proof concrete geometry course. As a result, many of their general mathematics students take four years of mathematics.

This effort signals -- as do dozens of similar stories from other programs -- the steps ventured beyond the traditional test-monitoring to take the measure of "How are we doing?" The common cost of these efforts is time, and once again, it is the leaders who are usually setting the pace. We found some of the daily schedules truly daunting, and I offer a few quotes:

> "It's been a long time since I left here before 7:00 in the evening." Department head, North Carolina high school.

> "I usually have breakfast with a few of the teachers at 6:30. I go home late in the afternoon, but my wife knows that department work has my attention until 10:00 at night." Department head, Massachusetts high school.

Generally, the rest of the teachers follow suit, and devote what time and efforts are necessary to stay on top of their students' needs, making sure that they are correctly placed in courses and that they get what help they need. In a phrase, it is rare for needy students to stay invisible or unhelped in these programs.

Visionary Leadership

In a 1983 report on business leaders, researchers at the Stanford Engineering and Management Systems Company cited a distinction "between management, which implies maintaining the status quo, and leadership, which implies change," and a "related distinction . . . between short-term operations and long-term vision. The true visionaries manage the change process so that the two are congruent." (3, p.16) I hope that the examples I have cited above convey our sense that something similar was going on in the majority of the exemplary mathematics programs we visited. Managing the short-term operations is essential to the continued success of these programs, but so, in most of them, is the inclination to look ahead and to bring congruence between short-term operations in the programs and the vision of the future.

As I am using it, the term "vision" encompasses several notions -- general enthusiasm and high expectations, a team spirit, and, most importantly, a set of shared and well-defined goals. "We are a team working toward a goal," a Michigan department head proudly told me when I noted how frequently I had seen her teachers interact with each other. Her most pressing responsibility as leader, and one that she seemed to relish, is to sustain that team esprit. Another department head keeps his own eyes riveted on the difficult questions, "What is good mathematics and what kind of mathematics ought we be teaching?" -- and works to keep the rest of the staff concerned about the same questions. Others we visited are committed to

department cultures that cherish the concept of teacher-as-learner, ever open to learning new skills and new ideas, or the concept of teacher-as-leader, with appropriate training provided.

C. Recommendations

Not all of the leaders we visited in our study were catalysts for improvement. Some department heads, for example, were good teachers, but little more than functionaries or figureheads in their administrative roles. We saw enough exemplary leadership at the program level, however,to begin to think of mathematics leaders as a viable force for change and to develop two basic recommendations.

Recommendation 1.

As Gene Hall points out in the quote cited earlier, training for the role of department head is nonexistent. We are convinced, however, that much of what the leaders we visited do so well can be learned. The first recommendation, therefore, is that formal training be made available to mathematics leaders, perhaps organized according to the six categories listed earlier from Fineran et al.

Recommendation 2.

There is a small but significant list of items about which our exemplary leaders were not in total agreement. For example, we heard both sides of the issue of whether to teach algebra in the eighth grade. Furthermore, many of the leaders are highly enthusiastic about mathematics competitions, but a few others wondered whether competitions don't merely encourage the learning of tricks at the expense of learning how to do mathematics. The list continues, through opinions about

computer programming and software, the limitations of texts, and so on. In light of these opposing opinions, we recommend that there be some organized and focused communication among mathematics leaders. It could take the form of occasional local or regional roundtable discussions under the auspices of the National Council of Supervisors of Mathematics, or a series of broader, foundation-funded conferences. In any case, it is important that school mathematics leaders have some vehicle through which they can talk and listen to each other.

Concluding Remark. In the past decade, we in mathematics education have developed a litany of phrases we preach, a list which includes problem-solving, use of technology, mathematical applications, thinking skills, diagnostic teaching, and so on. How well each is finding its way into the classrooms is debatable. We believe that our study, as it relates to leadership in mathematics and as it is funneled into the above two recommendations, offers an exciting prospect for hastening the process along.

References

1. Hall, Gene E. et al. "Change in High Schools: Rolling Stones or Asleep at the Wheel?" in Educational Leadership, March 1984, pp 58-62.

2. Fineran, Don et al. District Level Needs for Mathematics Leadership. unpublished monograph for Association of State Supervisors of Mathematics, 1984.

3. Stanford Engineering and Management Systems Company, Inc. Visionary Leaders (Interim Report), Arlington, VA: Stanford Engineering and Management Systems, Inc., July, 1983.

Leadership Factors Identified in A Study of Exemplary Mathematics Programs

by Mark Driscoll, Ph.D.
Northeast Regional Exchange, Inc.

A. Introduction

For the past two years, we at the Northeast Regional Exchange have been engaged in A Study of Exemplary Mathematics Programs. Funded by the National Institute of Education, we have conducted this research project with the express purpose of identifying and describing factors and conditions associated with excellence in precollege mathematics. Toward this end, 8 of us -- in teams of 1 and 2 -- have visited 28 exemplary programs (grades 4 through 12) in 16 states and the District of Columbia, and have also studied several dozen other exemplary programs by telephone and mail.

The programs were rated by a panel of 6 expert consultants on the basis of evidence sent by the schools in 7 categories of student outcomes, covering aspects of test scores, course enrollment, awards, extracurricular involvement, and other, less traditional categories of student outcomes. The 28 programs we chose to visit represented not only a sampling of the top-rated programs; they also represented the variety we desired: schools of different sizes (from a school with 190 students to several with nearly 2500) and different grade levels; schools with different social settings and ethnic profiles; and schools which, as a group, contained exemplars in all of the categories of excellence.

The site visits were conducted during the fall of 1983, followed by interviews with staff at other exemplary programs during the winter and spring of 1984. The hypotheses developed about factors and conditions associated with excellence were tested during this period and our panel of experts met once again to weigh the evidence and to rate the hypotheses on the basis of that evidence.

As a result of our research, we believe we have convincing evidence in several categories, described in detail in our final report and in 10 case studies drawn from our site visits. In the present article, I will concentrate on one of those categories -- Leadership.

In the majority of the programs we visited, it was clear that the tone of excellence has been set by the style and influence of the program leaders. In high schools, this role was usually taken by the department head; in the other programs, the leadership appeared in various positions -- influential teachers, school administrators, or district administrators. No matter the official position, these individuals lead their staffs in defining the standards of excellence and then in the pursuit of excellence. When changes are required, they find ways to effect them.

The majority of the programs we visited were high schools (see Table I), a proportion commensurate with the percentage of high schools represented in the pool of schools that sent us evidence of excellence. (Our total pool numbered 150.) This makes the strength of the leadership we observed all the more impressive, because it flies in the face of what apparently is the norm. In a recent article in this journal, Gene Hall and his colleagues made the following observation about the viability of the high school department as a unit of change (1, p.61):

> "All too often, department heads report that their role is basically one of checking books in and out, keeping records, passing on communications from "above," and ordering supplies. In general, they do not appear to have the time or opportunity to serve as active leaders, nor do they see themselves as having responsibility for initiating or facilitating change. Their selection typically has little to do with leadership ability and training for the role is nonexistent. . . . Further, there frequently is not enough staff unity and identity with the department for it to automatically serve as a unit for the adoption of major changes in high schools."

This sweeping assessment was based on a series of visits to high schools across the country, and it speaks to the state of the typical American high school. As noted above, it does not describe the majority of the mathematics programs visited in the Study of Exemplary Mathematics Programs. In those programs, leadership makes a significant difference, and it does so in some clearly defined ways.

Because of this stark contract between the leadership norm and what exists in exemplary programs, we have two primary recommendations concerning future attention to mathematics leaders, one pertaining to their training and the other to their communication with one another. We describe these recommendations after an account of our findings.

B. Findings

Fineran et al. have categorized problems commonly encountered by mathematics leaders in their work with teachers, and suggest the same six categories for describing critical leadership skills in mathematics (2):

1. communication
2. instructional materials
3. teaching strategies
4. program coordination and articulation
5. curriculum development
6. program assessment

I will use the same categories to describe the exemplary leadership we observed, but will add a seventh which does not fit easily under any of the above 6 rubrics, yet encompasses some of the more striking features we observed:

7. development of program esprit and vision.

1. Communication

Two kinds of communication challenge leaders at the department level -- communication within the department and communication with individuals and entities outside the department. Communication among the teachers in a program was one of the strongest factors we identified. Collegiality and sharing among teachers appeared to undergird the success of the majority of the programs we visited. A few quotes from our site notes can heighten the flavor of this factor's importance:

> "This is the fifth school in the district I've taught in, and it's the first one in which the teachers readily share. We share ideas, problem sheets, magazine articles -- whatever looks like it might help." Fourth-grade teacher in Michigan.
>
> "Our mathematics teachers are an interlocking, mutually supportive, yet diversely unique group of people." Principal, West Virginia middle school.
>
> "Many an evening, we are on the phone with each other at 11:30 at night, putting together worksheets." Teacher, California high school.

There were many other examples. In a New Hampshire high school, the entire mathematics department of six people meet over lunch every day and discuss students -- who is having trouble, who is placed in the wrong course, and so on. On a less formal basis, this kind of lunchtime convening of teacher groups to discuss professional matters took place at a large handful of the other schools. (Ordinarily, of course, schedules do not cooperate to allow this to happen at midday.) One memorable example deserves mention. In a New Jersey middle school, the two guidance counselors (the best guidance people we saw) usually have lunch with the mathematics teachers. In separate interviews, the guidance people and a couple of teachers cited this vehicle of communication as a strong contributor to the school's superb record of success in mathematics, a record partially reflected in the following extraordinary figures. The program has five tiers and, in the last eight years, the school's seventh-graders have gone from the 49th percentile on the ITBS mathematics exam to the 99th percentile, while the eighth-graders have moved from the 51st percentile to the 99th percentile. The fluid lines of communication appear to be a major factor in this phenomenal improvement.

What role do the leaders play in this fluid communication? It varies in form from program to program, but the effect is usually to facilitate the fluidity. In only a few cases did we hear them talk about the ideal of "communication" as such; if they alluded to communication at all, they expressed it in terms of more concrete goals, like student placement. Recall that these were all successful programs, usually dependent for success on ensuring that their students are suitably placed. This

requires the teachers to be talking to each other frequently about the students who do not seem to be suitably placed or are otherwise having trouble. Some of the programs have regular -- primarily monthly -- departmental meetings but the role and frequency of these did not seem to be exceptional. Communication happens in more informal settings. For example, perhaps a quarter of these programs have teachers' offices or desks all located in a central area along with the department head's office. Students can visit, resources can be passed back and forth, and blackboards and bulletin boards can serve to communicate ideas. Not every school can afford such luxury. (That it is considered a luxury at all speaks to the hard times in our profession.) Indeed, several of the leaders we met have had to use political muscle to put together such a space, but it appears to be a very effective mechanism for encouraging professional communication among teachers.

There are other techniques we saw for nurturing communication among staff. One example is the delegation of authority to teams of teachers for such tasks as test development and curriculum coordination within courses. For example, all of the geometry teachers in a high school might meet weekly to put together tests and to ensure that they are coordinated in coverage of course material.

In the end, however, the methods employed are less important than the fact that the teachers find ways to communicate. And their leaders generally help the process along. The majority of leaders we studied are models of the fluid communication they want to see in their programs. They talk about teaching, they share, they listen.

The other kind of communication -- that with people and entities outside the department -- seems tightly tied to leadership. When we asked the veteran head of an exemplary high school program in Boston to describe how he would reproduce his program's success in another school, he listed several conditions, but stressed, "It would have to be run by someone who could work closely with the principal to get things done for the program." This notion was reinforced for us when we sat with the principal of the New Hampshire high school mentioned above -- the one where the six department members meet every day at lunch to discuss student needs. The group is relatively democratic, with a rotating, rather powerless department chair. The principal listed what he saw as the strengths of the department, and then pointed to what he thought was a major weakness: "They don't push or sell their program well enough in the community. They're not visible enough." As a result, he concluded, they are far less effective in securing what they feel they need from the school board. Our minds went back to that Boston chairman and his dictum, and we had one of those connecting, finger-snapping, "Aha!" insights. In most of the programs we visited, the leaders find ways to communicate the consistent message, "Look, our math teachers are doing a superb job, and we deserve x," whatever need x happens to be. The larger the school district, the harder it is for leaders to bear fruit from this process, of course, but the good ones keep trying. At yet another school, the conviction about the importance of visibility was planted firmly for us. When we asked the principal about the reported jealousy toward the mathematics department among the heads of other departments,

he waved his hands impatiently and said, "When they are as forceful and convincing as (the mathematics chairman), then they'll get the same sort of support." Exemplary mathematics leaders, we found out, can be exemplary at sales and public relations.

2. Instructional Materials

Even in exemplary programs, program leaders are at the mercy of their school's social setting when it comes to procuring desired instructional materials. For example, in the large cities -- and we visited schools in New York City, Washington, Boston, and Milwaukee -- there are often few means available to crack the system and get more than the central office gives you. Again, the best strategy seemed to be that of the politically savvy Boston chairman, mentioned above, who had the deep respect of his principal (also a very savvy man) and worked closely with him to ensure that the program got what it needed.

The other noteworthy piece of evidence in this category is that we heard hardly an grousing about textbooks from the approximately 150 teachers we interviewed at the 28 exemplary programs we visited. The monitoring processes are rarely formalized, but the program leaders in these programs apparently do monitor well enough to ensure that currently used texts meet teacher and student needs. This is a tricky phenomenon to gauge with regard to leadership, however, because the teachers in these programs, for their part, generally proved so capable that supplementing texts when needed seemed no great challenge.

3. Teaching strategies

Formal training to influence teaching strategies occurred at approximately a quarter of the programs visited. When the training was formal, it occurred at the school or district level, and most often it took the form of effective teacher training a la Madeleine Hunter. One program had actively implemented the Good-Grouws effective mathematics teaching model; at another, the regular training is embedded in the school's adoption of the Comprehensive School Mathematics Program (CSMP).

At the program level, leaders displayed two primary strategies besides formal training to ensure that the teaching in their programs is done the way they think it should be done -- modeling and open trust. There were a few with rather elaborate evaluation schedules by the department head, but most did not deviate much from what is normal in formal evaluation. When we asked the question of leaders, "How do you know when one of your teachers is not teaching up to your standards?", the most common response was, "The students let me know -- or their parents."

Modeling has limited effectiveness for influencing teaching patterns within departments, since most teacher schedules do not permit teachers to observe one another. (A pity -- when it occurred in the programs we observed, it seemed a powerful tool for learning.) And yet modeling wasa factor we could not ignore. In more than a third of the high school programs visited, the department head was the most effective teacher

observed. Indeed, three of them were selected as their states' winners of the Presidential Award for most outstanding mathematics teachers (one chosen per state). Because communication within the departments is generally very fluid, they find ways to pass on their suggestions and advice in meetings and informal conversations.

The open trust is a phenonemon that is especially hard to quantify or pin down, but we were struck by the relatively large number of teachers who, when questioned by us about their programs' strengths, told us, "For one thing, I am treated like a professional here." Generally, this meant two things: that their opinions counted for something in the course of the program's development and that they were trusted to do well in the classroom. For us, however, this apparent strength is confounded with a glaring weakness in many of the programs we visited -- a lack of anything but the most traditional and textbound goals for class discussion. There were some wonderful exceptions to this, classes where teachers cleverly contrived to get students to discuss problem-solving and to ponder such issues as, "Why should we be concerned about ratios in geometry?" But generally we were disappointed by the narrow definitions of classroom discourse and the lack of initiative on the part of the leaders to effect some change. It is, however, a delicate challenge for them -- to effect change without trampling on something the teachers evidently value very much, the message that they are very much trusted as professionals in the classroom. Nonetheless, it is a challenge that many leaders need to confront, and something to be made part of any future training program for mathematics leaders.

4. Program Coordination and Articulation

There were no consistent patterns in this category but, given the wide variety of settings we deliberately chose to visit, this is not surprising. For one thing, control over coordination is, in part, a function of district size. Large-city high school program heads are severely limited in their control over coordination with presecondary programs. The most glaring example of this, perhaps, was the magnet school we visited which requires all incoming freshmen to take algebra yet, with 51 feeder schools, the mathematics staff must strain to meet the needs of students who represent a wide variety of prealgebra backgrounds.

Even in the suburban programs, however, there was no consistency. For example, three of the high school programs were at odds with their middle school counterparts in prealgebra or algebra. In three other programs, the high school department heads supervised middle school curricula and teaching, and articulation was made smooth by the dual responsibility. When it is feasible, this latter arrangement seems to facilitate articulation at the high school level. We are unable to say, however, if it has any deleterious effects at the feeder school level, since we were generally limited by time to interviewing staff at only one school per site.

5. Curriculum Development

Quite naturally, as we travelled from site to site, we wondered if any clear patterns in curriculum factors would show up. As we surveyed our curriculum data at the end of the visits, however, one of our site visitors aptly characterized the wide range: "We saw some innovative programs, but there are a lot of good programs out there which are textbound and proud of it."

We did see innovations -- e.g., a few refreshing general mathematics programs developed by teachers, a host of teacher-developed computer courses and computer-based modules for regular courses like geometry, an imaginative calculus course for talented students which is built around the problem of determining the amount of work it takes to compress a spring. We also visited two schools which are incorporating the International Baccalaureate Program. But, generally, traditional textbooks determined most of what we observed in the exemplary programs' mathematics courses. The processes of text selection varied, again partly a function of district size, but what was notably universal, as I mentioned earlier, was the absence of grousing about texts by the teachers. (Indeed, an absence of grousing in general!). Text inadequacies are identified and the necessary supplements devised -- it is that simple a process. A favorite example of mine illustrating this phenomenon of adaptation is the elementary school which has adopted the CSMP Program. Generally, the teachers are pleased with the program, but at each level (we visited grades 4-6), the teachers were unwilling to rely totally on CSMP. In our 2 days in the school, we witnessed a delightful number facts pattern game devised by the fourth-grade teacher, a fifth-grade teacher using his own LOGO and problem-solving activities, and a sixth-grade teacher using consumer-related activities he had developed. Similar adaptations appeared in the majority of the visited programs.

Leaders in the "textbound" programs monitor the suitability of the textbooks for current student and teacher needs. For example, in the five-tiered middle-school program cited above, this monitoring -- in tandem with the fluid communication between staff and guidance, goes a long way toward explaining the phenomenal 49 to 99 and 51 to 99 percentile jumps in the ITBS. Both the superintendent and principal involved district teachers in an ongoing process of rewriting district competency tests, rewriting curriculum objectives, and reevaluating texts, so that now in the middle school the students in the top tier are using a new, more challenging text than their counterparts used several years ago, while the second tier is using the text recently abandoned by the first tier, and so on. The program is a superb and classic example of the benefits which can flow from involving teachers deeply in curriculum development and from leaders' involving them -- in deeds, not just words -- in a shared quest for improvement. The superintendent told us, "We believed in the idea that what was wrong with much of public education was the failure of responsible people to make tough

judgements." We would only add that the ensuing success derived in good part from the responsible role delegated to the teachers in making those judgements.

6. Program Assessment

One of the abiding thrills for us as we traveled from exemplary program to exemplary program was witnessing the extraordinary intolerance of student failure among the teachers. This was nearly universal, and for many of them it extended to an intolerance of disinterest for mathematics among their students. By this I mean they labored not only to render the students successful in their current courses, but also to keep them enrolling in mathematics courses. A memorable example was a California high school in which the teachers, in the words of the department head, "were determined that general mathematics not be the terminal course it usually is in high schools." Toward this end, they developed over 150 worksheets as the backbone of the course; they then completed a similar task for a course which spreads algebra I over two years, and developed a non-proof concrete geometry course. As a result, many of their general mathematics students take four years of mathematics.

This may seem more like information which should come under the heading Curriculum Development, but it signals -- as do dozens of similar stories from other programs -- the steps ventured beyond the traditional test-monitoring to take the measure of "How are we doing?" The common cost of these efforts is time, and once again, it is the leaders who are usually setting the pace. We found some of the daily schedules truly daunting, and I offer a few quotes:

> "It's been a long time since I left here before 7:00 in the evening." Department head, North Carolina high school.
>
> "I usually have breakfast with a few of the teachers at 6:30. I go home late in the afternoon, but my wife knows that department work has my attention until 10:00 at night." Department head, Massachusetts high school.
>
> "I have to give my children some attention during the day, but most of my time between 5:30 in the morning and midnight is devoted to department work." Department head, California high school, who is also the mother of two small children.

Generally, the rest of the teachers follow suit, and devote what time and efforts are necessary to stay on top of their students' needs, making sure that they are correctly placed in courses and that they get what help they need. In a phrase, it is rare for needy students to stay invisible or unhelped in these programs.

There were exceptions to this in a few programs, generally in the form of a slackening of effort in whatever course or two appear at the lowest

rung on the curriculum ladder -- for example, in general mathematics. And there was a more widespread and glaring weakness in in-class assessment -- a dearth of sensitivity to comments or facial expressions that students typically use to imply confusion. This is, of course, a universal problem among teachers, and one that offers no easy solutions because of the energy it threatens to drain away from the coverage of new material in class.

These exceptions aside, we witnessed an extraordinary pattern of leadership over, and participation by teachers in, a commitment to watch over students and not to rely on test scores alone to monitor the health of their programs. In their widely acclaimed book, In Search of Excellence (Harper and Row, 1982), Peters and Waterman cited the propensity of successful companies to keep their eyes trained on their customers' needs and wants. We saw their educational counterpart in these exemplary programs.

7. Visionary Leadership

In a 1983 report on business leaders, researchers at the Stanford Engineering and Management Systems Company cited a distinction "between management, which implies maintaining the status quo, and leadership, which implies change," and a "related distinction... between short-term operations and long-term vision. The true visionaries manage the change process so that the two are congruent." (3, p.16) I hope that the examples I have cited to illustrate the preceding 6 categories convey our sense that something similar was going on in the majority of the exemplary mathematics programs we visited. Managing the short-term operations is essential to the continued success of these programs, but so, in most of them, is the inclination to look ahead and to bring congruence between short-term operations in the programs and the vision of the future.

As I am using it, the term "vision" encompasses several notions -- general enthusiasm and high expectations, a team spirit, and, most importantly, a set of shared and well-defined goals. "We are a team working toward a goal, a Michigan department head proudly told me when I noted how frequently I had seen her teachers interact with each other. Her most pressing responsibility as leader, and one that she seemed to relish, is to sustain that team esprit. Another department head keeps his own eyes riveted on the difficult questions, "What is good mathematics and what kind of mathematics ought we be teaching?"-- and works to keep the rest of the staff concerned about the same questions. Another is committed to a department culture that will cherish the concept of teacher-as-learner, ever open to learning new skills and new ideas. Two other leaders are equally committed to the concept of teacher-as-leader, and see that the appropriate training is made available and that conditions permit the implementation of the idea. And so on, through the several programs that aspire to chart new territory in creating challenges for talented students, and the dozen or so programs that make their mathematics teams the causes of tremendous pride and higher expectations among their staff and students.

Without their vision, I doubt whether the leaders we met would be able to devote the tremendous amount of time, thought, and energy to their programs. And if they had failed as leaders in sharing the vision with their staffs, I doubt whether they, in turn, would be able to sustain their own intense dedication.

C. Recommendations

Not all of the leaders we visited in our study were catalysts for improvement. Some department heads, for example, were good teachers, but little more than functionaries or figureheads in their administrative roles. We saw enough exemplary leadership at the program level, however, to begin to think of mathematics leaders as a viable force for change and to develop two basic recommendations.

Recommendation 1.

As Gene Hall points out in the quote cited earlier, training for the role of department head is nonexistent. Many of the topnotch leaders we ran across are so successful, not because of training, but because of the strength of their personalities. Much of what they do so well, however, can be learned. The first recommendation, therefore, is that formal training be made available to mathematics leaders, perhaps organized according to the six categories listed earlier from Fineran et al. and concentrating on some of the benefits which good leadership can evidently bring to mathematics programs.

Recommendation 2.

There is a small but significant list of items about which our exemplary leaders were not in total agreement. For example, we heard both sides of the issue of whether to teach algebra in the eighth grade. Furthermore, many of the leaders are highly enthusiastic about mathematics competitions, but a few others wondered whether competitions don't encourage the learning of tricks at the expense of learning how to do mathematics. The list continues, through opinions about computer programming and software, the limitations of texts, and so on. There are many issues about which even these exemplary leaders are divided in their opinions. Hence, we recommend that there be some organized and focused communication among mathematics leaders. Given the Olympian work schedules of most of the leaders we visited, this recommendation might be difficult to implement, but it seems important. It could take the form of occasional local or regional roundtable discussions under the auspices of the National Council of Supervisors of Mathematics or a series of broader, foundation-funded conferences. In any case, it is important that school mathematics leaders have some vehicle through which they can talk and listen to each other.

Concluding Remark. In the past decade, we in mathematics education have developed a litany of phrases we preach, a list which includes problem-solving, use of technology, mathematical applications, thinking skills, diagnostic teaching, and so on. How well each is finding its way into the classrooms is debatable. We believe that our study, as it relates to leadership in mathematics and as it is funneled into the above two recommendations, offers an exciting prospect for hastening the process along.

References

1. Hall, Gene E. et al. "Change in High Schools: Rolling Stones or Asleep at the Wheel?" in Educational Leadership, March 1984, pp 58-62.

2. Fineran, Don et al. District Level Needs for Mathematics Leadership. unpublished monograph for Association of State Supervisors of Mathematics, 1984.

3. Stanford Engineering and Management Systems Company, Inc. Visionary Leaders (Interim Report), Arlington, VA: Stanford Engineering and Management Systems, Inc., July, 1983.

Table I

Some Leadership Features of Schools Visited

in

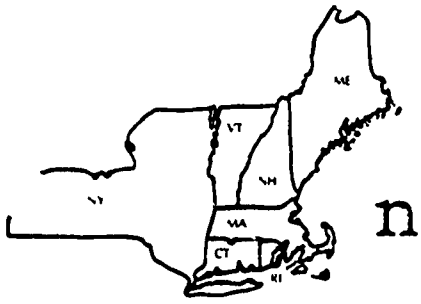
A Study of Exemplary Mathematics Programs

- Schools 1-20 are high schools, including some with junior high grades
- Schools 21-28 are elementary, or middle, or junior high schools

SCHOOL	SETTING	SOME LEADERSHIP FEATURES
	large city high school	This is the mathematics department chair's first year. Tremendous energy and efforts are required to keep the program running smoothly -- dealing with equipment problems, budget problems, etc. The chair is avid to continue tradition of winning math team and Westinghouse prizes; plans new courses like numerical analysis.
2	6-year-old magnet school, a large city high school with 51 feeder schools	The department head does not have much official clout. Until recently, strong influence was the former principal, who is now assistant superintendent. The department chair fosters sharing and and team spirit among staff, and she fosters enthusiasm for the International Baccalaureate Program.
3	rural high school influenced by nearby Ivy League college; mix of rural and college families	The department chair has considerable authority: he hires and evaluates. He set up a resource center where staff can interact; he was effective in securing budget approvals. He uses the resource center to stimulate staff communication.
4	an old, established academic high school in a large city; a mix of students from all over the city, in grades 7-12	The chair works tightly with the headmaster; there is a strong mutual respect. The headmaster is a strong advocate for the math department. Distractions for teachers and students are hard to remove in this old noisy school. The department chair and his assistant are strong advocates for math competitions. The chair models a deep commitment to the school's tradition of excellence; he works long hours (6:00 am to 10:00 pm).
5	small school for gifted in grades 7-12; loose connection with university; strong academic values	Not much managerial leadership. The department is small and loosely structured. The department head feels little support from above for the kind of program he has and wants to develop. The department head's vision of mathematics education and instruction are a deep part of the program and its success. He thinks deeply about "what mathematics ought we be teaching?"
6	high school near a university and a military base; some high academic values. University ties are helpful.	Staff is run democratically; chair is rotated. The principal noted, with disapproval, their inattention to "selling themselves" to the community. Staff provide their own direction through lunchtime meetings.
7	female private school for grades 7-12; parents get involved.	The department head shares some of hiring responsibilities with the rest of the staff. He is influential in setting the tone of cooperation among staff; he worked to bring staff together into one building.
8	4-year-old state-supported, state-wide gifted school located in a high tech area; grades 11-12. The school specializes in science and math but has stiff requirements in the humanities.	The department head is a dynamo; he appears to have tremendous cooperation of the administration. He makes himself very visible to them and argues persuasively for what he wants. He does all the hiring, etc. The department head shows superb vision. He fosters "teacher-as-learner" atmosphere and serves as a very good model.
9	high school in a well-to-do suburb where mathematics is quietly valued a lot	The principal and department head work closely to tighten and facilitate management; well managed program. The department head keeps standards high (e.g., leans on staff to enforce homework rules), delegates authority, and models effective teaching behavior. He has excellent computer setup.
10	high school in small midwestern city; parents are professional, academic	The principal takes a no-nonsense approach to handling environment and leaves teachers free to teach. In 7 years, he has turned around the school's image. Evaluation is done by principal and assistant principal. The department head is strongly committed to keeping students from failing or dropping math; he personally reviews every record of every student.

SCHOOL	SETTING	SOME LEADERSHIP FEATURES
11	high school in upper middle class community	The department head hires, supervises, and makes teachers earn course assignments; this is done fairly. He is a resource teacher and visits each teacher's class at least 3 times a year. He has formed a close-knit, conservative department around his values. His teachers say they are treated like professionals.
12	high school in small city; the nearby large university has some influence, though not a tremendous amount	The department head works very closely with the principal and the district coordinator. There is lots of strong mutual respect and support. She has pushed for computer support. She was cited by her staff as an excellent listener and model. She strives to maintain an attitude of "we are a team working toward a goal."
13	an 8-year-old urban magnet school; academic school which focuses on math and science, music, and performing arts. Many students come from oil company families and university families.	The department head has minimal authority; she is primarily a "liaison with the principal." She seems satisfied with a rather democratic approach. The school has a strong commitment to keeping students in math and successful, but that vision is pretty much a group-developed phenomenon. "We push students to stay in math."
14	large suburban high school, rapidly growing	The department chair is primarily managerial. A core of 5 females teachers really run the department. The chair spearheaded the ambitious mathematics contest program. She is seen as "nonautocratic, caring, and supportive."
15	large suburban high school in a middle-class setting	In the past few years, there have been 5 changes in principal, yet the school is smoothly run because the department heads run it. The mathematics department head does outstanding job of delegating authority, allowing staff to experiment with the curriculum. He pushes them to meet often.
16	suburban high school influenced by local high tech industries	The superintendent is a strong advocate of the program and of the coordinator with the board. The coordinator acts as department head but loses some contact because of K-12 duties. The superintendent and mathematics coordinator act in concert to nurture professionalism of staff. The coordinator has taken leadership in computer use, maintains good communication with science department. The math staff shows a lot of initiative of their own.
17	a new program in math/science within a large inner-city high school; parent volunteers	There have been 5 principals since 1975. The program arose through collaboration between coordinator and district coordinator for mathematics.
18	a small rural town in which the mathematics team has gained fame	The former principal and superintendent brought success to the program by developing, with the mathematics teacher, a winning math team and changing popular perceptions of the program. The vision of excellence through math team success is now sustained by the mathematics teacher.
19	suburban community high school	The department head works well with her staff; all are somewhat antagonistic toward administration and have a sense of going it alone. The 5 core members of her department admire her and share her vision about keeping the quality of general math high, but they are almost independent of her.
20	high school in suburban community which is very conscious of the success of the math program through publicity about the math team	The department head stands way above other department heads in the school in his effectiveness with the administration. He gets what he wants (separate wing for math department, hiring, etc.). Department head has powerful vision about the value of the math team. He leans on staff to be involved with students outside of class; gets most of staff together each day for lunch.

SCHOOL	SETTING	SOME LEADERSHIP FEATURES
21	junior high school in upper middle-class suburb	Principal started "school-within-a-school" model and makes sure its implementation works well. He is strong on delegating authority. He fought school board successfully for funding of a gifted director. The principal delegates much of the authority for curriculum, diagnosis, and evaluation to his teams of teachers. He works closely with the superintendent to maintain high standards. He is avid to expand and enrich the gifted program.
22	a middle school in rural Appalachia	There are strong bonds of communication and mutual respect among the 4 math teachers, the principal, and the assistant superintendent in charge of curriculum. The assistant superintendent reads, sends ideas to math staff who ponder, buy pieces of it, and implement. Administrators openly encourage and demonstrate their regard for teachers' innovations in the curriculum.
23	an 8-year-old rural middle school in a financially strapped district	Principal is an active and open planner who makes plans for the school explicit to staff. The school is run on a "school-within-a-school" model called "rivers." The principal gives teachers in each of the 4 rivers a fair amount of autonomy, even in hiring. The superintendent talks with teachers about what he plans to discuss with the school board.
24	grades 4-6 in a small city, middle class, near a large university	The principal and district math coordinator have worked together to implement K-6 adoption of CSMP math curriculum. The principal has shuffled teachers to move toward subject specialization. There is a bit of staff resistance to both CSMP and specialization that he glossed over in making changes take effect. Both the principal and district coordinator are strong advocates of innovative math curriculum, especially of CSMP. They support and encourage teachers to be innovative, to adapt to CSMP, to interact professionally.
25	suburban junior high school (grades 7-8), lower middle to middle class; community is becoming appreciative of math through newspaper coverage and math team success	The principal keeps the school quiet, orderly. The superintendent provides much of the instructional leadership. He has developed an extremely well-managed program of curriculum revision conducted by the teachers on Saturdays. The superintendent has infused the teachers and the community with enthusiasm for turning math program around. Math teachers also get quiet, solid leadership from chairman, who is both a lawyer and union representative.
26	rural elementary school with strong educational values; grade 6 only	The principal is a strong leader who sets high expectations, disdains compensatory programs as interfering with high expectations. Frequent progress reports are sent home (the principal's way of keeping ties with parents strong). She facilitates the implementation of the school-within-a-school model.
27	grades 7-8 in small city; comoletely individualized program	This is a state demonstration program with a director who handles some of the administration. The department head supervises curriculum reform, works closely with the principal. The principal instituted meetings of department heads as group, to improve communication. She believes in "teacher as leader" concept; sent her staff to Madeleine Hunter training.
28	focus on grade 7-8 program for talented students in junior high in middle-class suburb influenced by high tech families	The department head is a perfunctory honor; has the same teaching load as everyone else; does not observe teachers. The teacher who designed the program got morey from the district to develop the program during the summer.



northeast regional exchange, inc.

the resource exchange for educational services

January 7, 1985

Robert W. Cole, Jr.
Editor
Phi Delta Kappan
Eighth Street and Union Avenue
Box 789
Bloomington, Indiana 47402

Dear Mr. Cole:

Thank you for your note. I have enclosed a copy of the article I hope you will publish. After a dozen or so years in and around mathematics education, I have absolutely no doubt that it addresses an issue of critical importance in our country.

I hope that you decide to publish it. After a conversation with Ken Travers the other day, I regret that I didn't send you this in time to appear in the issue with his article on the International Mathematics Study. Juxtaposed, I think the two articles would give readers much to ponder.

Sincerely,

Mark Driscoll

Mark Driscoll, Ph.D.
Principal Investigator
A Study of Exemplary Mathematics Programs

MD/ac

P.S. As an afterthought, I constructed an overview chart for the 3 programs, which I believe will help readers. It is attached to the article.

MDF

NEREX, 34 Littleton Road, Chelmsford, Massachusetts 01824 617/256-3987

Mark J. Driscoll
NEREX, Inc.
34 Littleton Road
Chelmsford, MA 01824
(617) 256-3987

About 6,000 words
First Serial Rights

Teaching the Mathematically Talented:

Three American Programs

In Hungary, talented young mathematicians are considered a precious national resource. From what I have heard and read, this attitude has influenced educational decisions for decades, with the mathematically talented receiving the best available in curricula and teaching. The policy has paid dividends, as anyone can attest who follows international mathematics competitions or is familiar with the roster of important mathematicians of the twentieth century.

I am not aware of any controversy in Hungary surrounding this commitment. If that is the case, then the country is truly exceptional, because educating the talented is generally a task fraught with challenges. In the Soviet Union, Marxist ideologues officially bristle at the thought of recognizing any kind of elite. Yet, with science being the lifeforce of the Marxist philosophy, the Soviet government dances around the issue, rationalizes away the conflict, and nurtures its elite in mathematics and science anyway. In the United States, our own ideology is not of this rigid variety, yet our commitment to universal education, combined with local school budgets which are predominantly very tight, lead in most school districts to half-hearted attempts to meet the needs of talented students or, worse, to no attempts at all. More than one school

administrator has had to scrap plans for talented programs when the cries of "elitism" began to rise.

Making matters worse in mathematics is the nature of the subject matter, which seems (not is, but seems) confined to the lockstep approach given it by the vast majority of teachers and textbooks. This is the result of two misconceptions heaped one on top of the other. Since mathematics appears to be developed by mathematicians in an orderly progression of fact-proof-new fact (this is the first misconception -- the incisive work of people like Lakatos (1) present the development of mathematics as much more lively and disputatious), then that orderly progression must be reflected in the way students learn mathematics (this is the second misconception -- reams of research attest to the individual stamps students put on their construction of mathematical understanding (2,3)). All students are robbed by ths rigid and misguided approach to mathematics curricula; talented students in particular are robbed because the approach to teaching them has traditionally been, "Give them more of the same, but give it to them faster." Often, such accelerated programs propel students, still wet behind the ears, into college at the age of sixteen, with little preparation to do mathematics the way it should be done -- with an overview of the field and its applications, with flexible thinking about the issues and problems which arise, and with a set of heuristics for facing the unknown.

Interviews with notable mathematicians have occasionally revealed that they feel they succeeded in spite of the courses they took (including some of the Hungarians, thus showing that even that country does not have the final answer). Writers, artists, and musicians might say the same thing, but that does little to lessen the sadness of the statement. Is it

inevitable? No, it is not. We have recently studied several programs that inspire as well as train talented mathematics students, and this article tells the stories of three of them. But first I need to provide some background information.

For the past two years, we at the Northeast Regional Exchange have been engaged in A Study of Exemplary Mathematics Programs, a research study funded by the National Institute of Education. We studied a variety of school programs with track records of excellent student outcomes in mathematics for grades 4 through 12. We visited 28 of these programs in 16 states and the District of Columbia, and we studied others by phone and mail. Our goal has been to uncover some of the factors and conditions that have brought these programs to their exemplary standing.

We deliberately chose a pool of excellent programs which varied in setting, size, and student population. Some were small, poor, rural schools; others large, urban schools where money may or may not be available if the right strings are pulled or the right buttons are pushed; still others were suburban schools with access to a comfortable amount of financial resources. Three of the programs -- the three I want to discuss in this article -- are high schools designed for talented students (there were others which are also selective, but the three described here are the most selective).

The three are very different from each other and so are exciting because of the different possibilities they represent. They also have some basic elements to their success in common, and so are even more exciting because of the focus this gives to their chances of replication. Most exciting of

all, perhaps, is the conviction left by visits to these programs that they are a rich source of ideas and examples for regular school programs as well as programs for the talented.

We have written full case studies of the three programs (and of other exemplary programs we visited, as well). From each of those case studies, I have adapted an excerpt which briefly describes the program's background and students. Following these descriptions is a discussion of the factors that affect the program's success most strongly.

(Note: By agreement with the National Institute of Education, we are committed to maintaining the anonymity of the programs we studied. Only the school names and the names of individuals are disguised, however. The rest of the program information is accurate. Indeed, readers who are at all familiar with American school programs in mathematics will probably be able to identify one or more of the programs.)

Background: School A

School A is a specialized public school in a large Northeastern metropolis, a comprehensive school which students enter through a very selective entrance examination. They represent the intellectual cream of the city's young people, and the quality shows. The school is a perennial contender for the nation's most prestigious prizes in school mathematics.

The students' talents and interests are wide-ranging, as evidenced by their more than 70 extracurricular clubs and organizations, including the traditionally serious, like Chess Club and the Bio-Med Seminar Society, as well as the imaginative and frivolous, such as the Mad Scientists Club and the Sports Collectors Memorabilia Club.

The school, which contains approximately 2,500 students, is housed in a narrow five-story building, and the hourly flow of students and teachers up the up-staircases and down the down-staircases adds to the impressive energy level in the school. As in all the city's schools, the entranceway is monitored by uniformed guards, a precaution that, however necessary, still seemed excessive and out of place because of the healthy and friendly energy in the hallways and the businesslike intensity in the classrooms.

The energy and intensity are consistent with School A's impressive record in mathematics: approximately 300-400 students a year in Advanced Placement calculus courses, with average scores well above the national averages in both the AB and BC Advanced Placement exams; 3 winners of Westinghouse Science prizes, all in mathematics, in the past decade; top ranking more often than any other school in the past decade in the American High School Mathematics Examination. SAT scores, extracurricular involvement, and upper-level course enrollments all add testimony to the exceptional talent and enthusiasm of the mathematics students.

The program's success does not hinge on the quality or the quantity of its educational materials. Quite the opposite. The word "decrepit" was used by the district's computer coordinator to describe the school's computer facilities. According to one of the teachers of computer courses, several of his colleagues were ready to leave the school because of the state of the equipment. Furthermore, two teachers bemoaned their having to carry chalk and erasers from classroom to classroom in order to effect a crisp beginning to their classes, free of the need to scrounge and search that apparently haunts those who are less prepared. Talent and tradition buoy the mathematics program at School A, but money and material resources are sorely lacking.

Background: School B

School B is a small school for talented students (graduating around 40 a year) with a tradition of excellence reflected in its alumni rolls, a list which boasts a couple of Nobel Prize winners and several famous authors. It is also a school in transition, and the strain of transition could undermine some of the qualities that have made it shine -- in particular, the exemplary mathematics program which drew us there for a visit.

Originally designed to be part of the college of education of a large Midwestern state university -- a laboratory gifted school for the training of teachers and the implementation of new ideas and new methods -- School B became semi-detached from the university several years ago. It is no longer part of the college of education, yet the university still maintains some control over the school. Indeed, a university

faculty committee has spearheaded the program to give the school a new footing and new direction. A university mathematics professor has been named to be interim director on a half-time basis. Now financially independent from the university, the school has been able to pick up sixty percent of its operating budget from the state (a set-aside fund for laboratory schools). There is no tuition, so many parents have chipped in with donations (the norm is $1,000 per family) and thirty percent of the operating budget has been covered in this way. The remaining ten percent is "scraped together," in the words of a parent, and the university helps with the building overhead. The distribution of these numbers speaks to the underlying sense of some dislocation among its staff and supporters as School B restructures itself.

It is a time during which staff, parents, and university faculty are asking basic questions about the school: Do we stress acceleration over depth in our curriculum? Are we doing as much as we can to identify those students who require a slower pace and more direction? The questions themselves are healthy; quite often, however, the questioning process has left its scars on the school's staff. The challenge facing those involved in reshaping School B is clear: through all of the questioning and wrangling, the exemplary aspects of the program -- in particular, in the mathematics program -- must be retained.

School B begins at the seventh grade and runs through the twelfth grade. The eighth grade is omitted, however, since it is felt that enough is covered in the seventh grade to consider the second year of the school the ninth grade. The students come to School B typically three years ahead of their peers in the local county. By one teacher's estimate,

about two-thirds of the students come from families where at least one parent is a university faculty member or is of similar professional standing -- doctors, lawyers, and so on. The school itself shows no signs of special privilege, housed as it is in a brick and stone structure that would satisfy anyone's set of criteria for "the typical American school building." In part because the school underplays its role in keeping order and setting discipline, the hallways reverberate with noise -- much of it serious, intellectual conversation, but just as much arguing and joking, with a smattering of light wrestling thrown in.

Background: School C

The buildings that now house School C used to house a state hospital. Acres of space and stately oaks still suggest the restfulness of a hospital but, in doing so, they belie the environment within. Whatever peace and tranquility used to reign in the hospital's rooms and hallways are gone, replaced by an intellectual energy that seems both pervasive and neverending. Teachers and students thrive on the energy and on their contact with each other; and because School C is a boarding school with teachers who log long workdays, that contact is extensive.

School C began in 1980, with the special support and funding by the state governor's office, as a statewide school for 11th and 12th graders deemed talented in mathematics and science. The approximately 400 students -- carefully chosen to represent a cross-sampling of the state's population -- live at the school and are completely subsidized for tuition, room, and board. The program's cost has not been cheap: state coffers provide

3.5 million dollars a year. (Ninety percent of the operating budget is state-financed.) To offset the cost to the state, the school's development office has raised more than 7 million dollars from private sources, many of them companies represented in the technologically fertile area where the school is located. Federal support has been minimal, despite the original intentions of the school's designers that the federal government share equally with the state and private sources in the running of the school.

The students at School C are clearly exceptional, but teachers and administrators were careful to inform us that they are not necessarily the top students in the state. According to the school's dean, "Less than 50 percent of the student body could be described as gifted." This is a result of the multiple criteria used to select students, which aim for a balance by race, sex, and geographic distribution through the entire state. To bring together these young people is an ambitious undertaking, especially since the state's profile extends from several large cities to a broad expanse of rural communities, a mixture made even more complex by the Southern history of racial polarization. Consequently, there is an elaborate selection process that combines nominations, interviews, testing, and then more interviews. Generally there are around 800 applicants for 200 places in an incoming class, and the resulting student population runs the gamut from the confident and gifted to students who, despite their previous records and proven potential for further success in science and mathematics, are conservative, cautious, and even a bit intimidated.

Distinctive Features

Programs A, B, and C differed from each other in some substantial ways. For example, School C has employed several careful strategies to identify and take care of any serious emotional needs that might arise in its students. In particular, there are student support groups run by a strong guidance department and each student is paired with a faculty advisor, for the most part resulting in useful relationships. On the other hand, Schools A and B provide little such attention to the emotional needs of their students.

This is too confined a space in which to elaborate on the program differences; a full reading of our case studies can provide this information. Instead, I would like to concentrate on the several threads of similar strength that run through these programs: Curriculum Features, Teacher Behavior in Class, and Teacher Activity Out of Class.

Curriculum Features

School A: The guiding principle behind curriculum development in School A's mathematics program has been to provide the content that will meet the needs of their special student population. Because both talent and experience are assumed for incoming students, most of the attention has been focused at the upper end. Two new courses were introduced this

year, programming in Pascal and advanced calculus, and when we visited the program, the department head was already talking about a new numerical analysis course for next term, if he could find someone to teach it ("though I may end up doing it myself."), and more Pascal sections. In the recent past, the department has offered courses in number theory and the history of mathematics. For students who began the SSMCIS Unified Mathematics curriculum before entering the school, there is a Unified Mathematics curriculum strand in the program. The variety of mathematics courses was richer at School A than in any other program we visited. Even within the school, the variety stands out; I was informed that the mathematics department offers more courses than any department in the school.

School A's teachers use textbooks, but no teacher I observed seemed tied to the text. In the geometry class I visited, the teacher developed his own treatment of indirect proof. The honors precalculus teacher led a discussion about converting graphical representations of conic sections to equations; his students dutifully took notes during the discussion and, as several mentioned to me, it would be their notes rather than the text that they would appeal to for their homework. One of the computer teachers told me that all of the computer courses were being taught from teacher notes rather than textbooks.

The mathematics program thrives on the development of courses as sophisticated and challenging as the students can handle. Hence, it relies on teacher development beyond the texts and on the self-motivation of students. Most students enter the school in their freshman year; a

smaller percentage of sophomore transfers are admitted every year, but no transfer students are admitted after sophomore year. There are no honors courses for first-year students; the honors program begins in second semester of the second year. The students are expected to pass the state achievement exam in intermediate algebra and trigonometry before they graduate, but that requirement puts little demand on most of the students. In a school that admits between 500 and 600 freshmen each year, there are but 3 sections of elementary algebra; the large majority have taken algebra in junior high school and get very quickly to trigonometry.

School B: An emphasis on understanding mathematics, as opposed to merely being able to use it, is one of the distinctive features of School B. It is a pedagogical principle often preached in this country, but it is hard to imagine a more thorough or consistent attempt to put it into practice than that observed at this school. It is the bedrock of the curriculum developed primarily by the department head. The teachers place minimal value on students' being able to regurgitate memorized material and they avoid an algorithmic approach to teaching mathematics; instead, they place a premium on students' taking the time to reconstruct formulas and other constructs on the basis of understanding. In the words of the department head, "We work for a deeper understanding of key concepts, and for more comprehension of the heuristic planning that ought to guide many decisions during the process of analyzing a problem."

The central role given to understanding implies another distinctive feature of this program -- use of time. Again, the words of the department head: "We have based our notion of use of time on the belief that ordinary curricula squander time on easy topics. We try not to. Instead, at any point a class will take time to review a topic, or to look at it more deeply, or to look at it in more minute detail, if that seems appropriate." As an example, he mentioned that logarithms are typically approached in four different ways in order to heighten understanding. He tells the other teachers to rely on their instincts and to "use your time where you need it."

Though the philosophy of teaching for understanding and of using time as an ally in this process extend throughout the curriculum, it finds its richest manifestation in calculus. It is an innovative course which begins, not with the nction of differentiation but with integration -- in particular, as it represents the work done in compressing a spring. From the posing of that initial work problem, students are led into a view and appreciation of calculus that few other students in this country get. It is a challenging regimen, as evidenced by the department head's statement about the homework policy espoused in the course: "We use small, bite-sized tasks only occasionally -- to avoid allowing students to succeed in doing homework without thinking about it." Instead, students are assigned problems which require time and thought to solve, and which often connect the mathematics to the real work in imaginative and memorable ways. During an interview I had with a program graduate, he was able to recall one such problem, word for word, and the challenge in solving it even though it was four years since it had been assigned.

School B's teachers have found that not all of their students display exceptional proficiency in mathematics. Consequently, they try to maintain a two-track program. Again, the words of the department head:

"Past experience has demonstrated that those students who are mathematically gifted usually reveal themselves early in the seventh grade. This is not a matter of opinion, but of fact. Consequently, we try to begin the two-track program before the end of the seventh grade.

"For the faster track, the curriculum consists of algebra in grade seven; more advanced algebra, including trigonometry, in grade nine; geometry in grade ten; and calculus in grades eleven and twelve. A few students sometimes take one or more math-related courses in addition to this, such as the course in finite mathematics, university courses in computer science, or university courses in mathematics, physics, or chemistry.

"For the alternative track, the seventh grade program is also algebra, but -- from the time when a separation is made -- the pace of the course is somewhat slower. The ninth grade course is again similar, but with a slower pace. Grade ten is devoted to geometry. Grade eleven is a 'pre-calculus' course that reviews and extends the work in algebra, geometry, and trigonometry. In grade twelve, students may begin calculus (if they appear to be ready), or may take finite mathematics."

School C: As noted above, School C includes only the 11th and 12th grades. Students who are admitted to the school have had algebra II in their previous schools, but for some of them, that background is inadequate; so the school offers several courses which cover algebra II plus aspects of trigonometry and precalculus.

All students are required to take precalculus, which is the acknowledged "center of the curriculum," and the staff's careful thinking about the course has determined their thinking about the rest of the mathematics courses, as well. The precalculus syllabus contains 6 pages of topics alone, and the staff is united in their notions about approaching those topics. As the department head described it: "We avoid stressing facts, memorization, and the traditional theorem-proof approach. Instead, we aim for a discovery, think-it-through approach." There is much that unites the school's mathematics teachers, but their unity on this pedagogical approach is especially rock-solid.

The attention to how students learn in their mathematics courses extends beyond precalculus and, in fact, has influenced staff decisions about what students learn. The prime example is in programming where courses in BASIC have been replaced by courses in LOGO. The teachers seemed unanimous in their opinion that, with its emphasis on programming structures called procedures, LOGO is superior in inducing students to think about "What do I need to know" in order to solve a particular problem. As if to underscore the wisdom of their decision during our visit, a student reported to one of the teachers, "I'm doing much better in math now that I treat problems as if they were LOGO programs and break them up into pieces."

Teacher Behavior In Class

In all three programs, teacher behavior in class is consistently exemplary in two aspects:

- o challenging questioning
- o coaching and setting high expectations

challenging questioning: Nothing can illustrate the quality of these questioning patterns as well as the following examples -- samples of what we heard during our site visits in a variety of classes:

School A -- "How do you begin the analysis of this graph?"
"What construction does this remind you of?"
"What would you have to do to prove that?"

School B -- "Why should we be concerned about ratios in geometry?"
"What makes these problems particularly hard?"
"How can you tell?" -- asked again and again in class discussions.

School C -- "How many of you think you can take log base two of both sides of an inequality and preserve the inequality? Why or why not?"
"What would that tell you about the lines?"
"Bill says 4. Tom says 5. Why the 4? Why the 5?"

These questions, no matter the setting, the content, or the motives, had the same end result -- the students were required to think and discuss. The last one, in particular, is especially instructive. The teacher was not letting on whether the 4 or the 5 was the correct answer, but focussed the students' attention instead on whatever process might have produced two answers so close to each other -- i.e., on the mathematics involved, not on the answer. There is nothing about these questions that has a "talented" tag attached to it. They are the kinds of questions that all mathematics teachers ought to be using.

coaching and setting high expectations: In these 3 programs, students are consistently made to realize that a lot is expected of them --

1. that they think and explain clearly (Examples: "I think I understand your question, but others do not. Try and rephrase it." -- School C. "You can give a better answer than that." -- School A.)

2. that they act responsibly about their own learning (Examples: "Those of you who are still having trouble with this -- about half of you -- find someone in the class to work with you on it. I'll give you ten minutes to work in pairs on it." -- School B.
"We try to impress on the students that they ought to look to themselves first, before they go to blaming teacher, book, or school." -- teacher interview at School C.)

Furthermore, the teachers communicate high expectations indirectly, too. School B has its pervasive and consistently used strategy of expecting students to rederive formulas and to reconstruct their understanding of concepts, instead of appealing to memorized formulas. School A's teachers expect that students can and will start to put homework solutions on the blackboard even before class begins.

Teacher Activity Out of Class

At School A, the hustle and bustle and the fact that teachers have neither offices nor homerooms make individual student contact very difficult. Time outside of class is concentrated in extracurricular activities. My site-visit notes relate the following:

> In order to watch the math team in action, I had to arrive at 8:00, an hour before classes begin, when the nearly 70 students who make up the A and B teams arrive every day of the week, some travelling on public transportation for an hour and a half. The chairman said that the session I watched was typical: the group divided into 2 smaller groups, juniors and seniors in one, freshmen and sophomores in the other. Both groups were run by students, one male, one female, who led discussions about problems just encountered in a surprise quiz, although the word "quiz" hardly fits, since, judging from their enthusiasm, these young people apparently thrive on being challenged to stay sharp. Obviously, the school's superb team record is built on hard work and sacrifice as well as talent. And pride . . . The chairman told me that many team members stay in touch with each other after graduation, much the way champion sports team members do.

There are other manifestations of enthusiasm for mathematics beyond the classroom. During my visit, every bulletin board in the school contained an invitation to attend an after-school lecture on problem solving in geometry by a mathematician from one of the city's universities. The teacher in charge of such lectures (one occurs every couple of weeks) was confident that 200 students would attend.

School B's teachers have only informal contact with their students outside of class. All of the teachers have desks in the same open area, and students are free to spend time there, even for casual conversation. As one student told me, "This is the way we get known by them. They find out what we know and what we don't know."

At School C, a student stunned us by saying, "I can usually get help from one or the other of the math teachers anytime between 8 in the morning and 10 at night." Even taking into account that this is a boarding school, and so students have reason to be around at night, this is an amazing piece of information and speaks to the generosity of the teachers. They <u>always</u> find time to help students.

In addition, three women teachers run a very popular club for female mathematics students, an enterprise which resulted from interviews with several girls a few years ago that revealed how intimidated they felt in class with so many talented boys -- often perceived as aggressive -- no matter how talented they themselves were. The resulting patterns would be familiar to teachers in other mathematics programs: boys dominated discussions in the classroom and dominated the use of computers outside of the classroom.

The women teachers convened an after-school session for female students, allowed some airing of feelings, and suggested they meet on a regular basis. They have continued to meet and the group has evolved into a popular club where, according to one of the three women teachers, "We

raise their consciousness about the importance of asking questions in class. We discuss and practice some of the tricks the boys have learned in order to succeed, and we have established some problem-solving groups. Several boys have begun to show up for the meetings, and the girls decided to let them take part." One effect of the club has been a tendency toward balancing the computer use among male and female students.

Conclusion

I think that there are two important lessons in what we learned from Schools A, B, and C. First, they are living proof that successful programs for the mathematically talented can take on many forms. For example, like School A, they can rely heavily on textbooks or, like School B, they can choose to avoid them whenever possible. They can be deeply committed to frequent staff interactions about content and students, as is School C, or they can get along with them, like the crowded and tight-scheduled School A. They can thrive in the arena of formal mathematical extracurricular activities, like School A with its superb mathematics team and record of Westinghouse awards, or they can have little to do with the arena, like Schools B and C.

Second, while there is no doubt that the special talents of their students make it more inviting for programs A, B, and C to implement their innovative and distinctive characteristics, there is nothing inherently exclusive about most of these characteristics. They can and should be part of more typical, comprehensive programs, as well. Furthermore, the challenging, nondirective questioning patterns and the

coaching seem essential to the success of programs A, B, and C (and they are definitely exceptional in American education), but we witnessed the same kind of teacher behavior in many classrooms in other exemplary, but nonexclusive, programs we studied.

As further examples, School C is finding LOGO to be an excellent vehicle for learning mathematical heuristics in high school, and they are also taking careful steps to deal with the anxiety felt by many young women in competitive high school mathematics courses. Where is the indication that these efforts can succeed only with talented students? There is none, of course; the practices are models for all schools. As a final example, School B's teachers take pains to develop in their students a nose for recognizing where mathematics can appear, often surprisingly, in everyday experiences. Not every student can develop such a nose -- and not every teacher would be comfortable taking on the instructional challenge -- but there are many teachers and students not in programs for the talented, who could thrive with the experience.

Our country sorely needs models for the talented, like programs A. B. and C -- programs that offer more than the simplistic but common strategy, "Give them more of the same, but faster." But it is shortsighted to focus on the elitism in these programs. For one thing, to do so is to ignore that many of their students are not particularly gifted in mathematics. More importantly, it ignores the experimental value of such programs. They are viable laboratories for testing ideas, methods, and materials that can enrich the mathematical education of most American students.

There are several ways whch come to mind whereby we can capitalize on the modeling potential of these programs. First of all, because of their intensely busy schedules, the teachers in the 50 exemplary programs we studied rarely, if ever, get to sit with each other and share ideas. To those of us with the luxury to visit these programs, it is evident that they can learn quite a lot from each other. It is in the national interest for someone -- the federal government, a corporation, or a foundation -- to bring these people together for that sharing and so that they might work to define and plan the exemplary mathematics programs of the future.

Secondly, since much of the excellence of these programs derives from the behavior of their teachers, it would benefit teacher-training programs tremendously to have a videotape illustrating the exemplary teaching behavior. Once again, it is in the national interest for such a videotape to be made and made available.

There is a common reaction in this country which dismisses information about mathematics programs like those at Schools A, B, and C with remarks like, "Oh sure -- if we had students and teachers of that caliber, we could get those results, too." It is time to look beyond such short-sightedness. The teachers in Schools A,B, and C are experimenting with curriculum ideas and teaching strategies which can apply well beyond their special students. Let us begin to look at what the programs are doing right, and make good use of the information to improve the quality of all American school mathematics programs.

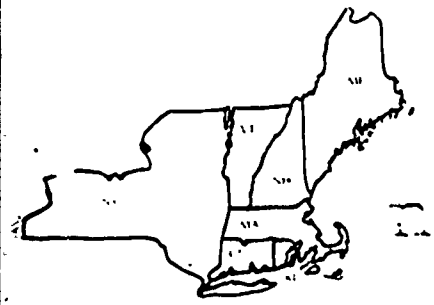
REFERENCES

1. Lakatos, Imre. Edited by John Worrall and Elie Zahar. Proof and Refutations. Cambridge, England: Cambridge University Press. 1976. 174p.

2. Driscoll, Mark. Research Within Reach: Elementary School Mathematics. Reston, VA: National Council of Teachers of Mathematics. 1980. 142p.

3. Driscoll, Mark. Research Within Reach: Secondary School Mathematics. Reston, VA: National Council of Teachers of Mathematics. 1983. 190p.

	School A	School B	School C
source of support for operating budget	100% city school	60% state 40% privately collected	90% state 10% private and federal
grade levels	9-12	7, 9-12	11, 12
number of students	circa 2,500	circa 180	circa 400
number of mathematics teachers	23	4	8
age of program	has grown with city system	about 11 years in present form	the school and program are 4 years old
method of student selection	city-developed examination	school-developed exam (changing to nationally standardized exam)	process of nomination, interview, examination, and matching with geographical, sex, and ethnic criteria
some distinctive characteristics of mathematics program	• highly successful extra-curriculars • large number of courses -- text-based but teacher-supplemented	• curriculum based solidly on student understanding and on a commitment to connecting mathematics to the world • teaching style stresses coaching and student use of heuristics	• strong and extensive support structure for students • closely cooperative and interactive staff • nontraditional high school computer programming courses (e.g., LOGO,"C")



northeast regional exchange, inc.

the resource exchange for educational services

December 11, 1984

Joseph T. Newlin
Rural Education Association
300 Education Building
Colorado State University
Fort Collins, CO 80523

Dear Mr. Newlin:

I have enclosed an article for Rural Education. It is a brief case study of one of the mathematics programs we visited in our Study of Exemplary Mathematics Programs, a national research project conducted by the Northeast Regional Exchange for the past two years with funding from the National Institute of Education. I have included a brief overview of the study as an introduction to the story of Deer Run, and an additional introductory page which adds some perspective to the story.

I hope that you will be able to use the article for your journal. I believe that there is much to appreciate and to be learned from the story of Deer Run's success in mathematics.

Thank you for your consideration.

Sincerely,

Mark J. Driscoll, Ph.D.
Principal Investigator

encls.

RURAL SCHOOL CASE STUDY

from

A STUDY OF EXEMPLARY MATHEMATICS PROGRAMS

Mark Driscoll, Ph.D.
Principal Investigator

- Brief Overview of the Study
- Deer Run Case Study

A Study of Exemplary Mathematics Programs

Background

Begun in December 1982 at the Northeast Regional Exchange (NEREX) and funded by the National Institute of Education, this two-year project was designed to: (1) collect a pool of exemplary programs in pre-college mathematics beginning at grade 4, (2) examine a portion of that pool in considerable detail in order to hypothesize what factors are associated with their exemplary qualities, and (3) provide a systematic means to test those hypotheses on a larger sample of programs.

Candidates for the study were self-nominated. Approximately 150 programs from around the country sent us evidence of their excellence, and most of them worked with us in follow-up phone interviews to supplement the information. The evidence we sought was targeted to student outcomes. In particular, we looked at standardized test scores, the percentages of students taking critical mathematics courses, the intensity of involvement in extracurricular mathematics, and any associated measures of success such as awards or contest results, and the extent to which graduates enter technical fields requiring mathematics. In addition, we looked for evidence of success with female students and with students from several minority groups.

To be a candidate, a program must have been in operation for more than a year. It did not, however, need to be a comprehensive program. A sizable minority of candidates were partial programs, some targeted to remedial students, others to honors or gifted students. A few schools submitted computer instruction progams that they considered exemplary.

When the pool was complete (approximately 150 programs), we convened a meeting of expert consultants to guide us in analyzing and using the evidence. The expert panel rated the programs and, once they were rated, we were able to select programs for site visits from among the top-rated programs. The top programs were rich in variety and, since we intended to study a cross-section of programs, we were delighted to be able to choose 28 exemplary programs that ranged across 16 states and the District of Columbia. The group comprised schools of all sizes, in rural, suburban, and urban settings and, because some of the schools were multi-leveled, we were able to visit 20 that included high school grades, 9 that included junior high school grades, and 6 that included at least one elementary school grade. (The relative proportions were roughly the same as the proportions of school levels in the entire pool.) Of equal importance to us, the group of progams selected included at least several schools in each of the categories of excellence outlined above.

The 28 site visits took place during the Fall of 1983 and permitted us to hypothesize what factors are associated with excellence. They also resulted in a set of case studies of some of the programs visited.

The following case study, like the others which have been derived from A Study of Exemplary Mathematics Programs, preserves the anonymity of the school and individuals involved. There is good reason in this case, however, to stretch the anonymity a bit and to name the state which contains the community we have called Deer Run. It is Illinois, a state whose professional mathematics teacher organizations have done a marvelous job of fostering enthusiasm for mathematics competitions, and so have played a key indirect role in the Deer Run success story.

As we note in the case study, competitions as vehicles for learning are not without their critics. They worry that, by teaching "tricks" to solve the contest problems, competitions reinforce the wrong impression of what doing mathematics is and should be all about. In our opinion, there is some validity in the fear, but the danger for most programs -- especially remote rural programs like Deer Run's -- is far outweighed by the pride and enthusiasm engendered by success in the competitions, which invariably leads to greater participation in mathematics programs by both teachers and students. We have talked with other Illinois teachers whose programs are actively involved in competitions. They relish the opportunities to visit with each other and to learn from each other that are afforded by the competitions. Their communities take greater pride in the programs, and that pride eventually filters back to help the programs.

We saw competitions being used just as successfully in other places, such as California and New England, but nowhere did we see them used as well for the benefit of small rural schools as we did in Illinois.

DEER RUN

"Results follow perceptions. The way to improve a program is to change people's perceptions first. Then good results will follow."

Former principal, Deer Run High School

"Mary works very, very hard for the program. American education is heavily subsidized by underpaid women like her."

Present principal, Deer Run High School

By standards set at many urban and suburban schools, Deer Run's high school mathematics program might not be considered exemplary at all. Relatively few courses are offered and, while test scores are good, they do not shine very brightly when taken out of context. Context was important in our study, however, along with absolute standards for excellence; we sought out programs that far exceed expectations for success in their particular settings and with their particular students, as well as programs that would meet anyone's criteria for success.

By this standard, Deer Run was a welcome addition to our study, an exemplar of an important yet fragile commodity in this country -- successful mathematics programs at tiny rural high schools. Like the small farms that surround them, these programs usually have meager financial resources, and they struggle. With the spreading teacher shortages in mathematics, their struggle has become especially acute: often, the well-being and even survival of a program revolves around one person. Should that person leave the program or become ill, the students must do without all but the most basic of mathematics courses until a substitute can be found, someone who has the appropriate background and is willing to work in a small town for light pay.

Deer Run has shown that one way -- perhaps the only way -- out of mediocrity for such programs is a combination of enlightened leadership and dedicated teaching that, together, squeeze the most out of available resources. The leadership found a mechanism -- team competitions -- to convince the school and even the Deer Run community that there was more potential for success in mathematics than they believed, and the teaching took a bit of newfound success and worked it into an expected pattern. Now test scores and course enrollments are up, spurred upward by the general enthusiasm for mathematics competitions. The drive to overcome mediocrity in Deer Run's mathematics program is by no means complete. There were rough spots -- for example, some of the teaching behavior we observed -- that cut down on the program's glitter for us. Even so, all of the problems we noted are surmountable, if conditions continue to invite the staff to experiment with improvements. Those conditions are anything but assured. The fragility that haunts much of rural education continues to hover over their established pattern of success, and makes Deer Run's struggle to sustain their success an especially heroic American educational story.

Background

Deer Run is a small Midwestern town of 1100 people, set in the middle of corn and soybean fields. No building in the town exceeds three stories except for the grain elevator and that, in classic fashion, looms for miles from its perch next to the railroad tracks. The houses along the main street, all freshly painted white in celebration of the town's 150th anniversery, add to the town's special, simple appeal.

Mr. Atkinson, the high school principal, described Deer Run as filled with "a strong Protestant ethic and Dutch blue-eyed conservative families." It is a stable community, as well -- seventy-five percent of last year's high school

graduating class were schooled in Deer Run since kindergarten. Most of the high school's 18 teachers are also from the immediate area. Familiarity and roots are about the only attractions that can offset the town's low teacher salaries.

Though Deer Run is small, its school district covers a 62.5 square mile area. The high school contains 190 students in grades 9 through 12, most of whom live on farms in the area. The demands of farm life, coupled with the distances traveled to and from school, understandably cut into students' attachments to school. In addition, the common practice of passing farms from parents to children has traditionally cut into school ties even more, especially as those ties were linked to postsecondary education. But lately there has been a turnaround in Deer Run. When Sam Walker, Deer Run's former high school principal and superintendent (and now superintendent in a larger, neighboring town), took over the high school nine years ago, only 4 of 45 graduating seniors were going to college. In 1982-83, 18 of 39 chose to continue their education beyond high school.

In a community like Deer Run, which has few college graduates besides its teachers, such a change is revolutionary. In part, as a recent series in the Wall Street Journal made clear, the change can be explained by the social fabric changes in farm communities in the past decade. Farming remains a viable life for fewer and fewer young people, and they are obliged to look to other careers. Even so, an hour's conversation with Sam Walker is enough to convince a visitor that social forces alone have not made the difference in Deer Run. His pursuit of change has been vigorous and intense, and the pursuit has touched mathematics more than any other subject.

The mathematics department has 1.5 teachers: the fulltime person, Mary Vandenburg, teaches general math, algebra I, algebra II, precalculus, and a double session of computer science (BASIC); the half-time teacher teaches business math, algebra I, and geometry; a course in Fortran is taught by one of the science teachers. Two aspects of the mathematics program made it particularly attractive for a site visit. First of all, nearly 80 percent of the students were enrolled in at least one mathematics course. Second, in state and local competitions, the school has fared well, despite the fact that, as Principal Atkinson told us, "In every math, computer, or biology tournament we enter, we're the smallest school." Like the increase in college-bound students, these two changes have been relatively recent.

Mathematics competitions have become Deer Run's lever to success primarily because of Walker's zeal and Vanderburg's hard work, but another factor has also helped. The state mathematics teachers' association is one of the most active in the country in organizing competitions on all levels -- local, regional, and statewide -- and they do a remarkable job of publicizing and generating enthusiasm for them. "They get the maximum out of what has to be a meager budget," Walker said.

"But it works. People are generally aware of the competitions. Around this area, if you win math competitions, they think you have an excellent program."

Leadership

Walker mused about the value of perceptions as he sat with us in his office in a nearby town, where he had recently begun as superintendent of schools. It is a larger town than Deer Run, with a more diverse population, a wider range

of interests, and more complex problems, yet he is already priming his high school's mathematics team to win. With a mixture of pride and disappointment, born of his old and new ties, he reported that the team had just placed second to Deer Run in a county competition.

He is confident, however, that history will repeat itself, that once again his intuition is correct: if visible improvements occur (in this case, a steady climb in competitions), then he, as leader, can change the school's and community's perceptions of their mathematics program. At that point, he will be able to spring from their changed perceptions into demands for more improvements. "I am more sure than ever," he told us. "Results follow perceptions."

On the scale that Walker experiments with his "Results Follow Perceptions" notion, only small towns would seem to qualify as laboratories. Larger settings carry too many variables, too many people to allow his kind of frontal assault. But we did see the phenomenon at larger schools, expressed, however, in more subtle forms: mathematics staffs that make themselves more visible in their schools and communities than other departments by their extraordinary availability to students, by their exceptional efforts to work with feeder schools to unify programs, as well as by their well-publicized successes in competitions. In various settings, principals and superintendents told us such things as: "They're our stalwarts;" "They're my hardest working department;" "I try to give them what they ask for. They earn every bit of it." For their parts, the exemplary mathematics programs do ask more, and also demand more of themselves. It is not their nature to rest on laurels, and it is generally not in the nature of their leaders to let them rest on laurels. Walker was principal and superintendent, not department head, but his leadership toward visibility and affecting perceptions has its manifestations in other exemplary programs, usually, in high schools, through department heads.

The program at Deer Run apparently lacked any lustre until 7 years ago, when Walker had an idea and took some initiative on it. His idea was as simple as it was forceful: first, he would guide the program to some gains, then he would turn the community's favorable impressions of the gains into fodder for further gains. The particular route he chose was through mathematics competitions, because it was relatively inexpensive and because it lent itself to visibility quite readily.

At the beginning, he worked with a teacher at a local junior college to locate as many collections of mathematics contest problems as they could lay their hands on. He then engaged Mary Vandenburg, the fulltime mathematics teacher, then relatively new in the school and new to teaching, to work on developing a math team by using the contest problems in her courses. They expected a modest, if not humbling, beginning to their contest results. But Walker told Ms. Vandenburg to aim to move up one place per year, on the average, in local and state competitions. After a few years, when that had begun to happen, he went to the school board, improved results in hand, and persuaded them to raise the mathematics requirement at Deer Run High School to 2 years. In the meantime, he acted, in his own words, "like an athletic coach." He and Vandenburg identified 10 or 15 talented students in each grade of the high school and began to groom them for the team, even, in some cases, asking athletic coaches to release students early for mathematics competitions.

In 1983-84, 33 of the 190 students were involved in mathematics competitions. In previous years, the number has been as large as 50. Enthusiasm for the competitions is so keen that students who aren't even enrolled in a math course come to Ms. Vandenburg to ask if they can be on the team. The new principal, Mr. Atkinson, a former engineer and mathematics teacher, has been bitten by the contest bug, and so continues to support the school's involvement in mathematics competitions. (As we arrived the first day of our visit, he was in the hallway posting the results of the most recent contest, in which Deer Run nosed Walker's team for first place.)

With Sam Walker gone, and Ms. Vandenburg comfortably settled into the mathematics program after 8 years, Atkinson's role in the continued success of the program is somewhat secondary, but his enthusiam and support are important. And he too is getting ambitious. "Pretty regularly, we have a small handful of students who can handle all the mathematics we throw at them. We need something to offer them. I've asked Mary to look into the Elements of Mathematics program for them." This program, called EM for short in the mathematics education community, is a program that has been adopted for use with gifted students in St. Louis County in Missouri, and elsewhere. To us, it seemed a surprisingly ambitious choice, but it fit nonetheless into the fervor for mathematics that has bitten the Deer Run community.

One other note on Atkinson: his wife and home are fifty miles from Deer Run, in the suburbs of the nearest major city, where his wife is a school administrator. He rents an apartment near Deer Run during the school week, and returns home for weekends. "I left engineering for education in middle age and got involved in a doctoral dissertation on school climate and school improvements. When the job opened in Deer Run, I took it, because of the real school improvement that has been going on here." Obviously, his interest in the program is no longer clinical, and his chosen life in education, with its hardships and sacrifice, makes for a heartwarming story, one that fits nicely into the broader Deer Run picture that unfolded for us.

The school community and, indeed, the entire Deer Run community, now share in the pride and support of the program. The school librarian, a former mathematics major in college, makes herself available to students for math tutoring in the library. The woman who until last year was the school guidance counselor, had established a reputation for careful attention to placing students in mathematics. She occasionally used the results from the Differential Aptitude Test to have selected students reverse the usual order

and take algebra II before geometry, if they seemed from their test results to be unprepared for geometrical thinking. She also established a reputation for encouraging girls in the middle school and the high school to think beyond nursing and school-teaching as possible careers. (A parent: "My daughter used to think about nursing. Conversations with Jean directed her toward engineering. Now she wants to be an engineer.")

The middle school now has its own Math Team. Through its carefully designed set of objectives for its mathematics curriculum (really an unofficial mastery learning program) and through its sharing of a teacher on a half-time basis with the high school, the middle school has established some continuity with the high school program.

The town is well aware of the Math Team. When Mary Vandenburg wanted to send an especially talented student to a competition in the East last year, she garnered some financial support from the Lioness Club in Deer Run, some more support from a town merchant, and the rest from school funds. The student was able to go to the competition. (By all accounts, it appears he was an exceptional student, and a source of local pride. He is now at MIT, and 3 or 4 of the school's teachers avidly shared anecdotes about his experiences at MIT with us over lunch.)

One further anecdote caps the story of the Math Team in this tiny community. The district's new superintendent told us how, on the evening of the most recent competition, he was roused from supper by automobile horn-blaring and the ringing of his doorbell. "I really didn't know what was going on. When I opened the front door, there were Mary and the team waving and flashing their first-place ribbon."

Curriculum and Implementation

Not surprisingly, competitions are on Mary Vandenburg's mind as she manages the Deer Run mathematics curriculum and implements it from day to day. (The curriculum is really her responsibility alone -- the half-time teacher from the middle school has little to say about the curriculum.) They are on her mind as she begins teaching Algebra I each September: "I look for candidates in that group and I start recruiting." They are also on her mind as she makes herself available to students "before school, after school, during lunch, during breaks, and during my planning periods."

During these times, when she is not providing remedial and general help, she is working with her team members. Occasionally -- as, for example, during our visit -- she will have team members give presentations, during class, on their contest work. Contest activities are not restricted to the math team. Approximately 80 students a year (more than a third of the school) take the American High School Mathematics Examination (AHSME) of the Mathematics Association of America. A small group are involved in the contests in mathematics and science called Test of Engineering Aptitude in Math and Science (TEAMS) Last year, Deer Run won their district and regional competitions, and then placed fourth at the state level. Typically, they were the smallest school represented at the state level.

The value of mathematics competitions to a school's program -- especia ly when they are as pervasive as at Deer Run -- is open to debate. One department head we visited in our study told us that he avoided them "because they mainly teach tricks" and are not conducive to a thoughtful approach to mathematics.

Other department heads we visited allow them to play but a minimal role in their programs..And, of course, there are the schools we described in case studies like East High School and Trinity High School, where contest victories are considered a valuable measure of success. Their value to Deer Run in this regard is clear, but we happened across what seems another good reason for their prominence in the school, when we interviewed Glenn, a senior year student in precalculus: " I like being involved in the competitions because, in preparing for them, you learn things like inverting matrices that you wouldn't ordinarily learn in class." It is difficult to gauge how many such topics there are that enter the curriculum through competitions, but the pace of precalculus seemed slower at Deer Run than at other programs we visited, so it is believable that Glenn was on target.

The pace of the curriculum was one factor that sets Deer Run apart from the vast majority of the exemplary programs we visited. Another was the use of homework. In some of the Deer Run courses, students are permitted to do their homework in class, and teachers make themselves available for help. While this runs counter to the practices in the other programs we visited, and so is of questionable value, the practice was singled out by a couple of students from farms as valuable to their learning, because " it's hard if you get stuck at home on an assignment."

Given its small size, the mathematics program at Deer Run presents no complicated student placement challenges, and yet Mr. Atkinson was strong in his praise of the guidance counselor who had left at the end of the previous year, and equally strong in his disappointment in the performance of her successor. Apparently, the former counselor had been a strong influence on the students, especially the girls; her departure, seen in the light of the recent turnovers in superintendent and high school principal, made the mathematics program seem a bit more vulnerable to us.

Because she teaches most of the courses, and because she is keen to meet all students' needs, Ms Vandenburg risks overextending herself. On the one end of the curriculum, she has seen the need to introduce calculus to the several students who exhaust the course offerings by senior year, and was planning to incorporate it as a semester course, combined with a semester of number theory. On the other end, she has decided to introduce a prealgebra course for those ninth-graders who are not fully prepared for algebra, but who need something more challenging than general mathematics. While he was in charge, Sam Walker refused to allow her to teach prealgebra, because of the time taken from planning. The new principal and superintendent have given their blessings, however, and Vandenburg was eager to get the course up and running.

Teaching and Staffing

After the careful planning of Sam Walker, Mary Vandenburg's dedication and hard work constitute the second major factor behind the progress of the mathematics program. She is the mother of two small children, with all the concomitant responsibilities and constraints that come from leading a double life. For example, our first morning in her class was interrupted by a call from her nursery school, whose staff had temporarily misplaced her younger child. Vandenburg seemed slightly envious that other math team coaches whom she knows are able to use after-school time to prepare their students for competitions. She cannot, because of her family responsibilities and because the majority of her students are dispersed at the end of the school day across the wide expanse of the school district, many to farm chores that will not wait. In any case, this dedicated teacher finds the time, during class, during lunch, during homerooms and preparation periods, to prepare students for the contests.

During her 8 years at Deer Run, Vandenburg has been the only full-time mathematics teacher and, although she lunches once a week with the part-time teacher so that they might coordinate their algebra teaching, she really is a department unto herself. In so many of the programs we visited, continued success appears to be tied to the collegiality of staff and the strength they draw from each other. In that light, the professional loneliness of Mary Vandenburg seems all the more poignant, and her sustained enthusiasm and commitment all the more laudatory.

Her dedication, and the dedication of many of her rural teacher colleagues, has a special quality to it because of the relatively limited opportunities for young people growing up in an isolated community the size of Deer Run. There is a strong commitment on the part of these teachers to expose their students to as much as possible of what is new and different and to push them to open their eyes to it. Thus, the special appeal of regional and state competitions as vehicles for program improvement, and Mary Vandenburg's commitment to involve as many students as possible in them: "When freshmen come into our school they want to be part of that winning team. I have had students who are not taking math in their senior year ask if they could still go to math contests. I try to encourage all of them." Glenn, the senior quoted earlier, put it in a slightly homier way: "If the dumbest person came up to Ms Vandenburg and asked to be on the Math Team, she'd find a place for him."

Money is an issue remarkably removed from the issue of teacher dedication in Deer Run (and, it is reasonable to assume, in communities like it). It is a sad corollary to the perpetual dearth of money for education. Generally, in this school and community, there is a sense of pride in making it on very little. In the metropolis 50 miles away, a newspaper article appeared on the Deer Run schools under the headline "Excellence for Peanuts."

In any case, money has little bearing on Mary Vandenburg's dedication to the mathematics program. When we asked whether the Master's degree she hopes to earn would increase her salary significantly, she looked surprised, even a bit annoyed by the question: "I don't know. That's not why I'd get it. I don't care what they pay me. I'd get it to help me teach better."

Money could definitely help the Deer Run High School mathematics program, however. There are spots where it evidently suffers from the district's skimpy financial resources--for example, in training for broader teaching skills. We observed 5 classes and were struck by several aspects of theclassroom interactions. For one, we were struck by the occasional impatience expressed--by both mathematics teachers-- in the lower-level courses like general mathematics. Furthermore, the part-time teacher was often sarcastic in addressing her students, a behavior notably absent in the vast majority of classrooms visited in our study.

A second disappointment was the lack of much development of student questions into further learning for the students. Ms Vandenburg took the time to answer questions, but several of the answers we witnessed seemed to leave the questioners hanging. For example, as she drew a circle on the blackboard in her precalculus course, with radian and degree measures listed for angles, a student asked, " Is that a function?" The answer: " Sine and cosine are functions, but we haven't covered them yet;" then she went on with what she had begun. This was not only a confusing answer which did not satisfy the student, but it was a missed opportunity to spring from the question to a discussion of functions and trigonometric functions, in particular, and to get the students to voice their understandings and misunderstandings about the concepts. Later in the class, the same student came back with another question, during a discussion of odd and even functions: " Are parabolas and hyperbolas even functions?" The quick and unsatisfying answer from Ms Vandenburg was, "Hyperbolas are not functions." Again, a missed opportunity to probe the students' thinking and to get them involved in a meaty discussion.

Mary Vandenburg's deep dedication to her students makes it clear that the missed opportunities and occasional careless behavior (such as inappropriate expressions of impatience) do not derive from a lack of concern. Rather, they derive from her professional loneliness as a department unto herself, and from the financial inability of the school district to provide much professional development. As it is, the principal stretches the budget to send her to state mathematics teacher meetings and to the competitions.

Isolation and a lack of funds are also hampering Deer Run's attempts to expand its curriculum wisely. The grant proposal Mr. Wilkinson has written to fund the purchase of the Elements of Mathematics materials for the high school's talented students, however nobly motivated, may be shortsighted. The materials are very sophisticated mathematically, and the program at Deer Run is not. Again, the geographic and financial isolation of the program has limited its options for finding appropriate curricular changes.

Conclusion

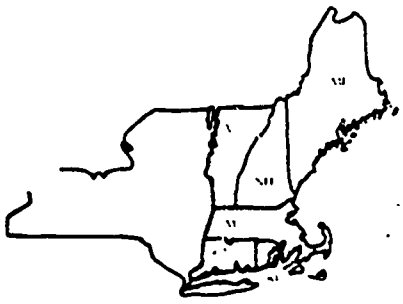
Sam Walker told us, from his new vantage point as another district's superintendent, "Deer Run High School has done more with what they have than any other school in the state." A biased and subjective assessment, no doubt, but it does reflect the truth about the school's valiant and fragile efforts in mathematics.

In studying exemplary programs, our researchers have travelled from inner city schools to suburban schools to rural schools. Each type has its own set of special challenges, and each has designed its own set of responses. In Deer Run's case, the challenges were a low budget and a traditional set of values that kept educational success on a rather low plane. Their response, through

forceful and imaginative leadership and dedicated teaching, was to use a steady improvement in mathematics competitions as both a motivator for students and citizens, and their standard for setting the tone of the entire mathematics program.

Success in mathematics continues to develop at Deer Run High School, yet it also continues to be a fragile sort of success. Funds are and always will be low, administrative turnover has been high, and the program relies on the deep dedication of one woman. Indeed, it is reasonable to say that, when compared with the other 27 programs we visited, Deer Run will have the hardest time sustaining its recent record of excellence.

1544 on 0033 Rec. 1/10/85



BEST COPY AVAILABLE

the resource exchange for educational services

January 10, 1985

Elizabeth Crow
Editor
Parents Magazine
685 3rd Avenue
New York, NY 10017

Dear Ms Crow:

I have enclosed an article I hope you will publish in Parents Magazine. In it, I write to parents about the quality of mathematics teaching in this country.

There have been a host of warnings and complaints in the past few years about declining test scores in mathematics and the dwindling supply of mathematics teachers. Sorely lacking has been some clarity about models for success. Which schools are generating highest scores and enthusiasm for mathematics among their students? What are they doing to keep their heads well above water while so many programs are thrashing about?

For the past two years, we at the Northeast Regional Exchange have been conducting A Study of Exemplary Mathematics Programs, with funding from the National Institute of Education. We have visited and studied closely 28 exemplary programs in 16 states and the District of Columbia and have studied a comparable number by telephone and mail. There are several informative, even inspirational findings and I have endeavored to describe them for your readers.

Ours has been a qualitative, not quantitative study, meaning that its findings are not expressed in numbers as much as in very human and social terms. I believe the article will make for interesting reading for the vast numbers of your readers with a stake in school improvement. I hope you agree.

Thank you for your consideration. If you wish to telephone me, you can reach me at my office (617) 256-3987.

Sincerely,

Mark Driscoll, Ph.D.
Principal Investigator

Encl.

MD/ac

Mark Driscoll
NEREX, Inc.
34 Littleton Road
Chelmsford, MA 01824
(617) 256-3987

About 2,500 words
First serial rights

A Formula for Success in Teaching Mathematics

My teaching career began in a warehouse in 1970. Its windowless walls, leaky ceiling, and sloping concrete floors housed an alternative high school on the fringe of the St. Louis ghetto. Seven of us founded the school -- one gifted, visionary director named Dennis O'Brien and six very enthusiastic teachers. Together, we renovated the warehouse, painstakingly established a guiding philosophy and curriculum, and, in the spirit of total renewal which drove our enterprise, even labored over the choice of a school name. In the end, we named the school Logos, passing over names connoting freedom or change, and choosing instead to identify ourselves with the reverence for learning of the ancient Greeks. Then, one frigid day in January, before we could think about the risks of our venture for very long, we opened our doors (one in the front and one to the alley in back) to the dropouts, young rebels, and educational misfits of St. Louis.

We felt isolated much of the time during the early days, but we knew we were part of a national movement, and we were buoyed by the spirit of that movement. While Logos and its underlying ideals were taking root in St. Louis, similar schools were appearing all across the country in warehouses, church basements, renovated tenements, and in dozens of other innovative settings. Discontent was in the air during those years, and

so was the desire for reform. Thousands of talented and committed people -- many who were Teacher Corps veterans, Peace Corps veterans, or Vietnam veterans -- became teachers in the late sixties and early seventies because of their desire for reform. The idealism that was rampant found one comfortable home in the new alternative schools. Unfortunately, in too many of these schools, it was an ungrounded, evanescent sort of idealism, and the schools failed. In those years, it was too tempting to focus on politics and lifestyle, and too easy to lose sight of sensible educational principles.

Logos is still thriving, fifteen years after its birth. Although it has moved to a larger building and narrowed its focus to emotionally troubled adolescents, the original ideas and educational ideals are firmly in place, driving staff decisions about curriculum, teacher training, hirings and firings, and so on. Underneath, those Logos ideas and ideals are tied to one abiding Truth, to which the teachers there have always committed their professional lives : the student -- not the teacher; certainly not the text, lecture notes, or syllabus -- must be the center of classroom activities. Easy words, often preached, but we found it a difficult Truth to live in consistently. To do so, we disciplined ourselves with some regular routines; the foremost among them were group training exercises: we observed each other's classes -- especially the troublesome ones -- and videotaped each other in class, then poured over the tapes together once a week to look for stumbling points and to suggest changes. We all learned how to teach to the tune of questions like, "What did you want to see happen there?" and "Where in that class

did you start to feel dissatisfied with what was going on?" The ensuing discussions were rarely easy, especially for the teachers on tape, but the sessions kept us focused on the students and kept us true to their needs.

My own association with Logos ended in 1978, when I began a new career in mathematics educational research, but I often look back at that Truth and to the strategies we developed to keep ourselves tied to it. In light of my recent career, it is ironic that there was no formal educational research behind the development of those strategies. We read and discussed the education writers, from Plato to Jonathan Kozol, but when it came to deciding what we as a staff were going to do in our school, we relied on our own instincts. And if, in those early days, an educational researcher had dared to visit the school and impugn our ways, he or she would quickly have seen the way to our back alley.

So it came to pass that, in 1983, I donned my researcher cap and set out with others to study exemplary school mathematics programs around the country. Our particular research study, funded by the National Institute of Education, was called A Study of Exemplary Mathematics Programs. My colleagues and I from the Northeast Regional Exchange traveled to 28 exemplary programs around the country, where we watched, listened, and probed for the conditions that made them exemplary in mathematics. These were programs with track records of generating extraordinary success in mathematics and enthusiasm for mathematics among their students; our job was to peer beneath the success to uncover what they were doing right.

When all of the evidence from our site visits was in, sorted, and analyzed, when a panel of outside experts had had their say in interpreting what we had brought home, the conclusion was inescapable: the Truth my friends and I committed ourselves to at Logos is alive and deeply ingrained in a variety of school settings. Teachers in the really good mathematics programs keep their eyes riveted on their students' needs and put them above all other concerns. In doing so, the best of these teachers cross the wide line between merely doing a job, and being artists.

The importance and difficulty of what these teachers do should not be taken lightly. On paper, their success is evident; their students' test scores, math team records, heavy mathematics course enrollments all attest to the quality of their efforts. Our visits, however, revealed the deeper, more subtle success they have achieved: they have dignified the learning of mathematics for their students. In their perspective of teaching, they are not merely in the business of teaching mathematics to kids; they are in the business of teaching kids mathematics. The distinction is critical, and not merely semantic. The words of a few illustrate:

The teacher of a 7th grade remedial class in Nutley, New Jersey, which meets every morning at 8 o'clock:

> "Some mornings it's difficult to face these students and the trouble they have learning. What I do on those mornings is to picture them as my own kids, and I try to treat them as I would want my own kids treated."

The veteran teacher of a calculus course in Canton, Massachusetts:

> "Teaching is still a high for me . When I walk into a classroom, everything else is shut out. And it's us -- the students and me."

A 6th grade teacher in Ann Arbor, Michigan:

> "We are very success-oriented. We want the students to feel successful. . . . We especially like the challenge posed by their coming into the 6th grade with their preconceptions about who is good in mathematics and who isn't. We highlight the accomplishments of the ones they don't expect to succeed, and make them rethink their expectations."

Each of these speaks, in its own way and at different grade levels, of dignity and the excitement of student-centered mathematics teaching. A remarkably common feature of all the programs we visited was the consistency of the dignity and excitement in the teaching. We saw, for example, only a tiny amount of teacher sarcasm, the fallback strategy of too many teachers when they feel uncomfortable, and one that robs students of dignity in their learning. From nearly one hundred classes I visited, I can recall only three in which the teacher resorted to sarcasm, and the effects in each case were memorable. The students in one of the classes laughed coldly and nervously; in the second, they responded to the teacher in kind; in the third, they sat in fearful silence -- in all three cases, sad and wasteful behaviors. Again,

however, these were rare exceptions, and to someone who has witnessed how often teachers -- especially at the secondary level -- feel driven to sarcasm by the behavior of students, the record of teachers in exemplary mathematics programs seems remarkable indeed.

The dignity and integrity even kept their power in conversations with the teachers outside of class. One of our site visitors is statewide mathematics consultant in a populous Northeast state, who routinely visits scores of schools and talks with their mathematics teachers. After his site visits, he marveled at the absence of remarks or facial gestures connoting "You know what group that is," when teachers talked of their department's remedial classes. "It's something I see much too much of in the typical school setting," he remarked. Dignity, the teachers in exemplary programs have found, cannot work in a selective or part-time way.

The teachers have learned what we learned at Logos with our especially demanding students: in order for students to cooperate in the excitement of learning, it is essential that the environment be constantly conducive to their being invested in the excitement. It does little good if the dignity is there one day and missing the next. When that happens, the students invest too much energy in caution, and their excitement about learning tends to be muted.

The learning atmosphere was anything but muted in the 28 exemplary programs we visited. The proof was in the faces of the students, which,

unfortunately, cannot be reproduced here. Their words, however, stand as wonderful substitutes. Here are some examples:

David, a geometry student in Glendale, Wisconsin:

> "I like the different ways my geometry teacher finds to give all the students a chance to succeed. Like his 'Mulligans', surprise quizzes that only count if you do well. . . . I also like the fact that I can always get help from one or another of the math teachers anytime after 7:30 in the morning."

Another David, a graduate of a high school we visited in Urbana, Illinois:

> "I remember specific problems that Mr. Davis posed in class four years ago, and how I thought about them for days and would come to his office to talk with him about them. He always seemed available. I wish I could get that kind of help in my college math courses. There, all that seems to matter is how much you remember on the tests."

Lee, a high school senior in Albany, California:

> "Every Friday, all the math teachers in courses from Algebra on give out especially challenging problems for extra credit, and give a week or two to solve them. Occasionally, we talk about the tougher ones in class before they're due, and you can almost always hear students talking about them in the snackbar at lunchtime."

These are students talking about their teachers in settings away from the classroom -- trustworthy remarks, but not nearly as revealing as their behavior in the classroom. Their remarks there, whether made to themselves, other students, or the teacher, are fairly accurate barometers of the level of trust between students and teacher -- in particular, trust in the safety to take risks. We heard a bit of mumbling and grumbling, but more often, we heard openly expressed remarks like:

"That's where I made my mistake."

"I don't think I have that down yet. I got too many wrong on the homework."

"Could you go over that again?"

Consistently minimizing risks and maximizing trust was a common quality among the teachers we met in the exemplary mathematics programs. More often than not, it was an outgrowth of their unified commitment to making success in mathematics available to all students, their unbending intolerance of failure and their unwillingness to let students drop from mathematics courses. I mentioned this unwillingness in a presentation about the study I gave last year in New Jersey. A woman from the audience approached me afterward and said: "One of your researchers visited my daughter's high school, so I thought you'd like hearing a story about her Advanced Placement math teacher." Her daughter's school is one in which the department head had carefully delegated authority to his staff; they, in turn, responded by unifying their procedures and

commitment for staying on top of students. "She wanted to drop from the BC level (the more difficult) of Advanced Placement to the AB level -- not drop out altogether, mind you, but just change levels! He tried to talk her out of it and failed, so he told her he'd let her drop down if she talked it over with her father and me, and if she beat him in a tennis match. Well, we said okay, and she beat him at tennis a few weeks ago, so he let her move down. But I was impressed with how much effort he put into keeping her in the upper level."

With similar passion, the teachers in Albany (California) High School worked after school for a year to develop a 150-page curriculum for their 9th-grade general mathematics course because, in the words of the department head, "We didn't want general mathematics to be the dead-end course it usually is in other schools." As a result of their efforts, a large percentage of these students now take four years of mathematics during their stay in high school.

As these examples illustrate, teachers we visited vary in how they devote time outside of class to their programs; they coach mathematics teams, work with students on computers, and monitor tutorial or remedial programs. When it comes to how much time they donate, however, they are uniformly and consistently very generous. Often, the computer has contributed to this propensity to spend extra time. "The computer," said one department head, "has driven lots of teachers back to school, both to learn and to rethink how they teach." (Oddly, in the reams that have been written about the computer in schools, this aspect -- what it is doing to regenerate the skills of many teachers -- gets scant attention.)

Principal after principal in the schools we visited told us: "They stay longer than any of our other departments," or "They are my hardest-working department." And, no matter how they spend their time for the curriculum and the students, they share with each other -- ideas, materials, journal articles, and so on. This, unfortunately, is less typical of American school staffs than it should be. One of the teachers in an Ann Arbor elementary school told us: "This is the fifth school in the district I've taught in, and it's the first one in which the teachers readily share with each other."

In ideal situations, such as my friends and I had at Logos, teachers can be totally collegial, sitting in on each other's classes, meeting regularly and exchanging ideas about pedagogy. In the typical, less than ideal school setting, the demands and constraints are too great, too complex, and it is easy for teachers to sink into near-solitude, much as Horace in Theodore Sizer's poignant teacher portrait, Horace's Compromise. The teachers in exemplary mathematics programs, however, fight the solitude and find ways to work together, or at least to unify their efforts. There was no better nor more concise description of their success than that given by the principal of a West Virginia middle school, who described his mathematics staff as "interlocking, mutually supportive, and diversely unique people." Time does not always permit collegiality to be completely formalized among teachers, but in most exemplary mathematics programs, it takes root because the teachers thrive on it and will not do without it.

Often it takes root under the guidance of a visionary leader, a department head, or principal who encourages staff unity and commitment and sets up mechanisms to make them happen. Generally, these leaders see their mathematics teachers as the professionals they are, and encourage their professionalism by delegating authority and by showing active respect for their opinions. More often than not, they are staunch champions of their staffs within the school district's hierarchy, and get them what they need to be effective and to grow professionally. The head of an exemplary program in Boston mused out loud, at our request, about how he might reproduce his program's excellence in another school. He listed several items that he thought were essential, but stressed that the program "would have to have a leader who was able to work with the principal to make the right things happen for the program."

Style is neither hard nor fast among these leaders. We saw the full range of styles, from tight management to a free-form, "Take the issues as they come" style. What is common to all of these leaders is vision that looks beyond test scores and refuses to be one-dimensional about excellence. And, whether their curricula are text-bound or not, they stay alert for weaknesses, and work with their staffs to overcome them. Like their teachers, they are consistently intolerant of failure and even disinterest among their students.

It is important to point out how exceptional this leadership is. Research studies of how planned change happens in high schools generally cast department heads as rather unimportant factors; their roles are usually too circumscribed, ill-defined, or subject to the whims of their

administrative superiors. In the programs we studied, conditions are vastly different. If it is the teachers who bring life and dignity to these exemplary programs, it is the leaders who frequently bring life and dignity to the teachers.

Conclusion:

The exemplary mathematics programs we studied represent a variety of settings: they cover the full gamut of grade levels (grades 4 through 12), school size, and social settings. In addition, different categories of excellence were represented: high test scores, outstanding course enrollments, winning mathematics teams, innovative curricula, and programs having special success with populations traditionally underserved in mathematics, such as females and minorities.

Despite the variety in settings and outcomes, we found all those common threads outlined above: the exemplary leadership, the strategies for putting together curricula that work for students and the equally important strategies for making them work consistently, and, most important of all, the exemplary behavior of the teachers. In its portrayal of the teachers, in particular, our study should be taken as a joyful report. We should all rejoice that there are individuals willing and able to devote such consistent passion and care to a student-centered approach to teaching mathematics.

For me, the phrase that most aptly describes the attitude of these teachers toward their students and their profession appeared recently in

an article on Japanese education. Harvard researcher Merry White wrote an article entitled "Japanese Education: How Do They Do It?" (The Public Interest, Summer 1984), in which she reported: "Across the population, among parents, at all institutional and bureaucratic levels, and highest on the list of priorities is the stress on excellence in education. This is not just rhetoric. If the consensus, societal mobilization, and personal commitment - all focused on education - are not available to Americans, the reason is not genetic, nor are we locked in an immutable cultural pattern. We are simply not mobilized around our children." The striking phrase is the last one. The teachers we studied in the exemplary mathematics programs are mobilized around our children.

Why, however, do they continue to be such a small minority? To answer "Teacher shortages in mathematics" is to beg the question, or at least to change the question to "What happened to the fervor for educational reform, the flooding of the teaching profession with individuals passionate for student-centered teaching that marked the late sixties and early seventies?" If you listen to the spate of studies, polls, and reports of the last few years, the noises of discontent seem as strong as they did 15 years ago. Yet, underneath, they seem to be little more than noises, unaccompanied by any passion for real reform. Bluntly put, in light of White's article, maybe the Japanese mean it when they say they value excellence in education, and we do not.

We can hope that it is a cyclical phenomenon. Perhaps we must wait until our society is disposed once again to be passionate about the dignity of teaching, as it was when my friends and I started Logos School in 1970. In the meantime, it is a shame that so many models for real reform -- the individuals met in our study and portrayed in this article -- are going to waste. Instead, let's explore ways to learn from them to benefit all school mathematics programs. We could bring a representative group of them together to chart the exemplary program of the future, or we could videotape their exemplary teaching behavior and use the tapes to train other mathematics teachers. I am sure that there are many ways in which we can learn from them. For our children's sake, however, let us not waste them.