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The Impact of a Professional Development Program on Elementary Teachers' Science Knowledge and Pedagogical Skills

Maria Madalena Ferreira

College of Education, Wayne State University

281 Education Bldg., Detroit, MI 48202, United States

E-mail: m.ferreira@wayne.edu

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Abstract

Teacher professional development plays an important role in a teacher's growth and every year school districts spend a large portion of their budgets in professional development activities. However, as districts face increasing budget cuts, funds for professional development compete against other district priorities. As a result, partnerships between school districts and teacher training institutions can play an important role in supplying school districts with professional development activities to fit their teachers' needs. This article describes a partnership between a school district and a local university to provide over 100 hours of professional development to 30 elementary school teachers. Results from the evaluation of the program indicate that the program had a significant impact on participating teachers' perceptions of their science knowledge and pedagogical skills.

Keywords: Professional development, Elementary education, Teachers, Science

1. Introduction

Teacher quality requires that teachers possess the knowledge and skills in the discipline they teach (Blank & Alas, 2010; Margolis, 2008). Although teachers acquire such skills during their certification program, professional development plays an important role in a teacher's future growth. According to Margolis (2008), teachers need opportunities to enhance their knowledge and skills, sustain their motivation, and widen their collaborations with others in the profession. Guskey (2009) stressed that: "No improvement effort in the history of education has ever succeeded without thoughtfully planned and well-implemented professional development activities designed to enhance educators' knowledge and skills" (p. 226).

Professional development is particularly critical for beginning teachers who need to become familiar with the norms of the profession. Indeed, teachers who leave the profession often mention lack of professional development as one of the reasons for their decision to leave (Futernick, 2007). Professional development can also facilitate teachers' access to increasing leadership roles. This is especially important to teachers who are in the last stage of their career and whose commitment and motivation might be declining (Day & Gu, 2007).

However, professional development activities also vary in their level of effectiveness. According to Lieberman and Mace (2008), teachers often find professional development activities fragmented and irrelevant to the problems of classroom practice. As a result, professional development is most useful when designed to fit teachers' needs (Zepeda, 2008). For example, novice teachers have different professional development needs than their more experienced colleagues, as do elementary teachers when compared to their secondary counterparts (Boyle, While, & Boyle, 2004). Elementary teachers are expected to teach all subjects when assigned to self-contained classrooms and developing the necessary knowledge and skills in all the content areas is difficult to achieve during their certification preparation (Mensah, 2010). As a result, elementary teachers without a major or minor in science often shy away from integrating science activities in their teaching repertoire (Mensah, 2010). Consequently, professional development activities must empower these teachers with science content and pedagogical skills and the realization that teaching science does not have to compete with reading, writing or mathematics (Blank & Alas, 2010; Mensah, 2010).

Research examining the impacts of professional development indicates that when well conceptualized, professional development can play a significant role in teacher and student outcomes (Blank & Alas, 2010; Glazer & Hannafin, 2006; Holmstrom, 2010). A meta-analysis of the research on the impact of professional development in mathematics and science indicated that professional development in these areas had a significant impact in teacher development and student achievement (Blank & Alas, 2010). However, such professional development activities are most successful when they focus on subject content as well as pedagogical knowledge and are at least 6 months in length (Blank & Alas, 2010). Successful professional development strategies also include active learning in which teachers participate with others in meaningful activities (Supovitz, 2002). These types of activities foster engagement and active participation, which in turn facilitate the development of a community of practice (Lave & Wenger, 1991; McNamara, 2010; Supovitz, 2002). As indicated by Glazer and Hannafin (2006), teacher development increases when teachers work together in a common setting and toward a common goal.

School districts across the nation are aware of the importance of professional development to the professional growth of their faculty. Indeed, every year school districts spend a large portion of their budgets in professional development activities. According to a report from the National Center for Educational Statistics, public schools spend around 20 billion dollars annually in professional development activities (NCES, 2008). However, the current budget cuts facing most school districts force them to make difficult choices regarding the allocation of their limited funds.

1.1 University-School Partnerships

Partnerships between school districts and local teacher preparation institutions can help offset a school district's costs related to professional development. Collaboration in the identification of sources of funding and design of professional development activities, can save a school district significant funds and tailor the professional development to the district's needs. Teacher professional development activities often focus on developing skills in specific content areas such as science; pedagogical content knowledge; classroom management and the integration of technology in the curriculum. However, school districts are not the only ones benefiting from such partnerships (Chorzempa, Isabelle, & de Groot, 2010; Cozza, 2010). For example, local schools often serve as the setting for pre-service teachers' field experiences and as contexts for faculty research projects. Other benefits include collaborations in the development of college readiness programs and in the establishment of school to university pipelines (Cohn, 2010; Ek, Machado-Casas, Sanchez, & Alanis, 2010). These examples illustrate the "mutualistic" or "symbiotic" (Chorzempa et al., 2010: p. 307) nature of many partnerships between school districts and universities, particularly those with large teacher certification programs.

According to Mountford (2005), successful partnerships foster institutional renewal in the partnering organizations and lead to a collaborative culture based on trust, mutual respect and accountability. The program described here is the result of a partnership between a large urban school district and a local university.

1.1.1 Aim of the Study

The purpose of this study was to examine the impact of a professional development program on a group of elementary teachers' science content and pedagogical knowledge.

2. Method

This study used a mixed methods design that included quantitative and qualitative approaches to data collection and analysis (Creswell, 2015).

2.1 Context and Participants

The program took place at a large, research intensive, urban university located in the cultural center of a large city in the mid-west of the US. The university had a student population of nearly 29,000 students and offered 370 academic programs through 13 schools and colleges. The College of Education offered teacher certification programs at the elementary and secondary levels and was the main teacher certification institution in the area with a student population close to 3,000 students.

The school district was the largest in the state and 22nd in the nation and at the time of the study it was undergoing significant restructuring under the leadership of a state appointed emergency financial manager. As part of this restructuring the district was closing many of its schools due to the loss of about half of its student population (70,000), as many of the families moved out of the city or placed their children in the many charter schools that had been established throughout the city and its surrounding area. Over 80% of the students were African American

and received free or reduced lunch – an indicator of their low socioeconomic status.

The program targeted a group of elementary teachers (grades 3-5) that district partners identified as having the greatest need of professional development: those without a science major or minor, teaching in self-contained classrooms, in schools that had not made adequate yearly progress (AYP). Thirty teachers from eleven elementary schools volunteered to participate in the program. All the teachers, except one, were female and 63% of them were African American.

To protect the participants' anonymity, a code composed of a letter and a number was assigned to each participant. The letter represented a particular school, whereas the number denoted a specific participant within that school.

2.2 Background on the Partnership

This project was the result of a Title II grant from the Department of Education to implement a professional development program for elementary teachers. The program was designed in collaboration with the school district and included the following four components: (1) one week of all-day workshops addressing various aspects of pedagogy such as teaching through inquiry, alternative forms of assessment, classroom management, and technology integration; (2) one week of all-day workshops on a variety of ready-made, integrated curriculum that could be easily implement in the classroom; (3) a semester long course on earth/space science; and (4) a semester long action research academy.

2.3 Program Implementation

During the summer the teachers participated in a two-week series of workshops (5 days/week; 6 hrs/day). The first week focused on pedagogy (constructivism and inquiry, alternative forms of assessment, classroom management, technology integration and locating resources, including small grants for teachers). The second week provided training on outdoor and environmental education support curricula such as Project Wild/Wild Aquatic, and three units of the Michigan Environmental Education Curriculum Support (MEECS): Ecosystems and Biodiversity, Energy, and Land Use. These resources were chosen because they provided participants with readymade lessons that integrated other areas of the curriculum in addition to science. Participating teachers received free copies of the Project Wild books and all the instructional materials related to each unit of the MEECS. Teacher collaboration permeated all the workshop sessions as they worked in groups to explore approaches to implement activities in their classroom.

During the following fall semester the teachers participated in a 3-credit hour earth/space science course. The course had been included in the professional development program because district students usually scored the lowest on concepts related to earth/space science in the state standardized tests. In addition to covering basic concepts related to earth and space science, the course provided the teachers with inquiry-based activities that they could take back to their classrooms to explore such concepts with their students. Funds from the grant were also used to buy instructional materials related to the earth/space science topics covered in the course. Each participating school received the following materials: an outdoor

weather station, weather activity kit, star theater, rock formation and identification kit, a solar system model and a physiographic relief globe.

In the following semester the teachers participated in an "action research academy" in which they became familiar with action research, how to use action research to examine one's practice, and approaches to data collection and analysis to support action research. The teachers were grouped into teams based on school or research interest and identified a "problem" related to their school or their practice that they wanted to investigate using action research. Participants read some of the literature on the topic related to their research problem and designed an action research study, which they implemented. At the end of the semester they shared the results of their action research projects in a conference style presentation.

2.4 Data Collection and Analysis

A four-point Likert-type survey from 1 (not adequately prepared) to 4 (very well prepared), developed by the program evaluator, was used with the participants to rate their level of preparedness (before and after the implementation of the program) to teach concepts related to the areas in which they received professional development, as well as the pedagogical approaches they used with their students. The Cronbach's alpha reliability coefficient for the survey was .83. Paired sample *t* tests were used to determine any significant differences between their "before" and "after" program ratings with statistical significance determined at $p < 0.05$.

Electronic portfolios were also used to collect additional data related to the impact of the program on teachers' practice. Participants used electronic portfolios to record their reflections on the extent to which the professional development activities impacted their teaching practice by describing their practice in various areas "before" and "after" participating in the program. These qualitative data were analyzed using techniques of naturalistic inquiry (Lincoln & Guba, 1985; Miles & Huberman, 1994). As data were read several times, individual segments of data were coded and similar codes grouped into themes.

3. Results

Pre and post program comparisons indicated the program had a significant impact on the participating teachers' perception of their level of preparedness to teach concepts related to life, earth/space and environmental science. Results also indicated their willingness to shift their pedagogy from teacher-centered to a more student-centered approach.

3.1 Impact of the Program on Participants' Perception of Their Science Knowledge

As indicated in Table 1, there was a significant difference in teachers' perception of their knowledge, before and after participating in the program, of science concepts related to: organization of living things, ecosystems, and major topics in earth and space science (geosphere, hydrosphere, atmosphere and weather, and the solar system).

Table 1. Teachers' perception of their science knowledge: Pre- and post-treatment

Science topic	Pre-treatment mean	Post-treatment mean	Mean difference
Organization of living things	2.11	2.56	0.45*
Ecosystems	2.63	3.30	0.67*
The geosphere	2.04	2.62	0.58*
The hydrosphere	2.04	2.50	0.46*
The atmosphere and weather	2.79	3.21	0.42*
The solar system, galaxy & universe	2.61	3.25	0.64*

Note. $^{*}p < .05$.

Qualitative data support the results from the surveys. When commenting about the earth/space course one of the teachers wrote: "The course filled a whole in the amount of information I had about Earth Science. I feel a lot more comfortable and prepared to work with my students." Another one wrote that she had "learned a lot [she] did not know before about energy;" while another one pointed out the "amount of science content useful for the classroom was great."

Not only did participants feel the workshops extended they science knowledge, they also felt empowered to teach many of the concepts in which they received professional development because of the read-to-use activities or full lessons they had received and/or developed. One of the participants commented she had "received in-class activities that were readily adaptable to implementing in the classroom − extremely helpful!" Another stated she had "already implemented many of the activities."

The teachers were particularly excited about the Project Wild/Aquatic Wild and MEECS activities, which integrated science with other areas of the curriculum. When commenting on the value of the Project Wild/Aquatic Wild workshops, one of the participants wrote: "This workshop should be available to all science teachers I will use these activities next school year; the kids will love them and they can't help learning as they do them." Another one added: "I received a lot of information to use in my class and I cannot wait to do some of the activities." Similarly, another teacher commented that [she] "will use this [Project Wild activities] as part of our plan for becoming a Michigan green school."

Participating teachers were similarly excited about the ready-to-use activities they received as part of the MEECS units. According to one of them the activities were "easy, friendly hands-on activities. The kids will love them." Another teacher wrote: "Great workshop! Can't wait to do these lessons!" Another teacher felt the activities were also great for her school's science club: "I will use this information with grades 4-6 and science club."

3.2 Impact of the Program on Participants' Perception of their Pedagogical Knowledge

After participating in the program, the teachers also felt better prepared to facilitate problem solving among their students; help their students make connections within and between science topics; make connections from science to real-world situations; engage their students in hands-on/project-based activities; help their students take responsibility for their own learning; encourage their students to communicate scientifically; and embed assessments in regular class activities (See Table 2 below).

Table 2. Teachers' perception of their science pedagogical skills: Pre- and post-treatment

Science topic	Pre-treatment mean	Post-treatment mean	Mean difference
Involve students in problem-solving	3.21	3.61	0.40*
Help students make connections within and between science topics	2.93	3.37	0.44*
Help students make connections from science to real world situations	3.19	3.52	0.33*
Engage students in hands-on and project-based activities	3.07	3.50	0.43*
Help students take responsibility for their own learning	3.14	3.71	0.57*
Encourage students to communicate scientifically	3.23	3.85	0.62*
Embed assessments in regular class activities	3.48	3.96	0.48*

Note. $^{*}p < .05$.

The qualitative data support the findings in Table 2 and indicate teachers' increasing awareness of their teaching style and confidence in teaching science. When commenting on the first week of workshops, which had focused on pedagogy, one teacher summarized their value in the following manner:

The constructivism workshop helped me identify and define my teaching style. The assessment workshop made me more aware of how to use informal assessments. The technology workshop showed me how much is out there to find out about and use in the classroom. I did not know much about the science/math resource centers and I now have even more knowledge about grant resources. *Participant B 2*

Another teacher felt "stronger and more confident in presenting and demonstrating science to [her] students in a more constructive and fun way! " Similarly another teacher wrote: "The

classroom information was so valuable. It impacted my instructional style to examine my delivery of instruction."

Data from teacher electronic portfolios point to a shift in teachers' pedagogical practice from a teacher-centered to a more student-centered approach as illustrated in the following teacher reflections related to their pedagogical approaches "before" and "after" the professional development activities. These quotes illustrate three themes found in the teacher reflections: (1) a shift to a more interactive approach to teaching because of the ready-made curriculum and activities they received in the program; (2) feeling reenergized and supported in the use of a more constructivist approach to teaching; and (3) a greater sense of self efficacy in the teaching of science.

Before this program I was teaching in front of my class with the students sitting in rows and being taught from the textbook. They would read the chapter, copy the vocabulary words, write the definitions, answer the check point questions, and go over the end of chapter questions and answers. Now and during the program I learned lots of fun activities that I implemented in my classroom. I started using them right away to see if there would be different results in student learning. Students liked to come to science class and doing hands-on/minds-on activities. *Participant A 3*

I have always believed that if students are having fun, they will learn more. However, I have succumbed to the "old ways" of keeping students quiet and busy at all times because it is expected by most principals and coworkers. This project has encouraged me to return to my beliefs that school can and should be fun, hands-on, and project oriented. The children respond with great enthusiasm and excitement. They are more involved and I know they are learning by how they interact with purpose and intelligence. *Participant D 1*

Before participating in this program I was very uncomfortable teaching science. I was uncomfortable because I didn't have any organization. I was intimidated as I attempted to hold the kids' attention. The students would talk consistently during the lesson. I had to stop instruction constantly to correct behavior and the lesson didn't get taught. It became very difficult for the students who were interested, to learn. Parents began complaining that the classroom was noisy and their children didn't get enough homework. As a result of this barrage I felt defeated and I wanted to quit teaching science. Because of this program I'm comfortable teaching science and have learned how to communicate with the students more effectively and am better prepared. I no longer resist the lesson planning stage and I take more time to do it. I use the Internet more to look for lessons and creative ideas to enhance my lessons. I now use cooperative groups in the classroom so that the students can talk with each other about the assignments. The students are fully engaged, even productively debating to create and settle their own theories. *Participant C 3*

3.3 Impact of the Program in the Development of a Community of Practice

The results of this study also indicate the program facilitated the development of a sense of community among the participants. The amount of time the teachers spent together and the interactive nature of the professional development activities lead to the development of a

community of practice over time. Teachers learned from each other as they collaborated in assignments and shared ideas during class discussions. As pointed out by one of them: "I have learned a lot from other teachers through helpful dialogue." Another teacher wrote:

Each session of the workshop was very stimulating. I always appreciated the gathering of my colleagues to see how/what they were doing in their classrooms. The collaboration was very beneficial for keeping abreast with new ideas and techniques in the classroom. *Participant C 4*

Another teacher echoed similar feelings when she wrote that, "one of the most useful aspects of the professional development activities is sharing with other teachers; I don't usually teach science, so I enjoyed the exchange."

Collaboration and community were particularly important during the semester-long action research academy in which teachers worked in groups to address a problem related to their school or classroom. One of the participants commented that she "enjoyed working with my peers on critical issues that affected our school, diagnosing the problem and coming up with solutions." Similarly, another wrote that one of the most rewarding experiences in the program had been "working with my group collaboratively to find strategies and tools that will benefit our students." Another one felt that "working with my research committee weekly at Starbucks was a classroom within itself. Every time I came to study group I learned something new."

4. Discussion and Conclusion

The results from the program evaluation indicate the professional development program was successful in improving participating teachers' science content knowledge and pedagogical skills. These results were due in part to the sense of empowerment that elementary teachers began to feel as they participated in the professional development activities. Teachers learned science concepts using ready-to-use activities and supporting materials that they could in turn use with their students. As they implemented these activities in their classrooms and witnessed their students' engagement and interest, their confidence in their ability to teach science grew. Their sense of empowerment was further developed as teachers shared strategies with each other and collaborated in their action research projects. Collaborative problem solving is one of the core elements in teacher professional development, according to Supovitz (2002). In this program teachers collaborated with others in their school to identify a problem that they could examine using action research. For example, one of the schools had not achieved Adequate Yearly Progress (AYP) because of low student attendance. They examined school records to identify patterns in student attendance and found that student attendance was lowest during school half days and the day before a holiday. Based on this knowledge and in collaboration with their school administration, they implemented various strategies that led to a significant increase in student attendance. Another group worked with colleagues in the development and implementation of a common classroom management plan that helped students become more responsible for their own behavior. As these examples suggest, the collaboration led to a sense of shared purpose and facilitated the development of a sense of community in their school (Friedman, 2009; Supovitz, 2002).

These results also support other researchers' findings that teacher participation in professional development gives them opportunities to develop networks as well as improve a variety of skills (Borrero, 2010; Day & Gu, 2007). Like the teachers in McNamara's (2010) study, the teachers in this program enjoyed interacting with their colleagues in the professional learning community that developed over time.

Researchers (e.g., Blank & Alas, 2010) found that professional development activities are most successful when they focus on teacher needs and last a minimum of six months. The professional activities in this program took place over a 10-month period and were designed to address participating teachers' needs in areas that the district had identified. In this program the university worked closely with the district's Elementary Science Supervisor to determine the areas in which their elementary teachers had the greatest need of professional development. For example, the semester-long course in earth/space science was included in the program based on districts' data showing their students' difficulties in answering questions in the state standardized test related to earth/space science.

The program was also successful in strengthening the partnership that existed between the school district and the university. According to Friedman (2009), location is important in the development of a successful partnership because "proximity diminishes opportunity costs for ongoing collaboration" (p. 92). In the partnership described here, the fact that the district's central administration office was within walking distance from the university played an important role in facilitating the development of collaborative projects between the two.

A history of trust is another key component of collaborative partnerships (Friedman, 2009). The sense of trust that existed between the school district and the university in this program had been developed over a long history of collaboration in grant projects and various aspects of the teacher preparation program. The district's schools serve as clinical settings for pre-service teachers' field experiences and the university is the main source of teachers and administrators for the district. The school district in turn benefits from programs such as the one described here by facilitating their teachers' access to professional development at no cost to the district. Some of the district's master teachers and administrators also serve in advisory roles in various university programs and as adjunct faculty in the College of Education, further playing a role in the training of their potential staff. Other collaborative projects include summer math and science camps for district students and research internships for district's teachers and high school students. The university campus also serves as a site for field trips, to help their students experience campus and become socialized into what it means to be a college student. During these trips students attend shows at the planetarium, visit research laboratories, libraries, bookstores and eat in the campus' cafeterias. All these endeavors have helped develop a collaborative culture (Cozza, 2010) between the university and the school district.

Professional development is essential to teacher professional growth and development. However, today more than ever school districts face budget cuts due to the local, state and national budget shortfalls. As a result, school districts have increasing difficulty securing the necessary funds to support the professional development of their faculty and staff. The

partnership described in this article shows that collaborations between universities and school districts can be mutually beneficial and go a long way in a common effort to facilitate teacher growth and student achievement.

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