Improving Teacher Quality Grants
Cycle 4

Science Education and Quantitative Literacy: An Integrated Inquiry-based Approach

FINAL REPORT

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PROJECT ABSTRACT

This second year of a three year program provided professional development to 29 mathematics and science teachers from the south central region of Missouri. We presented inquiry-based activities that can be used to educate children from high-poverty and underserved areas. An integrated approach that highlights the synergy between science experimentation and the use of mathematics to model and understand experimental data has enhanced teacher and student learning. This second year targeted 6th and 7th grade teachers. Instructional material was developed through a cooperative effort between Education, Mathematics, and Physics faculty members at the University of Missouri-Rolla, several teachers from the participating schools, and two master teachers. The project targeted Missouri Grade Level Expectations and the experimental design and mathematical skills necessary for exemplary performance on MAP performance events.

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LIST OF SCHOOL DISTRICTS

The fourteen school districts that participated in the program are listed below in Table 1. This includes thirteen public school districts and the Interparish Visitation School in Vienna, a private Catholic school. Note that the high need districts as determined by Department of Higher Education (DHE) specified criteria are highlighted.

Represented Districts	Number of Teachers
Phelps R-1	1
Salem R-80	1
Rolla R-31	6
Newburg R-11	2
Dixon R-1 Schools	1
Sullivan Public Schools	2
Saint James R-1	1
North Wood R-IV*	2
Vienna	1
Crawford County R-2	4
Marries County R-2	3
Licking R-8*	3
Pulaski County R-IV*	1
Richland	1
TOTAL	29

Table 1. Participating School Districts
Note: High need districts are denoted by an asterisk.

Table 2 provides additional details about participating districts, such as the number of participants from each district and the grades they teach. The gender distribution of the participants and other statistics are given in Table 3.

Grade Levels	Number of Teachers
1 through 6	1
6	11
5 through 7	1
6 through 7	1
7	5
6 through 8	3
7 through 8	1
8	2
7 through 9	1
8 through 9	2

Table 2. Grade Levels Taught by Participating Teachers
Note: These grade levels are based on what participants taught in previous years and are subject to change in the future.

Number of Males	8
Number of Females	21
Elementary	5
Middle School	17
Teaching Math	14
Teaching Science	10
Teaching Both	4

Table 3. Profile of Participating Teachers

Project activities took place from June 2006 through May 2007. Teachers participated in a summer workshop from July 17-20 and 24-27, 2006, eight hours per day, and three six-hour follow-up meetings. In addition, project coordinators attended planning meetings in June and July 2006, and all teachers received one or more follow-up visits during the 2006-2007 school year. The average contact time per participant was approximately 82 hours ("extra" time during planning meetings and follow-ups roughly balanced time missed due to absences).

PROJECT ACTIVITIES

INTRODUCTION

The Science Education and Quantitative Literacy (SEQL) professional development project aims to improve student performance in mathematics and science by providing middle school mathematics and science teachers with an integrated, inquiry-based training program that emphasizes both content and pedagogy. Twenty eight teachers (mainly teaching sixth and seventh grades) from thirteen public school districts and one private school participated in the program.

Its main objectives are:

Objective 1: To increase teacher participants' knowledge and understanding of key concepts in mathematics and science as aligned with project's content focus.

Objective 2: To improve teacher participants' practices in inquiry-based instruction.

Objective 3: To enhance participants' use of assessment data to monitor the effectiveness of their instruction.

Objective 4: To improve student achievement in math and science content areas.

Objective 5: To demonstrate a measurable impact on the preparation of pre-service teachers through improvements in math and science courses.

Objective 6: To enhance teacher participants' ability to link mathematics and science education through the synergy that exists between scientific inquiry and mathematical problem solving.

This is the second year of a three-year project. The first year focused on teachers instructing grades five and six. This year focuses on teachers instructing grades six and seven. Professional development activities during the second year included an eight day summer workshop, three full-day follow-up meetings and classroom visits by the project directors.

SUMMER WORKSHOP

The summer workshop was held from July 17 through 20, and July 24 through 27, 2006, meeting for eight hours each day. At the summer workshop, participants took part in inquiry-based activities that focused on content specific knowledge in areas of mathematics selected by school coordinators from high need as well as some of the other school districts, through an extensive dialog with the professional development team.

These discussions focused on the new Missouri Grade Level Expectations (GLEs) and areas of student underperformance in the MAP test. In addition, attention was paid to selecting activities that were designed to expose and train the participants in pedagogical techniques for effectively teaching the selected concepts and skills at the targeted grade levels through inquiry-based methods. As was the case last year, the key concepts and skills targeted by the project were

arrived at by the project team through discussions with school coordinators designated by each participating school district. These discussions focused on school/teacher needs in meeting the new Missouri Grade Level Expectations (GLEs) and areas of student underperformance in the MAP test. Input from those who participated in the Cycle 3 program was also used in designing the Cycle 4 professional development program.

Moreover, sessions on effective methods of student assessment, and the use of assessment as a tool for optimizing student learning, were conducted. Assessments similar to what we expect the participants to employ in their classrooms were utilized during the summer workshop to ascertain the degree of participant learning and misconceptions. Participants also took part in designing pre and post tests that can be administered to measure student learning in the key areas targeted by the workshop. Copies of these tests and participant designed grading rubrics were distributed to all participants. The pre and post tests have already being administered to students in participants' classes by eleven participating teachers. Results show that statistically significant learning took place on the tested topics (based on paired t-tests). The above efforts directly address Objective 3.

As was done the prior year, mathematics and science teachers attended sessions together. Mathematics sessions were conducted in the morning, followed by afternoon science sessions. Unlike the cycle 3 project, however, most of the science and mathematics components were planned so that some of the math activities had a science component and all of the science activities had a mathematics component. The mathematics sessions, in many instances, incorporated science related projects. The afternoon science activities invariably involved data collection, data summary, and graphing, which are some of the key statistical concepts specified in the GLE's. Throughout the workshop, effort was made to emphasize the synergy that exists between scientific inquiry and mathematical problem solving. The second week of the summer workshop was very heavy focused on conducting integrated activities. We found that this integration was much more of a success than what we achieved in Cycle 3.

Teachers were assigned to groups of three or four, with each group having at least one science and math teacher and a participant who attended the Cycle 3 workshop conducted during the summer of 2005. We found that this mix played a significant role in group dynamics with each teacher using their strengths to help others in their team.

Many workshop activities modeled inquiry-based methods of teaching key concepts. This directly related to meeting Objectives 1 and 2. As a capstone to this effort, the teachers in small groups had to complete projects that integrated math and science as exemplified in the workshop. These projects were presented on the last day of the workshop and were briefly critiqued by the project staff. Each participant individually developed one lesson plan based on the content and pedagogy of the summer workshop. Participants were given feedback on their draft lesson plans by the project team and encouraged to implement these plans in their classroom. Final drafts of the lesson plans, modified to take into account the comments by the project team and teachers' own classroom experience, were due Oct. 28, 2006. The instructional material developed during the project, including the participant lesson plans, will be used by UMR faculty in mathematics and physics courses aimed at pre-service teacher training, thus fulfilling Objective 5.

Tables 4 and 5 display a summary of the mathematics and science topics that were covered during the summer workshop. Each topic was introduced through an inquiry-based activity that can be easily adapted to classroom use. Rather than instruct the participants at the outset on the mathematics and sciences content relevant to each activity, we designed the activities in such a way that content-specific knowledge is learned through self-inquiry and group activities. Clarification of main concepts and providing additional content-specific information followed these inquiry-based activities. Participants were given a quiz each day to assess their learning. Quizzes were graded and handed back with suggestion and clarifications. Topics that a majority of the participants had difficulty with were revisited, either during the summer workshop, or during a follow-up meeting. Participants who had difficulties were also helped on a one-on-one basis. This assessment activity was introduced as a direct result of recommendations provided by the external evaluators during the Cycle 3 project.

Week One	**Week Two**
Day 1 – July 17 o Introductions – ice breaker o Line plots and radar diagrams (assessment) o Understanding graphs o Measures of center and dispersion o Stem and leaf plots o Box plots (optional)	**Day 5 – July 24** o Simulation o Probability (Baseball) o Gathering data (Whirlybirds) o Assessment info o Project time

Day 2 – July 18
o Scatter plots
o Introduction to graphing calculators
o Introduce probability
o Project introduction (select topic)
	Day 6 – July 25
	o Physics day
	  o Roller coaster
	  o Balloon (Newton's laws)
	  o Pendulum
	o Project time

Day 3 – July 19 o Probability – geometric probability o Review all plots (Challenger activity) o Sampling – Capture/recapture o Sampling – Grass o Project time	**Day 7 – July 26** o Bubble data o Physics experiments and graphing o Assessment o Project time
Day 4 – July 20 o Excel (in computer lab) o Probability (globe and Montana Red Dog) o Project time	**Day 8 – July 27** o Project presentations o "Catch-up" time o Evaluations and planning for future activities

Table 4. Mathematics Activities Conducted During the Summer Workshop

Week One	**Week Two**
Day 1 – July 17 o Measurement o Gro-Beasts (measurement, line graphs) o Evaporation from a Sponge (measurement, line graphs) o A Cubic Meter of Air (measurement, weather) o Room Measurement (measurement, units) o Guided Four Questions Activity: Drops of Water on a Coin	**Day 5 – July 24** o MAP Intermediate Performance Event Template and MAP Grading Practice o Barbie Bungee (experimental design, data collection, linear graphs, extrapolation)
Day 2 – July 18 o Moon on a Stick, Part I (phases of the moon) o Your Shadow and the Sun (path of the sun in the sky, seasons) o Toilet Paper Rocket to the Planets (solar system, measurement) o Graphing the Solar System (graphing) o Guided Four Questions Activity: Drops of Liquid on a Coin (new variations)	**Day 6 – July 25** o Four Questions Activity: The Pendulum o Balloon Rocket (forces, motion, energy) o Roller Coasters (forces, motion, energy)
Day 3 – July 19 o Electricity Activities (conductors, insulators, circuits)	**Day 7 – July 26** o Four Questions Activity: Dissolving Rate of Effervescent Tablets o Four Questions Activity: Gum
Day 4 – July 20 o Moon on a Stick, Part II (continuation) o Four Questions Activity: Toilet Paper (teachers design experiments)	**Day 8 – July 27** o Project presentations o Liquid Nitrogen Ice Cream o Evaluations and planning for future activities

Table 5. Science Activities Conducted During the Summer Workshop

Some of the activities we conducted during the Cycle 3 summer workshop were repeated during the Cycle 4 workshop, based on school coordinator input. Coordinators found these activities to be very beneficial and felt that we should keep them in the program for the benefit of the new participants. Even those who participated in our Cycle 3 professional development program felt that revisiting these activities and topics provided them with a better and deeper understanding of the concepts that were targeted. The activities were, however, enhanced to some extent, to accommodate the needs of seventh grade teachers.

For reasons of brevity, we will explore in detail only a few of the above activities. As indicated, morning of Day 1 of the summer workshop was devoted to introducing graphing concepts and exploring their uses through various hands-on activities. The data for each of the plots were generated through an activity. For instance, box plots were introduced using years of teaching experience participants had as the source data. After the teachers understood the concepts, a human box plot was build by the teachers.

Review of graphs on Day 3 included a segment on the proper and improper use of graphs. Participants used the data some NASA officials employed to determine whether there is a greater risk involved with cold weather launches. The graphs they generated showed no conclusive evidence of increased risk. Then they were given the complete set of data, which included not only launches that had one or more O-ring failures, but also data that showed no failures. An appropriate graph based on the complete data set showed, with clarity, that there is, in fact, an increased risk of O-ring failure with colder temperatures. The idea of doing this activity was not merely to introduce graphing, but also to highlight the importance of using proper data and to illustrate how a correctly constructed graph can lead to valid conclusions while incorrectly constructed graph can lead to invalid and, in some cases, disastrous conclusions.

The segments on probability were taught using several activities. For instance, groups of participants played several chance-based games where one outcome seems more probable than others. Compilation of the results across groups showed that the intuitive reasoning was false. Then the theoretical probability of each outcome was computed using the sample space. This confirmed the results the participants obtained using their game activity, which is termed simulation based probability. Such simulations were also carried out to introduce the idea of sampling and estimates based on a sample. A good example is estimating the land area of earth or the area of a given continent as a fraction of the total area of earth. Participants paired up and tossed an inflated globe between them. They counted the number of times their right thumb fell on land or the continent whose land area they are estimating. If carried out many times, the proportion of times their right thumb fell on land area (or the continent) is a very good approximation of the actual proportion. This activity not only teaches concepts about probability (i.e. probability of your thumb falling on Africa for instance), but can also be used to teach fractions, proportions, and percentages.

Another probability based activity was the simulation of a baseball game. Participants drew baseball cards of batters. They then recorded the number of times they had hits, the number of doubles and triples, the number of home runs, and the number of times at bat. They then used the data to figure out the number of singles. These figures were then converted into probabilities;

probability of getting a single, probability of hitting a home run, etc. Two teams were then formed, with each participant playing the role of a batter for his/her team. A ten by ten grid was marked by each participant to reflect probability of each type of even. So, if probability of getting a single is 0.1, then ten of the one hundred squares in the grid were marked "single". The game consisted of each batter selecting a square on the grid randomly. If the selected square said "a single", then the batter gets a single. This activity was chosen to show how a game that most students would enjoy can be employed to teach a variety of skills. The activity starts with skills such as addition and subtraction, but move on to fractions, representing fractions geometrically thus introducing geometric probability, and finally to probabilistic simulation.

The mathematics portion of the sessions also included several activities that integrated mathematics and science. The roller coaster activity is one of them. Participants built roller coasters out of pipe insulators and rolled marbles down them to illustrate concepts of potential and kinetic energy. The activity also introduced measurement of time and distance. The balloon activity was similar. Participants shot inflated balloons across strings (balloons were attached to a drinking straw through which the string was threaded) and plotted distance traveled as a function of balloon circumference. Ideas about Newton's third law, conservation of momentum, as well as measurement and graphing concepts were targeted by this activity.

As the above examples show, the mathematics activities carried out by the participants are fun-to-do, yet address a broad set of skills and concepts covered by the GLE's. They would be exciting to do in a classroom, capture the attention of students, have multiple modes of impacting students (e.g. they are visual, hands-on, involve measurements or observations, have both pencil and paper components as well as those that can done using a calculator), and all the separate steps combine to yield a final result or an answer to an interesting question.

The science activities carried out during the summer workshop are displayed in Table 5. These were, in general carried out during the afternoon session. Some of the activities were carried out at the Havener Center where the workshop was held while others were carried out in a Physics teaching laboratory. An important new feature we introduced during the Cycle 4 program in teaching experimental design ideas was the "Four Questions Strategy." As mentioned in the formative evaluation report, the workshop was successful in consistently demonstrating a four-question strategy to guide participants in the design of science experiments for their students. This helped integrate the science and mathematics in a clear way, as the formative evaluation reported indicated, while giving the teachers a simple template to create effective inquiry-based experiments for students.

After deciding upon a phenomenon or object they wish to center the activity on (e.g., a balloon rocket), the teachers asks four simple questions and records a range of answers to them. The answers are used to design an experiment. The next page is a brief summary of the process.

Experimental design using the Four Question Strategy (Cothron, Giese, and Rezba, ***Students and Research***, 2000). (Web: http://www.kendallhunt.com, search for "Cothron.")

The Four Questions

Choose a topic you are interested in doing experiments on and then answer questions 1-4.

1. What materials are readily available for conducting experiments on _____.

2. How does/do _____ behave? *Provide a list of verbs.*

3. How can I CHANGE the set of _____ materials to affect the action?

List several ways to change each of the (appropriate) materials you listed in question 1.

4. How can I MEASURE or describe the response of _____ to the change?

Choose one of the "behaves" responses in question 2 and list several ways you could measure the "behaves" action.

Design the Experiment

Circle one of the responses to question 3. This is your independent variable. Circle one of the responses to question 4. This is your dependent variable.

Constants are all non-circled responses in question 3.

Experiment title: *"The Effect of (circled item from question 3) on (circled item from question 4)."*

Hypothesis: *"If I (say how I am going to change circled item in question 3) the (circled item from question 4) then (state change predicted)."*

Fill out optional experimental design diagram.

Design a data table.

Design a procedure.

Do the Experiment

Carry out your experiment.

Make an appropriate graph.

Write summary and conclusions.

Missouri Science MAP performance events borrow heavily from the Four Questions technique. The activity requires students to identify their problem, formulate a hypothesis, identify their independent and dependent variables and constants, design a data table and an experimental procedure, graph the data, and draw conclusions. Even the 10x10 grid which will be used for performance events is the same grid originally used by Cothron, who developed the technique. A student who participates in a Four Questions activity is practicing a MAP performance event.

The Four Questions technique is also an excellent way for students to develop science fair projects. Anything that can be manipulated in a variety of ways can be the subject of a Four Questions experiment, and following the technique guides the student to develop an effective project.

All science activities involved measurement, recording data, and graphing, which are skills targeted by the sixth and seventh grade mathematics GLE's. Thus, similar to the way the math activities touched on some of the science GLE's, sciences activities can be used by math teachers to address mathematics GLE's.

One key element of our professional development project is school visits. These are scheduled throughout the academic year. Dr. Evalee Lasater, our pedagogical specialist, completed all her school visits during fall 2006. Dr. Bieniek, Dr. Pringle, and Dr. Samaranayake made school visits during spring 2007. During such visits, we took note of the efforts participants have made in implementing workshop ideas in their classroom. Judging by what we observed, all participants have implemented workshop material and ideas in their classroom, as reflected by the logs they have kept. Further, discussions with the participants during the three post workshop meetings have shown a very high level of commitment to incorporating what they learned at the workshop into their lesson plans. Participants have also indicated their belief that such incorporation has resulted in more effective teaching and an increase in students' participation in active learning.

There have been three major additional project activities subsequent to the summer workshop: namely, three full-day follow-up meetings of the participants, on September 23, October 28, 2006, and April 14, 2007 (all Saturdays). During the first follow-up meeting, a MAP coordinator talked on MAP grading policies and gave insights into the rubrics that are used, in order to provide information that will assist teachers optimally design their inquiry-based activities. The three mathematics activities and one science activity that were conducted during the September 23 meeting were used as a springboard for an open discussion about challenges faced by teachers in implementing workshop ideas in the classroom. The second follow-up meeting (October 28) had activities that focused on measurement and analysis of experimental data using experiments in sound and fluid-flow. Science concepts behind the experiments and the mathematics behind data analysis strategies were discussed. The third follow-up meeting was mostly devoted to conducting several math-science integrated activities and a simulation of a Nobel Prize winning Physics experiment that required a simple mathematical analysis. During a working lunch, participants discussed their experiences in introducing the workshop activities in their classroom.

It is hoped that the professional development received by the participants during this project will enhance their effectiveness in the classroom, thereby improving the performance of their students in key areas of mathematics and science. Judging by the positive workshop evaluation provided by the participants and the observations made by the Project Co-Directors during school visits, it is apparent that progress is made in achieving the above goal, which is our Objective 4.

SUBSTANTIVE MODIFICATIONS TO THE ORIGINAL PROJECT

No substantive changes have been made to the original project, except a continuing and successful effort at improving the integration of the math and science components of the project.

Based on the preliminary report of the external evaluators, a number of changes were made in our daily routine. Quizzes and post-activity feedback sessions and group discussions were used to ensure that teachers were not left with misconceptions about the activity. As suggested by the evaluators, we made an effort to clarify the main concepts and provide additional content specific information following the inquiry-based activities. Finally, experimental design is not always an intuitive task, and evaluators commented that teachers were sometimes frustrated by "vague" instructions for some of the Cycle 3 science activities. Adoption of the Four Questions technique provided a clear set of guidelines for the experimental design process and reduced teacher anxiety during inquiry-based activities.

PROJECT OBJECTIVES

Objective 1: To increase teacher participants' knowledge and understanding of key concepts in mathematics and science as aligned with project's content focus.

Objective 2: To improve teacher participants' practices in inquiry-based instruction.

Objective 3: To enhance participants' use of assessment data to monitor the effectiveness of their instruction.

Objective 4: To improve student achievement in math and science content areas.

Objective 5: To demonstrate a measurable impact on the preparation of pre-service teachers through improvements in math and science courses.

Objective 6: To enhance teacher participants' ability to link mathematics and science education through the synergy that exists between scientific inquiry and mathematical problem solving.

PROGRESS TOWARDS MEETING PROJECT OBJECTIVES

The project activities as described earlier, were designed to meet each of the six goals mentioned at the beginning of this report. For instance, the content areas we targeted were selected based on teacher needs and areas of poor student performance, as determined by our discussions with the school coordinators. They were aligned with the state specified GLE's. This is clearly aimed at fulfilling Goal 1. Further, some of the Cycle 4 project participants were enrolled in our 2005 summer workshop. It was the observation of all instructors that these returning teachers have shown tremendous growth in their confidence as well as in their ability to design and conduct inquiry-based mathematics and science activities. This is a strong indication that we have succeeded in fulfilling Goal 1.

All activities were designed to be hands-on, with content knowledge introduced through inquiry. This targets Goal 2. Our school visits have shown us that teachers are indeed using inquiry-based methods to teach topics such as probability; another indication of the success with Goal 2.

The administering of pre and post tests to the students to obtain a measure of how much students learned through the course of an academic year, helped us bring in the question of assessment as a tool to fine tune what is taught and how it is taught, and our discussion with teachers show that they are taking continuing assessment seriously.

Hard evidence that shows that student learning has improved due to teachers participation in our project is yet to be seen through improvements in standardized tests because control scores are not available. The results from our pre and post tests, however, show a tremendous improvement in student content knowledge in chosen areas of mathematics. Eleven out of the twenty seven teachers administered both the pre test (at the beginning of the school year) and the post test (at the end of the school year). Pre and post test scores for each student were recorded. For each class, a paired t-test was carried out to test the null hypothesis that there is no improvement vs. the alternative hypothesis that there is a significant improvement. In all eleven cases, we found a highly statistically significant (at a significant level of 0.01) improvement. This is an indication that we are, at least to the extent that is measured by the pre and post tests, well on our way to achieving Goal 4.

UMR's teacher education program will continue to benefit from the innovations we have introduced through this project. The instructional material we have developed have become part of some of our courses (Stat 306, Physics 302), and many pre-service as well as current teachers will be taking these courses. Thus, we are on our way to meeting Goal 5.

Many of the participants in our project are both science and mathematics teachers. Feedback from these teachers have indicated that while in the past they treated these subjects as separate and taught them as such. The experience they gained in the workshop has given them insight into how they can exploit the natural synergy that exists between mathematics and science. Many have already begun to do science activities that can be carried into their mathematics classroom as graphing or number sense projects. Those participants who taught only one subject has begun to work with their science and mathematics counterparts. While most of these partnerships are still in their infancy, a dialog had begun between science and mathematics teachers in school

buildings. With additional teachers from those building recruited to attend out future workshops (ours is a multi-year project), we expect such collaborations to increase and prosper. Thus we are encouraged that Goal 6 can be fulfilled.

At the end of the summer workshop, participants were given a workshop evaluation. Results of this evaluation are given in Table 6.

Questions Posed	**How the workshop rate compared to your expectations (percentage responding)**					
	Much Below	**Below**	**As Expected**	**Above**	**Much Above**	**Average Score***
Content *of the workshop rate compared to your expectations*			23.81	**47.62**	28.57	4.05
Activity based format *of workshop rate compared to expectations*			14.29	**42.86**	**42.86**	4.29
Teaching material *received rate compared to your expectations?*		4.76	4.76	33.33	**57.14**	4.43
Quality of instruction of the ***lead math instructor*** *rate compared to your expectations?*			23.81	23.81	**52.38**	4.29
Quality of instruction of the ***lead science instructor*** *rate compared to your expectations?*			19.05	19.05	**61.90**	4.43
Quality of help *received from UMR Project Team and assistants rate compared to your expectations?*			19.05	28.57	**52.38**	4.33
Facilities *where the workshop was held, rate compared to your expectations?*			14.29	19.05		4.52
Computer facilities *that were available rate compared to your expectations?*	4.76	28.57	**42.86**	14.29	9.52	2.95
Overall logistics *of the workshop rate compared to your expectations?*			14.29	**47.62**	38.10	4.24
Overall value *of the workshop rate compared to your expectations?*			9.52	38.10	**52.38**	4.43

Table 6. Participants' Workshop Evaluation
Note: Most frequent rating is in boldface.

As seen from the results, most participants rated various aspects of the workshop as above expectation or as much better than expected. The only exception, namely computer facilities, obtained an "as expected" from a plurality of participants.

In addition to the workshop evaluation, we administered a pre-workshop questionnaire at the beginning of the summer workshop and gave the same questionnaire, with some additional questions, at the third follow-up meeting. Table 7 reports the results from the pre-workshop questionnaire while Table 8 reports those from the post-workshop questionnaire. The difference between the pre and post responses are given in Table 9. The questions posed in these surveys target teacher confidence (Questions 1-4 and 6-24) in being able to effectively teach subject content specified by the math and sciences GLE's. Data reported in Table 9 shows that the mode of the distribution (figures in **bold face denotes percent who responded** at the mode value) of teacher responses to these questions, in most cases, increased. For example 56% of the participants said that they somewhat disagreed with the statement that they are "confident of how to teach Probability and statistics according to NCTM and Missouri standards and GLE's" (Question 6). At the end of the project 60% somewhat agreed with the statement while 33% strongly agreed.

Part II of the pre-workshop questionnaire addressed the issue of utilizing hands-on activities in teaching the targeted skills. Again, in most cases we find an improvement from the pre-workshop figures to post-workshop figures.

Part III of the post-workshop questionnaire looks at the participant perception of the assistance the professional development project had in their ability to teach the skills and concepts specified by the GLE's (we limited our questions to those covered during the project, namely, probability, statistics, number sense, and science). Again we see that most said they received substantial or extreme help.The post-workshop questionnaire has a not applicable column. This is because, while teachers who taught only one subject answered questions about both subjects when they answered the pre-workshop survey, they refrained from doing so with the post-workshop questionnaire.

Following the questions about how the professional development program has helped in being able to teach the skills and content specified by the Missouri GLE's, participants were asked how the program has impacted their students. Questions 10-15 in Part III address these issues. All respondents (*when relevant based on their specialty*) answered yes to all questions asked in this regard, ranging from students learned more to students showing more interest in the subject. The questions regarding increasing participant knowledge (items 16-19) in the various topics also received a similar response.

It is clear from the data in Tables 7, 8, and 9 that the workshop has achieved most of its goals or has set in motion a trend towards fulfilling the stated goals. With some of the participants returning to the 2006 workshop and others from the participating school districts expected to take part in the 2006 and 2007 programs, we expect to train a core of teachers from each school district so that a critical mass of teachers will be present at each school building to sustain the ideas and concepts we have attempted to impart to the participating teachers.

Table 7. Results of Pre-Workshop Questionnaire, Part I.

	"P&S" = Probability and Statistics	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agee	Strongly Agree	Not Apply
1	Found it easy to incorporate P&S in math curriculum		14.3	**28.6**	**28.6**	10.7	17.9
2	Found it easy to teach above topics with real life ex & projects		7.1	**50**	17.9	17.9	7.1
3	Found it easy to integrate P&S with science	7.1	14.3	**35.7**	21.0	7.1	14.3
4	Easy to find instructional material to teach P&S		14.3	**50**	25.0		10.7
5	Currently have resources to teach P&S according to NCTM/Missouri stds & GLE	14.3	10.7	**32.1**	28.6		14.3
6	Confident of how to teach P&S according to NCTM/Missouri stds & GLE	7.1	7.1	**42.9**	28.6	3.6	10.7
7	Confident of how to incorporate web resources to teach above topics	3.6	21.4	**32.1**	32.1	7.1	3.6
8	Find P&S & data analysis easy to teach at the grade level you instruct		17.9	**42.9**	32.1	3.6	3.6
9	Believe that students find P&S & data analysis fun to learn	3.6	10.7	35.7	**39.3**	3.6	7.1
10	Found it very easy to develop own hands to projects to teach P&S in class	3.6	25.0	**32.1**	**32.1**		7.1
11	Found it easy to incorporate number sense in math curriculum		3.6	17.9	**42.9**	25.0	10.7
12	Found it easy to teach number sense using real life examples/hands on projects		21.4	**32.1**	14.3	21.0	10.7
13	Found it easy to integrate number sense with science	3.6	25.0	**28.6**	17.9	7.1	17.9
14	Easy to find instructional material to teach number sense		**25.0**	**25.0**	**25.0**	17.9	7.1
15	Currently have resources to teach number sense according to NCTM/Missouri stds & GLE	3.6	14.3	**32.1**	17.9	17.9	14.3
16	Confident of how to teach number.sense skills according to NCTM/Missouri stds & GLE		14.3	**28.6**	21.0	25.0	10.7
17	Confident of how to incorporate web resources to teach number sense topics		21.4	**32.1**	21.0	14.3	10.7

	"P&S" = Probability and Statistics	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agee	Strongly Agree	Not Apply
18	Find number sense skills easy to teach at the grade level you instruct		21.4	**25.0**	**25.0**	14.3	14.3
19	Believe that students find number sense topics fun to learn	10.7	17.9	**32.1**	25.0		14.3
20	Found it very easy to develop own hands to projects to teach numbers sense in class	3.6	**32.1**	28.6	17.9	3.6	14.3
21	Confident of understanding of variables in a science experiment		3.6	21.0	25.0	14.3	**35.7**
22	Confident in correctly using graphs in a science class or experiment		3.6	25.0	21.0	14.3	**35.7**
23	Confident in correctly using data tables in a science class or experiment		7.1	21.0	21.0	14.3	**35.7**
24	Confident that I understand what is meant by "inquiry"		7.1	7.1	39.3	10.7	**35.7**
25	Confident in designing a " good " science experiment		7.1	21.0	32.1	3.6	**35.7**
26	Spend most time in lecturing or showing demonstrations	10.7	17.9	21.0	10.7	3.6	**35.7**
27	Spend most time in supervising student experiments	10.7	14.3	28.6	10.7		**35.7**
28	Easy to find useful science activities/information on internet	7.1	7.1	25.0	14.3	10.7	**35.7**
29	Take time to develop appropriate activity/experiment to teach a science concept	3.6		10.7	32.1	14.3	**39.3**
30	Frequently use science lessons to review math concepts	3.6	14.3	17.9	21.0	3.6	**39.3**
31	Currently have resources to teach science concepts according to NCTM/Missouri stds & GLE	7.1	25.0	14.3	10.7		**42.9**
32	Confident of how to teach science concepts according to NCTM/Missouri stds & GLE	3.6	3.6	10.7	35.7	3.6	**42.9**

Table 7. Results of Pre-Workshop Questionnaire, Part II.

	"P&S" = Probability and Statistics	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agee	Strongly Agree	Not Apply
1	Freq in usage of real life examples to illustrate P&S concepts		10.7	**39.3**	35.1	10.7	3.57
2	Freq in usage of hands on activities/projects to illustrate P&S concepts		14.3	**39.3**	**39.3**	3.57	3.57
3	Calculator usage in solving P&S & data analysis problems	10.7	**32.1**	25.0	21.4	7.1	3.57
4	Degree to which P&S integrated with other subjects	7.1	25.0	**46.43**	17.9		3.57
5	Develop own material for activity based teaching of math	7.1	17.9	**39.3**	21.4	3.57	10.7
6	Freq in usage of real life examples to illustrate number sense concepts		21.4	21.4	**42.9**	7.1	7.1
7	Freq in usage of hands on activities/projects to teach number sense skills concepts	3.57	25.0	**39.3**	25.0		7.1
8	Calculator usage in solving number sense problems	14.3	**39.3**	28.6	10.7	3.57	3.57
9	Degree to which number sense integrated with other subjects	14.3	17.9	**42.9**	14.3	7.1	3.57
10	Develop own material for activity based teaching of number sense skills	3.57	32.1	**35.1**	21.4		7.1
11	Freq in usage of real life examples to illustrate science concepts	7.1	7.1	10.7	**35.1**	14.3	25.0
12	Freq in usage of hands on activities/projects to illustrate science concepts	10.7	10.7	17.9	**28.6**	7.1	25.0
13	Calculator usage in solving science problems	10.7	**32.1**	17.9	3.57	10.7	25.0
14	Degree to which science integrated with other subjects	7.1	14.3	25.0	**28.6**		25.0
15	Develop own material for activity based teaching of science	10.7	14.3	**25.0**	21.4	3.57	**25.0**

Table 8. Results of Post-Workshop Questionnaire, Part I.

	"P&S" = Probability and Statistics	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agee	Strongly Agree	Not Apply
1	Found it easy to incorporate P&S in math curriculum			14.3	21.4	**35.1**	28.6
2	Found it easy to teach above topics with real life ex & projects		7.1		**35.1**	28.6	28.6
3	Found it easy to integrate P&S with science		7.1	21.4	14.3	**28.6**	28.6
4	Easy to find instructional material to teach P&S		7.1	7.1	28.6	**28.6**	28.6
5	Currently have resources to teach P&S according to NCTM/Missouri stds & GLE			7.1	21.4	**42.9**	28.6
6	Confident of how to teach P&S according to NCTM/Missouri stds & GLE				14.3	**57.1**	28.6
7	Confident of how to incorporate web resources to teach above topics	7.1			28.6	28.6	**35.1**
8	Find P&S & data analysis easy to teach at the grade level you instruct				**50**	21.4	28.6
9	Believe that students find P&S & data analysis fun to learn			7.1	**35.1**	28.6	28.6
10	Found it very easy to develop own hands to projects to teach P&S in class		7.1	14.3	**35.1**	14.3	28.6
11	Found it easy to incorporate number sense in math curriculum			7.1	14.3	**50**	28.6
12	Found it easy to teach number sense using real life examples/hands on projects			7.1	**35.1**	28.6	28.6
13	Found it easy to integrate number sense with science			21.4	28.6	7.1	**42.9**
14	Easy to find instructional material to teach number sense			7.1	**42.9**	21.4	28.6
15	Currently have resources to teach number sense according to NCTM/Missouri stds & GLE			7.1	**35.1**	28.6	28.6
16	Confident of how to teach number.sense skills according to NCTM/Missouri stds & GLE			7.1	28.6	**35.1**	28.6
17	Confident of how to incorporate web resources to teach number sense topics		7.1	7.1	28.6	**28.6**	28.6

	"P&S" = Probability and Statistics	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agee	Strongly Agree	Not Apply
18	Find number sense skills easy to teach at the grade level you instruct			7.1	28.6	**35.1**	28.6
19	Believe that students find number sense topics fun to learn		7.1	21.4	**28.6**	14.3	28.6
20	Found it very easy to develop own hands to projects to teach numbers sense in class		7.1	14.3	**35.1**	14.3	28.6
21	Confident of understanding of variables in a science experiment				14.3	**50**	35.1
22	Confident in correctly using graphs in a science class or experiment			7.1	14.3	**50**	28.6
23	Confident in correctly using data tables in a science class or experiment				21.4	**42.9**	35.1
24	Confident that I understand what is meant by "inquiry"				14.3	**50**	35.1
25	Confident in designing a " good " science experiment				28.6	**35.1**	35.1
26	Spend most time in lecturing or showing demonstrations	7.1	14.3	28.6		7.1	**42.9**
27	Spend most time in supervising student experiments		7.1	28.6	7.1	7.1	**50**
28	Easy to find useful science activities/information on internet			7.1	21.4	21.4	**50**
29	Take time to develop appropriate activity/experiment to teach a science concept			7.1	7.1	42.9	**42.9**
30	Frequently use science lessons to review math concepts		7.1		21.4	21.4	**50**
31	Currently have resources to teach science concepts according to NCTM/Missouri stds & GLE			7.1	35.1	7.1	**50**
32	Confident of how to teach science concepts according to NCTM/Missouri stds & GLE			7.1	28.6	14.3	**50**

Table 8. Results of Post-Workshop Questionnaire, Part II.

	"P&S" = Probability and Statistics	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agee	Strongly Agree	Not Apply
1	Freq in usage of real life examples to illustrate P&S concepts			7.1	**50**	14.3	28.6
2	Freq in usage of hands on activities/projects to illustrate P&S concepts			21.4	**42.9**	7.1	28.6
3	Calculator usage in solving P&S & data analysis problems	7.1	7.1	14.3	**28.6**	14.3	**28.6**
4	Degree to which P&S integrated with other subjects			7.1	28.6	**35.1**	28.6
5	Develop own material for activity based teaching of math				**42.9**	28.6	28.6
6	Freq in usage of real life examples to illustrate number sense concepts			14.3	**50**	7.1	28.6
7	Freq in usage of hands on activities/projects to teach number sense skills concepts			28.6	**35.1**	7.1	28.6
8	Calculator usage in solving number sense problems		7.1	**35.1**	7.1	21.4	28.6
9	Degree to which number sense integrated with other subjects		7.1	**28.6**	21.4	14.3	**28.6**
10	Develop own material for activity based teaching of number sense skills				35.1	**35.1**	28.6
11	Freq in usage of real life examples to illustrate science concepts		7.1		28.6	**35.1**	28.6
12	Freq in usage of hands on activities/projects to illustrate science concepts		7.1	7.1	**35.1**	14.3	35.1
13	Calculator usage in solving science problems			**35.1**	28.6		**35.1**
14	Degree to which science integrated with other subjects			28.6	28.6	7.1	**35.1**
15	Develop own material for activity based teaching of science		14.3	28.6	14.3	7.1	**35.1**

Table 8. Results of Post-Workshop Questionnaire, Part IIIa.

		No Help	Minimal Help	Some Help	Substantial Help	Extreme Help	Not Apply
1	Helpfulness of workshop in teaching P&S,data analysis according to MO standard & GLE				35.1	**35.1**	28.6
2	Helpfulness of workshop in incorporating inquiry based lessons in teaching P&S,data analysis				28.6	**42.9**	28.6
3	Helpfulness of workshop in incorporating cross disciplinary topics in teaching P&S,data analysis			7.1	28.6	**35.1**	28.6
4	Helpfulness of workshop in teaching number sense skills listed in MO standard & GLE			14.3	**35.1**	21.4	28.6
5	Helpfulness of workshop in incorporating inquiry based lessons in teaching number sense skills			14.3	28.6	**28.6**	28.6
6	Helpfulness of workshop in incorporating cross disciplinary topics in teaching number sense skills		7.1	7.1	**50**		35.1
7	Helpfulness of workshop in teaching science concepts listed in MO standard & GLE			7.1	28.6	**35.1**	28.6
8	Helpfulness of workshop in incorporating inquiry based lessons in teaching science			7.1	28.6	28.6	**35.1**
9	Helpfulness of workshop in incorporating cross disciplinary topics in teaching science			14.3	21.4	21.4	**42.9**

Table 8. Results of Post-Workshop Questionnaire, Part IIIb.

		Yes	No
10	Students learned more P&S,data analysis because of your learning in workshop	**78.6**	21.4
11	Students shown more interest in P&S related activities as you incorporated workshop ideas	**71.4**	28.6
12	Students learned more number sense skills because of your learning in workshop	**64.3**	35.7
13	Students shown more interest in number sense skills related activities as you incorporated workshop ideas	**93.8**	6.2
14	Students learned more science concepts because of your learning in workshop	**71.4**	28.6
15	Students shown more interest in science related activities as you incorporated workshop ideas	**81.3**	18.7
16	Has workshop increased your content knowledge about P&S specified in MO standards & GLE	**100**	
17	Has workshop increased your pedagogical knowledge in teaching P&S,number sense topics listed in MO standards & GLE	**100**	
18	Has workshop increased your content knowledge of key science topics specified in MO standards & GLE	**93.8**	6.2
19	Has workshop increased your pedagogical knowledge in teaching science topics listed in MO standards & GLE	**87.5**	12.5
20	Have you changed your teaching practices because of attending the workshop	**100**	

Table 9. Post- vs. Pre-Workshop Responses for Matching Candidates, Part I.

	"P&S" = Probability and Statistics	-4	-3	-2	-1	0	1	2	3	4
1	Found it easy to incorporate P&S in math curriculum				22.2	**33.3**	22.2	11.1	11.1	
2	Found it easy to teach above topics with real life ex & projects				**30**	20	20	**30**		
3	Found it easy to integrate P&S with science					**50**		25.0	25.0	
4	Easy to find instructional material to teach P&S				12.5		**50**	37.5		
5	Currently have resources to teach P&S according to NCTM/Missouri stds & GLE				11.1		33.3	11.1	**44.4**	
6	Confident of how to teach P&S according to NCTM/Missouri stds & GLE						**44.4**	33.3	22.2	
7	Confident of how to incorporate web resources to teach above topics				12.5		25.0	**37.5**	12.5	12.5
8	Find P&S & data analysis easy to teach at the grade level you instruct					**44.4**	33.3	22.2		
9	Believe that students find P&S & data analysis fun to learn				11.1	22.2	22.2	**33.3**	11.1	
10	Found it very easy to develop own hands to projects to teach P&S in class				11.1	**33.3**	22.2	**33.3**		
11	Found it easy to incorporate number sense in math curriculum				22.2	**33.3**	**33.3**	11.1		
12	Found it easy to teach number sense using real life examples/hands on projects				11.1	22.2	11.1	**44.4**	11.1	
13	Found it easy to integrate number sense with science				16.7	16.7	16.7	**50**		
14	Easy to find instructional material to teach number sense				22.2	11.1	**33.3**	**33.3**		
15	Currently have resources to teach number sense according to NCTM/Missouri stds & GLE				12.5	12.5	**37.5**	25.0	12.5	
16	Confident of how to teach number.sense skills according to NCTM/Missouri stds & GLE					25.0	**50**	25.0		
17	Confident of how to incorporate web resources to teach number sense topics					**25.0**	**25.0**	**25.0**	**25.0**	

	“P&S” = Probability and Statistics	-4	-3	-2	-1	0	1	2	3	4
18	Find number sense skills easy to teach at the grade level you instruct					**37.5**	25.0	25.0	12.5	
19	Believe that students find number sense topics fun to learn					25.0	**37.5**	**37.5**		
20	Found it very easy to develop own hands to projects to teach numbers sense in class				12.5		25.0	**37.5**	25.0	
21	Confident of understanding of variables in a science experiment					20	**80**			
22	Confident in correctly using graphs in a science class or experiment					20	**80**			
23	Confident in correctly using data tables in a science class or experiment					20	**60**	20		
24	Confident that I understand what is meant by "inquiry"					20	**80**			
25	Confident in designing a “ good “ science experiment					20	**80**			
26	Spend most time in lecturing or showing demonstrations				**50**	25.0	25.0			
27	Spend most time in supervising student experiments				25.0	**50**	25.0			
28	Easy to find useful science activities/information on internet					**50**	25.0	25.0		
29	Take time to develop appropriate activity/experiment to teach a science concept					20	**80**			
30	Frequently use science lessons to review math concepts					25.0	**50**	25.0		
31	Currently have resources to teach science concepts according to NCTM/Missouri stds & GLE					33.3	**66.7**			
32	Confident of how to teach science concepts according to NCTM/Missouri stds & GLE					**50**	**50**			

Table 9. Post- vs. Pre-Workshop Responses for Matching Candidates, Part II.

	"P&S" = Probability and Statistics	-4	-3	-2	-1	0	1	2	3	4
1	Freq in usage of real life examples to illustrate P&S concepts			11.1	22.2		**55.56**	11.1		
2	Freq in usage of hands on activities/projects to illustrate P&S concepts				33.3	**44.4**	11.1	11.1		
3	Calculator usage in solving P&S & data analysis problems					**44.4**	33.3	22.2		
4	Degree to which P&S integrated with other subjects			10		**40**	**40**	10		
5	Develop own material for activity based teaching of math			12.5	12.5	**50**	25.0			
6	Freq in usage of real life examples to illustrate number sense concepts				12.5	**37.5**	**37.5**	12.5		
7	Freq in usage of hands on activities/projects to teach number sense skills concepts					25.0	**62.50**	12.5		
8	Calculator usage in solving number sense problems					22.2	**33.3**	**33.3**	11.1	
9	Degree to which number sense integrated with other subjects			11.1		11.1	**33.3**	**33.3**		11.1
10	Develop own material for activity based teaching of number sense skills				12.5	**50**	25.0	12.5		
11	Freq in usage of real life examples to illustrate science concepts					**50**	16.7	33.3		
12	Freq in usage of hands on activities/projects to illustrate science concepts					**50**	16.7	16.7	16.7	
13	Calculator usage in solving science problems					16.7	16.7	**66.7**		
14	Degree to which science integrated with other subjects				16.7	**33.3**	**33.3**	16.7		
15	Develop own material for activity based teaching of science					**33.3**	**33.3**	16.7	16.7	

PROJECT CONNECTION TO SHOW-ME STANDARDS AND GLE'S

The content areas and skills targeted by the project were determined by the project team through discussion with the participating school districts. Teachers from these school districts were contacted to determine their needs. Specifically, ten school districts nominated one of the participants as a school coordinator. School coordinators were assigned the duty of determining the teacher needs and areas where students are underperforming. They used past MAP performance result and discussions with peers and school principals in determining their needs.

Formal meetings were held prior to the summer workshop to discuss the content areas and skills specified in the Show-Me Standards as well as the grade appropriate GLE's we would focus on during the summer workshop and the follow-up meetings. The list of content areas and skills we covered during the program were selected through this process and every one of the skills or content areas we covered related directly to an item specified in the GLE's.

The use of the Four Questions strategy allows teachers a chance to provide their students practice for the MAP science performance events. Every Four Questions experiment *is* a practice performance event.

DISSEMINATION OF THE PROJECT

Project ideas were disseminated by participating teachers within their building through sharing of material and lesson plans. The lesson plans developed by the project will be made available to all participants electronically by September this year. In addition, we are developing a website that will be available not only to the participants, but to all Missouri teachers. A temporary resource site is currently available at http://campus.umr.edu/lead/sciconsort/msseql/ . Other resources are available at http://campus.umr.edu/lead/sciconsort/. The project's final web site, http://campus.umr.edu/seql/, is now available, and is under development.

The project director talked about the workshop at the Council of Chapters Governing Board Meeting at the Joint Statistical Meetings held in Minneapolis, Minnesota in August 2005, as well as at a follow-up meeting in February 2006. The Governing Board was interested in encouraging members of the American Statistical Association (ASA) to conduct K-12 professional development programs, and our workshop was presented as a possible model to emulate.

Co-Director Dr. Evalee Lasater also disseminated information about the workshop during her numerous visits to area schools. We have also disseminated information to teachers who are currently enrolled in or interested in our Masters in Science for Teachers Program. Pre-service teachers in our teacher training program have also being made aware of the workshop and the two courses we have developed through this program.

Co-Director Dr. Allan Pringle will be presenting a session at the 2007 fall Science Teachers of Missouri conference on the Four Questions technique, using lessons learned during the Cycle 4 project.

CONCLUSIONS AND LESSONS LEARNED

Designing a truly integrated math/science profession development project is not as easy as it sounds. Math and science teachers bring to the project apparently-conflicting needs which are tightly focused on GLE's. There is a danger that science teachers will "turn off" during "math time" and math teachers during "science time."

Our Cycle 3 project represented the first steps towards providing a project that appeals to both math and science teachers. During the course of that project we found that true integration happened when both mathematics and science professional development staff actively participated in design and presentation of project activities. Although time constraints make it impossible for math and science staff to participate equally in all activities, we made significant steps towards this goal during our Cycle 4 project, and observed teachers of both disciplines participating more fully in activities for the "other" discipline.

The use of quizzes and feedback sessions was an important tool to avoid the temptation of presenting activities for their own sake without paying attention to math and science content. There is never enough time to do all planned activities, and constant vigilance must be exercised to avoid rushing just to finish and move on to the next activity.

We spent a considerable amount of project time developing pre- and post- math and science tests, as well as practicing scoring of exemplary MAP responses released by DESE. Practice scoring led to many animated discussions about correctness of answers, and although participants generally wanted to move on to "fun" activities, they also recognized the importance of practice assessments. The improved performance of their students on the post-test demonstrated that the practice time was time well-spent.

The use of the Four Questions strategy reduced teacher frustrations about designing valid experiments. The use of this strategy represents a compromise between presenting specific content related to GLEs and preparing students for MAP performance events. Our participants told us that they were confident they could teach specific content required by GLEs, but needed help with experimental design and inquiry. A Four Questions experiment is very time-consuming, requiring multiple class periods when it is being introduced to students, but is exciting because students "own" their experiments, and provides invaluable performance event practice time. Participating teachers from Licking R-8 school adopted the Four Questions strategy for their science fair projects, and report using it during their after-school science club with great success.

Allowing teachers to participate for a second year had several benefits. They served as valuable resource people for new participants, and they were able to improve their depth of understanding in content covered during both Cycle 3 and Cycle 4. More important from our point of view, we could see them adapting our activities to use in their schools, and maturing as teachers and leaders.

NEXT YEAR'S ACTIVITIES
(MULTI-YEAR PROJECTS)

During the third year of this three-year project, we will continue to emphasize the synergy between mathematics and science by presenting math and science lessons that require tools from both disciplines to analyze.

Project activities will follow the format of the previous two years, with an eight-day summer workshop and three day-long follow-up meetings, with activities based on input and feedback from participating teachers.

For the third year, we will emphasize seventh and eight grade science and mathematics, although teachers from other grade levels will be allowed to participate if appropriate, and some slots will be allotted to teachers who participated during the first two years. Over half of our participants will be "new,' but multi-year participation by some of our teachers will provide a core group of highly-trained teachers in several of our high-needs schools. Because the project spans grade levels 5-8 and MAP science testing will also cover grades 5-8, many of our science activities will use the Four Questions strategy with a goal of teaching inquiry and experimental design, and thereby preparing students for MAP performance events.

We will be mindful of lessons learned during the first two years, especially those of constantly monitoring teachers for misconceptions, and remembering to discuss math and science content rather than presenting activities for the sake of activity.