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Rural Research Brief

Vertical Teaming: K-12 Teachers Engaged in Scientific Research in Rural Settings

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Improving the knowledge and skills of practicing K-12 science teachers is our challenge. By doing so, teachers bring a renewed understanding and excitement for science to classrooms and can pass along their enhanced skills and growing expertise to their K-12 students. Yet, many K-12 teachers, particularly those in rural areas, find themselves isolated from other scientists and science educators and often have scarce resources for experiments and other classroom activities. Enochs (1988) points to the isolation of rural teachers as a prime cause for the problems surrounding the recruitment and retention of qualified teachers in rural settings. To help counter this isolating tendency, Enochs suggests that rural schools "connect science instruction to their rural environment," (p. 9) using local "industries, businesses, and state and county agencies" (p. 10) as partners in the effort. Others promote similar approaches, such as Colton (1981), who encourages teachers to develop an interdisciplinary approach to science education that focuses on local resources to help rural students connect science to their lives. This study explores the outcomes of a form of experiential professional development in science education for rural educators that involved teachers working in multi-grade level teams on field-based practical science projects with scientists.

Teacher Professional Development

Alberts (2009), the editor of the journal, Science, asserts that besides the ability to "know, use, and interpret scientific information," our next generation of students also needs to be able "to generate and evaluate scientific evidence and explanations, to understand the nature and development of scientific knowledge, and to participate productively in scientific practices and discourse" (p. 437). One way of encouraging deeper and more engaged methods for the teaching of science is to provide scientific research experiences for science teachers. The teachers can use these experiences to help communicate these notions of scientific inquiry to their students.
Typically, the design for such professional development programs involves teachers at the same or close to the same level. Three examples of professional development programs with teachers within their own grade levels are the a) NRC Chemistry Roundtable (2009), b) US Department of Energy Office of Workforce Development for Teachers and Scientists (2010), and c) Columbia University's Summer Research Program for Science Teachers (2009). Rarely, however, do such professional development programs incorporate both elementary school and secondary teachers into their approach (Loucks-Horsley, Hewson, Love, & Stiles, 1998).
Our science teacher professional development program for the rural panhandle region of North Florida is similar in many ways to the Columbia University project. Rather than at a university, however, our teachers conducted their scientific research in the field within their rural district and worked with area organizations and scientists (Science Collaboration: Immersion, Inquiry, Innovation, Sc:iii, n.d.). Another important distinction is that the Columbia project admitted only secondary teachers, the majority of whom were high school level, while our program created vertical teams of K-12 teachers, spanning elementary, middle and high schools. This concept of vertical teaming started in the early 1990s; its initial focus, however, was to facilitate and improve curricular development rather than teacher professional development.

Vertical Teaming

Vertical teaming engages "a small number of people from different levels within an organization who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable" (Bertrand, Roberts & Buchanan, 2006, p.18). Vertical teaming involves the collaboration and exchange of ideas among educators across the grade levels. Bertrand et al. (2006) enunciate the four goals of vertical teaming as "collegiality, professional growth, school improvement, and transition" (p. 2).
Other states with a high number of rural districts and

teachers, like Oklahoma, South Dakota, and Colorado, use vertical teaming for a number of purposes: Curriculum alignment in reading and mathematics for grades 5-12, and mentoring/tutoring for students (Oklahoma State Regents for Higher Education K-21 Initiatives, n.d.); "long-term, embedded professional development that impacts teaching and learning and is determined after thoughtful consideration of the school's improvement goals" (Technology and Innovation in Education, (n.d., p. 3); and enhanced literacy for the underrepresented students, the Latinos, and the ESL students (Larner & Quake, 2007). For rural regions particularly, vertical teaming offers science teachers a greater ability to communicate with other district teachers, share ideas and learn about local resources, and feel connected both to the larger scientific discipline as well as the educational community.

The Study

Participants in this study were 80 grades 3-12 teachers from rural schools in the panhandle of Florida. These teachers were in a two-semester program, *Science Collaboration: Immersion, Inquiry, Innovation* (Sc:iii, n.d.), which offered free, graduate credit to its teacher participants. The first semester was an on-line course, *Nature of Scientific Inquiry*, followed by a summer course, *Scientific Research Experience*, in which teachers engaged in scientific research at a site in their home or neighboring county. The Sc:iii program produced a monograph (Calvin & Gilmer, 2008, 2009) that includes chapters by ten teachers about their experiences during the scientific research, and an hour-long, award-winning DVD, *Teachers Doing Real Science in the Real World* (PAEC, 2008).

As an early model, the NSF-funded professional development program called CO-LEARNERS (Gilmer, 2002; Hahn, 2002) used vertical teaming with pre-service and practicing secondary science and mathematics teachers and a practicing scientist. The articulation of prospective and practicing mathematics and science teachers during the scientific research proved productive in terms of learning science and mathematics content as well as pedagogy. Therefore, we chose a similar collaborative approach in the Sci:iii program, this time, though, grouping practicing teachers from different levels of local schools.

In the Sc:iii program, each of 29 collaborative teams included one scientist and, ideally, one practicing teacher from each level of K-12 education—elementary, middle, and high school. Due to geographical constraints, however, some teams only had two teachers, generally from different levels, instead of three. In teams, the teachers' task was to engage collaboratively in scientific research with each other and the participating scientist at their rural research sites (Sc:iii, n.d.; Calvin & Gilmer, 2008, 2009).

Overall, our program's goals for the two-semester sequence in the Sc:iii program included the following:

1. To help the teachers understand the nature of science and scientific inquiry.
2. To enhance the teachers' understanding of science content knowledge and the practice of science process skills through scientific research.
3. To provide opportunities for teachers to collaborate in vertical teams across grade levels.
4. To enhance teachers' grasp of technology, using both on-line learning and research conducted with scientific equipment.

Research Questions Guiding the Study

The following two research questions guided this study, which was conducted one academic year after the conclusion of Sc:iii program.

1. How did vertical teaming influence the science content knowledge and science process skill of the grade 3-12 teachers.
2. How did teachers incorporate experiences such as vertical teaming, collaboration and scientific research to their grades 3-12 classrooms?

Methods

Quantitative and qualitative data in this study were taken from an anonymous survey administered on-line, one academic year after the conclusion of the summer scientific research. The study garnered responses from 53% of the teachers. Of these responses 38% were from elementary, 31% from middle, and 31% from high school teachers. Since most of the teachers in the program were women and the survey was anonymous, to simplify, I use feminine pronouns to refer to all teachers and their comments. The survey questions included demographics – the level of K-12 education and specific grade levels at which they and their vertical team members taught. Survey questions focused primarily on the teachers' learning from the vertical teaming and its application to their classrooms (grades 3-12). The quantitative question asked participants to rate on a scale of 1 to 10, (with 10 being the most effective), the effectiveness of vertical teaming in helping teachers exchange ideas about the teaching of scientific inquiry in public schools. Open-ended qualitative questions asked participants to describe: (a) the ways in which vertical teaming enhanced and contradicted the Sc:iii research experience; (b) what they had already done or intended to do in class to help prepare their students for science classes in their next level of education; (c) the type of experiences they had implemented or were planning to implement for their students, and their expectations of what their students

might learn from the project; (d) their perceptions on how working with older/younger students might enrich their own students' learning experience, and (e) their perceptions of how vertical teaming between educators might improve science FCAT scores.

Findings

The researcher coded the data from the qualitative questions using the qualitative software program, QSR. The qualitative data sorted into four main coding categories: (a) curriculum, (b) science content knowledge, (c) science process skills, and (d) students engaged in inquiry.

Curriculum

Teachers found that working together in vertical teams influenced both planning of grade level curriculum and laying foundational knowledge for students for the next grade.

Planning curriculum. The results of this survey included data on the effect of vertical teaming on curriculum planning. For example, one elementary school teacher commented, "Vertical teaming allowed us to see what was being taught across the grades in our school systems. It made us realize how important a strong base in elementary school helps [to] develop the middle and high school student." Another teacher commented, "I could see what topics we were covering across the grade levels and how effective we were being over the years." These two teachers saw more clearly their role in the larger development of children's education. As one middle school teacher noted, because of the exposure the teachers gained in vertical teaming "we can revise our planning and teaching to emphasize some of the middle school's weaknesses." Through the interaction facilitated by Sc:iii's vertical teams, the teachers had the chance to broaden their views of their students' education. Additionally, teachers in vertical teams were able to discuss the topics and approaches used by other team members, thereby stimulating thoughtful pedagogical discussions as well as building personal connections between the teachers from not only the same district but also across grade levels. One high school teacher realized that her science expertise is not common to all the science teachers.

> In our [larger] county group, it was very informative to understand what coursework those teachers were familiar with and taught in their classrooms. In one instance, with the middle school teachers, I will get those students in my classrooms [as they advance to high school]. That [middle] school is the feeder school to my high school. It was good to know what they were teaching....Within our little group of four teachers [on our team], we had only one elementary teacher and three high school teachers... The two of us who were strong in science helped those who were not, to better understand the subject... I took for granted having been in the science field in the beginning of my career and leaving it to teach, that some scientific topics can be difficult to understand, even as an adult.

Each teacher brings different expertise to the vertical team, thereby allowing the opportunity to teach and learn from one another. Based on their experience, 92% of the surveyed teachers believed that vertical teaming between educators would help the students score better on the state-mandated Florida Comprehensive Assessment Test (FCAT, 2010) for grades 5, 8, and 11. In part, teachers assumed this outcome because of vertical team's capacity to provide continuity in scientific content for their students. By discussing both science and science education in the multi-grade teams, teachers gained increased understanding of the curriculum at various levels, which can only benefit sequential student learning.

Addressing teachers' needs in laying foundation for students' next grades. An elementary school teacher commented that vertical teaming "helped me to understand what I need to teach in order for my elementary students to be prepared for the next level." A middle school teacher remarked that now after Sc:iii, "I talk with my high school contact person often about what I am doing in class and what skills my kids need to improve on, etc." Another teacher stated vertical teaming "enhanced my ability to see the bigger picture of what is happening with our science curriculum." This increased communication helps teachers prepare their students for learning at the next school level and become less isolated in their instructional methodology.

Science Content Knowledge: Pushing the Boundaries in Environmental Science

Most of the projects in the Sc:iii program were environmentally focused, with teachers working with state park rangers, estuarine wildlife managers, fish and wildlife scientists, or environmental chemists. Many teachers translated their Sc:iii research experiences into their classrooms by involving their students in environmental research similar to their Sc:iii research.

One teacher, for example, led her students in conducting research similar to her work the previous summer in Sc:iii at a habitat restoration area, and shared activities, including animal and plant life, found there. Another teacher had her 5th grade students develop a

model of an aquifer system, which she learned in her Sc:iii research experience, and share it with younger students at the same school. In this exercise, she enabled her students to become the 'experts,' a process that helped solidify their knowledge. In a variety of ways, these teachers translated and extended their research experiences from Sc:iii to their own students.

Science Process Skills

Skills gained included how to foster collaboration and engage students in scientific inquiry in the classroom.

Engaging in collaboration and providing similar experiences for others. The quantitative survey question asked teachers to rate how effectively vertical teaming helped them exchange ideas about teaching of scientific inquiry; half of the respondents scored this area as 8 or higher (on a scale of 1 to 10), indicating the ability of vertical teaming to improve collaborative learning, which was reinforced by comments such as, vertical teaming "helped me to understand working collaboratively." Many of the teachers saw the benefits of extending such collaborative skills and approaches to their students as well, and have begun grouping their students in collaborative teams to emphasize the importance of shared activities and enhanced critical thinking skills.

Collaboration, though, can be hard to organize. One teacher mentioned the difficulty of getting "administrators at all levels on board with collaboration," saying "due to schedules, it is almost impossible to get groups together." Within her school, however, this teacher embraced a model for collaboration, pairing 5th graders with kindergarten students, and noted, "both groups seem to benefit from the experiences." While collaboration may be difficult sometimes to coordinate, the benefits can be worth the effort. Some teachers embraced the model of vertical teaming from the Sc:iii program and encouraged their students to work with students of different levels and noted benefits such as improved understanding and increased self-esteem.

> If my students can explain to younger students how to do something or how it functions, that helps them to retain [the information] and proves their comprehension. The older students can increase their own sense of self-esteem, as they can be teachers and role models for the younger ones. The teaching by the older helps to reinforce the knowledge they gained and now pass on to the younger ones.

Students tend to learn well from their peers. As one teacher noted, "Hands-on activities, peer-based, are an effective tool of education. [Students] are more responsive to their peers and not afraid of failure." Therefore, when older students teach younger students, the mentor learns the content better through teaching and the mentee is more at ease learning science from an older student. Vertical teaming provides not only a model for teachers to interact with local peers, but also acts as a model of learning for students within the classroom.

Teachers' understanding of scientific inquiry. For teachers to foster inquiry-based learning, they must first understand what the concept means. Teachers' levels of understanding concerning scientific inquiry varied widely. For example, one teacher observed that inquiry is "observing, recording, classifying, discussing, and modeling the behavior of scientists." This definition, however, is only a small part of the inquiry process; missing from her response is the idea that inquiry is a process of asking questions. Such questions direct scientists' thoughts, actions, and methods of data analysis, which often results in asking more questions. In comparison, a different teacher used a broader conception of scientific inquiry in her class activity that involved testing for bacteria at several sites within the school. She explained how she provided experiences for students that allow them to question, collect information, modify their ideas, and discover science for themselves. She encouraged her students to ask questions before, during, and after the data collection.

Students Engaged in Environmental Research

Many teachers, who used their hands-on learning during the Sc:iii program, similarly involved their students in environmental research near their schools. Some teachers, especially those at the elementary school level, engaged their students in yearlong projects. One elementary school teacher, for instance, conducted environmental research at a local bayou. Shortly after the Sc:iii program ended, another teacher applied for funding from a local environmental group to support the purchase of equipment for water sampling and recording data. Her 4th grade students spent the year measuring the water quality and collecting data about plants and animals around this lake. They recorded weekly data and were able to analyze the data to determine trends and patterns associated with the lake's water quality. At the end of the academic year, the students' learning in all these projects culminated in student poster presentations on the findings from their various studies to other students, parents, scientists, engineers, politicians, and even a newspaper reporter. The opportunity to share their projects served to connect the students to their school, community members, and the local environment.

It is very important that the inquiry-based projects in which teachers are involved are applicable to student learning in the classroom, and that teachers see the relevance and opportunity for future application. In addition, once teachers are committed and involved in inquiry-based science, they need ongoing support so that the impetus is not lost at the end of grant funding. Such

ongoing support would help teachers bring further enriched learning experiences to their students. The Columbia University (2009) program, for example, does provide a level of ongoing support from a graduate student during the academic year after the teacher's scientific research experience. Unfortunately, our Sc:iii program, funded through the spring and summer semester from the US Department of Education, did not continue into the next school year, inhibiting us from providing further resources and mentoring.

Benefits of Vertical Teaming

Several participants noted benefits they derived from working with peers across school and grade levels. One teacher summarized her opinion of the benefits of vertical teaming as

> I think it is very important to work across curriculum as well as across grade levels. Although curriculum mapping is supposed to do that, we do not live in a perfect world! I loved the vertical teaming approach in this experience.

Teachers provided examples of learning from their vertical team members including science content knowledge, strategies for teaching students with lower reading or understanding capacities, and higher order questioning for more advanced students. One teacher commented, "We were able to develop lessons plans that dealt with the same topic, but on multiple levels. My middle school partner also worked with ESE students, so this gave us a chance to learn how to modify lessons for her students."

Teachers provided examples in which they could ease the transition of students from one grade or level of schooling to the next. These included (a) developing knowledge and group and collaborative skills while students are still in 5th grade so that they will be ready for middle school; (b) providing access to science fundamentals, starting at lower grade levels; (c) involving students and teacher in real-world science, so that science is less abstract; (d) preparing middle school students for reading levels needed in high school, and (e) improving communication among teachers at various levels. Vertical teaming facilitates interactions among teachers and facilitates educational initiatives across grades.

Conclusion

In summary, teachers viewed vertical teaming as an effective way of learning not only science content and process skills but also becoming familiar with the breadth of the curriculum spanning the K-12 system. While teachers collected research data in the field they also discussed curriculum with each other and explored ways in which they could enhance the learning of their students. Teachers in vertical teams shared information with each other. Each teacher brought to the research experience different strengths and weaknesses. Through communication and collaboration, they taught each other an understanding of the science content-knowledge and processes while doing scientific research.

Professional development generally involves teachers at the same level of teaching. However, vertical teaming provides a different way for educators to learn science content, process, and teaching strategies from each other and to work towards common goals. This approach exposes teachers to the overall K-12 curriculum, so that they can see a broader view and define their place within the curriculum. Teachers learn about new resources available to them to support the learning of their students. The opportunity for teachers to conduct scientific research provides them with real-world science experiences. Vertical teaming helps teachers develop relationships with other local teachers and scientists who contribute time, materials, and expertise, even after the research experience concludes and helps place these science classrooms and their students within a larger web of scientific inquiry and discovery.

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