Missouri DHE Teacher Quality Grants **"Scaffolding Authentic Learning by Inquiry: A Field-Based Project for Middle School,"**

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Abstract/summary:

The project directors focused on delivering a deeper understanding of investigative place-based experiments during the second year of the Title II TQIG, "Scaffolding Authentic Learning. . ." project. Eight participants from the previous year out of thirty one attendees joined the summer workshop of 2006. All activities were designed to engage participants in authentic inquiry through multiple instructional methods. The purpose was to help participants improve their skills in promoting students' engagement and learning so that the students master the content and the process skills embedded in the science GLEs and standards. All activities including the summer workshop, call back meetings, middle school science symposium and ongoing "electronic and on site" mentoring were tied to the state objectives identified in the proposal.

Participants were trained to help their students design and conduct authentic and meaningful investigative experiments tied to the middle school science curriculum in individual schools. All projects were supervised from the inception in design, data collection by students, analysis of data, and presentation at the middle school symposium via continual dialogue with the project directors and mentors by electronic means and on-site visits. Five higher education faculty were directly involved in conducting the summer workshop and in the mentoring process. A number of other faculty from UCM as well as outside experts from government agencies provided valuable assistance on various occasions in a voluntary basis. Twenty six projects, based on DESE science objectives, covered a variety of content and skill areas embedded in inquiry. Participants received 2 hours of graduate credit in chemistry and 2 hours in curriculum and instruction.

Changes during the second year included an enhanced effort in mentoring and monitoring the project and an increased level of individualized instruction in response to the teachers' differential experience and circumstance. The activities and outcomes of the project were disseminated in national, regional, and school board meetings throughout the year by the investigators and the participants.

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School District	Number of participants
Raymore Peculiar	1
Osage R-II*	1
Johnson County R-VII	2
Grain valley R-V	2
Independence School	1
Kingsville R-I	1
North Shelby	1
Sedalia # 200	1
Van-Far R-I	1
Hazelwood School District	3
Hume R-VIII	1
North Callaway	1
Leeton R-X	2
Knob Knoster R-VIII	1
Cole County R-I	1
Fort Zumwalt	3
Warrensburg R-VI	2
Hollister R-V*	1
Waynesville R-VI	1
Clever Middle	1
Morgan County R-I*	1
Marshal	1

*** Means high need school as listed in Cycle III RFP. Osage County R-II is not shown as high need in the external evaluator's report.**

Please note that six participants out of thirty one dropped at various points of the project. All participants listed above finished sixty hours of summer workshop. The contacts with the participants were made through two six-hour call back

sessions, a six-hour middle school science symposium, on site mentoring and frequent electronic communication. The numbers of contact hours form June 06-May 07 is approximately 95 hours per participant.

II. Description of Project activities

We have completed the following representative activities associated with the project. An approximate completion date is furnished for each activity. Tables detailing information regarding the summer activities are included in Appendix I and II.

- Summer workshop on content knowledge, inquiry strategies, assessment, field activities.(6/30/06)
- A task analysis plan with pre-test items and budget for supplies (8/31/06)
- Call back meeting and status of field projects (10/21/06). Twenty two participants attended the call back meeting and reported on progress of their project.
- Starting of student projects by participants in their respective schools. (8/31/06-9/31/06)
- Several mentor visits to the participants' schools and on going communication among participants, project director and the mentors during fall and spring (8/31/06-4/31/07)
- Several participants administered pre-tests and post tests in fall session
- A second call back session was held in January, 2007
- Participants prepared spring project planning by the beginning of February and implemented them in their classroom
- Middle school science symposium held on May 9th, 2007 at the University of Central Missouri where representative students presented their findings form the project.

III. Description of any Substantive Modification

There was no substantive modification to the original project. We took the feedback from external evaluator and the participants from Cycle III into consideration and made some adjustments to instructional methods primarily using focus groups, individualized instruction and some added flexibility with the projects.

IV. List of objectives

(1) To increase the teacher participants' knowledge and understanding of key concepts in selected content areas in middle school sciences (chemistry, biology, earth science)

(2) To improve teacher participants' practice in inquiry-based instruction

(3) To enhance participants' use of assessment data to monitor the effectiveness of their instruction

(4) To improve student achievement in science content areas

(5) To demonstrate a measurable impact on the preparation of pre-service teachers through improvements in science content or pedagogy courses

(6) To increase competency at using field-based pedagogy in order to integrate meaningful students' experiences with the content and process standards.

V. Progress toward Achievement of State and Project Objectives

We adapted some tables from the external evaluator's report when appropriate to demonstrate the degree of achievement in meeting our objectives. The use of the tables from the evaluators' report was permitted by the DHE and external evaluators. We are aware of the fact that these are self reported data and therefore may not be the strongest evidence toward meeting the objectives. Realizing that the number of participants who completed end of the PD survey is low, we looked at the patterns to make meaningful conclusions. We have also used some of our qualitative and quantitative data gathered during the project cycle to support some of the evaluation results represented in the self reporting surveys.

This section is done in two steps

- Demonstrating overall progress by using necessary tables from the external evaluators' report
- Demonstrating evidence in specifically achieving each objective which include data gathered during the project

Demonstrating overall progress by using necessary tables from the external evaluators' report

The following table provided by the external evaluators demonstrates that objective **1** on content knowledge, objective **6** on standards, objective **2** on instructional methods and objective **3** on assessment, have been perceived at the "somewhat useful" or "very useful" level by more than 70% of the participants in all categories during the summer instructions.

Participants rating of usefulness of PD characteristics (n= 31) [Table 1.13, p. 17, external evaluator report]

PD characteristics	**No response**		**Not at all useful**		**Minimally useful**		**Somewhat useful**		**Very useful**	
	n	%	n	%	n	%	n	%	n	%
Content knowledge	1	3.3	3	9.7	6	19.4	14	45.2	7	22.6
Content Standard	1	3.2	2	6.5	5	16.1	12	38.7	11	35.5
Instructional methods	1	3.2	1	3.2	5	16.1	18	58.1	6	19.4
Assessing Student learning	1	3.2	1	3.2	6	19.4	16	51.6	7	22.6

From the responses of the participants surveyed on the emphasis of the professional development by the end of the summer workshop and at the end of the PD program, it is evident that the program was designed in a way to meet objectives as stated in the proposal in all categories, especially content, assessment, inquiry and designing experiments. It should be particularly noted how almost all participants mentioned that inquiry was the highest emphasis in two categories, namely "using inquiry based/problem centered teaching" and "managing inquiry-based/problem centered classroom"

Emphasis of professional Development Component [Table II.5, p. 28, external evaluators' report]

Subject area	End of Summer Institute							End of PD program						
	Frequencies				Descriptive Statistics			Frequencies				Descriptive Statistics		
	0	1	2	3	n	M	SD	0	1	2	3	n	M	SD
Improving Content knowledge	1	2	9	9	21	2.2	0.8	1	2	3	4	10	2.0	1.1
Creating lessons aligned with GLE's	0	5	7	9	21	2.2	0.8	1	1	4	4	10	2.1	1.0
Assessing Student learning	1	4	8	8	21	2.1	0.9	1	1	2	6	10	2.3	1.1
Using inquiry base/problem centered teaching	0	0	1	20	21	3.0	0.2	0	0	2	8	10	2.8	0.4
Implementing activities in your classroom	0	1	6	14	21	2.6	0.6	0	0	2	8	10	2.8	0.4
Developing materials for use with students	1	4	6	10	21	2.2	0.9	0	1	4	5	10	2.4	0.7
Managing inquiry-based/problem centered classrooms	0	0	0	21	21	3.0	0.0	0	1	0	9	10	2.8	0.6

0= no emphasis; 1= a little; 2= moderate; 3= high

The following table describes the perceived improvement in teaching practices. Improvement in teaching practices in inquiry-based instruction is one of the major objectives of the project. It can be clearly seen from the survey data that objectives in "improving content knowledge", "standard-based instruction", " assessment ",and "inquiry-based practices" has been perceived to improve the teaching at a substantial degree.

Perceived Improvement in Teaching Practice [Table II.8, p. 30, external evaluators' report]

Subject area	End of Summer Institute							End of PD program						
	Frequencies				Descriptive Statistics			Frequencies				Descriptive Statistics		
	0	1	2	3	n	M	SD	0	1	2	3	n	M	SD
Improving Content knowledge	1	5	8	7	21	2.0	0.9	1	1	5	3	10	2.0	0.9
Creating lessons aligned with GLE's	1	5	8	7	21	2.0	0.9	1	0	5	3	9	2.1	0.9
Assessing Student learning	2	5	10	4	21	1.9	1.0	1	0	7	2	10	2.0	0.8
Using inquiry base/problem centered teaching	0	4	4	13	21	2.4	0.8	1	0	1	7	9	2.6	1.0
Implementing activities in your classroom	1	5	5	10	21	2.1	1.0	0	0	4	6	10	2.6	0.5
Developing materials for use with students	1	5	6	9	21	2.1	0.9	0	0	0	7	3	2.3	0.5
Managing inquiry-based/problem centered classrooms	1	6	4	10	21	2.1	1.0	1	0	3	6	10	2.4	1.0

0= no emphasis; 1= a little; 2= moderate; 3= high

The following table originates from the end of the PD project. Responses from nine participants evaluate how the professional development influenced their teaching practice throughout the year. The measured items relate to five of the six objectives. It is clear that most participants felt that the project influenced their professional practice and thus met the objectives to a high degree. One particular aspect to note in the survey is the large standard deviations in the results. This indicates that the opinions of the respondents vary to a large degree with most of them finding that it influenced their

practice while a few of them did not think so. This is not surprising because we moved more toward individualized instructions and on-site mentoring in a voluntary basis during this project cycle. The pattern of responses suggests that participants who remained engaged in continuing dialogue have succeeded immensely.

Extent to which Professional Development Content Influenced professional Practice [Table II.11, p. 33, evaluation report]

Aspects of PD Project	End of PD program (n = 9)	
	M	SD
Content knowledge (improving knowledge about science)	6.1	3.1
Pedagogy (Improving how I teach and interact with students)	6.9	2.9
Instructional materials (developing or revising lessons and related materials)	7.6	2.1
Assessment (developing and gauging methods for student learning)	6.7	2.6
Communication/Collaboration/professionalism (developing working relationship with other PD teachers, instructors, and /or staff	7.2	3.0

0 = none to 10 = very much

Demonstrating evidence in specifically achieving each objective which include data gathered during the project

(1) To increase the teacher participants' knowledge and understanding of key concepts in selected content areas in middle school sciences (chemistry, biology, earth science):

We have included the following table from the external evaluators' report that was designed to measure this specific objective. It can be seen that at the end of summer institute 15 out of 21 participants (66%) responded either in the category of "most of the gain was relevant" or "all of the gain was relevant". This has substantially increased to 80% (8 participants out of 10) by the end of the PD program.

Improvement in Content Knowledge [Table II.4, p. 27, external evaluators' report]

Subject area	End of Summer Institute									End of PD program								
Science	Frequencies						Descriptive Statistics			Frequencies						Descriptive Statistics		
	0	1	2	3	4	5	n	M	SD	0	1	2	3	4	5	n	M	SD
	0	0	3	3	7	8	21	4.0	1.1	1	0	0	1	3	5	10	4	1.6

0= no gain of content knowledge; 1= none of the gain was relevant to my teaching assignment; 2= very little was relevant; 3= moderate amount was relevant; 4= most of the gain was relevant; 5= all of the gain was relevant

We designed and administered an half an hour pre and post test on content that was covered during the summer workshop. We have included the raw scores per participants in Appendix III. It is clear form the scores that in most cases there is a gain in the score, a few cases the scores remain the same or dropped a few points. We have not performed item analysis on the data because they are not standardized tests and the reliability and the validity of these have not been determined.

During the design of the student projects in fall and spring, there was continuing dialogue with the mentors in formulating a good question, gathering necessary information, learning necessary skill to collect data. An example of dialogues from Cycle IV and Cycle V is included in Appendix IV from the same participant engaged in two different projects. These dialogues truly represent an ongoing increase in content and skill knowledge during the project.

(2) To improve teacher participants' practice in inquiry-based instruction

We have included the following table from the external evaluators' report that was designed to measure this specific objective. It can be seen that at the end of summer institute almost 100% of participants reported a high gain in scientific inquiry in two categories, namely "Inquiry approach to science education", and "scientific inquiry". It is also evident from the responses at the end of the PD project. The table presented from the twenty one surveys at the end of summer institute and 10 surveys at the end of the PD activities, unequivocally demonstrates that scientific inquiry and the inquiry approach to science education have been the central idea behind our workshop. We consider this a remarkable achievement toward meeting objective 2. While this table does not show the improvement in practice, a recognition of inquiry practice is indicated. Recognition is the first step toward successful implementation in the classroom. We wish that we had surveys from all participants at the end of PD activities. However, participants who filled out the survey after their

experience in design and implementation of inquiry projects guided by the mentor and project directors in fall of 06 and spring of 07 continue to believe that scientific inquiry is what the workshop delivered.

Extent of Subject Emphasis (Science) [Table II.2b, p. 25, external evaluators' report]

Subject area	End of Summer Institute							End of PD program						
	Frequencies				Descriptive Statistics			Frequencies				Descriptive Statistics		
	0	1	2	3	n	M	SD	0	1	2	3	n	M	SD
Inquiry approach to Science Education	0	0	1	20	21	3.0	0.2	0	1	0	9	10	2.8	0.6
Scientific Inquiry	0	0	0	21	21	3.0	0.0	0	1	0	9	10	2.8	0.6

0= no emphasis; 1= a little; 2= moderate; 3= high

About twenty one participants finished investigative projects during fall 06 and engaged in authentic inquiry with their students. All participants submitted student generated reports and a reflection statement on the inquiry process associated with the project, A majority of them participated in the May 9th symposium and brought students who presented their work. We have included a case study from Cycle III and Cycle IV as an example of ongoing dialogue in the design of the project to represent the continual growth in teacher's ability in inquiry. We administered a pre and post test on pedagogy. However, the test items were used as a formative assessment item to design our instruction in pedagogy during the summer workshop and throughout the project cycle.

(3) To enhance participants' use of assessment data to monitor the effectiveness of their instruction

Participants have developed pre-test and post-test to evaluate the content and skills that are taught through these projects. The project directors and the mentors advised them during the development of the pre-test and guided them to construct better assessment items. We have administered a pre and post test item on writing assessments where participants were given an example of a student written report to assess and were asked to report on what feedback they would provide to the student. We have used this as a formative item for our project design to help us determine our participants' needs in the area of assessment. We have achieved a part of this through on site visits by mentors during

the times of formulating questions, data collection or data analysis part of the project by the participants in their respective classrooms.

(4) To improve student achievement in science content areas

The following table from the external evaluator was generated to evaluate this specific objective at the end of the PD project. Responses from nine participants demonstrate that participants perceive student learning to have been improved among various categories to a fairly high degree.

Teacher perception of PD components that Improved Student learning [Table II.10, p. 32, external evaluators' report]

Subject area	Frequencies					Descriptive Statistics	
	0	1	2	3	4	M	SD
Improving Content knowledge	0	3	5	2	0	1.9	0.7
Creating lessons aligned with GLE's	0	1	5	3	1	2.2	0.7
Assessing Student learning	0	0	6	2	1	2.3	0.5
analyzing student performance data	0	0	7	2	1	2.2	0.4
Using inquiry base/problem centered teaching	0	0	3	6	1	2.7	0.5
Implementing activities in your classroom	0	3	6	0	1	1.7	0.5
Developing materials for use with students	0	5	4	0	1	1.4	0.5
Managing inquiry-based/problem centered classroom	0	4	5	0	1	1.6	0.5

0= none; 1= little; 2= moderate; 3= high; 4=no improvement in my practice

*descriptive statistics do not include "no improvement in my practice"

We have asked all a participants to administer a pre and post test on the units that they would teach through the field-based projects. The participants submitted the student scores. These scores vary quiet a bit from one end of the spectrum to the other. Since these are not standardized tests, the quality, length and the items of the test vary. In most cases substantial gain is observed. An example of such a report from a weather unit is attached. We did not do an analysis because each unit is different, each test is different, and how it is administered is different. Therefore aggregate data and necessary statistics may not be meaningful on these scores.

(5) To demonstrate a measurable impact on the preparation of pre-service teachers through improvements in science content or pedagogy courses,

We have a small middle school program. I have been communicating with the Dean of Education regarding this objective. We have a new Dean that I plan to forward this report. We do not have any measurable impact on pre-service teacher education

(6) To increase competency at using field-based pedagogy in order to integrate meaningful students' experiences with the content and process standards.

Approximately 95% of the participants provided a task analysis plan by July 30, 2006, 80% of them completed a field project in fall by November1, 2006, and approximately 50% completed a spring 07 project embedded in inquiry. The projects were in diverse content areas, content rich, and involved authentic inquiry. Most participants have never been involved in field-based projects prior to starting this professional development workshop. The numbers of participants completing the projects reflect that we have accomplished this objective to a very high degree.

VI. Description of how the project was connected to Show-Me Standards

We made sure that all activities related to the project connected with the Show-Me standards and GLE's.

- During the selection of the activities for the summer workshop, we checked the activities with the GLE's and the Show-me standards.
- All participants were required to submit how their specific project related to the GLE's and Show-me standards. The project director read all the project plans and the described standards associated with them and recommended modifications as necessary.

VII. Dissemination

Middle School Science Symposium, posters and oral presentation by students on their investigative projects, University of Central Missouri, May 9, 2007

MIDDLE SCHOOL INVESTIGATIVE STUDY: TEMPERATURE EFFECTS ON INSECT DIVERSITY. * Ferguson-Heggar, P. Sedalia Middle School, and S.H. Mills. Department of Biology, University of Central Missouri. Poster presented at the Missouri Academy of Sciences meeting, Missouri Western State University, April 20-21, 2007

Scaffolding Authentic Learning by Inquiry: Professional Development for Middle School Science Teachers, Somnath Sarkar & Richard Frazier, presented at the national conference of the National Science Teachers Association (NSTA), Chicago, IL, April 1, 2007

MIDDLE SCHOOL INVESTIGATIVE STUDY: TEMPERATURE EFFECTS ON INSECT DIVERSITY. * Ferguson-Heggar, P. Sedalia Middle School, and S.H. Mills. Department of Biology, University of Central Missouri. Poster presented at the national conference of the National Science Teachers Association (NSTA), Chicago, IL, April 1, 2007

Starting form the Middle: Improving Teacher Quality in Science, Somnath Sarkar, an invited talk presented at American Chemical Society MOKANOK (Missouri, Kansas, Oklahoma) section, April 12, 2006

VIII. Lessons Learned

- Consistent and continuing dialogue among the participants, the mentors and the project directors needs to be implemented from the beginning to ensure significant improvement in teacher practices in content knowledge, assessment and inquiry-based instruction. Teacher practices do not change substantially during a single year of isolated engagement. We are noticing substantial changes in teacher practices and the nature of the ongoing dialogue for those participants who stayed with us for two or three years.

- The external evaluators' evaluation system primarily is focused on self reported data; therefore, it does not provide direct evidence of an increase in knowledge of content, assessment and inquiry-based practice in the classroom. We have unsuccessfully tried to use the mentor for the purposes of collecting data on classroom practices in the

Cycle III. We changed this role to focus solely on mentoring and not on evaluation. This change improved the project quality and the success rate immensely. We realize at this time that we need a separate set of people who would be able to provide classroom observation data associated with improving content knowledge, assessment to improve instruction and inquiry-practices of individual teachers. We have neither the budget nor the trained personnel we would need to conduct satisfactory observation to gain knowledge of teacher practices. We are looking into providing training to the building administrators to serve in this role during Cycle V.

- Student improvement by comparison of the teacher designed pre and post score may be useful for the specific teacher and for the unit but it does not reflect a continuous growth in acquiring scientific knowledge and skills. We strongly feel that student performance in the middle school symposium, which includes presentation, communication with other middle school students, and directly engaging in answering questions from the audience is much more reflective of an increase in skills, practice and learning.

- Pre and post tests during summer workshop in the content area for the middle level for the participants may not be the best way to judge an increase in content knowledge. We believe the individualized instruction and ongoing dialogue with the mentors and the project directors during design, data collection and analysis phase expose teachers more fully to meaningful interdisciplinary content. Through the dialogue exhibited at the beginning and the later phase of these projects, participants demonstrate that they have gained a deeper understanding of related knowledge. We find that this is a better qualitative method as compared to scores in pre and post test.

- Many teachers follow traditional way of teaching science through textbook and workbook and canned demonstration because they find them easy to adopt with the available time. Some of them also lack the motivation and confidence to venture into authentic scientific investigation. The teacher success in this type of endeavor in Cycle III, IV and ongoing cycle V shows that some teachers who are enthusiastically engaged perform very well and continue to gain confidence. Others who treat the professional development activity as merely a requirement for the course do not show such gain in confidence as evidenced from the dialogue.

- Each individual participant has different needs. Responding to individuals appropriately is critical to helping participants discover their own unique needs in the self exploration process. A professional development workshop will be more valuable if it meets the unique needs instead of only addressing the GLE's, Show-Me standards and the MAP scores.

- A support staff is absolutely necessary to coordinate all non-instructional aspects of the project because the scope is fairly large communicating with administrators, meeting equipment needs, handling paperwork for the budget etc.

IX. How activities in the 2007-2008 cycle were built upon foundation created in 2005-2006 and 2006-2007

- Continued involvement of mentors to engage in face to face and electronic dialogue with participants, to help with the development of project plans, to assist with the evaluation of material and logistical needs, to make on-site visits to provide advice to participants and assistance to their middle school students.

- Increase in effort to tailor mentoring by project director and faculty mentors to individual participants' unique needs as developing teachers.

- Continued highlighting of the value of field-based inquiry with appropriate adaptations to participants' individual needs (situation, experience—years teaching, background in science—especially field science, comfort with inquiry, and administrative support).

- Our first week continuing activity during summer workshop used UCM campus as field site to design and conduct investigative experiment. In the second week we used a local stream for a thorough introduction to water quality study. Both activities were based on the projects conducted by participants during the previous years to shed light on the difference between performing an activity and performing a scientific investigation.

- Most activities started with concept mapping that related to GLE's and Show-Me standards for the appropriate grade level and concluded with a refined concept map that participants could display in their classrooms as evidence for meeting the standards.

- Field-based definition expanded to include any part of the school environment (cracks in the concrete study, for example).

- Workshop organized around themes of environmental importance such as air quality and water quality- two ubiquitous and significant substances that provide extensive curricular connections. We realized that it is important to make projects meaningful for middle school students who are often concerned with the environment. We discovered this particularly from a project in the first cycle where middle school students showed positive involvement in a water quality investigation related to whether a stream was safe for swimming.

- Introduction to workshop involved presentations by each returning participant of their project—especially using examples of student work.

- Stronger focus on design activities—embodying an “engineers” approach to inquiry. Our research in the middle level science learning convinced us this approach to inquiry instruction is particularly useful for middle school. The desired outcome is defined while the path to the outcome is full of possibilities for creative inquiry. One can engage in a design project and make progress without having full theoretical knowledge in advance. The nature of the problem can increase the opportunities for students to engage in exploration and experimentation with relevant phenomena.

- Stronger focus on instrumentation with the goal of understanding measurement (as a kind of comparison), tolerance-error-variation in measurement, and operational definition of variables. The Goal was to take some of the “mystery” out of scientific inquiry and to build critical skills in evaluating data.

Summer Workshop Schedule

Second Week (June 26-June 30)

Monday, June 26	Tuesday, Jun 27	Wednesday, Jun 28	Thursday, June 29	Friday, June 30
9:00-9:20 **Record readings**, dismantle evaporation and gas solubility apparatus	9:00-9:45 Characteristics of authentic inquiry (focus group) Talk about 5-E and learning cycle 9:45-12:00 with breaks Types of questions Discussion on questions and refining questions form teacher designed experiments Set up experiment	9:00-10:00 Generating Pre-Test questions (everybody gets a copy of the printout of questions). 5 questions, groups of three multiple choice question either address concepts from here or what they are considering for their projects 10:00-10:00 Break	9:00-12:00 Small 40 minutes sessions Project planning With breaks Individuals finding time to complete experiment	9:00-10:45 **Post test** three thirty minutes tests with 5-minutes break (For DHE evaluation purpose)

9:20-10:00 Group discussion on final evaporation data. Analysis of data.	12:00-12:30 W**orking Lunch** Building a presence (Networking), **Jerusha**	10:10-11:00 **Project Planning** returning teachers serve as panel member, present last years' project Q & A **Describe project** **Discussion of ownership of projects** Initiative and courage to overcome barriers in field investigation		10:45-12:00 **Brief presentations** of plans for feedback
	12:30-2:00	11:00-12:00 **Task Analysis** (focus groups), Make a list of tasks that need to be performed to successfully implement the plan	12:00-12:30 **Working Lunch**	12:00-12:30 **Working Lunch**
Monday, June 26	Tuesday, Jun 27	Wednesday, Jun 28	Thursday, June 29	Friday, June 30
		12:00-12:30 **Working Lunch** **Creative scheduling in the middle school**	12:30-3:00 **Individualized instruction** on technical skill, process skill, or content	12:30-2:00 continue **presentations** of plan for feedback

			knowledge by the P.I,s and mentors	
10:10-12:00 WCM 424 **Write individual reports addressing Question #1 with associated graphs for the evaporation study, compare with extended experiment. The report should include a data table, appropriate graphs, and an analysis that leads to and includes a conclusion. Submission of report through Blackboard.**	**12:30-3:00** **Assessment by testing** different types of testing Pre-test and post test writing (Use the document from DESE web site on test questions they wrote), and GLE focus groups by grade Use questions from the pedagogy test and also discuss the e questions we asked with experiments **Focus group:** **How do the activities and their variations and concepts we taught meet your GLE? Vance will prepare list of activities we have done. not out of blue.** **Reinforce fact that activities**	12:30: 1:30 Participants present findings from their experiments (up to this point). Question-Expectation, Procedure, Findings.		2:00-3:00 **Filling out paperwork** and wrap-up

12:00-12:30 Working Lunch Discuss questions with peers regarding proposed experiments—be sure to include question, materials, timeline		1:30-3:00 **Individualized instruction** Participants work on a plan that uses field-based investigation including school yard location Finish experiments Blackboard orientation and submission of evap. Reports Computer lab 224 or in 231		
12:30-2:15 **Assessment and planning** Focus group to describe and interpret student work to plan instructional strategy				
2:15-3:00 Focus group Discussion on characteristics of authentic inquiry				

First Week (June 19- June 23)

Monday, June 19	Tuesday, June 20	Wednesday , June 21	Thursday, June 22	Friday, June 23
8:30-9:00 Breakfast	9:00-9:20 Record readings from evaporation.	9:00—9:20 Record readings from evaporation including expanded version. Transpiration set up/outdoor	9:00-9:30 Record readings from evaporation experiments and gas solubility Transpiration record/outdoor Transpiration set up/indoor	9:00-9:30 Record data
9:00-9:25 Orientation	9:20-9:50 Unit Pre-Test Evaporation, boiling, freezing, vapor pressure, temperature and thermal energy, physical change, graphing Room 224	9:20-9:50 Unit Pre-Test Gases, solubility of gases, Electrolysis, photosynthesis, physical and chemical change, conservation of mass	9:45- 11:30 Experimental set up Conservation of mass in living and nonliving system Generation of Nitrogen Work on the completed transpiration experiment from outdorr	9:30- 10:30 Solar still—design problem Discussion on water cycle
9:25-9:45 Enrollment	9:50-10:00 Break	9:50-10:00 Break	10:30-12:00 Discussion of concepts and questions from Photosynthesis Electrolysis	10:30-12:00 Gases and gas behavior, chemistry of gases with discussion

			Boiling of water	12:00-12:30 working lunch Pre-Test on pedagogy
9:45-10:00 Break Field trip to Pertle Spring	10:00-10:10 Discussion of evaporation data	10:00-11:30		12:30-1:00 Transpiration Data analysis Outdoor and indoor
Monday, June 19	Tuesday, June 20	Wednesday , June 21	Thursday, June 22	Friday, June 23
10:00-11:45 Field Study & Water Quality testing	10:10-11:20 Observable Characteristics of authentic inquiry (focus groups)	11:30-12:00 Discussion of results and students' interpretations and misconceptions, Inquiry from Children's perspective	12:00-12:30 Lunch Differential instruction from special ed perspective	1:00-1:30 Pre-Test
12:00-12:30 Working Lunch Enter field data electronically in a class table	11:20-12:00 Understanding variables in a scientific experiment Modification of the evaporation experiment	12:00-12:30 Working lunch		
12:30-1:30 GLE (focus group) What does it mean by	12:00-12:30 Working Lunch	12:30-3:00 Experiments on Bubbles Experiments on Photosynthesis,	12:00-12:30 Working Lunch	1:30-3:00 Assessment and Instructional Planning Activities

alignment?		electrolysis, fermentation		
1:30-2:30 Discussion on data What to do with data when it does not support your hypothesis? 2:30-3:00 Evaporation, experiment set up Fill out evaluation in the computer lab	12:30-2:30 Experiments on boiling and freezing, graph cooling curve 2:30-3:00 Discussion of results from freezing and boiling, Record Evaporation data	2:30-3:00 Set up, Record, Evaporation data Transpiration data collection/outdoor Dismantle photosynthesis	12:30-3:00 Discussion contd. Vapor pressure, atmospheric pressure, gas solubility, some aspects of experimental design, discussion on exploration in informal settings Gather all data Dismantle photosynthesis	

Appendix II: Pre and post test Scores on the content area (15 points)

Participants	Pre test	Post test
1	11	11
2	7	11
3	12	11
4	8	11
5	11	13
6	8	7
7	9	12
8	5	9
9	7	
10	13	11
11	10	11
12	9	11
13	13	14
14	10	12
15	9	13
16	14	
17	7	
18	5	10
19	10	11
20	9	11
21	10	11
22		13
23	10	11
24	7	9
25	10	10
26	10	11
27	9	7
28	8	9
29	9	10
30	6	8
31	12	14

Appendix III:
Example of a task Analysis plan and ongoing dialogue between a participant and the mentor form Cycle IV and Cycle V.

We have had twenty six of these plans and several e-mails communications with project director and mentors at all phases of the implementation of these plans.

Cycle IV communication

Title II
July 15, 2006
Task Analysis plan
Mendy Brewington
Please note that the project Investigator's comment is in italics embedded within the task plan.

- **Question/Problem/General Topic**

General Question: How does temperature affect the cracks and/or joints in our concrete sidewalks?

Looking at the joints in the concrete and the large cracks that are obviously beginning to show in the concrete around our school, how does temperature (and possibly other variables…. weather, ice melt, traffic) affect their size?

How would you isolate the variables if you are going to study them? One may be able to isolate some of these factors if you have accurate data at different conditions.

- **Rationale**

According to RPMS curriculum for 7th Grade Science and Missouri GLE's, students are to understand that physical changes in matter that result from thermal changes can be explained by the Kinetic Theory of matter.

I may be wrong, but I am not aware of Kinetic theory of matter. I am aware of kinetic molecular theory that applies for the gases. I know what you are talking about. You are talking about thermal expansion and contractions of solids, and how heat and cold plays a

role. There are many application of this principle in construction of bridges, homes, and train lines. Every solid has a coefficient of thermal expansion and thermal expansion is a physical property.

In this project students will be developing an understanding of this concept, however, not in the traditional classroom setting. Students will be using a "hands on" approach by actually monitoring the cracks and joints in the concrete sidewalks around their school. They will be measuring the length, width and depth (cubic centimeters) of the cracks and/or joints to determine how their size is directly related to the increase or decrease in the temperature of the concrete.

- **Concept List & How Applies To Project**
- Standard 2.A.k – Recognize thermal energy as the random motion (kinetic energy of molecules within a substance. & Standard 2.A.l – Use the kinetic molecular model to explain changes in the temperature of a material.

Applies to project: students will be monitoring and observing concrete over 4 weeks in October. They should see during this length of time that the concrete expands as the temperature increases and contracts as the temperature decreases. This is due to the Kinetic Molecular Theory. (*This primarily applies to gases. However, I think what you want your student to understanding that that heat causes the kinetic energy to increase for the particles in a solid. The particles try to move away from each other. While remaining in the solid state it expands. If you put in lot more thermal energy, the solid changes into a liquid. Therefore expansion of a solid is generally the pathway to becoming a liquid.)*

Standard 2.A.o – Describe how heat is transferred by conduction, convection, and radiation and classify examples of each.

Applies to project: as students monitor concrete, they will observe the relationship between outside temperature and the temperature of the concrete. They will then be able to classify the increase in temperature of the concrete due to the sun as radiation.

- **Logistics**

Time Frame: 4 weeks
Materials: aerial map of school, student field notebooks, butcher paper for large class map
Permission Slips

- **Supplies & Budget**

Infrared Thermometers – Borrow from CMSU (buy 1 additional from Fisher Scientific $71.00)
8 Calipers – Fisher Scientific $12.70 (total $101.60)
2 dozen reusable Rubber Gloves – $ 25.50 per dozen (total $51.00)
Digital Camera – Borrow from CMSU
Thermometers – n/a
Meter Sticks/Rulers – n/a
(Sieves, Mortar Mix, Styrofoam Cups, Ziploc Bags-teacher/school purchase)
Cycle IV

- **Experimental Design**

Students will first be divided into teams of 3-4. Each team member will be assigned a task (materials manager, written recorder, photographer or sketcher, and instrument reader). These tasks will rotate throughout the duration of the project. All team members will need to take field journals to field to record observations and measurements. After student groups have been assigned, students will be given a portion of sidewalk/patio/or other concrete to investigate. These sections will be numbered 1-21 (7 groups per class). Students will then complete their assigned daily tasks:

When will you teach the student how to make a measurement with all the equipments they will use? It would be important that all students follow a certain protocol that they agree upon while measuring. For example, if they were to measure air temperature, everybody may want to measure at the same height from the ground. You need to think about these protocols.

Week 1:

Day 1: Become familiar with your section of concrete. Estimate the total area of your section and record in field journal. (20-30 minutes) Begin recording observations of your area including a sketch or photograph of any and all cracks, joints, temperature of concrete, air temperature and weather. (20-30 minutes) Report on initial observations in classroom. (20 minutes)

Day 2: Continue to discuss in class what students found in their initial observations and begin to have student's group recorder transmit this information to a large class map. The teacher will also direct students to begin putting their observations and recordable data into a data table. Outside, students will complete observations and sketches. (20-30 minutes) They will begin to put their recordings into their data table including air temperature, concrete temperature, weather, length, width and depth (cm^3) of cracks and/or joints. (15-20 minutes) In the classroom, students will complete classroom map. After all classes have reported on their observations, a classroom discussion will be held to determine if there is any particular area with more "wear" than others and possible reasons why. (20 minutes)

Week 2:
Day 3: Students will check measurements of all joints/cracks and record in data tables. (15-20 minutes)
Day 4: Students will check measurements of all joints/cracks and record in data tables. (15-20 minutes)
Day 5: Students will check measurements of all joints/cracks and record in data tables. (15-20 minutes)

Week 3:
Day 6 (after 1-2 weeks): Students will check measurements of all joints/cracks and record in data tables. (15-20 minutes)
Day 7: Students will check measurements of all joints/cracks and record in data tables and begin to draw conclusions about effect of temperature or weather on the size of joints/cracks. (20-30 minutes)
Week 4:
Day 8: Students will finalize data tables and begin to display their results in a line graph showing the relationship of temperature and cm^3 of their largest crack or joint. Students will begin to discuss why they obtained their results and begin lab write-up to report their findings. (20-30 minutes)

What is the thermal expansion coefficient of most concrete materials? Is their going to be an observable effect?
Day 9: Continue working on lab write-ups. (20-30 minutes)
Day 10: Complete lab write-ups. (20-30 minutes) Class discussion over project.
Week 5:
Day 11: Post-Test

- **Pedagogical Design**

September:
Students will be working to develop their understanding of matter and the properties used to describe and classify types of matter. This will include students using physical and chemical properties of materials to classify them as pure substances or mixtures and understand ways that are used to separate the components of a mixture. (1.1.A.d, 1.1.B.a-b) In addition, student will be identifying chemical and physical changes that occur in matter. (1.1.G.a-c) During this learning process students will be looking at many different types of objects *including* concrete and the materials used to make this

very familiar mixture. Students will practice separating the components used in concrete and make their own sample cylinders of concrete, some of which will be used to illustrate the conservation of mass. (1.1.I.a)

I like the idea how you bring in conservation of mass. Are their ways to separate components used in concrete? Is that why you are thinking of using sieves? You may be able to separate the materials depending on size, but that does not mean that they would be chemically different materials. But certainly separation by size is a way to get to a part of the problem. There is a separation techniques that uses size of molecules (enzymes and proteins are separated this way) called size exclusion chromatography.

October:

Students will then be introduced to the kinetic theory model and the relationship between temperature and phase changes. A pre-test will be given prior to beginning this unit. During discussion on this unit, I will help direct students to think about the concrete that they have previously been working with so that they may address the causes of the cracks in the concrete sidewalks and patios around the school. We will discuss their opinions of the causes of the cracks and if they may be getting larger or smaller and why. Students will then be presented with the project they are to complete throughout the month of October. Upon completion of project, students will be given a post-test to determine their understanding of the relationship between temperature and phase changes as well as how heat is transferred to materials.

Response from Mentor

Date: 14 August 2006
To: Mendy Brewington
From: Mike Powers
Re: Task Analysis Plan for Mendy Brewington

I have read your TAP and I believe that your General Question is quite practical and well worth investigating. The degradation of concrete structures, such as roads, bridges, sidewalks, buildings, etc. is a major issue. The knowledge of what affects this degradation and how to reduce or halt the degradation is well worth having.

When I read beyond the Question/Problem/General Topic I see a collection of scientific concepts such as Kinetic-Molecular Theory, physical change, chemical change, phase change, thermal expansion, mixtures, pure substances, and

others. While these topics/concepts do relate to the General Question, I do not see, however, how these topics/concepts are integrated and how they are related is a systematic way to the General Question.

Let me continue with more specific considerations. The coefficient of thermal expansion for concrete is about 1 x 10^{-6} per ^{o}C. This means that for a piece of concrete 1 meter in length, it will expand by 1 x 10^{-6} meters or 0.001 millimeters for a temperature increase of 1 ^{0}C. Hence, a temperature increase of 1000 ^{0}C is required for a 1-millimeter change in the length of the concrete. While there are devices to measure such changes, these devices are very expensive, and much more complicated than Vernier calipers. This is not to say that your plan is not “doable.”

I am no engineer, however, I believe that the degradation of concrete, for example a sidewalk, is the formation of a crack due to a stress fracture and then the crack fills with water and the subsequent freezing and thawing of the water causes the crack to widen. This process could be simulated in the classroom and measured in the field and the extent of the effect would be far larger than that due to thermal expansion alone. Now perhaps to something more specific.

I can envision a series of observations of sidewalk cracks. Suppose that students were to go around the school grounds and find sidewalks with cracks. The cracks would be labeled; perhaps by noting the distance and direction from the school building. For example, crack 12E would be twelve meters from the east side of the building. A spot in that crack would be identified with arrows facing each other, such as - -, with the crack between the arrows. The crack I.D. could be added with black paint so that on the sidewalk it might appear as 12E . This particular part of the crack would be photographed, making sure to use the same camera held above the sidewalk at a fixed and consistent distance; say 1 meter. This same spot would be photographed at various times during the day with notes such as air temperature, ground temperature, sunlight or shade, wet or dry, etc. Photographs of each of the labeled cracks could be made over a period of time during which the air and ground temperature would vary greatly; perhaps as much as 100 Fahrenheit degrees or approximately 83 Celsius degrees.

The digital photographs could be downloaded to a CD and the CD image can be projected onto a screen or smooth wall using a LCD projector. The LCD projector and settings would have to be standardized. The projected image of the crack would give an enlargement factor of 10 to 20 on the screen; hence, a 1-millimeter crack would now be 1- to 2-centimeters in width and this type of distance could be accurately measured with a caliper. In addition to the enlargement factor, the digital image would be a permanent record of the crack at a particular day and time, measurement could be delayed until

convenient, and several students could repeat the measurements for greater accuracy. In addition to providing data for the experiment, the photos could be used later to construct an A/V presentation.

The information collected from these photo images and subsequent crack measurements could then be correlated with data such as air temperature, ground temperature, moisture conditions, amount of sunlight or shade, amount of foot traffic, or what ever was of interest, and the variation in crack size, if present.

I can also envision a series of experiments in which students concoct concrete “slabs” of various compositions to test for strength. Portland cement is a mixture of various pure substances (compounds) and these compounds have been identified. The cement is mixed with an aggregate, for example pure silica sand, the compound SiO_2, and water to make concrete. As this mixture “sets” various physical and chemical and phase changes occur.

The composition could vary from 100% Portland cement and sufficient water to wet the cement and transferred to a mold and allowed to set. Other composition could include 90% cement and 10% sand, 80% cement and 20% sand, etc., etc., all the way to 10% cement and 90% sand. To each mixture would be added sufficient water to wet the components. The amount of cement and sand could be massed and the mass of the slab upon setting minus the mass of the cement and sand would give the mass of the water present. These experiments would bring together the concepts of pure substances (compounds) and mixtures. Also, these experiments would allow students to observe changes in physical properties, e.g., hardness and mass. The setting of concrete is also a chemical process, generally accompanied with an evolution of heat energy, because the set concrete is stronger than the mixture of the components chemical bonds have been formed. Phase changes are also observed such as the evaporation of water and the conversion of a liquid mixture to a solid solution.

If the slabs are made such that each has the same dimensions, they could be tested for relative strength, e.g., load bearing strength. Each slab could be suspended near the ends between two small boards and a can placed in the middle. Sand could be added to the can until the slab broke and the mass of the sand in the can measured and recorded. Numerous variations could be included such as the inclusion or omission of reinforcement and inclusion or omission of additives that give the concrete more or less strength.

With the types of experiments that I have noted above, I believe that it is possible to integrate the concepts you mentioned throughout your TAP such as physical change, chemical change, phase change, thermal expansion, mixtures, pure substances, and the degradation of concrete caused by the freezing and thawing of water.

I cannot guarantee that the above suggestions are the best of all possible suggestions. I am most willing to meet with you and discuss details, if you would like. I look forward to your reply.

Cycle V Communication

Dr. Mills,

I started back to school today and had a chance to meet with the three other 8th grade science teachers I work with and talk more about the rain garden. After talking with them, I really think my project should take a new direction. First, we would really like to keep with the one large location between our two wings...our hope is that if we are successful at this garden that we can make it a yearly project to build another rain garden around the school. In keeping with one location, however, this would make my project of locating the rain garden unnecessary. Second, the other teachers really have no interest in helping design the garden with respect to picking out plants etc... They, actually, are more interested in the manual labor part...works for me!

This lead me to do some research this afternoon to try and tie in the designing of the garden with an inquiry based question. After doing some more research online, I have found that I think I can still have my students test the soil, but more to determine its type: once they have determined its type then they can choose the type of plants that are best suited for what type of soil we have at our determined location. I found an interesting resource for this at the attached website (http://www.rainkc.com/PDF/DESIGNS_pg4.pdf). In addition, I believe this will be a place where our conservation agent can be very helpful in choosing the specific plants for our area and our soil.

Personally, I feel more excited and comfortable going this route with my project and think the design aspect of choosing the plants will be more engaging for the students. Also, after talking with my co-workers, I really think emphasizing the real purpose of the rain garden as helping to prevent storm water runoff really helps tie into our ecology unit. Our ecology unit has a real emphasis on man's impact on the environment, so this fits perfectly. I need to work on a specific question such as how the soil type affects the types of plants in the rain garden, but I wanted to get your take, and Dr. Sarkar's, on this before I proceeded.

Thanks, Mendy Brewington

sarkar@ucmo.edu wrote:
Mendy,
I have read your proposed plan and made some comments. Your plan is moving in the right direction but needs some refinement. I have made some suggestions in the attached document. Please work with Steve, finalize the plan, and see what you need to order to carry out your experiment. I also do not have your pre-test. Please send me a pre-test when you get time. Make sure to include some questions on inquiry strand besides the content standards. Good luck and best. Keep me posted. At this point, I am not going to submit a grade because your plan has a little bit to go. I will do that when I see the refined document.

Som

Dr. Mills,
Attached is my revised TAP for the percolation tests. You'll notice that I indicated in the plan that the final sites have not been located, because I have not heard back from my principal on where our building roof plans are. I'll keep you posted on that.

After I put this plan together that gave me the ideas on how to dig the test holes and how to perform the perc tests, I have learned that the water may take longer than my class time of 70 minutes to soak into the soil. Therefore I've been trying to research other ways to test and came across one idea of using metal cans that I wanted to get your opinion on. You can perform the test by taking both ends off the can and pushing the can a certain distance into the soil. You then pour the water into the can (in the end sticking out of the soil) and time how long the water takes to run out. Is this testing more surface runoff than percolation or would this work better than digging 12 inch holes in our school yard?

Thanks for your help. I look forward to any other suggestions.
Mendy

smills@ucmo.edu wrote:
Mendy,
Thanks for your hospitality and tour of your campus and outdoor classroom. Thanks for sharing the hard copy of your Task Analysis Plan. I think you could draw parallels between the larger catch-basin wetland with its drainage area and the proposed water garden could be emphasized. The catch basin wetland already has the diversity to which the water garden might eventually develop. For the standards related to ecosystems, you have the catch basin which can be studied and the model to which the future water garden might be directed. How do you want to manage the water garden differently from the catch basin? Do you think the catch basin soil characteristics maximize water absorption by the soil or water retention as a pond?

I do not want to discourage your ideas about potentially harmful pollutants. For example, A retention pond is often used as a means to catch accidental spills. What soil characteristics would help retain spills vs release the pollutant into the water table? Are there potential pollutants that might be released from the building roof?

From:
mendy mcgowen
Monday - July 9, 2007 5:55 PM
To:
Subject:
Re: Mendy's ideas
At

Thanks Steve, I'll plan on the 23rd at 1:00pm.
Mendy

smills@ucmo.edu wrote:
i believe I found the middle school on mapquest. We will probably be traveling north on 71 if current plans remain unchanged. steve
>>> mendy mcgowen 07/06/07 11:07 AM >>>
Yes that will work for me. Would you like me to give you an address or any specific directions? We can meet in the front parking lot of the middle school at 1:00pm.Thanks again, Mendy

smills@ucmo.edu wrote:
How about 1pm on 7/23?
>>> mendy mcgowen 07/05/07 9:35 AM >>>
Steve,
The 23rd does work for me, however, I do have plans already at 3:30pm...I can do earlier in the day, but don't know how that works for you. Peculiar is located off of 71 highway north of Harrisonville and south of Grandview. It is about 30 minutes south of Kansas City. I hope this helps some.
thanks again, Mendy

smills@ucmo.edu wrote:
Mendy,
I am glad that you are available throughout the month. I think Monday, 7/23 might work well for me. I may try to combine the trip with one of many trips down Highway 71. I am thinking that 3pm might work well as part of return trip from southern Missouri but I am adaptable. Maybe late afternoon in July would be a challenge to be walking around outside. Remind me again of your school location. Let me know how this sounds. steve

>>> mendy mcgowen 07/02/07 1:59 PM >>>
Dr. Mills,
Thank you so much for contacting me so quickly! ...and thank you for your help in considering what specifically to do for my project. I think it would be helpful to meet on site and see what exactly there might be to work with. I am available throughout July but am thinking maybe towards the end might work better? I'm thinking possibly the week of the 23rd? Is there any day that may work better for you? Thanks again for your help and I look forward to this upcoming year!
Mendy Brewington

smills@ucmo.edu wrote:
Mendy,
Thanks for sharing your research ideas at the workshop. I hope we can continue the conversation by email. I would like to summarize our conversations while my memory is fresh relative to your plans a fall investigative study and hope you will edit my misunderstandings. Please send me an electronic version of your draft plan for comments.

I understand that you want to involve your students in asking the question which is the best site for the rain garden you are planning for your school campus. You may want to consider the sites in terms of the avenues of water input and outflow. Water input will primarily depend upon rainfall and the area of the roof which is drained by the downpout serving the area. Outflow may depend upon soil type, slope, and any retaining concrete structures. You may want to evaluate the desirable characteristics for a rain garden auto flow. Are their negative characteristics which you want to avoid? Maybe you will want locate and to take the students to any wetlands in the outdoor classroom or neighborhood in order to help them determine these characteristics.

As you consider your plan, please do not hesitate to let me know if you would want me to help evaluate the area or refine your question and plan. Keep me in the conversation as you seek other input. It would probably be best for me to try to make any on-site in July rather than in early August. I will probably not be available on-site during Aug 6-24 but hope to continue the email conversations as the plan develops. Do not hesitate to email or call me at 660-441-8309. steve

Appendix IV

Student Pre and Post test scores on weather unit showing substantial gain with most students

1st Hour	Pretest	Post-test
1	33	90
2	29	63
3	52	87
4	33	77
5	62	50
6	29	77
7	33	33
8	52	83
9	48	60
10	29	70
11	52	73
12	57	73
13	38	75
14	43	73
15	43	83
16	67	80
17	48	93
18	43	83
19	33	80
20	43	83
21	33	83
Average	42.8	74.7

2nd Hour	Pretest	Post-test
1	62	70
2	43	83
3	38	97
4	19	67
5	33	63
6	43	67
7	24	40
8	43	77
9	52	83
10	33	60
11	24	83
12	48	93
13	29	70
14	38	83
15	43	77
16	52	53
17	71	90
18	14	63
19	67	83
20	62	97
Average	41.9	74.9