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Inquiry Science Professional Development Combined with a Science Summer Camp for Immediate Application

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This study evaluated the effectiveness of an intensive three-week science institute for preservice and inservice elementary teachers that was funded by an Eisenhower Professional Development grant and a Regents' Initiative Research grant. The institute was held in combination with a summer science camp for elementary children. Pre- and post-assessments indicated an increased level of comfort with inquiry-based teaching, as well as an increase in content and pedagogical knowledge. On an open-ended questionnaire, the teachers indicated that the opportunity for immediate application of their own learning with children in the camp was a valuable part of the program.

Elementary teachers rarely use inquiry-based science teaching. Although this area has been an ongoing focus of efforts by many science educators, efforts to provide professional development for inservice teachers have varying levels of success depending on the types of activities undertaken. The Dwight D. Eisenhower Mathematics and Science professional development model followed in Texas includes many of the facets of effective professional development identified by researchers (Klein, 2001; Loucks-Horsley, Hewson, Love, & Stiles, 1998; Stiegelbauer, 1994). The program described here is one project funded through this model.

The project included a three-week summer institute where preservice and inservice teachers learned about Newton's Law and the physics of flight in an interactive, hands-on mode and could immediately apply their knowledge with elementary students. A key aspect for teacher change came from reflecting upon how they might use their knowledge and skills at some future time. The elementary students experienced authentic science instruction and learned actively while whetting their interest in science.

The course design and camp activities were guided by the tenet of the National Science Education Standards that students, engaged in inquiry learning, "develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world" (National Research Council, 1996, p. 23). The course included content instruction, hands-on learning of the activities that would later be taught to the students, a component on teaching learners who represent diverse socioeconomic and cultural backgrounds, a component on

teaching children with diverse learning abilities and needs, and a component on crosscurricular integration with an emphasis on reading, writing, and mathematics.

Corresponding with the summer institute was a science camp for second through sixth grade students in the partnering school districts. They attended the camp for four hours per day for seven days. Two to three teachers worked as a team to facilitate the instruction based on learning activities they had recently completed in their coursework. The opportunity to team-teach in a small group was intended to provide a relatively safe atmosphere for trying out inquiry-based science. Each day, the teachers alternated half the time teaching in the camp and half the time learning new material with the institute instructors. While five of the teaching teams were in class, the other five teams were teaching the elementary students who were divided into groups of eight or nine.

Several studies indicate that science teaching attitudes and beliefs are influenced by teachers' own science learning experiences enhanced by reflective practice (Bell, 2001; Chambers & Stacey, 1999; Riggs & Enochs, 1990; Swafford, Jones, Thornton, Stump, & Miller, 1999). Since these experiences influence what teachers believe about teaching and their ability to teach, their beliefs may be a major factor in science education reform (Lumpe, Haney, & Czerniak, 2000). Although teachers usually report that they enjoy engaging in hands-on instruction as learners, this does not always lead to changes in teaching practices (Baird, Ellis, & Kuerbis, 1989). The intent of the project's concurrent professional development and summer camp was to provide an immediate opportunity for teachers to implement their newly gained knowledge and skills. A similar program found that this format was highly valued by teachers (Greenwood & Haury, 1995). Learning experiences at teacher institutes and student camps were based on active exploration with concrete objects and the building of knowledge through shared discourse.

This study evaluated the success of this professional development program in which preservice and inservice teachers engaged in hands-on, inquiry-based science learning and had the opportunity to apply their learning by working with students in the concurrent science summer camp.

Methods

Twenty-one female and one male K-8 teachers (17 inservice and 5 preservice) were participants in the summer institute that included enrollment in a university course. The teachers' levels of experience ranged from novice (preservice) to 20+ years. The inservice teachers were all public school teachers in rural or suburban schools with the exception of one teacher who taught in a private school in an urban area. The majority of the teachers taught in self-contained classrooms and had teaching specializations in areas other than science. The 42 child participants were evenly distributed with regard to gender. They represented about 1% Asian, 4% Hispanic, 1% African American, and the balance were Caucasian. About 47% were of low socioeconomic status.

Several measures were used to assess participant knowledge, beliefs, attitudes, and performance. An adaptation of the Science Teaching Efficacy Belief Instrument (STEBI-B) (Riggs & Enoch, 1990) measured general beliefs and attitudes about science and science teaching. The STEBI-B was modified to include four additional questions on comfort with open-ended questioning, open-ended student assignments, and the assessment of open-ended assignments. An

instructor-designed content test measured knowledge gained during the institute, and a performance-based test measured science process skills and application of content knowledge. In addition, participant journals and open-ended responses on the course evaluation instrument provided qualitative data.

Program Analysis and Findings

Nineteen out of the 22 participants demonstrated an increase in content knowledge as measured by the pre-/post-content test. A t-test indicated a significant difference with an average pretest score of 10.8 and an average posttest score of 14.1 out of a possible 21 points. Scores on the performance test tended to be high, with many participants increasing their score with an average increase of 0.5 points for the group. A comparison of total pre- and post-assessment scores on the modified STEBI-B indicated an important improvement in beliefs and attitudes toward science and science teaching. No significant differences were found on either the outcomes or expectancy scales, however. The following table summarizes the pre-/posttest results.

Table 1
Pre-/Posttest Results

Instrument	Mean Increase	Significance Level
Instructor-Designed Content Test	3.3	.05
Instructor-Designed Performance Test	0.5	.10
Modified STEBI-B	0.11*	.20

*Difference on average response not total score

Surveys, journal responses, and evaluations of the summer science institute indicated a positive shift in beliefs and attitudes toward science and inquiry-based science teaching. The inservice teachers were more likely to indicate intent to implement inquiry-based science into their teaching practices.

Comments on evaluations indicated that some of the teachers' concerns had been mitigated by their own learning experiences:

I was happy to see students love doing science.

It helped me to know that science can be fun and isn't too difficult.

Science seems less complex and fearsome.

All respondents indicated that one of the most important benefits was an increase in science knowledge:

This science camp has presented many challenges for me as a seasoned teacher. . . . The inquiry method causes the students as well as the teacher to become higher-order thinkers.

I really learned a lot from the inquiry learning lessons.

I really enjoyed the science content. They were hands-on and very fun.

Journal responses from some of the inservice teachers indicated concerns about inquiry-based teaching, raised confidence, and increased knowledge.

I have begun to see new ways of motivating and teaching my students in the classroom that will correlate all subjects.

(Pre summer institute journal) *I was a little nervous about this class. When I was in school, science wasn't "fun." It was a lot of bookwork without much hands-on. I grew up believing that science and experimenting were dangerous.* (Post summer institute journal – same individual) *I do not feel the* (content) *test showed how much I learned. It didn't have a place to put what I now know about cabbage juice indicators, pH, bubbles, roller coasters, and bouncing balls. I never would have believed all the things I would get (ideas) from these two weeks. I am much more comfortable with science.*

Inquiry teaching is not easy. My mouth wants to tell all. I see students learn more and understand best if I allow them to discover. I have learned to ask questions leading to the answer rather than giving the answer.

Hands-on and inquiry are not the same thing.

Students understand better when they experience the concepts.

I can see how the students learn much more from this approach rather than a lecture approach.

Participant evaluations of the summer science institute indicated that their expectations of learning science activities to motivate their students and how to manage and implement inquiry-based science in their teaching practices were more than adequately met:

I learned new ideas and extension activities for teaching science.

I learned new ideas to spark the interest of my students in science.

Learning new things to interest kids in science was invaluable.

The institute went well beyond what I hoped it would be.

I'm much more excited about teaching science.

Teaching and learning science can be fun. It gave me ideas on how to bring experiments into the classroom.

Overwhelmingly, the participants indicated that one of the greatest benefits of the institute was the opportunity to work with partners and to try the experiments and lessons with small groups of children:

". . . being able to try ideas/experiments with children so I could make modifications and anticipate behaviors . . ."

Collaborating with a partner, the exchange of ideas, and shared responsibility helped me to be more confident and made the experience more interesting. I witnessed firsthand how children enjoy this way of learning.

Implementing the activities with children was an invaluable experience.

This class has been one of the best classes I've taken. There is nothing like learning something then practicing it on a kid. You can sit in a class all day and have all this stuff thrown at you and you don't learn as much as we are learning when we have actual guinea pigs to practice on.

The participants' views of science and science teaching were affected appreciably by their experiences:

The institute has given me an increased understanding and appreciation of how science can be taught.

Science seems less complex and fearsome. I have more confidence.

Teaching science is feasible, even in a class of 30.

It opened my eyes. There's not just one correct way to achieve a goal.

I am less fearful and more confident.

I was apprehensive before, now I look forward to teaching science.

I'm more open and feel more comfortable teaching using inquiry techniques.

Inquiry will cause me to use questions that cause students to think.

The participants indicated that their summer institute experiences influenced their views of how their students understand and learn science:

They will remember what they have learned with hands-on learning.

Students can apply what they learn, not just spit out facts.

Students use a higher level of thinking than with worksheets.

The more they can "do" it, the more they can understand it.

The camp experiences showed me that students are smarter than I thought; they come up with ingenious ideas

Hands-on will motivate students.

After working with the students, it is obvious to me that even lower achieving students can gain an understanding by using inquiry.

Safety and structure creates a deeper learning environment that fully engages students in learning.

All hands-on learning is not inquiry.

The teachers were asked to compare their perceptions of teaching and learning science through inquiry and note any changes from the beginning of the institute to the end of the institute:

I dreaded science before; now I see how much fun it can be.

Our experiences of using inquiry eased my concerns.

Implementing inquiry in my classroom may not be so difficult.

I feel more comfortable letting students do a lot of the learning process themselves.

I feel more comfortable about teaching by inquiry because we were shown how inquiry works and then we practiced what we learned.

All measures used to evaluate the preservice and inservice teachers' beliefs and attitudes showed that they experienced improved confidence and attitudes toward teaching inquiry-based science and understood its value for their elementary students' learning. Overall, participants expressed beliefs that their science content knowledge had increased; they had greater confidence in science teaching; their understanding of inquiry-based science teaching increased; and they intended to teach active, inquiry-based science lessons more frequently in their classrooms.

The participants overwhelmingly indicated that the program met their needs, and they were better prepared to teach inquiry-based science. The opportunity to quickly apply what they were learning was a key factor that will make it more likely for them to implement the knowledge and skills in their classrooms during the academic year.

Further examination of this program and other similar programs will provide insight into their effectiveness to positively influence elementary student learning in science, as well as the sustainability of apparent changes in teacher beliefs, attitudes, and practices regarding science and science teaching. Following participants into their classrooms and determining if their beliefs and attitudes actually impact their teaching practices would further validate the results of this evaluation.

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