ENHANCING MATH AND SCIENCE EXPERIENCES IN THE MIDDLE GRADES

MDHE ITQG CYCLE 4
FINAL REPORT

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Abstract

This project focused on increasing middle grade teachers' (grades 4-8) knowledge base and hands-on experiences in the physical science areas of chemistry, physics, astronomy, and meteorology. A portion of the curriculum presented was designed for immediate application into 4th-8th grade science classes. Another portion of the curriculum was designed to help the teachers become better problem solvers. The 23 teachers participated in an intensive week long summer workshop in June 2006. Additionally, the teachers met once per month during the 2006-07 school year to discuss topics that they continued to find difficult or which were soon coming in their curriculum. The teachers were given a pretest, a post test following the workshop, and the same post test at the end of the project. In addition, several of the school districts allowed us to do pre and post testing on students within the participating teacher's classes. Pre and Post testing indicated an overall increase in comprehension by the teachers with more limited increases by students.

The project faculty consisted of three university faculty from Central Methodist University, three middle school teachers who also participated in the day-to-day activities of the project, and two undergraduate students (one pre-service education major and one math major). We believe this diversity of faculty allowed us to more effectively determine the best topics and activities for the project.

School Districts and Participant Information

List of Schools

District	No. of Participants	High Need
Slater	**6**	**Yes**
Sturgeon R-V	**3**	**Yes**
Miami R-1	**2**	**Yes**
Prairie Home R-5	**1**	**No**
Westran R-1	**2**	**No**
Montgomery County	**3**	**No**
Fayette	**1**	**No**
New Franklin	**1**	**No**
Cooper County R-4	**2**	**No**
Lewis & Clark (Jeff City)	**1**	**No**
Glasgow	**1**	**No**

Originally it was proposed that the project would serve 30 teachers. However, the timing of the workshop seemed to be problematic to some of the school districts. As an example, at the last minute six teachers from one school district all backed out of the project for unnamed reasons. Even with the lower numbers, we were given permission by Laura Vedenhaupt to continue with the project as planned. We remained true to the intent of the program in that 9/23 (39%) of the participants were from high-need districts. It should also be noted that the project include one middle school principal and special education teacher. The project benefited from their insight and unique perspective from these two individuals.

By projects end between the week-long workshop, evening and Saturday meetings during the school year, and math & science competitions the participants had about 100 hours of contact time with the faculty of the project. There was additional time spent with individual participants by phone or email discussing technology problems or project ideas.

Project Activities

In late June (June 26 – July 1), a week-long workshop was held in which the teachers engaged in the hands-on activities and problem-solving sessions in the areas of chemistry, physics, astronomy, and meteorology. The workshop schedule is attached as Appendix A. It should be noted that in the proposal the workshops were scheduled to be 2-day workshops scheduled throughout the summer, but we wanted to be flexible. The teachers indicated to us that it would be more advantageous for them to have the workshop all in one week which is what we decided to do.

The workshop ran from 8 am – 4 pm on Monday through Friday and from 8 – noon on Saturday. It was very fast paced. There were many topics with a lot of material to cover. Again, see Appendix A. A curriculum guide used for the project is also included with this final report as Appendix B. The curriculum was designed in two parts: activities and problem sets. The activities portion of the curriculum contain explicit instructions on the materials and procedures required to do the activity. The activities were designed to be as cost effective as possible, and they were designed to be immediately useful in the teachers' classrooms. The problem sets were designed more with the teachers in mind. Within the problem sets, the teachers were presented with a question or a problem to solve. They were given a set of materials but no instructions. It was up to them to brainstorm a solution. They had been through a brief discussion of the topic and the activities before having to face the problem sets. As an example, the teachers explored the topic of density and learned during the activities how the density of materials were measured. During the problem set portion of that topic, a group of teachers was given a common 3-hole brick and told to find the density. It was much larger than anything with which they had previously worked. They had a kitchen scale with which to measure mass. However, they had to brainstorm how to find the volume. The brick was too large to fit into a conventional graduated cylinder. Some settled on using water displacement in a larger vessel. Others decided to measure the brick ultimately taking into account the holes. Most of the teachers commented on how the problem sets "stretched" them quite a bit. We assured them that that indeed was the purpose of the exercises. The teachers noted how some of the problem sets could easily be adapted for use in their classes.

Admittedly, the curriculum guide contains a lot of different topics. Perhaps covering this amount of information was a bit ambitious. However, we wanted to give all of the teachers as many opportunities as possible to grow and learn. The teachers were some of the most enthusiastic with whom we have ever had the opportunity to work. They were very active participants who were willing to try new things and "hang in there" even when there were problems with some of the activities and technology. One small but significant indication that the teachers enjoyed the workshop was the fact that they wanted to design a T-shirt for the week. This fun idea allowed us to promote the program in an unexpected way as we and the teachers wore the shirts and talked about the program.

During the school year, we had about 10 monthly after school meetings with the participating teachers. During these meetings we discussed science topics of current interest to the teachers especially those in which they were continuing to find difficult or that were soon coming in their curriculum. The topics of our discussions included weather, simple machines, sound and optics, and chemical and physical changes. One of the after school sessions was reserved for participants to actually build simple machines including a lever, inclined planed and pulley system. Many of the teachers commented particularly on how their students enjoyed getting hands-on experience with the machines. Additionally, several of the teachers took advantage of bringing students to the Morrison Observatory at Central Methodist University for public viewing nights. Along with being able to view the stars and planets, our project student faculty members made hands-on physical science activities and demonstrations available for the attendees.

A significant portion of the workshop and some of the after school sessions focused on use of Texas Instruments Calculator Based Lab (CBL) systems. The CBLs allowed the teachers and their students to collect and analyze real time information using a variety of sensors including pH, force, motion, sound, and pressure. During one of the after school sessions the teachers were lead through activities in which different distance vs. time curves were drawn on the board. They then had to recreate those graphs with their own body movements using a motion sensor. They explored the concepts of linear and nonlinear motion in creating both straight and curved lines requiring constant and

changing velocities, respectively. This lead to a discussion of the motion produced by following objects as a result of the acceleration due to gravity.

One after school sessions was devoted to discussion of the creation of a middle school math and science competition. Materials were collected from teachers and the CMU faculty went to work creating 4th-5th grade exams in math and science and 6th-8th grade exams in math and science. Area schools were invited to bring as many 4-member teams as they liked to the competition. For this first year, the exams were strictly a paper and pencil tests. After having to reschedule the event twice due to poor weather, the competition was finally held in April 2007. There were about 100 participants from 6 schools that took part in the competition. Awards were given for the top three scoring teams in each division as well as a grand champion prize for the overall high scoring team. The teams and the teachers were highly enthusiastic about the event and all said that they wanted to return next year. Indeed, we plan to hold the event again. With the acquisition of "clicker technology" for the CMU classrooms, we are planning to make next year's competition much interactive, perhaps more like "group Jeopardy."

The activities and projects within the workshop and after school sessions were related to grade level expectations in Strand 1, 2, 5, 6, 7, and 8. Our project encompassed grades 4 through 8 which entails a broad range of topics and ability levels. It can be easily seen by looking at the workshop schedule and in the curriculum guide that specific activities were presented dealing with following concepts:

Strand/Concept	4th	5th	6th	7th	8th
1	Mixtures Electrical Circuts		Changes in matter Light and Sound	Heat, Electricity, and Magnetism	Physical and Chemical Properties and Changes
2	Laws of Motion	Work and Simple Machines		Force, Motion, and Work	
5		Weather		Weather and Climate	Rock Cycle and Plate Tectonics
6		Solar System			
7	Inquiry	Inquiry	Inquiry	Inquiry	Inquiry
8	Technology	Technology	Technology	Technology	Technology

As stated earlier, the activities in the curriculum guide dealt primarily with the science specific concepts while the problem sets allowed teachers to explore concepts in more of an inquiry-based fashion. They were required to develop their own methodologies for examining many of the questions in the problem sets. Lastly, the use of the CBLs addressed technology applications in the classroom.

While it was our intension to present the outcomes of our project at a conference such as Interface or the Missouri Academy of Science meeting as we have done in years past, the timing of those meetings was such that other responsibilities of the university faculty prohibited their attending. The participating teachers were encouraged to attend those meeting and perhaps give a presentation regarding their experiences. However, we found that most were still too uncomfortable to "stand and deliver" to their peers.

Local newspapers did report on the project activities and the math and science competitions that resulted from the project. We had very good response from individuals in the community as well as a few teachers asking if we would be doing similar projects in the future in which they could participate. The additional interest very encouraging.

Project Objectives and Outcomes

Objective 1: To improve student achievement in mathematics and science content areas.

While the program focused on working with teachers, the ultimate goal of the Improving Teacher Quality Grant Program is to increase student knowledge and ability in science and mathematics. We were fortunate to make arrangements with Dr. Marilyn Rhea who directs the PRISM project at Northwest Missouri State University to use 4th – 8th grade physical science pre/post tests that she has developed in her project. We believe that these assessment tools gave us valuable information as well as hopefully providing Dr. Rhea with comparative data for her project.

The PRISM tests were specifically written to address benchmark items within particular standards. Specific questions are not included in this report to protect the security of the PRISM exams. The exams were scored such that 90% was considered advanced, 80% was proficient, 70% was nearing proficient, 60% was progressing, and below 60% was below basic. There were increases, but they were marginal. The primary increases seen were from "below basic" to "progressing." However, there were several "nearing proficient" to "proficient" and "proficient" to "advanced" increases noted among the students. It should be noted that only three of the schools participated in allowing us to administer the exams to their students.

Objective 2: To increase teachers' knowledge and understanding of key concepts in targeted math and science content areas.

The first day of the workshop began with a general introduction of the grant faculty and of each participant. The teachers were then asked to complete registration forms and take the pretest designed for the project. The pretest was composed of 30 multiple choice questions written by the CMU faculty in the areas of physical science listed above and mathematics. The average score on the pretest was 20/30 (67%). As a point of comparison, this exam was also given to a group of freshman enrolled in the Concepts in Physical Science course at Central Methodist University. The 25 students in the course scored an average of 13/30 (43%).

At the conclusion of the workshop the teachers scored an average of 25/30 (83%) on the posttest. It should be noted that 22/23 of the teachers showed on improvement from their pretest score. In May 2007, at the end of the project, the teachers were again given the posttest. The average score at the conclusion of the project was 23/30 (77%). It was clear from these results that the majority of the teachers retained most of the knowledge that they had learned during the project.

The project to date has been fruitful in accomplishing the goals of increasing teacher knowledge and use of science, math and technology in their classrooms. It has also been very productive in establishing good working relationships between the university faculty and the middle grade teachers. Regardless of funding opportunities we are committed to continuing to build strong relationships with these and other area teachers.

For their efforts the teachers were given a total stipend of $750 and 3 hours of graduate credit from Central Methodist University. While there were some travel expenses that were defrayed with the stipend, many of the teachers used a significant portion of the stipend to provide materials and/or equipment for their classrooms.

Objective 3: To improve teachers' pedagogical knowledge and practices that utilize scientifically based research findings and best practices in inquiry-based instruction.

A major focus of the project was on the use of CBLs and the effectiveness of student learning with data collection through the use of sensors. The TI-CBL systems are hand-held battery-operated data collection devices with more than 40 different sensors that can be used to collect and analyze real-time data. There is more and more research showing that increased use of sensors within science classes is helping students improve tests scores. This increase in scores is attributed to increased comprehension as students are allowed to explore concepts by collecting, analyzing and drawing conclusions from data they have collected.

The teachers were given instruction during the summer workshop and additional instruction and practice time in the after school sessions on using the CBL technology. The teachers grew more and more comfortable with the technology and used the

technology within their classes. While one year was insufficient time to collect empirical data, we completely agree that students can't help but gain a greater understanding of science and math concepts if they are able to design their own experiments and collect and analyze their own data. It can be noted that upon a more detailed analysis of the middle school students' pre and post test results that some of the largest improvements came in the area of scientific inquiry which could support the claims that the use of technology increases students' reasoning abilities.

Objective 4: To enhance teachers' use of assessment data to monitor the effectiveness of their instruction.

While the project modeled for participants the idea of pre and post testing of concept comprehension, we did not require the participating teachers to incorporate this model into their classes. The middle-grade teachers work under very restrictive time constraints and most elected not to develop pre/post tests for their activities. Had the project faculty had more time, we could have been more proactive in helping the teachers design specific pre/post tests for their classes.

With all of that said, at the very least, the teachers were introduced to concepts and activities that they could use directly with their students. Many of the teachers had very little physical science experience. Therefore, they tended to be more comfortable teaching life science versus physical science concepts. This is reflected in a classroom practice inventory where on average teachers rated their comfort in teaching life sciences at 4/5 (on a 1-5 scale) versus teaching physical science at 3/5. Interestingly enough, the teachers indicated that they very much enjoyed learning more about physical science concepts rating an average of 4.7/5 on the practice inventory. The end-of-project teacher evaluations indicated that after the year long program the participating teachers were admittedly much more willing to introduce their students to these physical science concepts and to do the activities and demonstrations with their students. The teachers were much less afraid of the question "why". The project focused on getting the teachers to do more science which is obviously necessary before they can begin to accurately assess their math/science instruction.

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

Through previous grants funded through the Eisenhower Programs, we were able to develop a new course at Central Methodist University entitled "Concepts in Physical Science". This course is now required of CMU elementary education majors. Within this project, we had two undergraduates working with us. One of the students was a pre-service physics education major and the other was a math major. The physics education major graduated at the end of the fall semester and began working in a small rural school district. He immediately put into practice some of the activities, problem sets, and technology that he had experienced in the project. The school district was so impressed with his abilities that they stretched their budget to provide him with additional materials needed to continue application of activities and technology within the classroom.

Current and past students, especially undergraduate education majors, were positively impacted by this and previous programs. They were introduced to the latest possible science technology available for K-12 teachers. They witnessed first hand professionals from a variety of disciplines – chemistry, physics, and education – working very closely together to outline topics and techniques of instruction. They began to understand more fully the benefits of collaboration. They learned that they didn't have to be "afraid" to call one of the university faculty to ask questions or explore ideas. All of these things helped them to be not only certified but qualified to provide the best possible science instruction.

Evaluation Comments and Responses

The external evaluation team indicated at the end of the workshop that they were very impressed by how engaged the participants were in the project and how good the working relationship was between the project faculty and the participants. They did have three primary points of concern. They indicated that we tried to do too much with the teachers in a short amount of time. While we admit that there was a lot of material, again we wanted to give the teachers as much useful information and activities as possible. We did adjust the workshop schedule to accommodate their needs. The teachers indicated that they would like to spend some additional time with the CBL technology. They indicated that they really didn't do that much with the acid/base topic in their grade level. We decided to forgo coverage of that material on Wednesday to make more time for the technology.

The evaluation team was concerned that our teaching style was to give a brief lecture over the topics before the participants worked on the activities and problems. They pointed to literature that indicated that the teachers should be allowed to explore the activities first and then have their learning reinforced with lecture information. While a purely constructivist style of teaching has its merits, we have found that with little to no previous information on or experience with the topics the teachers had no idea of where to begin or what to even expect from the activities and problems. While some time for students to think and even flail can be productive, if it only leads to frustration or a complete misunderstanding of the point of the exercise then we would submit that it doesn't promote effective learning. We are strong proponents in having students experiment and try variations on the design and implementation of an activity. However, a little bit of knowledge up front can make those explorations very fruitful. We believe these brief lectures are particular important if the students have only a limited amount of time with the exercises. If they had an unlimited amount of time to continue to work on and study an activity or a problem, then perhaps the pure constructivist style would work. However, we have found anecdotally that it is very beneficial to give a little bit of information that can at least get the participants – be they teachers or our own students – "thinking in the right direction."

Lastly, the evaluation team indicated that they would like to see our curriculum guide aligned with the state standards. We agreed wholeheartedly. We want the teachers to have a curriculum guide that is as easy to use and as useful as possible. One of our project faculty, a middle-grade teacher, has volunteered to align all of the activities within the curriculum guide. Once completed we will either produce a revised curriculum guide or an addendum indicating the particular alignments. This portion of the project is still underway. We remain committed to getting this updated information to the teachers as soon as the alignment is completed.

Conclusions

As stated earlier the testing at the end of the project indicated that the teachers had retained knowledge through the course of the project and that some of their students have increased their knowledge and abilities in science. From teacher testimonials we know that they are at least beginning to do more and more physical science activities within their classes. They are using the technology to introduce students to data collection and analysis for the purpose of constructing knowledge and solving problems. While we would admit that perhaps we tried to cover to broad of a range of topics, we submit that every teacher in our broad 4th – 8th grade population was given at least some activities and ideas to take back into their classroom.

As in the past, we remain committed to partnering with area teachers to help in any ways possible increase their knowledge, abilities, and access to help for their students. We believe that through our development of math and science competitions and science fairs that we will provide both teachers and students with environments and opportunities for growth and testing of their grow in the areas of physical science.

We submit that we have reasonably met most of our goals in increasing both student and teacher comfort with and knowledge of and abilities in physical science. We have help the teacher's pedagogical knowledge and practices through the use of inquiry-based technology in their classes. Lastly, we have positively impacted the preparation of pre-service education majors as well as general math/science majors by having them work in the project and interact with the teachers. The participating teachers and undergraduates were able to share information which was mutually beneficial for both.

Central Methodist University is proud to have received funding through the Improving Teacher Quality Grant program. We are committed to maintaining and further nurturing our relationships with local schools. It is our belief that we have and will continue to make a positive difference in STEM education in our area.