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ABSTRACT

This report presents findings from a first year evaluation study of Integrated Math and Integrated Science curricular programs as they were implemented at Polk Academy, a high school in the San Francisco Bay area comprised of approximately 90% students of color. To promote scientific literacy, critical thinking, and communication skills, the school's task force recommended the adoption of new curricular programs emphasizing integrated mathematics and science learning for Polk Academy students. Educators have called for the integration of branches of these fields as a means for improving student comprehension and performance as well as developing positive attitudes towards math and science. This report presents an evaluation of the Integrated Math and Integrated Science programs as they were implemented during the 1996-97 school year at Polk Academy. Contains 17 references. (Author)

A First Year Evaluation Study of Integrated Math and Integrated Science Curricular Programs in an Inner City High School

by

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INTRODUCTION

This report presents findings from a first year evaluation study of Integrated Math and Integrated Science curricular programs as they were implemented at Polk Academy[1], a high school in the San Francisco Bay Area comprised of approximately 90% students of color. To promote scientific literacy, critical thinking, and communication skills, the school's task force recommended the adoption of new curricular programs emphasizing integrated mathematics and science learning for Polk Academy students. Educators have called for the integration of branches of these fields as a means for improving student comprehension and performance as well as developing positive attitudes towards math and science (Berlin & White, 1995). This report presents an evaluation of the Integrated Mathematics and Integrated Science programs as they were implemented during the 1996-97 school year at Polk Academy.

Goals of Evaluation

The primary goal of this study was to evaluate both programs based on current standards delineated within the National Council of Teachers of Mathematics (NCTM) and the National Science Education (NSE) curricular frameworks for secondary education. Specifically, the evaluation was guided by the following research questions:

1) What learning opportunities for acquiring scientific literacy, critical thinking, and communication skills are incorporated in each curricular program?

2) What are the particular strengths and limitations of each program as it was implemented this past year?

3) What successes and challenges are teachers experiencing in implementing the curriculum?

4) What impact are both programs having on student attitude and achievement?

[1] Pseudonyms are used throughout this paper to protect the identity of the school, its teachers, administrators, and students.

Methodology

Undergirding this project was a constructivist view of evaluation whereby the focus resided not on judgment for accountability or some form of selection, but rather on the processes involved in educational change (Jenness & Barley, 1995). From such a perspective, evaluation assumes an internal, on going, formative nature (Norris, 1990; Nevo, 1995; McColskey, Parke, Harman and Elliot, 1995). Harmon (1995) explains, "...assessment can assist project leaders and teachers to define and redefine goals in light of real people, real student reactions, and real teacher struggles" (p.47). Teachers and students play an integral role in assessment because the goal is to help the school community take ownership over the reform, that is to be able to clarify their mission, define problems and successes, and reach their own solutions.

Evaluators play a significant role in school reform within the constructivist framework. It is their responsibility to listen to teachers, students, and administrators about what takes place in the classroom, and to push participants to clarify their goals and reflect upon shifts made with respect to reform missions and implementations (OECD, 1995; Chrispeels, 1992). Thus, an ongoing, interactive dialogue among assessors, teachers, students, administrators, and other community members remained at the core of exploring the purposes, processes, and outcomes of restructuring efforts at Polk Academy.

Both quantitative and qualitative research methods were utilized in this study. The author spent two to three days each week for nine months gathering data at the school. The primary data sources were as follows:

Observations - 52 observational visits made to all Integrated Math and Science classrooms

Interviews - Interviews with 16 Integrated Math and Science teachers

Focal subjects - In depth observations and interviews with a focal group of three Integrated Math teachers, three Integrated Science teachers, and twenty 9th and 10th graders enrolled in such classes

Student Survey - Attitudinal survey administered to over 400 students enrolled in Integrated Math and Science courses

OVERVIEW: EVALUATION OF THE INTEGRATED MATH CURRICULUM

The adopted Integrated Math curriculum is based on principals, concepts, and standards consistent with the NCTM framework for secondary school mathematics education. The curriculum, in its first year of implementation at Polk Academy, was assessed according to the primary learning and instructional objectives on which it was developed. The next sections are organized in the following manner:

- 1) Evaluation of key curricular components
- 2) Instructional variables
- 3) Student attitudes and performance indicators
- 4) Implications for future planning

EVALUATING KEY CURRICULAR COMPONENTS

Process- and Communication-Based Learning

During the 1996-97 school year, the Integrated Mathematics course was taught by seven teachers who collectively provided instruction in a total of eleven classes. The curriculum is designed to develop students' ability to problem solve, think critically, work cooperatively with others, and communicate their ideas clearly through an integrated approach to the study of algebra, geometry, measurement, logical reasoning, statistics, probability, discrete mathematics, and functions. Students are challenged to develop conceptual understanding and problem solving skills through connections among the various branches of math, as well as between math and other subject areas such as science, art, sports, and social studies. Thus the program fosters learning via a visual and hands-on approach whereby students apply math to real-life situations in order to become confident, active, and curious learners who can effectively discuss and present mathematical ideas both in oral and written form. Learning is student-centered in which learners develop basic computational skills as well as become active in predicting, reasoning and presenting solutions (National Research Council, 1988; Clarke, Stephens & Waywood, 1992).

The strength of the Integrated Math curriculum lies in its rigor and process orientation in which students are required to explore their understanding of mathematical concepts. Lessons and activities are designed to tap students conceptual understandings by having them perform calculations, problem solve, and explain how they arrived at solutions. Most of the teachers praised the curriculum for both its strong depth and breadth, as in the following interview excerpt:

> I like the curriculum a lot because it asks a lot of questions that require them to think more in depth. You know a lot of questions don't come just like obvious. They really have to dig into it, so by looking at that I can truly tell whether they understand what we're trying to cover or not.

An excerpt from our classroom observations early in the school year well illustrate these aspects. When introducing students to a statistics unit on mean, median, and mode (Unit 3-2), many teachers began by having students examine data from the textbook on fat content in breads and crackers:

Figure 1
Data chart (*Integrated Mathematics*, Unit 3-2)

Breads and crackers	Fat content per serving (g)
cracked wheat break	0.9
whole wheat bread	1.1
pita bread	0.6
matzo	0.3
graham crackers	0.5
corn muffin	4.0
rice cake	0.3
tortilla	1.1
bran muffin	5.1
rye break	0.9
pumpernickel bread	1.1

After discussing consumption preferences and impressions of the above figures (e.g., patterns in data, predictions, etc.) through whole class discussions or in small groups, teachers asked the class to find the mean, median, and mode of the given data. From there, teachers typically discussed the strategies and formulas needed to solve the problems, while some implemented the "talk it over" activities in the text which asked students to work in groups to answer the following:

Explain why the mean of the data in Sample 1 is greater than the median and the mode.
Will the mean be greater than the median and the mode for any data set? Give examples to support your answer.

Classwork typically followed in which students were asked to solve varying types of problems, including process oriented questions (e.g., "Explain how to find the median of 23, 15..."), computation questions (e.g., "Compute the mean, median, and mode for the following test scores, swimming times, and salaries"), research questions (e.g., "Find the definition of astronomical unit in a dictionary. Does this definition use a mean, a median, or a mode?"), and word problems (e.g., Helen bowled six games. Her mean score was..."). As this lesson exemplifies, the curriculum provided multiple opportunities for exploring mathematical concepts through communication, collaboration, computation, active problem solving, and research. Students were required to go beyond determining a correct answer as teachers had them explain procedures for solving problems and analyze data in charts and graphs in learning statistical concepts.

<u>Textbook Strengths - Visual, Applied Learning</u>

Therefore, the Integrated Mathematics textbook appears to successfully integrate various branches of math by reinforcing similar concepts within these areas in succeeding chapters. This multiple representation of concepts is advantageous primarily because repeated exposure to principals and ideas allows students to see how the same concepts can be applied to distinct yet inseparable areas of math and to obtain the practice they need to strengthen their computational skills. One teacher commented extensively on this aspect of the curriculum:

> I was coming into solving equations today and I was pretty impressed when I saw that some geometry questions come back again like angles and polygons that we covered a while ago. And then we come back and they've forgotten some things but we're able to review it and I think that's good we're able to do this periodically because if it were not built into the curriculum I may not remember to bring it up again.....If students don't get the concepts or ideas the first time, it's gonna come back. Like we talk about convex and concave polygons before when we first introduced it. And now we come back and many of them remember polygons, but they don't remember what a convex polygon is. So we're able to do a little bit of review, and I think that's good... And I'm sure when it comes back again they have better retention.

Overall teachers expressed satisfaction with the Integrated Math curriculum not only because of it's rigor, integration of various areas of math, and application to real life, but also for its organization and resources. Each chapter of the textbook presented the following within a visually rich context:

Figure 2
Integrated Mathematics Textbook Components

Focus: learning goals for each unit
Application: related mathematical problems for discussion
Talk it over: questions intended to promote group discussion
Samples and responses: sample problems and strategies for solving them
Exercises and problems: reading, writing, computation, open ended, and research questions
Review and assessment: questions and problems to check for understanding, integration of topics, recall of earlier concepts, preparation for later concepts
Technology: problems, information, and data utilizing spreadsheets, calculators, etc.
Unit projects: theme based related projects applied to careers and daily life

Challenges for LEP Students

Although the Integrated Math text is effective for students who are native speakers of English, the text potentially creates obstacles for second language learners. In comparison to traditional computation based math curricular programs, the Integrated Math textbook is highly linguistically oriented, requiring extensive amounts of reading and writing to solve, analyze, and explain math problems. One bilingual teacher voiced her deep concern over the amount of explanations and translations she had to perform for her limited English proficient (LEP) students:

> I myself cannot do the written translations. I have to do all the verbal translations myself. The whole idea of using this book is so that they're open to a lot more things. But because of the language they're not open to a lot more things. I end up having to do basically your traditional curriculum just because... how are they going to read without my taking all this time to translate?....Any math curriculum is difficult for them. But to add to them all this, I think is just unfair.... I'm not saying there's anything wrong with this book, but it's very idealistic... We have this.. class that speaks... are native English speakers...It is for that population in my opinion. Otherwise it excludes a lot of people.

Teachers felt that their LEP students, despite computational proficiencies, were becoming increasingly frustrated in their struggles to comprehend the materials. In addition, implementing group work also proved difficult because teachers had to present mathematical concepts in a second language while explaining the sometimes elaborate directions of collaborative activities. Some made attempts at facilitating group learning structures, but eventually came to realize that it was too difficult unless an aide was present to provide assistance. The textbook provides suggestions for limited English proficient students, though the bilingual and ESL teachers in particular did not feel these instructional strategies were always feasible in their classes unless significant linguistic and material support were provided.

Challenges for Low Achieving Students

Furthermore, while the Integrated Math curriculum remains rigorous for a majority of students, teachers expressed concern that the program may not meet the needs of low achieving students. If the goal of the program is to engage all learners within a challenging math program and to prepare them for higher level math courses, then adjustments need to be made to ensure that the curriculum reaches low achieving students as well. For some, low basic computing skills seemed to prevent them from progressing, while for others low skills were evidenced along with low levels of motivation which teachers said were displayed in absenteeism, poor attitudes towards math, and failure to attempt assignments. Whatever the specific difficulty, it was clear that many were being left behind in the curriculum. Some teachers spoke of the difficulties their students were experiencing within a process, conceptually based math program that might not otherwise surface in such pronounced ways within a more traditional skills based curriculum:

> Some students don't do well due to the book. Those with basic skills in algebra do fine with the book. Students don't have enough of the basics to do this integrated book. They don't have the exposure and practice in doing these types of problems...The majority of them have a very weak grasp of their computational skills and concept skills, application skills.

Consequently, some teachers admitted that they watered down the curriculum (e.g., choosing easier problems for students to solve, assigning less homework, or not going as in depth as they would like in presenting concepts and principles) in order to make the material accessible to more students. Teachers felt that the curriculum was challenging, though not overly difficult for students to progress. During classroom observations, some students in fact seemed disinterested and disengaged despite the visual nature of the textbook. However, motivation was a key issue many commented on during their interviews. Although the text offered a range of tasks, students often lamented that they disliked having to read the explanations that accompanied them and therefore displayed minimal effort to perform beyond a "correct" calculation.

For the 1997-98 school year, the math lab courses are planned for elimination. Students with severely low math scores will be enrolled in a modified Integrated Math course in which only a portion of the text will be covered to allow for a slower pace and more intensive skill development. Consistent with the streamlining of course offerings in the math department (IMP and traditionally sequenced Algebra, Geometry, Advanced Algebra courses are being replaced by Integrated Math), this shift is a necessary one as several teachers questioned the effectiveness of math lab courses in preparing low achieving students for later math courses.

INSTRUCTIONAL VARIABLES

In this section, findings are presented based on data from classroom observations throughout the school year and interviews with Integrated Math teachers regarding their instructional practices. Specifically, evaluation of participant structures, assessment practices, and department leadership is presented.

Participant Structures

Based on classroom observations of all Integrated Math teachers, rates of instruction time were monitored and analyzed to determine dominant interactional structures. A total of 27 class visits were made throughout the school year on regular and block scheduled days (some classrooms were visited on several occasions), which revealed the following percentages of instructional time (see Table 1):

Table 1: Instruction time patterns from observations of Integrated Math classrooms[2]

Lectures	42.14%
Individual seat work	24.91%
Whole class discussions	20.75%
Group work	7.80%
Student presentations	4.40%

The significance of these findings is to reveal patterns in how Integrated Math classes were organized for varying forms of interaction. It appeared, then, that lecture based instruction occurred most frequently in which teachers directly presented concepts, principles, and formulas to students. Lectures were typically followed by whole class discussions when working out sample problems and individual seat work when students independently solved classwork or homework

[2] Lectures are defined as teacher presentations aimed at direct transfer of information; individual seat work as tasks given to students to be completed independently without assistance or interaction with others; whole class discussions as teacher led interactions that involved active discussion and exploration with students; group work as activities structured to promote interaction with peers in solving some task; and student presentations as speeches, presentations, or student led discussions on some topic.

assignments. Communication based instruction via group work was one of the least frequently observed structure, despite being a critical goal of the Integrated Math curriculum.

Philosophical tenets of instruction within the Integrated Mathematics curriculum is based upon the strengths of cooperative learning[3] (see also National Research Council, 1988). Each Integrated Math teacher incorporated some form of cooperative learning, although the extent varied from classroom to classroom. In most classrooms, teachers allowed students to work together in going over homework problems or collaboratively solving math problems in pairs or groups of four students. In other classrooms, students not only worked together to complete such problems but also presented them to the class as a whole. The forms of collaborative learning operated differently depending on how much structure, guidance, and monitoring teachers provided, however, few instances were observed in which teachers utilized the cooperative structures recommended in the text, such as the interview, jigsaw or roundtable activities. Nonetheless, most teachers remained fairly open towards implementing more cooperative learning yet struggled with how to better facilitate activities in the classroom, as one teacher noted:

> I started with a lot of group work but I find them to talk about non-related trivial topics to math so I narrowed it down to buddy systems...randomized pairing... As they enter they pick a card... I don't want them to be with their friends. They need to talk to people they don't like. They need to communicate their ideas with their partners. It forces them to communicate. The reading and talking it over in groups doesn't work. I need to go over the information with them. I tried to model the reading, answering questions, copying samples, then exercises and then have them try it. They either can't do it or won't do it.

One math teacher who was able to successfully incorporate a great deal of group work in her classroom commented on the positive changes that resulted:

[3] The benefits of cooperative learning as suggested by the NCTM Curriculum and Evaluation Standards lie in decreasing math anxiety; instilling confidence and encouraging motivation, self-esteem, curiosity; improved ability to solve problems as well as communicating mathematically.

> I could really see the teamwork... they spend time outside of class. They really do a lot of work. And they seem to split up the chores very well. And for one group project I also have them evaluate themselves as a group and evaluate other groups as they're doing their presentations.

The difference between this teacher and others was that she clearly assigned roles for students in each group, directed them on how to go about solving the problem, conveyed clear expectations for the processes and end product, and closely monitored each group during the activity. Consequently, students worked cohesively towards the same underlying goal that was explicitly discussed prior to the activity. However, it is important to note that these collaborative activities were conducted in an honors Integrated Math course where most students displayed comparatively higher levels of motivation and achievement.

<u>Assessment Practices</u>

A key component of the Integrated Math curriculum involves assessment practices extending beyond traditional evaluation that narrowly emphasizes "correct" calculations. Instead, the curriculum focuses on alternative methods of assessment that reflect the scope of the program - to have students solve problems, reason, and communicate. By doing so, assessment should work to broaden and deepen students' understanding of mathematics while encouraging them to perform to their potential. In particular, the goals of assessment include evaluating what students already know, their ability to communicate mathematical reasoning, and their individual growth.

Most Integrated Math teachers tended to utilize fairly traditional methods of assessment, in which composite scores were based on a combination of tests/quizzes, homework, projects and notebooks, and participation/attendance, with teachers weighting these various components differentially. A typical "formula" for determining student grades might look like the following, which represents an average weight for each criteria given by all the Integrated Math teachers:

Table 2: Composite formula for assessment in Integrated Math courses

Tests	45%
Homework	30%
Projects/notebooks	15%
Participation/attendance	10%

Tests and quizzes represented the most heavily weighted criteria teachers relied upon in measuring achievement. However, several were also beginning to implement a more holistic assessment of their students' work, a shift that was strongly encouraged by the department head. Teachers began to rely more heavily on projects and several adopted forms of portfolio assessment as a means for evaluating student performance. For example, teachers required students to keep a portfolio of reflection pieces about why they had difficulty with particular aspects of math or why they enjoyed performing certain kinds of math problems, as well as a log of drawings, unit projects from the text, and newspaper clippings related to math.

The importance of this shift is confirmed by student perceptions over the goals of assessment. A survey conducted with 211 enrolled students asked them to indicate the most important aspect of learning in their Integrated Math courses:

Table 3
Survey results - Assessment

Which is the most important in your math class?	
Doing well on tests/quizzes	23%
Learning to do calculations	22%
Showing individual improvement in learning	18%
Getting the right answer	15%
Communicating what I learn	13%
Research projects	6%
Portfolios	3%

Thus, students perceived tests, quizzes, and calculations as primary indicators of achievement in their classes. Projects and portfolios, on the other hand, were least frequently cited as important indicators. Students were aware of the rather traditional methods of assessment employed by their instructors, yet noted that individual improvement and communicating what one has learned does occupy some significance. As the department incorporates greater project- and portfolio-based evaluation, student perceptions should shift in related fashion.

Department Direction and Leadership

Although the Integrated Math teachers had distinct instructional styles, they appeared to be very clear on the overall direction of the math department, which functioned as a fairly cohesive unit. Teachers felt that the department head provided ongoing curricular support and feedback, represented their needs to the administration, and fostered a sense of enthusiasm and collegiality. Several teachers acknowledged that while they may occasionally differ in instructional philosophies, faculty were generally willing to work together and discuss issues that arose.

In many ways, the leadership within the mathematics department should be viewed as a model for the school to examine. The department head was active throughout the year in assessing the needs of her teachers, and in turn providing resources and support when possible. Within department meetings, she typically inquired as to what professional development resources or activities the staff needed, whether they be materials for the classroom, extra training, professional books or articles, one on one teacher support, or more frequent discussion among teachers themselves. During the academic year, teachers reached consensus on several areas of curricular development for all members of the staff to focus upon, including incorporating portfolios, communication based teaching/learning, and group work. More specifically, two teachers discussed having worked closely with the department head to develop more effective strategies in their classrooms and, as a result, students noticed improvements in these teachers' communication patterns and presentational styles over time.

STUDENT ATTITUDES AND PERFORMANCE

In this section, data is presented from a survey conducted with a total of 211 students enrolled in Integrated Math courses. All Integrated Math teachers administered the survey to their students during the month of April, 1997. Thus, students had the opportunity to experience the curriculum for almost two semesters when responding to the questions, which were designed to measure student perceptions and attitudes in three key areas (see Table 4 for list of questions and results):

1) Perceptions of learning in the Integrated Math program (Questions #1-8)
2) Assessments of instructional practices (Questions #9-20)
3) Attitudes towards math in general (Questions #21-24)

Overall Attitudes Towards Curriculum

Overall, students displayed slightly above average responses to how much they were learning in Integrated Math:

- On a scale of 1 to 5 (where 1 equaled "not at all," 5 equaled "a great deal," and 3 represented "somewhat," or an "average" score), students felt, overall, that the curriculum was helping them to learn about math concepts (e.g., functions, equations, etc.) (3.335) as well as how to solve math problems (3.357).
- They perceived the curriculum as helping them to see how the different branches of math are related (3.34) within the context of learning that was interesting (3.107) and applicable to their everyday lives (3.226).
- Lastly, they viewed the program as challenging but not overly difficult as they provided slightly below average scores in rating their difficulty of learning math concepts (2.914) and learning to solve math problems (2.955).

In terms of instructional practices, students identified particular strengths and weaknesses in their teachers' curricular implementation:

- Students pointed to their teachers' incorporation of visual learning strategies (e.g., charts, graphs, diagrams) to help learn concepts and solve problems (3.914) and hands on manipulatives (e.g., calculators, rulers, graphs, compasses and other objects) (3.968).

- Students conveyed an above average response to the textbook in helping them to learn curricular content (3.383). However, students also pointed to less frequent communication based instructional practices such as working in groups (2.778), talking about difficulties in class (2.644), and engaging in writing activities (2.973).
- Nonetheless, they did note their teachers' frequent ability to find different ways of teaching math (3.146), to foster an environment open to freedom of expression (3.407) and to control disruptive student behavior (3.896). However, they indicated the rare opportunities they had for computer use in Integrated Math (1.48).

Students' responses reflected slightly above average ratings in attitudes towards mathematics:

- Students tended to provide a response of "somewhat" to "a great deal" in terms of their enjoyment over: learning math (3.217); looking forward to taking more math classes (3.157); considering a career involving math in the future (3.175), and feeling prepared for higher level math classes (3.249).[4]

<u>Comparison of Attitudes Among ESL, Bilingual, Honors, and Regular Classes</u>

An analyses of the survey data reveals statistically significant differences among the ESL (.6), bilingual (.8), honors, and regular Integrated Math classes. Maintaining the regular Integrated Math courses as the basis for comparison, t-tests were performed to determine statistically significant differences ($p<.05$) in attitudes among students enrolled in these difference courses. Several important patterns were revealed:

Most notably, students in the ESL and bilingual classes found the curriculum to be more difficult particularly in terms of learning concepts.

[4] Although results of individual questions are not drastically different from one another, they do suggest prevalent patterns in student perceptions. A middle effect may have been operative in which students tended to provide a middle score (3) to questions, however it should be noted that the mode for several questions was not (3), and that most students provided a range of scores in their assessments, noting frequent and infrequent practices in their classroom as well as stronger or weaker attitudes and perceptions about math. In order to eliminate risk of a middle bias, the numerical values for possible responses were changed from 1-5 to 1-4 for the Integrated Science student survey. Again, however, students displayed slightly above average responses to these questions, as will be shown in a later section.

- LEP students did not claim greater difficulty in *solving* math problems but in learning concepts. They confirmed in interviews that they could perform the calculations in class with less difficulty than the word problems and activities which required linguistic comprehension and verbal and written skills to explain related math processes.
- Perhaps the above was linked to the much stronger perception, as the survey results indicated, on the part of LEP students that group work helps them to learn about math. Opportunities to collaborate with peers was a valuable resource in figuring out directions, aspects of an assigned task, and procedures for solving problems especially for LEP students, who claimed to benefit from group work at rates higher than students in both the regular and honors Integrated Math classes.

Overall, the honors Integrated Math program appears to be effectively implemented in all measured areas:

- In comparison to students enrolled in regular Integrated Math, honors students evidenced statistically significantly higher ratings of:

  1) perceived learning (finding the class to be more interesting; learning more about math concepts and math problems; needing less review of basic math),

  2) perceived stronger instructional practices (greater use of manipulatives and visual learning strategies; more open to freedom of expression and discussion; more control of student misconduct),

  3) positive math related attitudes (greater enjoyment in learning math; looking forward to taking more math classes; perceiving their Integrated Math course has prepared them for higher level math classes; and greater likelihood of considering a career or job involving math in the future).

<u>Comparison of Attitudes Between IMP and Integrated Math Classes</u>

Lastly, students enrolled in the Interactive Mathematics Program (IMP) were also administered the same survey to tap their perceptions and attitudes towards math (see Table 5). Comparing the overall results of the IMP students (120 students completed the survey) with those of the Integrated Math students produce noteworthy findings. Students from both program reported no statistically significant differences in several dimensions of learning math, assessing instructional practices, and attitudes towards math. However, some significant differences were evident ($p<.05$):

- Students in IMP classes said they were learning more about solving math problems and conducted more group work in these classes.
- Integrated Math students had a stronger attitude towards their text, felt better prepared by their previous math classes, and to a greater extent, looked forward to taking higher level math classes.

Table 4
Integrated Math Student Survey Results
(Scale 1-5 where 1 = not at all, 5=a great deal)
Averages scores presented for Regular Integrated Math courses, followed by the average increase/decrease for Honors, .6 ESL, and .8 Bilingual courses.

* denotes statistically significant difference (p<.05)

Question	Reg	Hon	ESL	BIL	Overall
1. How interesting do you find your math class?	2.907	+.713*	+.387	+.067	*3.107*
2. How much do you think you are learning about math concepts (for example, functions, equations)?	3.263	+.517*	-.204	-.16	*3.335*
3. How hard is it for you to learn these math concepts?	2.752	+.128	+.66*	+.575*	*2.914*
4.. How much do you think you are learning about solving math problems?	3.284	+.43*	-.0049	-.105	*3.357*
5. How hard is it for you to learn how to solve these math problems?	2.923	-.0023	+.202	+.128	*2.955*
6. Does this math class help you to see how different areas of math are related, that is, how algebra, geometry, statistics, and functions, are related?	3.356	+.344	+.056	-.51*	*3.348*
7. Does this math class help you to see how math is related to our everyday lives?	3.154	+.266	+.659	-.207	*3.226*
8. Did your previous math classes prepare you enough for this class?	3.373	+.087	-.56	-.296	*3.30*
9. Do you think this Integrated Math class should have more review of basic math (for example, fractions, decimals, percentages)?	2.819	-.659*	+.357	+.643*	*2.811*
10. How much group work with other students do you do in this class?	2.862	-.282	+.326	-.247	*2.778*
11. Does group work help you to learn about math?	3.153	-.233	+.729*	+.539*	*3.253*
12. Do you talk about the difficulties you're having with math in this class?.	2.579	+.156	-.05	+.19	*2.644*
13. How much writing do you do in this class (journal writing, essays or reports, taking notes)?	2.932	+.228	+.127	-.111	*2.973*

14. Do you use calculators, rulers, graphs, compasses, and other objects to help you solve problems?	3.752	+.828*	+.436	-.316	*3.914*
15. Does your teacher have you draw graphs, charts, diagrams, to help you learn concepts/solve problems?	3.698	+.642*	+.537*	+.481*	*3.968*
16. How often do you use computers for this class?	1.513	-.033	-.395*	+.025	*1.48*
17. Does your teacher make the class open to freedom of expression and discussions, rather than focusing on just getting the right answer?	3.25	+.65*	-.125	+.109	*3.407*
18. How much does your textbook help you to learn math?	3.188	+.572*	+.459	+.18	*3.383*
19. Does your teacher find different ways of teaching math to make it more interesting for you?	2.991	+.349	+.947*	+.06	*3.149*
20. Does your teacher notice when the class is not paying attention or misbehaving and stop it?	3.752	+.488*	+.436	+.017	*3.896*
21. How much do you enjoy learning math?	3.145	+.515*	-.086	-.248	*3.211*
22. Do you look forward to taking more math classes?	3.017	+.923*	-.017	-.376	*3.157*
23. Do you feel this class has prepared you for higher level math classes?	2.914	+.986*	+.649	+.368	*3.249*
24. How much would you consider a career or job involving math in the future?	3.06	+.5*	+.058	-.009	*3.175*

Table 5

Comparison of Integrated Math and IMP Survey Results

(Overall average scores given for Integrated Math, followed by the increase or decrease in overall averages scores for IMP)

* denotes statistically significant difference (p<.05)

Question	**Integrated Math**	**IMP**
1. How interesting do you find your math class?	3.107	+.001
2. How much do you think you are learning about math concepts (for example, functions, equations)?	3.335	-.209
3. How hard is it for you to learn these math concepts?	2.914	+.195
4.. How much do you think you are learning about solving math problems?	3.357	-.314*
5. How hard is it for you to learn how to solve these math problems?	2.955	+.062
6. Does this math class help you to see how different areas of math are related, that is, how algebra, geometry, statistics, and functions, are related?	3.348	-.156
7. Does this math class help you to see how math is related to our everyday lives?	3.226	-.159
8. Did your previous math classes prepare you enough for this class?	3.3	-.425*
9. Do you think this Integrated Math class should have more review of basic math (for example, fractions, decimals, percentages)?	2.811	+.239
10. How much group work with other students do you do in this class?	2.778	+.772*
11. Does group work help you to learn about math?	3.253	+.169
12. Do you talk about the difficulties you're having with math in this class?	2.644	+.093

13. How much writing do you do in this class (journal writing, essays or reports, taking notes)?	2.973	+.294
14. Do you use calculators, rulers, graphs, compasses, and other objects to help you solve problems?	3.914	+.136
15. Does your teacher have you draw graphs, charts, diagrams, to help you learn concepts/solve problems?	3.968	+.116
16. How often do you use computers for this class?	1.48	-.088
17. Does your teacher make the class open to freedom of expression and discussions, rather than focusing on just getting the right answer?	3.407	+.051
18. How much does your textbook help you to learn math?	3.383	-.543*
19. Does your teacher find different ways of teaching math to make it more interesting for you?	3.149	+.001
20. Does your teacher notice when the class is not paying attention or misbehaving and stop it?	3.896	-.371*
21. How much do you enjoy learning math?	3.211	+.033
22. Do you look forward to taking more math classes?	3.157	+.038
23. Do you feel this class has prepared you for higher level math classes?	3.249	-.403*
24. How much would you consider a career or job involving math in the future?	3.175	-.107

Student Performance Indicators

At the time in which this report was written, final semester grades for Spring, 1997 were not yet available from the district office. However, data from the Fall, 1996 semester provide insights into levels of student performance. Table 6 lists the percentage of students receiving Ds, Fs, or incompletes for regular, ESL, and bilingual Integrated Math classes:

Table 6
Grade point average in Integrated Math
(% of students receiving Ds, Fs, or incompletes, Fall 1996)

Regular Integrated Math	
First grading period	45%
Second grading period	46%
ESL (.6) Integrated Math	
First grading period	65%
Second grading period	51%
Bilingual (.8) Integrated Math	
First grading period	32%
Second grading period	42%

The performance data demonstrate, then, that close to half the students in regular courses, over half in ESL, and over one third in bilingual classes during the fall semester received a D, F, or incomplete grade. These figures are similar to grade point averages in other academic departments at Polk, and thus, is not specific to Integrated Math. Nonetheless, most teachers interviewed felt that students who flunked Integrated Math fell into one of several categories: 1) *no shows*, that is students that teachers didn't even know because they never showed up to class, 2) *apathetic learners*, that is students who only came to class occasionally and rarely completed assigned work in virtually all of their classes; 3) *apathetic math learners*, that is students who had little motivation for mathematics in particular and consequently, exhibited poor attendance and participation rates; and 4) *low skilled learners*, that is students with low basic computational skills who could not keep up with the curriculum.

Interviews with twenty focal students enrolled in different Integrated Math classes provided insight to these findings. Students failing these courses were asked about the factors contributing to their achievement level, and identified the following causes:

1) *Disinterest in math*: Because of their disinterest in math in general, students said they frequently cut class despite awareness that absenteeism was particularly costly in math classes since the curriculum built upon learned skills and concepts.

2) *Boredom*: Students felt the curriculum didn't make enough connections to real life applications, and consequently, saw some of the material as irrelevant.

3) *Lack of individualized attention*: Students maintained that the curriculum was not too difficult for them, however, they often needed, but failed to receive individualized help to guide them through problem solving processes.

4) *Literacy based curriculum*: Several asserted that Integrated Math didn't "feel like a real math class but more like an English class." Unprepared for

the wealth of required reading and writing, students, especially LEP students, said they wanted to be in "real" math classes (i.e., Algebra or Geometry) where they could perform straight forward calculations.

IMPLICATIONS FOR FUTURE PLANNING

In its first year of implementation, the Integrated Math curriculum overall experienced several successes as it was implemented in the classroom. Nonetheless, evaluating the curriculum along with student attitude and performance data raises several issues to consider for future planning in the areas of professional development, curricular considerations, and student performance and perceptions.

Professional Development

Staff development in strategies for teaching Integrated Math to second language learners should be a high priority. Adopting the Integrated Math curriculum presents new challenges to LEP students who must rely on greater linguistic ability as opposed to mere computational skills. These curricular changes require teachers to modify instructional strategies that will allow for the learning of English as a second language as students are learning mathematical concepts and processes. Teachers can benefit, for example, from strategies such as modifications to presentational styles, utilizing peers as mathematical resources for one another, student focused learning centers, and explicit attention to mathematical vocabulary development which are all practices advocated for LEP math students and their teachers (California Department of Education, 1992; Gagnon, 1996). Workshops, in services, readings, and consultants should provide resources for all teachers.

Teachers should be provided continued professional development in cooperative learning strategies. All Integrated Math teachers have agreed to incorporate some form of group work into their instruction yet collaborative learning seemed to be an underutilized structure. Teachers can benefit from specific staff training in organizing mathematically based group work activities (e.g., learning centers, jigsaw, roundtable) in which varying roles and structures are utilized to facilitate dialogue and shared responsibility (see Romberg, 1992).

Teachers should be provided continued professional development in alternative assessment tools. Assessment remains fairly traditional among Integrated Math teachers, however, all are experimenting with different assessment tools that are performance based. Expanding upon the projects, journal writing, literature logs, multimedia assessment, and out of classroom math activities already in existence will move the curricular program in the direction of measuring individual growth in conceptual understanding (National Research Council, 1988; National Center for Education Statistics, 1996).

Curricular Considerations

The Integrated Math program needs to develop a basic computational skills component. The entering mathematics skill level of many students demonstrates a tremendous need for mediating basic computational abilities to ensure greater opportunities for success in Integrated Math.[5] Based on classroom observations and interviews with low achieving students, it was apparent that many had difficulties solving assigned problems when they struggled with manipulations of decimals, percentages, and fractions. One teacher supplemented his curriculum by beginning each class period with a 5-10 minute quantitative activity to build upon students' computational skill levels. Perhaps with greater systematicity and organization, such a practice can be implemented across classrooms. Furthermore, classroom aides and volunteers will be immensely beneficial to assisting teachers in providing individualized help. Coordinating volunteers from community agencies, university students, and families to provide tutoring and group work facilitation both in and out of class should be a goal for the future.

Curricular planning should focus on incorporating greater computer use. Although a computer based learning program that supplements the Integrated Math curriculum is available, teachers had little time to pilot test the software

[5] The department head collected data in a basic math skills inventory during Summer, 1996 which found that only 30% of entering 9th graders correctly answered 70% or more of the questions. For example, 92% of the students were able to perform addition problems without calculators, 76% could perform subtraction, 62% multiplication, and 42% division. For decimal calculations, 68% of the students were able to do addition problems, 45% subtraction, 45% multiplication, and 37% division.

during this past year. Prepatory time is needed, then, to examine the program and to discuss ways in which it or other programs can become an integral part of the curriculum. Students frequently commented on limited computer use aside from utilizing the Internet to look up research for projects or using a word processing program to type up papers.

Curricular development needs to address the specific areas of difficulty students are experiencing with the Integrated Math curriculum. In interviews students pointed to aspects of the curriculum that they found particularly difficult, which teachers will need to address in planning meetings to discuss strategies for tackling these issues. Specifically, students noted difficulties in sections such as *Coordinates and Functions (Unit 4), Direct Variation (Unit 7), and Linear Equations as Models (Unit 8).* In general, students conveyed less difficulty with sections involving geometry and statistics, and greater challenge in advanced algebra sections.

<u>Student Preparation and Perceptions</u>

Teachers and administrators must continue to address students' perceptions of the Integrated Math curriculum. Some students, in particular Honors students, discussed dissatisfaction with the Integrated Math program based on their perceptions of the preparation that the curriculum provides. They called for enrollment in traditional algebra, geometry, advanced algebra sequenced courses because they had some familiarity with Integrated Math material from their middle school classes, and as a result, perceived Integrated Math as merely a "review" course. Many additionally believed the course would not count towards meeting University of California eligibility requirements, which further diminished their enthusiasm. Upon entrance to the school during orientation, students should be advised of the rigor of Integrated Math and the direction of mathematics within the school and district.

Accelerated math learning programs should be consulted. Plans have been developed to utilize the Integrated Math curriculum for all entering 9th graders, including those students with academic difficulties who might previously have been enrolled in Math lab courses. Utilizing the text at a slower rate will provide such students with opportunities to learn the various branches of math through exposure to the same curriculum others are experiencing. However, many reform educators argue that merely utilizing the same curriculum at a slower pace condemns students to never catching up. Thus, while the school is placing challenged math learners into slower paced Integrated Math courses, it should also consult models of accelerated math learning programs that enable students to catch up more quickly. Such models have been widely advocated at the elementary level, but growing research is examining such programs in secondary mathematics (see Hess, 1995).

Research into the impact of the Integrated Math curriculum should be ongoing. Research into the impact of the curriculum on student learning needs to be continued. Specifically, the survey utilized in this study should be administered to future cohorts to measure attitudes and perceptions. Over the next several years, course enrollment rates, grade point average from Integrated Math and higher level math classes, and CTBS Math scores will provide longitudinal evidence of student performance.

CONCLUSIONS

As this evaluation study has demonstrated, Integrated Math meets several of the NCTM standards for secondary mathematics education - most notably, the incorporation of a critical, process orientation to actively engage students in problem solving, applications to real life and career contexts, development of conceptual understanding, utilization of alternative assessment tools, and communication driven learning and teaching. As teachers become more familiar with the curriculum and as students perceptions evolve, the Integrated Math program should increasingly improve students' math achievement. The future success of the program, however, will lie in the school's ability to provide continued staff development, to motivate students towards greater mathematics learning, and to address the linguistic and skill level needs specific to Polk Academy student populations.

OVERVIEW: EVALUATION OF THE INTEGRATED SCIENCE CURRICULUM

The National Science Education Standards is guided by the principles that science is for all students, is an active process, and should reflect the experiences and cultures characterizing the practice of contemporary science. The framework delineates key standards for teaching, including: designing an inquiry based program to meet the knowledge, experiences, and abilities of students; facilitating learning through discourse around scientific ideas, modeling of skills, and active participation on the part of all students; managing learning environments that provide adequate time, space, and resources for learning science; and fostering a community of science learners who are challenged by intellectual rigor and collaboration (see National Science Education Standards, 1996 for all standards for science teaching, professional development, assessment, science content).

Integrated Science at Polk Academy incorporates the SEPUP (Science Education for Public Understanding Program) for 9th grade students and a school based science curriculum developed for 10th grade students. In its first year of full implementation, the Integrated Science curriculum was taught by nine teachers who provided instruction for fourteen 9th grade classes and eleven 10th grade classes. This evaluation study assessed the following:

- 1) Key curricular components
- 2) Instructional variables
- 3) Student attitude and performance
- 4) Implications for future planning

EVALUATING KEY CURRICULAR COMPONENTS

<u>Developing Scientific Concepts and Processes</u>

The Integrated Science courses implemented at Polk are effective in meeting several of the NSE standards for science education. In terms of providing an inquiry based curriculum that introduces students to scientific concepts and processes, both the 9th and 10th grade courses are appropriately designed. The 9th grade SEPUP program is driven by issues oriented units (e.g., chemical testing, investigating ground water, properties of materials, recycling, and energy from the sun) that involve students in the varying stages of scientific experimentation, including hypothesis generating, testing, revising predictions, and drawing conclusions. By emphasizing the learning of basic scientific concepts, the program adopts a hands on approach before introducing greater content in the 10th grade. Through active data collection and analysis, students connect scientific processes to the context of their everyday lives as they analyze and reflect upon the implications of their findings for larger environmental and social issues (e.g., pollution, water contamination, waste management). Each experiment from the utilized laboratory book, *Issues, Evidence, and You* (1995) incorporates an introduction, challenge, materials, procedures section, as well as data processing questions at the conclusion which typically ask students to summarize or analyze findings, to make recommendations, or to draw conclusions.

The 10th grade Integrated Science curriculum is designed around three environmental oriented units intended not only to engage students in laboratory based research but also to further develop important content knowledge and process related skills. Most students rotated during the past year as they spent 12 weeks with a teacher investigating *Energy and Environmental Future*, 12 weeks on *Managing our Natural Resources*, and 12 weeks on the *Living Environment and Human Impact*. Teachers utilized different conceptual biology, chemistry, and physics texts for each module, incorporating labs that foster more sophisticated scientific experimentation and problem solving around environmental issues.

An excerpt from conducted classroom observations is illustrative. Students were observed early in the school year conducting an experiment investigating the impact of levels of chlorination on microorganisms in water. After discussing the experiment and copying the related lab information into their notebooks, students worked in small groups to add different amounts of diluted household bleach to cups filled with green algae water. Maintaining a control cup, students treated the remaining cups with varying amounts of chlorine, and recorded their observations of color changes in the following chart listed in their lab manuals (see Figure 3):

Figure 3
Water Treatment by Chlorination
[sample chart, from *Issues, Evidence, & You*, pt 1, p. 46 (1996)]

Test Cups	Observations (before chlorine)	Treatment	Total Chlorine Concentration	Observations (after chlorine)
A				
B				
C				
D				
E				

Data charts and graphs such as these were common in Integrated Science experiments. Upon completion of data gathering and recording, students answered processing questions from their lab manuals which asked students to analyze their results and draw conclusions. Sample questions from the above experiment included the following:

- *Describe what happened in each of the five tests cups during the time you observed them.*
- *Based on your observations of the effect on algae, what concentration of chlorine would you recommend for water purification? Explain.*
- *Is this a fair test for determining the appropriate concentration of chlorine to treat drinking water?*

Several teachers perceived these hands on, process oriented experiments to be particularly helpful as an introduction to science for students at Polk who may not have strong interests in the field. Many teachers described the program as "fun," "interesting," and "not too difficult," as they noted the level of enthusiasm and interest of several of their students. One teacher explained,

> I really like the curriculum. I think getting them to learn the lab format is very important for them, which is something they need for other science classes. It's mostly

process oriented, but I think our students get a lot out of learning these basic science concepts and processes. Many of them seem to be responding well to it...

Another important strength of the Integrated Science courses is that the concepts and principles embedded in lab experiments are reinforced in varied forms in subsequent activities. Thus, students learn about concepts such as toxicity, threshold, or risk which they encounter in units devoted to the study of water, chemicals, and heat and energy. One teacher, who piloted the course the previous year, discussed the reinforcement of these concepts:

> One good thing about this curriculum is that ideas come back. Threshold will keep coming back... And even when we go into other topics the idea of threshold (comes back). In the last unit...when we're talking about solar energy, we sit out in the sun and we have a motor spinning based on solar panels and sometimes it spins and sometimes it doesn't spin and that's threshold cuz the minimal threshold it takes to spin of the voltage generated by the sun... so that concept comes back again even if it's not water, we're not talking about chemicals.

Both the 9th and 10th grade programs focus on critical thinking and conceptual understanding within the context of science issues that have relevance to students' lives. Activities such as analyzing gas and electric bills from home to study energy consumption, analyzing different types of water students consume to investigate qualities of water, and discussing reduction and recycling of hazardous materials to learn about waste management engaged students in activities connected to their lives outside the classroom. One teacher explained the importance that these links provided his students:

> With this stuff, it's like, how does drinking water affect my life. Well, every kid can say that. Everything we're doing is so topical, every lesson you could say this is how it affects your life. And it was intentionally designed to do that. That's built in there. I think that's great about it. I think kids have a hard time relating it to their life, so I think it's a good idea to start with a class like that. And then you get into chemistry and they're like, they realize that science is important to their lives. I have kids, we'll do a chemical reaction, and I'll write it out for them, and they won't understand it, and I say, "You'll get this later." And they really want to know what's happening.

> I think this class is laying that foundation where science is relevant, and that next year you'll study more in depth and next year even more in depth and maybe recall that it's relevant.

Lack of Depth and Rigor

The 10th grade curriculum appears to provide ample opportunities for students to examine environmental issues from biology, chemistry, and physics frameworks through focused, substantive lectures, readings, and labs. However, the 9th grade curriculum is notably less effective in teaching students scientific concepts and principles in an in-depth manner. Most experiments from the lab books provided only one page of text to introduce the topic and provide relevant background information. Moreover, the experiments typically did not require students to learn scientific notations or to perform complex calculations. Consequently, a majority of the 9th grade Integrated Science teachers, who felt the curriculum lacked rigor and only provided a superficial exposure to science concepts, recommended that the material covered in the 10th grade curriculum needed to be focused upon in the 9th grade. Representative of the sentiment expressed by several others, two teachers explained:

> There's no systematic learning going on. I don't think students can see how material and principals and concepts relate to one another. You can't train thinking without content. The students are not getting "real" science, but only a very low level conceptual discussion of theory.

> I'm not sure about this curriculum because there are very few concepts involved, and there is not enough reading material. It doesn't allow students to go in depth nor does it provide enough background information. There are also not enough calculations, and too many "why does this happen?" and "what do you see?"

In contrast, a few teachers felt that the lack of content was not necessarily a limiting dimension of the curriculum. Instead, they felt that introducing students to processes was more critical in the 9th grade to develop interest in science for the 10th grade and beyond. Particularly for Polk students who display low math skills and varying levels of interest in science, teachers commented on the advantages of a hands on curriculum.

Virtually all teachers, nonetheless, agreed that the curriculum needed to be augmented to provide more content, depth, and exposure in order to prepare students for higher level science courses. This perception probably accounted for the range of curricular activities and materials observed during classroom observations. Teachers supplemented the curriculum by bringing in outside readings, texts, and articles related to topics under investigation, modifying lab experiments, utilizing Internet resources, assigning projects and research papers, or at times, abandoning the SEPUP activities altogether for other projects and labs. While most teachers utilized the lab books and experiments incorporated in the curriculum, they also had little time to collaborate over ways to systematically modify the curriculum, which seemed to result in a lack of uniformity in material covered.

Development of Quantitative Skills

Although students were at times required to manipulate raw data in their experiments, the 9th grade curriculum did not provide consistent and systematic attention to the development of quantitative skills. Some of the experiments did incorporate, for example, calculations and ratios in figuring out threshold levels or determining acid-base neutralization. However, these tasks were not frequent nor intensive enough to adequately foster learning of scientific units nor computational skills. Furthermore, teachers pointed to the low mathematical skill level of students at Polk, and thus, the need for greater exposure in the 9th grade to scientific notation, standard units, and more complex calculations. Although such exposure is actively incorporated into the 10th grade courses, most teachers called for explicit attention to quantitative skills in the 9th grade if students were to be expected to perform in higher level science courses both in high school and later in college. Consequently, teachers integrated mathematical computation activities whenever possible, conducting drills to learn the metric system, having students perform daily warm up quantitative exercises focusing on formulas such as area and mass, and discussing scientific units such as joules and watts in physics labs.

INSTRUCTIONAL VARIABLES

In this section, instructional variables are assessed for their impact on creating meaningful opportunities for students to actively problem solve, communicate their understanding, and demonstrate individual conceptual growth. Specifically, evaluation was conducted in the following areas: *participant structures, assessment, and teacher collaboration.*

Participant Structures

An indicator of effective science teaching includes the utilization of varying participant structures. Conceiving of students as active participants in their own learning within the context of a community of science learners necessitates opportunities for meaningful collaboration around scientific ideas and problems. Based on 25 classroom visits with all of the Integrated Science teachers, Table 7 lists the percentage of instructional time utilized for each participant structure category:

Table 7
Instructional time patterns from observations of Integrated Science classrooms

Independent seat work	35.50%
Group work	30.47%
Lecture	20.22%
Whole class discussion	10.85%
Student presentations	2.96%

These findings demonstrate that group work accounted for almost one third of the total instructional time in the observed classrooms. Students worked actively in lab activities in which they typically worked in groups of four to complete the stages of an experiment. Some teachers assigned specific roles during these labs, asking students to assume responsibility for gathering materials, performing procedural tasks, recording results, or cleaning up. All teachers made several efforts to monitor students' progress by moving among groups to answer questions, ensure on task behavior, and to probe or extend students on what they were finding.

However, the dominant instructional structure in the observed classrooms was independent seat work. During these times, students frequently worked alone in copying down the challenge, procedures, graphs and charts, and data processing questions from their lab books. Because these books were not available for students to take home, most teachers utilized significant amounts of class time for students to copy these elements into their notebooks. Students in most classes seemed to passively copy the information word for word without paying attention to the content or utilizing critical thinking or communicative skills. Thus, familiarizing students with the aspects of an activity seemed essential, however, teachers needed to actively engage students in discussing and preparing for such work.

While students utilized oral communication skills in collaborating over the different stages of these hands on experiments, they were also engaged in significant writing tasks. In addition to writing lab challenges, procedures, questions and answers in their notebooks, different teachers assigned other tasks such as records of collected data, journal entries involving reflections on what students had learned, and written research projects on related topics. Overall, the Integrated Science curriculum provided, despite the amount of individual seat work, consistent opportunities for both oral and written communication based learning.

Assessment Practices

Assessment practices among the science teachers varied in terms of measures of learning that each emphasized. Most, though, employed a point system relying on completed lab reports and notebooks, classwork assignments, quizzes, and class participation as the primary basis for determining grades. Some teachers noted that it was difficult to implement tests for the 9th grade classes in particular because the curricular focus revolved around scientific process rather than easily quantifiable computations. However, as the year progressed, some said they became more familiar with developing questions that were process oriented but still incorporated critical thinking and reflection. For example, one teacher included the following questions on the final exam for his 9th grade class:

- *Electric cars are supposed to be the answer to automobile pollution. Do you agree with this or not? Support your answer with facts and opinions.*
- *In the supermarket we are usually asked what kind of bag we want, paper or plastic. What sort of environmental decisions are involved with this question, where do these bags come from? Which type of bag do you choose? Why? Can you justify using this type of bag?*
- *If you were trying to preserve a block of ice, how could you build a container that prevents the ice from melting? What materials would you choose? Why are these materials good for preserving ice? Draw a picture showing how an ice chest works, using arrows to represent heat.*

Teachers also developed alternative ways of assessing student performance. Lab books, in which data from experiments were recorded and analyzed, were required of all students. Teachers assigned individual and group research projects around related topics (e.g., disease, pollution, recycling), follow up assignments to conducted field trips and guest speakers, Internet activities for students to explore, and extra credit readings and written reports. When these multiple forms of assessment were utilized, students had different opportunities to demonstrate acquired knowledge and skills within challenging tasks. It should be noted that while varied assessment practices were evidenced in a majority observed classrooms, some teachers still relied solely on tests and lab books as indicators of learning.

<u>Teacher Collaboration</u>

Due mostly to time constraints, Integrated Science teachers did not formally and consistently come together to share their experiences, successes, and challenges in implementing the curriculum during the year. Department meetings were typically devoted to other pressing issues the staff confronted particularly given the focus on the science department in the restructuring of the school into a science academy. Still, lack of collaborative time appeared to result in a weak sense of the department as a cohesive unit. Teachers characterized the department as "collegial but no time for collaboration," "lack of unity," "strong individuals but no strong morale." While some teachers additionally said they functioned fairly autonomously, the lack of communication seemed severely limiting given the first year of implementing Integrated Science, especially for the new teachers in the department, who did not receive training prior to the start of the school year. One teacher explained:

> I'd like to talk about the nitty gritty. We need to, and we don't!...Like reorder lab stuff, or sharing equipment, or what are you supplementing SEPUP with, or what are you doing that works, what field trips are you going on, what speakers do you have. The nitty gritty! What are you teaching, where are you right now in the book. Like I'm pulling biology labs out of the books and some of them are working out really well. I'm sure that other teachers are doing that too, and I don't know what they're doing that works well.

Moreover, a few Integrated Science teachers had to teach several periods of the course without appropriate materials. A shortage of ordered SEPUP laboratory kits at the beginning of the year meant that these teachers had to borrow materials after their colleagues had completed labs with their own classes. This meant that teachers fell significantly behind in terms of the units they wished to cover. Because materials were not centralized, teachers were scattered in classrooms throughout the school rather than situated nearby one another, and the fact that teachers did not all share a common prepatory period, it was at times difficult to coordinate the sharing of materials or to come together to discuss the curriculum. Moreover, a majority of the teachers felt the science department head was highly organized and supportive yet overworked in her position, and consequently, she was not able to spend more time overseeing the implementation of the curriculum this past year.

STUDENT ATTITUDE AND PERFORMANCE

This section presents findings on the attitudes and performance of students in the Integrated Science courses. Attitudinal findings are based on a student survey implemented in ten 9th and 10th grade courses with 213 students responding.

Similar to the Integrated Math student survey, the science survey was administered to measure three key areas (see Table 8 for list of survey questions and results):

1) Perceptions of learning in the Integrated Science program (Questions #1-11)

2) Assessments of instructional practices (Questions #12-17)

3) Attitudes towards science in general (Questions #19-21)

<u>Overall Attitudes Towards Integrated Science</u>

Overall, students displayed average to slightly above average responses in their perceptions of learning in their Integrated Science classes:

- Table 8 demonstrates that based on ratings on a scale of 1 to 4 (where 1 equaled "not at all," 4 equaled "a great deal,"), students provided the highest responses in rating how the class helped them to see how science is related to our everyday lives (2.817), and how the different areas of science, that is biology, chemistry and physics, are related (2.601).
- Moreover, students gave an average ranking to how interesting they found their science class (2.514), and how much they were learning about scientific concepts and about solving science based problems (2.483).
- Lastly, they did not find the curriculum too difficult as their slightly below average ratings indicated that they did not find it significantly difficult to learn about science concepts (2.325) or about solving science problems (2.46).

The students' assessments of their teachers' instructional practices also revealed average to slightly above average responses:

- Most significantly, students recognized the process orientation of Integrated Science, indicating that they engaged in above average amounts of making decisions related to environmental and social issues (e.g., recycling, pollution, risk issues) (2.881), as well as in how much they were learning about conducting lab experiments (2.769), and engaging in group work (3.066).
- Students provided comparatively lower ratings of how much they were learning to collect and analyze data in graphs and tables (2.54) and learning math skills to solve science problems (2.573).

- Students perceived opportunities for communication based learning. They asserted they engaged in a great deal of writing (essays, reports, notes, journals) (3.066). While they said they interacted within a great deal of group work, they claimed they spent below average amounts of time on discussing difficulties they were having learning science (2.124). Moreover, while teachers were rated as average in finding different ways of teaching science to make learning more interesting (2.541), students also recognized the minimal use of computers incorporated into the curriculum (1.924).

Students' attitudes towards enjoying science were also average to slightly above average:

- Students provided above average responses to enjoying learning science (2.703) and looking forward to taking more science classes (2.667).
- Student provided slightly below average ratings in feeling that their class had prepared them for higher level science classes (2.416) and considering a career involving science in the future (2.472).

<u>Comparison of Attitudes Between 9th and 10th Grade Classes</u>

Patterns in students perceptions varied when comparing 9th grade with 10th grade respondents. Maintaining the regular Integrated Science courses as the basis for comparison, t-tests were performed to determine statistically significant differences ($p<.05$) in attitudes among students enrolled in these courses. While there were no significant differences on several dimensions, some differences were evidenced:

- The scientific process orientation was well recognized by the 9th graders who reported statistically significantly ($p<.05$) higher amounts of engaging in data collection, decision making, and group work.
- While 9th graders also reported more learning about scientific concepts and about solving science problems, the 10th graders, despite encountering a coordinated science curriculum, reported stronger perceptions of their class helping them to see how the different areas of science were related. Perhaps this is not surprising since students rotated among teachers specializing in chemistry,

biology, or physics, which thereby made the different branches of science more salient.

Comparison of Attitudes Between ESL and Regular Classes

Furthermore, comparing ESL Integrated Science classes with regular ones also indicated significant patterns:

- There were no differences between ESL and regular classes on numerous dimensions of learning or in assessment of teachers' instructional practices. However, ESL students reported more computer use and more opportunities for discussion in their classes.
- Students did display tremendous differences in their general attitudes towards science. ESL students, in comparison to their non-ESL classmates, reported statistically lower ratings of enjoying science, feeling less prepared for higher level science classes, and lower rates of considering a science related job in the future.

Table 8
Integrated Science Student Survey Results

(Scale 1-4 where 1 = not at all, 4=a great deal)
Averages scores presented for 1) 9th Grade Integrated Science courses, followed by the average increase/decrease for 10th grade, 2) a comparison of Regular and .6 ESL Integrated Science courses, and 3), an overall average.

* *denotes statistically significant difference (p<.05)*

Question	9th	10th		Regular	ESL		Overall
1. How interesting do you find your science class?	2.578	-.14		2.561	-.244		*2.514*
2. How much do you think you are learning about science concepts (for example, acids/bases, toxicity, threshold, etc.)?	2.726	-.337*		2.596	-.108		*2.575*
3. How hard is it for you to learn these science concepts?	2.224	+.224		2.372	-.247		*2.325*
4. How much do you think you are learning about solving science problems? (for example, data processing or interpreting graphs and tables)?	2.573	-.268*		2.415	+.195		*2.453*
5. How hard is it for you to learn how to solve these science problems?	2.376	+.187		2.436	+.125		*2.46*
6. Does this science class help you to see how different areas of science are related, that is, how biology, chemistry, and physics, are related?	2.419	+.404*		2.64	-.201		*2.601*
7. Does this science class help you to see how science is related to our everyday lives?	2.803	+.03		2.855	-.196		*2.817*

8. How much are you learning to collect and analyze data in tables and graphs?	2.698	-.351*		2.512	+.113		*2.54*
9. How much are you learning about making decisions related to environmental and social issues (for example, recycling, pollution, or risk issues)?	3.165	-.628*		2.941	-.316		*2.881*
10. How much are you learning about conducting lab experiments?	2.838	-.154		2.795	-.136		*2.769*
11. How much are you learning math skills (such as ratios, estimation, etc.) to learn to solve science problems?	2.652	-.173		2.612	-.197		*2.573*
12. How much group work with other students do you do in this class?	3.181	-.254*		3.064	+.009		*3.066*
13. Does group work help you to learn about science?	2.707	+.082		2.812	-.349		*2.744*
14. Do you talk about the difficulties you're having with science in this class?	2.148	-.052		2.042	+.421*		*2.124*
15. How much writing do you do in this class (journal writing, essays or reports, taking notes)?	3.409	-.409		3.182	+.218		*3.224*
16. How often do you use computers for this class?	1.983	.13		1.718	+1.06*		*1.924*
17. Does your teacher find different ways of teaching science to make it more interesting for you?	2.579	-.084		2.577	-.187		*2.541*
18. How much do you enjoy learning science?	2.595	+.16		2.766	-.327*		*2.703*
19. Do you look forward to taking more science classes?	2.741	-.085		2.811	-.738*		*2.667*
20. Do you feel this class has prepared you for higher level science classes?	2.595	+.16		2.482	+.336*		*2.416*
21. How much would you consider a career involving science in the future?	2.417	-.002		2.596	-.645*		*2.472*

Student Performance

Examining grade point averages in the Integrated Science courses reveals low patterns of achievement. Table 8 illustrates that during the Fall, 1996 semester, a significant percentage of students enrolled in regular, ESL, and bilingual courses received a D, F, or incomplete grade:

Table 9
Grade point average in Integrated Science
(% of students receiving Ds, Fs, or incompletes, Fall 1996):

Regular Integrated Science	
First grading period	32%
Second grading period	37%
ESL (.6) Integrated Science	
First grading period	49%
Second grading period	45%
Bilingual (.8) Integrated Science	
First grading period	14%

Second grading period	49%

Interviews with teachers about these patterns of achievement provided insight to the low performances of students. Teachers indicated that those who failed either 1) never or only occasionally showed up to class, or 2) showed up to class yet failed to complete class work or home work assignments. Despite the high percentage of students failing the Integrated Science courses, teachers maintained that the curriculum was by no means too difficult for students to complete. They explained that, for the most part, students who came to class and did the work would end up with at least a C grade.

In interviews with over twenty Integrated Science students, those who were failing similarly said poor absenteeism was often the primary cause of their failure. Such students typically found the course uninteresting and far removed from the context of their lives, except when personally meaningful topics that were covered (e.g., animal biology, properties of fire and energy, etc.). They asserted that labs were redundant and that teachers often failed to thoroughly discuss the concepts being learned. Rather than grasping the meanings and implications of experiments, students said they copied down procedures and findings, often from their peers' papers, in rote fashion.

IMPLICATIONS FOR FUTURE PLANNING

Assessing the experiences of both teachers and students raises several important issues to consider in future planning as they relate to curricular considerations, professional development, and materials.

Curricular Considerations

The 9th grade SEPUP curriculum should be systematically augmented to provide greater rigor and depth, and to ensure comparable exposure to content material. Lack of cognitively demanding work, quantitative skills, and preparation for future science classes were all primary criticisms by teachers of the program. However, limited shared collaboration time has resulted in a lack of uniformity in curricular implementation. Augmenting the existing SEPUP program with appropriate texts, labs, activities, and other supplemental exercises will remain crucial to developing a program that is not only inquiry based and issues oriented, but also rigorous in a way that promotes greater understanding of content issues, scientific notation, and metacognitive reflection (see National Research Council, 1988; National Center for Education Statistics, 1996).

The 10th grade Integrated Science curriculum should be developed to ensure greater integration of biology, physics, and chemistry. Currently, the 10th grade Integrated Science curriculum, created by Polk Academy teachers, represents a coordinated rather than integrated approach to science. Although an environmental focus is currently maintained in the curriculum, students rotate throughout the school year among three teachers who focus on either the biology, chemistry, or physics component. Some staff expressed concern that not all 10th grade teachers might feel comfortable covering all components due to subject affiliation or expertise. Thus, instructional training should parallel the development of the 10th grade curriculum.

Integrated Honors courses should be developed at both the 9th and 10th grade levels. Student performance data reveals a significant number of students failing to pass their Integrated Science courses, however, several students are also excelling. Both teachers and students indicated that the curriculum was too easy and unchallenging for some. Thus, honors courses should be developed to allow such students to explore material in greater depths.

Teachers need to prepare for the inclusion of Special Education students in Integrated Science courses. During the Fall, 1997 semester, Special Education students are expected to be mainstreamed into Integrated Science classrooms. The Special Education teachers will serve as co teachers in these classes assisting the science teacher and providing individualized attention for their students. Rather than relegating the Special Education teachers to marginal roles, the science department should view this as an opportunity for important collaboration and sharing of resources, including exploring strategies for behavioral control and modification; scientific content knowledge and skills; assessment of student learning styles; and fostering collaborative peer work among multi-level ability groups. Special education teachers will need to be integrated into planning and decision making of the science department, and meeting times between partnering teachers should be appropriately allocated.

Professional Development

Integrated Science teachers need crucial time for collaboration to address curricular issues. Teachers need common prepatory or meeting times to collaborate over their successes and challenges in implementing the 9th and 10th grade courses. For example, teachers have raised several issues around how to augment the 9th grade course, design research projects and activities, incorporate quantitative lessons, pare down the 10th grade curriculum binder to produce a more cohesive program, and how to assess student performance. The administration's proposed weekly forum period should contribute greatly to providing this needed time. Structures can be developed, for instance, to enable teachers to observe one another's classroom, to organize activities and lessons, to provide peer coaching/mentoring (especially for new teachers), and to spotlight upcoming curricular lessons (Fraser & Walberg, 1995).

Continued training in instructional strategies for teaching science to LEP students remains critical. As with the Integrated Math teachers, the Integrated Science teachers will benefit from continued professional development in strategies for teaching science to LEP students. Several teachers conveyed struggles in helping students to understand scientific concepts and processes as they are acquiring basic English forms. Observing expert bilingual and ESL science teachers, learning new strategies for teaching science content and language simultaneously, employing audiovisual techniques, and discussing presentational styles that model standard linguistic forms within challenging science based tasks are examples of activities to improve instruction for LEP learners (see National Science Education Standards, 1996).

Training in implementing the Integrated Science curriculum must occur for all new teachers including those who did not participate last year. Some entering teachers were late hires in Fall, 1996, and consequently, did not receive training in the SEPUP curriculum. This resulted in somewhat disorganized instruction at the beginning of the year as teachers acclimated themselves to the new curriculum. All teachers were provided a resource binder which significantly assisted them in planning and implementation. However, training was necessary to introduce staff to the learning objectives, curriculum organization, and materials of the program.

Future research into the impact of Integrated Science on student achievement should be conducted in the coming years. Research should include gathering and analyzing the following data in the coming years: grade point average data in Integrated Science classes as well as advance science classes; course enrollments in Integrated Science and advanced science classes; the student survey utilized in this study to measure attitudes and perceptions; and teacher views about the rigor of the curriculum.

<u>Material Resources and Access</u>

Science materials should be inventoried and new, updated materials should be purchased. As previously noted, some new teachers were not equipped with SEPUP kits at the beginning of the year and had to rely on borrowing from colleagues to conduct experiments. Moreover, teachers and their students complained of outdated materials and equipment in their classes, including poor chemicals, no bilingual readings, and insufficient laboratory products. Time is needed to inventory existing materials and to develop a list of needed resources for the administration, department head, and faculty to prioritize and act upon.

Materials should be centralized to provide access to all teachers. Staff members lamented over the lack of access to materials which inhibited their ability to plan and implement instruction more effectively. While most colleagues were willing to share resources, still some maintained that they did not possess keys to the storage areas and that others had a tendency to hoard materials. Centralization of materials, then, should be an important goal for the coming year.

The SEPUP laboratory book should be purchased, while supplemental texts should be identified. Students engaged in excessive amounts of passive copying from the laboratory books as pre labs for experiments. Students should have access to the books so they are able to complete such tasks, as well as any follow up activities, at home rather than utilizing important class time for this process. Given the concern over lack of depth in content, supplemental texts that can be used with the SEPUP curriculum should be sought, evaluated, and purchased as soon as funding becomes available.

CONCLUSIONS

The Integrated Science program meets many of the standards of the NSE framework. Most notably, the program is successful in fostering an inquiry based curriculum, promoting discourse around scientific concepts, actively engaging students in meaningful learning, and providing time, space, and resources for learning. The limitations of Integrated Science, however, reside in the failure to provide intellectual rigor and depth in covering thematic units and in developing students' skills in scientific calculations. Individual teachers in the science department have augmented the curriculum to mediate these shortcomings. Nonetheless, lack of shared collaboration resulted in unsystematic curriculum implementation. Recommendations, then, focus on creating structures for greater leadership and collaboration, development of instructional practices, and enhancing material resources and access.

REFERENCES

Berlin, D.F. & White, A.L. 1995. Using technology in assessing integrated science and mathematics learning. *Journal of Science Education and Technology*, 4, 47-56.

California Department of Education. 1992. *Mathematics framework for California public schools.* Sacramento, CA.

Clarke, D., Stephens, M. & Waywood, A. 1992. Communication and the learning of Mathematics. In T.A. Romberg (Ed.), *Mathematics assessment and evaluation.* State University of New York Press.

Chrispeels, J. 1992. *Purposeful restructuring: Creating a culture for learning and achievement in elementary schools.* Washington D.C.: Falmer Press.

Fraser, B.J. & Walberg, H.J. 1995. *Improving science education.* University of Chicago Press.

Gagnon, A. 1996. The picture unfolds. In D. Schifter (Ed.), *What's happening in math class?* New York: Teacher's College Press.

Harmon, M. 1995. The changing role of assessment in evaluating science education reform. In R.G. O'Sullivan (Ed.), *Emerging roles of evaluation in science education reform.* San Francisco: Jossey-Bass.

Hess, G.A. 1995. *Restructuring urban schools.* New York: Teacher's College Press.

Jenness, M and Barley, Z. 1995. Using cluster evaluation in the context of science education reform. In R.G. O'Sullivan (Ed.), *Emerging roles of evaluation in science education reform.* San Francisco: Jossey-Bass.

McColskey, W, Parke, H., Harman, P, and Elliot, R. 1995. Evaluators as collaborators in science education reform. In R.G. O'Sullivan (Ed.), *Emerging roles of evaluation in science education reform.* San Francisco: Jossey-Bass.

National Center for Education Statistics. 1996. *High school seniors' instructional experiences in science and mathematics.* Washington, D.C.: U.S. Department of Education, Office of Educational Research and Improvement.

National Research Council. 1996. *National Science Education Standards.* Washington, D.C.: National Academy Press.

National Research Council. 1988. *Improving indicators of the quality of science and mathematics education in grades K-12.* Washington, D.C.: National Academy Press.

Nevo, D. 1995. *School-based evaluation: A dialogue for school improvement.* Oxford: Pergamon.

Norris, N. 1990. *Understanding educational evaluation.* NY: St. Martin's Press

Organisation for Economic Co-Operation and Development. 1995. *Schools under scrutiny.* Paris: OECD.

Romberg, T.A. 1992. *Mathematics assessment and evaluation.* State University of New York Press.

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