Elementary Teacher Professional Development: Year 2 Implementation of the VISTA Model (Paper 2 in Paper Set)

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Abstract

The Virginia Initiative for Science Teaching and Achievement (VISTA) model provides intensive support and effective interventions to help teachers learn science content and develop experience and confidence in teaching inquiry-based science. This study investigated how elementary teachers learned to teach using inquiry-based models during the second year of implementation of the VISTA Elementary Science Institute (ESI).

Ninety-three participants attended the four-week summer institute offered at three sites. During week one, teachers learned science content and inquiry science based on a scientific theme selected from the lowest-scoring areas of science on standardized state tests. Also in week one, they collaboratively planned a problem-based learning unit (PBL) to use in weeks two and three. During weeks two and three, teachers collaboratively taught inquiry-based science to over 100 high-needs students in a PBL summer camp setting. In week four, teachers reflected on their summer teaching experience and planned a PBL unit to implement in their school using inquiry-based science. Teams of university educators, scientists, math specialists, and ELL and special education specialists provided on-going support and training during the institute. Data collection before and after the institute focused on the effectiveness of professional development. Year 2 findings from data, surveys, and feedback indicate that teachers did develop deeper understandings of inquiry-based learning but in practice may not fully apply those understandings to their classroom instruction. Trained coaches worked with teachers to improve their science instruction and to provide support after the summer institute. Year 2 findings indicate that after attending the ESI and implementing PBL units at their schools, teachers focused more on inquiry-based instruction, but experienced difficulties along the way. The findings indicate that teachers considered the ESI program and its support framework beneficial in implementing more inquiry-based learning in their classroom instruction.

Elementary Teacher Professional Development: Year 2 Implementation of the VISTA Model

Effective professional development to improve science teaching in elementary schools is important as these teachers teach more than one subject and may need additional training in science. Mensah (2010) described elementary teachers as "generalists, responsible for instructing students in all core subject areas." Many have a teaching degree but often lack a solid foundation in the inquiry-based nature of science (Akerson & Abd-El-Khalick, 2003; National Commission on Mathematics and Science Teaching for the 21st Century, 2000; NRC, 2007). Elementary teachers are often unprepared to teach an inquiry-based approach and lack the skills to teach conceptual understanding of science effectively. Research shows that elementary teachers' science content knowledge is limited (Rice, 2005). Professional development can give the teachers the skills to improve their knowledge and instruction. Loucks- Horsley, Stiles, Mundry, Love, & Hewson, (2010) found that "effective professional learning is directly aligned with student learning needs; is intensive, ongoing, and connected to practice; focuses on the teaching and learning of specific academic content; is connected to other school initiatives; provides time and opportunities for teachers to collaborate and build strong working relationships; and is continuously monitored and evaluated" (p.5). Professional development programs where teachers model inquiry can provide a basis for teachers to continue their experiences with inquiry science in the classroom (McDermott & DeWater, 2000). Hauck (2012) found that sustained science professional development for elementary teachers is necessary to improve classroom science instruction and classroom practices.

One goal of the VISTA model is to provide intensive support and effective interventions to help teachers learn science content and develop confidence through the experience of teaching

student- centered inquiry-based science. VISTA is a partnership with 67 Virginia K-12 school districts, six universities, and the Virginia Department of Education to increase student performance through the establishment of an infrastructure to provide sustained, intensive science teacher professional development to increase science achievement. VISTA provides an intensive four week long professional development program to upper elementary teachers (grades 4-6) on how to teach science using inquiry-based models and training in problem-based learning (PBL) instruction. Teachers also receive training in modules on various subjects such as: nature of science (NOS), inquiry, engineering design, misconceptions, discourse, science literacy, technology, resources, special education and English language learners. For Year 2, engineering design and more NOS instructional modules were added to institute based on the Year 1 outcomes.

Teachers worked in teams to design inquiry-based science lessons for students attending a summer science program. The Elementary Science Institute (ESI) also provided teachers with support from teams of university science educators, scientists, and specialists in mathematics, English language learning, and special education to plan and facilitate summer learning experiences. Throughout the summer institute and the academic year, the teachers were provided with a coach to support their learning process and to help them in the classroom. During the academic year, teachers implemented student-centered inquiry-based instruction through problem-based learning, attended follow-up workshops, and attended the Virginia Association of Science Teachers (VAST) conference to further expand their understanding of inquiry-based science. This paper examines the impact of the second ESI on teachers and their perceptions on the implementation of student-centered inquiry-based science using problem-based learning in the classroom.

Research Questions

The following research questions guided the assessment of the impact of the second ESI: a) What are teachers' perceptions of learning how to teach student-centered inquiry-based science using problem-based learning in the classroom? b) How do teachers perceive the implementation of learning how to teach student-centered inquiry-based science using problem-based learning in their classroom? c) What are teachers' perceptions of the ESI professional development, training, and instructional support in improving their teaching of student-centered inquiry-based science using problem-based learning?

Effective Professional Development

The *Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* with its broad set of expectations for students and the draft of the *Next Generation Science Standards* may guide future professional development for teachers of science as school districts revise their science curriculum (NRC, 2011; NGSS, 2013). Effective teacher professional development has been a high priority in improving instruction in schools. Teachers today need an extensive knowledge of their subject matter and the most effective pedagogies for teaching the subject. Effective professional development should lead to teacher learning, subsequent changes in classroom practices, and improved student learning outcomes (Borko, 2004; Fishman, Marx, Best, & Tal, 2003). The length of the professional development can influence its effectiveness. The research shows that when teachers participate in long-term or sustained problem solving or inquiry-based professional development, they will increase their use of inquiry in science classes (Hauck, 2012; Luft & Pizzini, 1998). Lakshmanan, Heath, and Elder (2010) noted that teacher beliefs as well as classroom practice must be addressed in professional development programs if teacher practices are to change. If professional development is done to

implement new teaching practices, then other factors that influence teacher efficacy must be addressed in the design process.

Inquiry Instruction

Teaching inquiry in the classroom may depend on whether the teachers are well-prepared. Keys and Bryan (2001) found teachers who teach science using an inquiry approach must have an in-depth knowledge and understanding of science content, student learning, the nature of science, and problem-solving strategies. Research suggests that there are many procedures for teachers to deliver inquiry-based instruction and different practices, teachers typically receive professional development before different practices are implemented (Drits & Stark, 2011; Minuskin, 2009; Wu & Krajcik, 2006).

High quality professional development opportunities can improve content knowledge, shift beliefs about inquiry science, and give support to positive outcomes of student learning (Banilower, Heck, & Weiss, 2007). Studies indicate that inquiry-based classroom instruction can increase the performance of students when compared to students taught by traditional text-based instruction (Chang & Mao 1999; Johnson & Lawson, 1998; Muscheno & Lawson, 1999). A meta-analysis of 160 studies by Wise and Okey (1983) found that inquiry instruction improved student outcomes, including achievement. Teaching inquiry does not always result in higher achievement. If the inquiry instruction involves no teacher guidance except for the lesson objective, then it can be less effective than teacher-centered instruction (Khlar & Nigam, 2004). Minuskin (2009) found that 4th grade teachers did not change their teaching practices significantly after 18 weeks of professional development; however this study did have many limitations such as the length of the study, the number of participants, and changes in leadership at the schools.

Teachers' Conceptions of Inquiry and Problem-Based Learning

One of the difficulties of preparing teachers to teach inquiry is that teachers have limited views and understanding of inquiry. They may refer to inquiry as projects, lab experiments, discovery learning, or activities (Windschitl, 2004). Teachers may believe that they understand and use inquiry-based instruction in the classroom. Desimone (2009) found that teachers often claim they are teaching inquiry, but observations of their instructional methods do not support those claims. They may believe they are implementing inquiry instruction but in reality this instruction is lacking. There have been many studies researching the conceptions teachers have on inquiry characteristics and teaching practices. Conceptions teachers already have of inquiry can influence their science instructional practices (Crawford, 2000; Wallace & Kang, 2004).

Not all elementary teachers are prepared to teach inquiry, as they have never experienced this type of instruction. It can be a difficult task to prepare teachers with no experience in inquiry to teach it (Kielborn & Gilmer, 1999). However, teachers are generally motivated and positive about introducing inquiry PBL or project-based learning in their classrooms, which can result in a deeper understanding of science practices and instruction (Blumfield, 1994; Rosenfield & Ben-Hur, 2001).

Science Content Knowledge of Elementary Teachers

To teach science in an effective manner, the subject matter needs to be understood (Michaels, Shouse, & Schweingruber, 2008). Swars and Dooley (2010) found that inadequate science content knowledge leads to lowered personal self-efficacy, and suggest the importance of providing professional development with both content and pedagogical components. Elementary teachers generally teach multiple subjects with inadequate content knowledge and pedagogical background. This practice can lead to lower academic achievement when elementary teachers

teach science without the content background (Darling-Hammond, 1999; Hartshorne, 2005; NCSESA & NRC, 1996). Other studies support the view that if you can deliver long-term effective professional development and incorporate instruction of content-level knowledge, then the prior science content knowledge of the teacher is not an issue (Fennema, Carpenter, Franke , Levi, Jacobs, & Empson, 1996; Hiebert, Fennema, Fuson, Human &Murray, 1996; Simon & Schifter,1991; Smith, Desimone & Ueno, 2005).

According to recent research, teachers without degrees in science or education have similar rates of hands-on activities in their science classes if they reported participating in over 35 hours sustained science or science-focused professional development (Smith, Desimone, Zeidner, Dunn, Bhatt & Rumyanteseva, 2007)

Structure of the Elementary Science Institute (ESI)

The ESI consists of a four-week summer institute with additional academic year support for elementary teachers (grades 4-6). The goal of the institute is to facilitate elementary teachers' effective science instruction through professional development. During the institute, the teachers are provided with intensive support and effective interventions to learn science content through the experience of scientific problem-based learning (PBL) and student-centered inquiry instruction. The teachers work in teams to deliver inquiry-based science instruction to elementary students. The schedule of the participants and support personnel is depicted in Table 1.

Table 1

VISTA Elementary Science Institute Participant and Support Schedule

Elementary Institute	Summer	Academic Year
Grade 4-6 science teachers	4 week institute	3 follow-up instructional sessions VAST conference 3 full days of classroom visits by VISTA coaches [a]
Support Team of Experts	As needed during institute	
Principals	1 day during institute	Various communications
Science Coordinators	2 days during institute	Attend VSELA conference
Coaches	5 days during institute	2 days coach training VAST conference
High-needs elementary students	2 week science camp during institute	
Parents of high-needs elementary students	Last day of summer camp	

[a]Classroom visits by coaches can be made over multiple days (a coach could visit 7 different times at 1 hour each day, and that would count as 1 day)

Each of the three VISTA sites delivered the same instruction to the participants as described in Table 2 (Appendix page 47). During week one, teachers learned science content and how to conduct inquiry-based science instruction based on a scientific theme selected from the lowest-scoring areas of science on the state's standardized science assessments. Beginning in the first week, VISTA instructors focused on teaching the participants about hands-on science, problem-based learning, nature of science (NOS) instruction, and inquiry instruction. VISTA defined these constructs as:

- Hands-on science: Students purposefully manipulating real science materials when safe and appropriate in a way similar to a scientist.
- Problem-based learning: Students solving a problem with multiple solutions over time like a scientist in a real-world context; both the problem and context must be meaningful to students.
- Inquiry: Students asking questions, collecting and analyzing data, and using evidence to solve problems.

- Nature of Science: the values and assumptions inherent to the development of scientific knowledge (i.e. the natural world is understandable, science demands evidence, science is a blend of logic and imagination, scientific knowledge is durable, scientific knowledge is subject to change, science is a complex social activity, and science identifies and avoids bias).

During weeks two and three, teachers alternated between collaboratively teaching inquiry-based science to students from high-needs schools in a problem-based learning science summer camp and participating in professional development modules for one week each. Week four included time for teachers to reflect on their camp teaching experience and to plan inquiry-based teaching units for the upcoming academic year. Academic and pedagogical support was given to the teachers by teams of university science educators, scientists, engineers, curriculum specialists (math, English language learners and special education), and instructional coaches for the duration of the institute. During week four, school principals and district-level science coordinators were invited to the institute to attend inquiry-based science training and to show support to their elementary teacher participants. During the academic year, the teachers implemented inquiry-based science in their classrooms and collaboratively shared and analyzed student work samples. In-class coaches also provided on-going instructional support to the teachers throughout the academic year. In the fall of the academic year, teachers attended the Virginia Association of Science Teachers (VAST) conference to continue their professional development at the state level. VISTA teachers also met as a large group to reflect on their VISTA experience and received additional professional development on hands-on, inquiry-based PBL instruction that integrated NOS.

Another component of the ESI program included the opportunity for the parents of students with high-needs attending summer camp to learn about college admissions, financial aid, and career planning. On the final day of the summer camp (end of week three), the parents are invited to learn about these college opportunities and to observe their children present solutions to problem-based issues investigated in camp and to meet the teachers who guided this instruction. A detailed schedule of the ESI is found in the appendix, page 28.

Methods

Participants

Ninety-three elementary teachers attended the 2012 summer institute at three ESI sites: 33 attended Virginia Commonwealth University, 26 attended George Mason University, and 36 attended The College of William and Mary. Participants in the VISTA Elementary Science Institute (ESI) were 14 males and 79 females from 28 different elementary school teams and 33 different districts in Virginia. There were one Hispanic, 27 African American, and 65 Caucasian participants. Participants' Virginia licensure and teaching experience are described in Table 3 (Bell, Konold, Maeng & Heinecke, 2012). All demographic data were self-reported.

Table 3

Licensure and Teaching Experience of the 2012 ESI VISTA Participants (Bell, Konold, Maeng & Heinecke, 2012)

Total	Virginia Licensure				Teaching Experience				
	Elem.	Elem. Sci.	MS	Sec Sci.	0-1yr	2-3yr	4-6 yr	7-10yr	>10 yr
93	84 (90.3%)	3 3.2%)	10 (10.8%)	7 (7.5%)	9 (9.8%)	9 (9.8%)	15 (16.3%)	17 (18.5%)	42 (45.7%)

Note. Gender and licensure data for all 93 participants. 1 participant did not report teaching experience (n=92).

Measures

Data collected consisted of participant exit slips, daily ESI debriefs, discussions, observations, and participant reflections collected from the start of summer 2012 ESI through the fall follow-up professional development sessions and included the Virginia Association of Science Teachers' Conference. Additional data were also collected from the participants' coaches and principals in the form of reflections, interviews, training exit tickets, and classroom observations. Responses were analyzed to determine the patterns (Patton, 2002) used by the participants to describe their experiences, perceptions on the ESI impact on their science instruction, and their perceptions of implementing student-centered inquiry-based science using problem-based learning in the classroom. Common patterns that emerged from the data were identified initially through a reduction technique with methods that identified coded key words and phrases (Miles & Huberman, 1994). The data were reviewed individually by different researchers to finalize the themes and categories for the study.

Results/Findings

This study posed three research questions: a) What are teachers' perceptions of learning how to teach student-centered inquiry-based science using problem-based learning in the classroom? b) How do teachers perceive the implementation of learning how to teach student-centered inquiry-based science using problem-based learning in their classroom? c) What are teachers' perceptions of the ESI professional development, training and instructional support in improving their teaching of student-centered inquiry-based science using problem-based learning? The findings for each research question are presented below:

Teachers' Perceptions of Learning How to Teach Student-Centered Inquiry-Based Science Using Problem-Based Learning in the Classroom

VISTA expects every teacher to develop a PBL unit. Teachers who attended the second ESI were given the experience to work through the process of developing skills to teach student-

centered inquiry-based science. They worked from scratch on how to develop a PBL unit from direct instruction, teaching modules, modeling strategies, and applied this knowledge directly to teaching students in the summer science camp. From participant responses about their teaching experiences and PBL training, several thematic categories emerged: PBL development, science connections, student engagement, traditional instruction and PBL instruction, and teacher role.

PBL Unit Development. In the beginning of the ESI, there was a lack of understanding of what a PBL unit is and how to develop one. Teachers were shown step by step how to develop a PBL unit by experiencing the process as a learner. Some teachers came with preconceived notions and a perception of what PBL was based on their prior knowledge and experience. During the ESI, they learned how to teach a PBL unit and were given the tools and professional development to achieve teaching one or developing one. As the process of developing a PBL unit unfolded, the teachers reflected on their understanding of how to plan and teach it. Teachers referred to the PBL units as "PBLs" and noted the following:

- I'm not sure how we are going to learn how to plan and teach a PBL in a few days. Ask me in 2 weeks. I want to learn but I'm not convinced I can do this. Maybe that's why I'm here to learn. (Day 1, ESI)
- It was a chore to plan a PBL. It was very difficult for our group to come up with a theme and question map with 25 other teachers for the student camp. The outcome was good but I don't think I would have understood how to do this if we didn't struggle. (Final camp debrief)
- I still have doubts if this PBL is worth it. I usually teach and lecture to my students. Learning to do a PBL with the question maps, developing roles for students, and problem solving is new to me. The little steps the VISTA staff is taking to train us is

tedious and time consuming. I see where they are going but are we there yet? (Day 3 ESI reflection)

- Themes, problem, scenarios, question maps, I think I'm getting it. Yes it's making sense. It's not what I thought a PBL is. This is hard. I hope I can see how this plays out in camp so I can visualize my role in facilitating this. (Day 3 ESI reflection)
- Planning is difficult when you have no idea knowing every question that a child will have when doing a question map. Also, just coming up with different activities to match the questions on the question map and to fit my student population's needs is a challenge. I think I need to take a look at different learning styles and abilities of the students and then plan the real hands-on activities (Fall follow-up VAST reflection)
- The camp itself and planning for the camp were the most beneficial to me. It was like student teaching for good science instruction. I got the most from trying it out myself. (Fall follow-up VAST reflection)

After planning and teaching a PBL unit to elementary students in the ESI summer science camp, many teachers began to understand how this could process could work for them. Teachers noted the following:

- It was challenging to work this summer to develop the PBL because I had never done it before. Developing the question map and including all the standards (SOLs) was a challenge because we still wanted it to make sense and have a meaningful flow. But it worked. (Fall follow-up reflection)
- The first week and half was unbelievably beneficial. We research PBL's at my school for two years but until you actually go through the PBL as a learner (or a kid)

you really understand what it's like to solve a problem and how much fun the learning can be. (Fall follow-up reflection)

- I don't think that you are ever really fully prepared to teach a PBL until you have taught one. I was as fully prepared as I could have been though. (Fall follow-up reflection)
- One of the biggest revelations to me that came from the summer institute was the idea of a problem based learning unit. I always presented the students with some sort of problem at the end of the unit that they needed to use their knowledge learned throughout to solve (for example: cleaning an oil spill), but I never thought to present them with this problem before the unit began to drive their own learning. Introducing the problem to students before they begin learning the standards in the unit not only allows students the opportunity to decide what they need to learn (that will fit with the standards if the lesson is planned properly), but also provides students with the motivation to continually question and strive to learn more. (Fall follow-up reflection)

Science Connections. During the institute, teachers interacted with scientists and learned about their scientific work. The scientists were also used as valuable resources to help teachers refine and craft a realistic problem for students to solve around a theme in which the scientists were experts. Teachers noted the following:

- Seeing and experiencing hydroponic set-ups was an exciting experience for me. I can see many connections I can make in my classroom. Seeing the variety of plants and having the opportunity to see them with the high powered microscopes helped me see and feel how my students feel (Scientist debrief)

- I enjoyed getting back into the classroom/lab and being a student for a change. I developed an appreciation for the complexity of plants, but all things related to science. The SOLs just skim the surface, but there is so much possibility in terms of the depth you can go with your students.(Scientist debrief)
- The scientists at our site went out of their way to include us in the learning new things. They also wanted to learn about us. We helped them as well to develop their presentation skills to relate science to non-science people. Our camp PBL came together with their help. (Final camp debrief)

Several teachers reported that the scientist sessions were too technical and not useful to them. They suggested that the scientists should look at the state standards and relate their work to teachers in ways they could use in the classroom. Some sites did have pre-camp meetings with the scientists and provided them with the state standards to plan their sessions and that was reflected in their presentations. Teachers noted the following:

- The science debriefing session brought it altogether for me. Initially it felt like a waste of time because it was so "over my head" but now it seems usable. (Fall follow-up reflection)
- I also did not benefit much from the scientist sessions that we had the opposite week of camp. I thought they did not cover anything we taught in elementary school so I could not bring back any of the information and apply it. I would have enjoyed and appreciated having a scientist explain to me the topics that I cover in fifth grade science so that I have more content knowledge to use in performing my PBL.

Student Engagement. During the ESI, teachers taught a PBL unit to students and were able to gauge firsthand the amount of student engagement. Teachers also observed how other teachers taught and the students' reaction to PBL. Teachers commented:

- Discussions with the students made it clear that the vocab and concepts were being used properly. Because each day built on the day before, the students were able to explain the activities to parents on the final parent day. (Final camp debrief)
- Students were always talking science to each other in their groups about their observations and ideas. (Final camp debrief)
- The students had a reason to learn about science and showed them that there are many solutions, reinforced NOS, and kept them engaged and gave them ownership. I do not believe that all the children bought into the problem, but it was novel and the kids had fun with it. (Final camp debrief)
- I have started doing all of my units towards the Problem Based Learning method. I think of things that students need to answer the questions and how letting them solve their own problems help them to learn more of what they need and even more. They are much more inquisitive and excited about coming to Science. They are asking questions and trying to figure out solutions. Students are doing more learning than I am even teaching. (Fall follow-up reflection)
- My students' engagement level has changed this year. I have a very difficult group of students this year, and I was very worried about doing a PBL with them, but they have been so engaged and have learned so much! (Fall follow-up)

Traditional Instruction. During the ESI, several teachers struggled to get away from traditional teaching methods. Losing "control" of their role as a teacher was hard for some

teachers to do. Teachers found that traditional ways of teaching were expected at their schools and slowly implemented their PBL units. Some commented:

- The ESI made me discover that I was a traditional teacher with traditional methods. It made me realize that given the opportunity the student will be successful when presented with a science activity with little or no direction. The student's inherent curiosity can be purposely manipulated by me the teacher to lead them to new discoveries. These new discoveries will last longer in their memories because the student directed the activity. I need to change.(Fall follow-up reflection)
- I'm not sure I can teach this way and let go of my control. This PBL way of teaching is hard to implement. I see the value but can I as an old dog be taught new tricks? I think I can but I like tradition. I'm feeling uncomfortable with this approach. (ESI Week 1 reflection)
- It is really hard to steer some teachers away from candy activities. I also learned the difference between hands-on inquiry and hands-on cookbook instruction. I am trying to change my cookbook lessons to more inquiry based instruction. (Fall follow-up reflection)
- I was so wrong. I really didn't like the PBL/Inquiry approach to learning as it messed up my neat little classroom schedule and traditional way of teaching. I have finished my PBL back at my school and I am now convinced the learning that was done was 100% better than the way I did it before. I think I will need to do more PBLs. My students learned and were engaged throughout my PBL. The impact at my school has been incredible. Now my other grade level teachers not in VISTA want to know why my students are excited about learning. (Fall follow-up reflection)

Teacher Role. As teachers went through the ESI experience, they noticed how their teaching could be impacted by introducing a PBL unit. As they planned a PBL unit for the students in camp and for their own classroom students, they realized that their roles may change from teacher to facilitator. Teachers commented:

- This PBL process is helping me become a better teacher. It will allow me to have the students become the leaders of their own instruction. I always have been in charge of creating and asking questions. I can still guide but the students are asking the questions. (ESI Week 1reflection)
- I realized that science is more than lecture. My job is changed. If your students have the opportunity to investigate, create, and inquire about topics, they will rise above your own expectations. Science is more than just rote memory, you as a teacher must get the students to use critical thinking. Students will learn science when they experience it. Science can be fun and meaningful, it is for the students not me. (Fall follow-up reflection)
- This has been the hardest thing to keep my mouth quiet while the students come up with solutions to a PBL. Try changing to be a facilitator and not in charge. I'm struggling to do this. I have to put my hands behind my back to remind me that this way of teaching does work as I saw firsthand in the summer camp. Those students were of mixed ability but all of them were engaged and contributed to the solutions to the problem. (Fall follow-up reflection)

Teachers' Perceptions of Implementation of Learning How to Teach Student-Centered Inquiry-Based Science Using Problem-Based Learning in Their Classroom

One of the requirements for teachers in the ESI is to incorporate inquiry into their classroom instruction. VISTA expects teachers to do this by creating and implementing a PBL unit in their school setting. After the summer institute, the teachers were invited to attend the 2012 Virginia Association of Science Teachers Conference. At the conference they also attended additional VISTA follow-up professional development sessions and were asked about the status of their PBL unit. Teachers not present were asked to send their PBL unit status report to each site. The results of that status update are shown in Table 4.

Table 4

Implementation Status of the PBL Unit for Cohort 2 ESI Teachers (as of November 2012)

	Implementation Status of PBL Unit			
Teachers Attending VISTA SITE	PBL Not Started	PBL in Progress	PBL Finished	Number of Responses (n=87)
George Mason University	10	14	1	25
Virginia Commonwealth University	13	12	7	32
The College of William & Mary	15	13	2	30
Total	38 (43.7%)	39 (44.8%)	10 (11.5%)	87 (100%)*

**87 of the 93 ESI teachers responded to this implementation query.*

Eighty seven teachers responded to the status of their PBL unit, 56.3% had started and/or completed their PBL unit. 11.5% teachers had completed the PBL unit and 43.7% indicated that they had not started.

Teachers were expected to implement a PBL unit in their school after attending the ESI and their responses on the implementation process fell into the following thematic categories: scheduling, curriculum pacing and standards, school barriers, support and resources, and coach role.

Scheduling. Planning, developing, and implementing PBL was a learning experience for all of the teachers that took a large amount of time. Teachers noted:

- Time is a major challenge for me. We have many interruptions from conferences, a hurricane, fire drills, etc. It's also hard to plan with a teammate and to keep the PBL momentum going. (Fall follow-up VAST reflection)
- Finding time to have students to research, write questions, and produce the question map is hard. In addition finding time for teaching it. I'm scheduled to teach science and social studies together daily in 45 minutes. (Fall follow-up VAST reflection)
- Most of the PBL takes more time than I can spend on it. (Fall follow-up VAST reflection)
- It has taken many, many hours to write my unit-partially because of the learning curve, finding resources, finding the science, and writing lessons clearly enough that they can be easily shared with teammates. I really want to succeed but this is hard. (Fall follow-up VAST reflection)

Curriculum, pacing, and standards. Teachers found that when they plan for their school implementation of a PBL unit they needed to make sure that they were planning using district guidelines. Sometimes this posed problems as they were unsure how to integrate PBL into their current pacing guide. Teachers noted the following:

- When planning our PBL to match our pacing guide, it was difficult narrowing down exactly what should be taught in order for students to fully understand the problem as well as to be able to create plausible strategies to solve the problem. (Fall follow-up VAST reflection)
- Bi-weekly and benchmark assessments are taking away from my time for the PBL. Due to this we don't have much time to get creative due to more prep for test than teaching. (Fall follow-up VAST reflection)

- I had to adjust my instruction for this. The kids got so excited about what they were doing that the lessons extended into other subjects. After the forestry worker came in, they were so into identifying what trees were in our courtyard that the next day we all went outside to look at the trees. However, I never got to math that day. Also, finding the time to plan for the project was non-existent. Time is my biggest issue. (Fall follow-up VAST reflection)
- We chose to teach one of the first standards in our pacing guide to be taught this year. In hindsight it was not a good idea. We had to postpone parts of our PBL to move along in the curriculum. We will pick up the PBL "story" and continue the scenario soon, The kids are disappointed but we will finish it soon. (Fall follow-up VAST reflection)

Some teachers managed to find ways to integrate the PBL unit into other academic subjects and felt they were able naturally blend the subjects together.

- I also find that I have broken down the barriers between subjects in science. Instead of teaching them in isolation or units, I know implement them as they are appropriate. I found that by teaching my PBL I covered over half the year in my unit. I not only covered ecosystems, but I included plants, some weather, some force and motion. Now I am finding that I don't have as much to teach and can extend the students learning much better. (Fall follow-up VAST reflection)
- I found I could integrate several subjects into my PBL to teach a more rounded curriculum. My administrators were supportive of this approach. Some of my colleagues thought I was not teaching the right way but I believe I am. My students

are learning and can put things in context, and apply their understandings to every day issues. (Fall follow-up VAST reflection)

School Barriers. Several teachers felt that when they returned to their schools they were not fully ready to implement the PBL units. Many cited administrative demands and school issues. Teachers noted the following:

- I would like to teach a PBL without interruptions. Our school days involve assemblies, fire drills, testing, conference, holidays, and weather related closings from Hurricane Sandy. However the hurricane made my PBL relevant. I know these things can't be helped but it does hinder our PBL implementation. (Fall follow-up VAST reflection)
- Bringing other staff/team mates into the idea of the PBL. They feel that we are getting "behind" and that we are not teaching directly enough for kids to get the information. The process of creating the lesson, putting hands on equipment, contacting specialists, career professionals that can enhance student learning on their relevance to PBL is time consuming. My school is not equipped for this. I feel the time I'm taking just writing emails and explaining what we are doing in a cohesive intelligent manner may have taken away from other subject areas I am teaching. My team mates want me to step back and slow down this PBL process. They are slowing down my students' progress. (Fall follow-up VAST reflection)
- My school is not supportive of this PBL approach. They can't understand why I am not scripting out everything I teach. They, the administrators, feel I'm not teaching as I should. They came by my classroom the other day and questioned why the kids

were so active and loud. What they didn't see were the interactions, connections, and learning going on. (Fall follow-up VAST reflection)

Ninety-three teachers from 28 different elementary school teams and 33 different districts in Virginia participated in the ESI. Each site invited the principals and science coordinators to the ESI to learn more about inquired-based instruction and to support their school teams. The science coordinators and principal commented:

- I can see why the teachers are excited about teaching this way. VISTA seems to have given help to some of my weak teachers. To get them asking questions and planning as a team is a plus. To get them to teach science in a way that students will engage in critical thinking is wonderful. I will give my support to this. (Principal interview during ESI)
- As a science coordinator I struggle to get my teachers into inquiry science. I like the way the VISTA program is modeling and aiding them with coaches to present science instruction. I like to see how this works during the regular school year. At this point the teachers are feeling good about teaching science. Thank you. It is very hard to engage teachers to move away from traditional teaching. (Science coordinator interview during ESI)

The teachers felt a little differently about the administrators' roles. They were apprehensive as to whether the principal would continue to support them at the school level.

- I believe my principal is trying to help me, but I think she worries too much about traditional ways of teaching and benchmark tests. I see her here today so I am encourages that she will support my PBL. (ESI Principals' Day)

- My science coordinator I know will help me implement the PBL unit. You can see that she is pushing inquiry learning. As for my principal she is an excellent leader but doesn't know much about science. It's a positive that she is here today and I think that means she will follow our team's PBL development. (ESI Principals' Day)
- My principal is not here. That says it all. She is not supportive of any new things we do. I'm not surprised she didn't show up today. (ESI Principals' Day)
- Our dynamic principal is excellent. She is here today; I saw her wearing the science goggles and doing inquiry experiments. She knows this is going to improve instruction and develop our young students' minds. She told me over lunch that she wants to see the PBL in the classroom. I will invite her in to visit my classroom when the time is right. (ESI Principals' Day)

Support and Resources. To assist teachers with implementing the PBL unit at their schools, VISTA provided teachers with resources, expert staff during camp, instructional resources, and monetary stipends to buy scientific equipment. As the units were being developed, the teachers were encouraged to use multiple resources and supplies. VISTA also provided science materials for the implementation of the PBL unit at the summer science camp. Teachers commented:

- The summer institute didn't change my way of thinking about science, what it did was support the ideas and thoughts I already had about how students learn. I have always had a constructivist approach to learning and this institute just solidified that thought and my practices. It has given me the tools I need to try and make changes about how science is taught in my district at the level I teach. Science isn't necessarily seen for its value and importance. Having taken this institute, I now have

fresh ideas, with research, to support that value and importance. (Fall follow-up reflection)

- We were given sufficient time to plan and had many resources available to us as we were doing so. There are some factors out of their control that leave me somewhat unprepared, such as a lack of accessible water to conduct the experiments we created in our Oceans PBL. Also, we planned some of our experiments around using probes that we ordered with our VISTA money, not realizing that a connector was necessary, so now we cannot use the probes unless we buy the connector which is expensive. However, having the experience in the camp made me feel much more open to trying the new methods and prepared for teaching inquiry science to my students. (Fall follow-up reflection).

Coach Role. Coaches were introduced to the teachers during the ESI. All sites asked coaches to attend five days so they could get to know the teachers and assist the teacher in planning their school PBL unit. During Year 2, each site tried to get the coaches more involved in the planning stages of the PBL unit as in Year 1 they were under-utilized as a resource. Some teachers commented:

- When my PBL was approaching this year I was very nervous and claimed to not be prepared. The part I was most nervous about was not having everything planned and finalized at VISTA due to time constraints, but then after talking to my coach, I realized that I could just tweak my old plans and not have to start from scratch. I definitively think it was easier once I got started with the PBL and it has definitely become second nature. (Fall follow-up reflection).

- I'm going to use my coach to help me. Having a second person to help our team is great. I've already bonded with my coach. We have planned to meet, go over resources and are trying to figure out pacing. She is setting our goals and working with me on the PBL. I'm not sure what else she can help me with but she's willing to do anything. (ESI Week 1 Reflection)

Teachers' perceptions of the ESI professional development, training and instructional support in improving their teaching of student-centered inquiry-based science using problem-based learning

Several themes emerged from the teacher responses on their perceptions of the ESI professional development: importance of inquiry based science (PBL, NOS, hands-on science and inquiry), teacher role, questioning and problem solving, connections to real world, coach role, support and professional learning community.

Importance of inquiry based science (PBL, NOS, hands-on science and inquiry). The ESI focused on preparing the teachers how to teach inquiry- based science and to implement a PBL unit. Table 5 shows the number of teachers that perceive that the ESI improved their preparation to teach science using student-centered inquiry-based science using PBL is 98.9 %. The data indicate that the teachers felt the ESI was useful to help them prepare to teach inquiry-based science.

Table 5

Year 2 Teachers' perceptions of the ESI professional development in improving their teaching of student-centered inquiry-based science using PBL

	Teacher Perception of the ESI Professional Development in Improving their teaching of student-centered inquiry-based science using PBL					
VISTA Outcome after Attending ESI	Strongly Agree	Disagree	Neither	Agree	Strongly Agree	Number of Responses (n=87)
Better prepared to teach science	0 (0%)	1 (1.1%)	0 (0%)	39(44.9%)	47(54.0%)	87(100%)
Changed how I plan and teach science	0(0%)	1(1.1%)	6(6.9%)	45(51.7%)	35(40.3%)	87(100%)

Teachers noted that the institute helped change or support their understanding of inquiry-based science:

- VISTA completely changed the way I think about teaching science. Coming into the program, I considered my lessons "hands-on," but after attending VISTA I learned how vital it is for students to have access to real Science materials and not just build models from food products. I also did not know anything about the "Nature of Science," which has completely changed the way I teach. VISTA gave my science lessons and activities purpose. I can now say to my students that we are doing this activity to answer this question on our question map and we need to collect evidence to prove what we think. I also focused a lot of this year on inquiry, really having the students come up with questions, and I've made it very clear to them that Science cannot exist without questions. We now start every day with a question, whereas I used to write my objectives as what they would know by the end of the period. Finally I would say that VISTA helped me take a step back from my students' learning and let them explore and discover on their own. VISTA has definitely changed my teaching for the better! (Fall follow-up reflection)

- The summer institute made look at teaching science with a fuller circle approach. While I have frequently endeavored to give students as much hands on experimenting experiences as possible, I now pay more attention to the authenticity of the experiments and the materials used. It also seems to me that the PBL also give the students a purpose for their learning. (Fall follow-up reflection)

After attending the ESI, Table 6 shows that 80 (89%) of the 87(100%) teachers who responded to the query felt comfortable with incorporating inquiry in their PBL. One (1.1%) felt she was not comfortable and six (6.9%) were neutral on the implementation issue.

Table 6

Teacher Perception of Feeling Comfortable Planning and Implementing VISTA Constructs in their PBL Unit

	Teacher Perception of Feeling Comfortable Planning and Implementing VISTA Constructs in their PBL Unit					
VISTA Construct	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree	Number of Responses (n=87)
Hands-on science	0 (0%)	2 (2.3%)	1(1.1%)	57(65.6%)	27(31.0%)	87 (100%)
Inquiry	0 (0%)	1 (1.1%)	6 (6.9)	58 (66.7%)	22 (25.3%)	87 (100%)
PBL	1(1.1%)	1 (1.1%)	8(9.2)	52 (59.9%)	25(28.7%)	87 (100%)
NOS	0 (0%)	1 (1.1%)	11 (12.7%)	41 (47.1%)	34 (39.1%)	87 (100%)

Teachers noted the following:

- I definitely have a better understanding for hands-on science. While some modeling activities are necessary and certainly “fun” with non-science materials such as candy, again concepts can be lost if students do not see how the fun activity applies to real life. Real science materials move toward preventing lost instruction. Now I just have to convince my teammates who did not attend VISTA of this same concept. (Fall follow-up reflection)

- The PBL was an enormous change to how I used to teach. I always thought I made my plans flow, but the PBL that I made at VISTA took it to a whole new level, putting it in front of the students so they could not only understand what we were learning, but know why we were learning. Another thing that has changed is my hands-on activities, which was students doing things with their hands, and is now students working on Science problems with real Science materials. (Fall follow-up reflection)
- The nature of science has been the most difficult for me to grasp and feel comfortable conveying accurately to students. Making a conscious effort to talk about the nature of science with the kids during camp and having the poster to refer to helped me develop a deeper and more confident understanding. The biggest impact on my understanding of these concepts was trying them in camp, collaborating, and getting feedback. (Retrospection, July 23, 2012)
- After completing the student camp I feel much more comfortable with inquiry and hands-on understanding. NOS still takes some effort to explicitly teach and sometimes it feels forced throughout the lesson(s), but overall I have a better understanding of all 3 components. (Retrospection, July 23, 2012)
- I spend the first 3 or 4 minutes of each science class reviewing the aspects of Nature of Science. My students are all actively participating in a hands-on Oceanography PBL. They are excited about each lesson and they are engaged in each activity. They are sharing their research and experimental design results with each other. I have integrated my Problem Based learning unit with all content areas. By using PBL I have learned that immersing students in a real world open-ended problem without a

clear-cut solution allows for deeper understanding, questioning, problem solving, and reflection. (Fall follow-up reflection)

Questioning and problem solving. During the ESI, teachers were introduced to teaching models that included sections on questioning. During the PBL training, teachers were taught how develop questions and how to use question maps. Teachers noted the following:

- Making question maps seemed meaningless at first but finally I got its importance. I had to experience it as a learner to get it. Now I can look at my science instruction and think about possible questions I can ask to guide my students. As we go over topics I am always try to visualize what possible questions they may ask. I prepare myself. Sometimes I don't know the answer but that's OK- we work it out as a group. My students guide me as to where we are going. They were slow at first to volunteer but now they ask intelligent questions. I never knew I could engage them at this level. (ESI reflection)
- The teaching module on discourse was very helpful to develop my questioning skills. I use discourse circles and have taught my students how to develop questions, I also liked the way VISTA made us observe other teachers teach. We were made to mark down the questions patterns (who was asking questions- whether it was student most of the time or teachers). That made me really think about my own instruction. I became more aware of my role. I want the students to ask other students questions not just questions of me. (ESI reflection)
- Problem solving and PBLs were unknowns for me before VISTA. I thought only gifted kids did PBLs. Seeing the students this summer in camp solve PBLs was amazing. Our teachers in our camp were blown away by some of the things these kids

> came up with. I really didn't think it would work, but I'm definitely a PBL fan now. I have learned that I will use questioning in a better way now. I will not just ask for straight knowledge answers. That's the old me. Now I ask questions with more open-ended answers to engage the students in critical thinking. (Fall follow-up reflection)

Connections to real world. Using PBL units to teach science introduces students to relevant applications of science to the world they live in. Making students see these connections is a challenge for some teachers. After the ESI, teachers noted the following:

- The biggest impact that Vista had on my thinking about science is in the planning of it. By making the connection to the "real world", connecting it back to the NOS, as well as making sure that I included experiments, not activities, my teaching and the students understanding have grown beyond belief. I wish I had been taught how to plan like this before. (Fall follow-up reflection)
- I really like using the concept of framing instruction around a bigger real life challenge/problem that can be applied to the science students are required to learn. I see great value in connecting concepts within science, math and our world as oppose to learning about these subjects in separate lines of instruction (essentially in a bubble.) Even if the lessons taught with a hands-on aspect to them, if they are not related to a bigger concept, I think the information is more easily lost after testing. (Fall follow-up reflection)

Support and professional learning community. As the ESI progressed, teachers developed professional relationships with other teachers and small professional learning communities began to emerge. Teachers began sharing resources, gave tips on how to teach

science concepts and encouraged each other with the PBL unit development. VISTA also provided Year 2 teachers with two Year 1 ESI teachers to help them plan the camp PBL unit.

- The most beneficial part of the institute was working with other teachers in my county to create our PBL together. This was such a new idea and concept for all of us that it was really comforting and helpful to have other minds at the table to bounce ideas off of. The other part I found beneficial was having the teachers from last year. When originally being introduced to the idea of PBL, it was very overwhelming, but hearing that teachers, just like us, were able to complete it and benefit from it, really helped me buy into PBL. (Fall follow-up reflection)
- The collaboration with other teachers from other districts was by far the most beneficial aspect of my experience. It is always good to see and hear what others are doing in their districts and compare notes about lessons, policies, and so much more. Many of these people have now become friends that I can share ideas with on a regular basis. We all know that teachers go outside of what their districts provide to make our students' experiences better. Having a new network of teachers (including the VISTA staff) has only broadened that sphere. (Fall follow-up reflection)

The teachers felt the follow-up sessions in the fall were useful to them in a supporting role. Some teachers commented:

- I felt more comfortable hearing the challenges from other teachers that have finished their PBL. Those were some of my worries as well(..time, student etc..). They helped me see that I can do this. (Fall follow-up reflection)
- I really am appreciative for the continued professional development VISTA is doing with NOS, inquiry, PBL, and hands-on science. I gain new insights and skills each

time I come. I also love the resources in Dropbox (on line) and have referred back to them often. (Fall follow-up reflection)

- I know this program only lasts a year but can I come back and do it again? The support you give to your teachers is phenomenal. I talk to my coach and I also email the curriculum specialist at our site and she always helps me get what I need to help my instruction. (Fall follow-up reflection)

Coach role. The coaches in the VISTA program were hired to provide a support service to the ESI teachers. They help the teachers plan lessons, co-teach if needed, and observe the teachers teach. They guide the teachers through the year to promote inquiry instruction and act as a science content expert. Their roles are many, and each coach will tailor their help to meet the needs of the teachers they coach. Many of the coaches are retired science teachers and were part of the ESI this summer, participating with the teachers and getting to know them for the first time. Later in the institute they helped the teachers to develop their PBL units and provide on-going coaching at their school. The majority of teachers reported positive interactions with their coaches. Teachers commented:

- I like the fact I can ask my coach for help. She has provided me with more resources and teaching ideas that I could get on my own. I know she coaches other teachers but I feel she looks out for me. She supports my teaching. I have definitely improved my science teaching because of the coach. She explains things to me in ways I couldn't get. I don't have a science background but I now do try and teach inquiry-based science. The coach always shows me by doing little changes how I can adapt my lessons to be more effective. (Fall follow-up reflection)

- To be honest I didn't like my coach at first. She was bossy and didn't seem like a person I could work with. I was scared at first having someone in the classroom critiquing me. But it wasn't like that. We focused on little things like questioning at first, then she helped me deal with NOS, and now she is helping me get the PBL started. The impact of the coach is huge and we have grown professionally together. I needed to have someone look at my teaching with a different lens and work with me on how to improve my teaching. (Fall follow-up reflection)

A few teachers were not happy with their coaches and felt that they could have been more effective. A teacher commented:

> My coach was not so prepared as I thought she would be. She seemed unsure of her role and mine. I felt I needed help in some areas of science and she didn't seem to respond to my requests. As time went by I realized I had to be more direct with her and tell her my needs. Since then her support has improved but I wish her science content was a little more useful to me. (Fall follow-up reflection)

Coaches of elementary teachers also faced some challenges and issues working with their teachers as they implemented inquiry and PBL units in the classroom. Coaches commented:

- At first the teachers were guarded with me. They find it hard to tell me what they want. I can see areas where they need help. But at first I want them to tell me what they need. Also, the amount of time they teach science is limited.[sic] Some elementary schools only offer 45 minutes of science per week. Not a lot I can do there. (VAST Coach reflection)
- With the 5th grade team I coach, the teachers were unwilling to dedicate time for me to provide coaching instruction. At the least, in hindsight, they could have gotten

science content instruction which was greatly needed. They need to use higher questioning skills and make time for me. (VAST Coach reflection)

- I was able to get my teacher to lay out her topics and lessons for the next 9 weeks. Prior to this she was teaching day to day. Now she can start looking at ways to increase inquiry and student participation in her classes. She was pleased I could help her in this way. I also have gotten her to see the value of arranging the room for small group discussion. (VAST Coach reflection)
- My teachers are gaining confidence and have come to a better understanding of designing lessons and teaching with inquiry, NOS, and hands-on activities. I can see the teachers begin to use the techniques, and methods they learned in the summer ESI. I think having a coach to talk to gives them confidence and resources to ask advice from and they are not falling back into their old teaching routine. (VAST Coach reflection)
- Only one of the teachers that I coach seems to be making a change in the area of teaching practices. Initially, the teacher felt that the only way students could learn was if he was doing all the teaching. I can see a change due to the fact that he is allowing the students to participate more. However, his students are not allowed to work in small groups. But I will work little by little to change this. (VAST Coach reflection)

There seemed to be a consensus among the coaches that they could achieve more with their coaching duties if the VISTA paperwork was decreased. As a coach, they fill out multiple forms to document their visits and several commented that the paperwork was hindering their effectiveness in helping the teachers in their classrooms.

Discussion and Limitations

The goal of the Virginia Initiative for Science Teaching and Achievement (VISTA) model is to provide intensive support and effective interventions to help teachers learn science content through experience and develop confidence in teaching inquiry-based science and problem-based learning. This is the second of five years of the VISTA model study and so far, the data collected indicate that teachers are more aware of teaching science through inquiry and more confident in teaching a PBL unit. This study investigated how elementary teachers learn how to teach using inquiry-based models. Professional development programs where teachers model inquiry provide a basis for teachers to continue their experiences with inquiry science in the classroom (McDermott & DeWater, 2000). Based on the participant exit slips, daily ESI debriefs, discussions, interviews and participant reflections collected for this study, this research supports that claim. Findings on learning how to teach inquiry-based science, implementation of inquiry- based science and professional development are discussed.

Learning How to Teach Inquiry-based Science. The findings of this study show that teachers perceived they had a better understanding of teaching inquiry and were confident that the PBL experience in the ESI professional development program gave them the tools and skills to teach inquiry. The findings suggest that many factors need to be considered in educating teachers about methods for teaching inquiry and engaging students through problem-based learning. These factors include the teachers' needs to experience the development of PBL units, make science connections, foster student engagement, change traditional instruction, implement PBL instruction, and understand their roles as teachers. This study shows that teachers need to rethink their traditional ways of teaching. What worked for them when they were students may not work for their students today. Loucks-Horsley et. al. (2010) suggest that as teachers learn to

change, they will need additional help and support to apply new behaviors in the classroom. VISTA provides on-going teacher support with instructional coaches. This supports the work of Steiner and Kowal (2007) which found that effective coaches need to be knowledgeable of student learning, have rich content understanding of subject matter, and be able to communicate with teachers.

VISTA teachers started to implement inquiry-based science in their classroom when they returned to their home schools. They found this challenging but rewarding and claimed they were able to apply what they experienced during the training and student camp directly to their lessons. This study supports the research that teachers need professional development that is relevant to their teaching practices, is on-going and updated, and allows the teacher to assimilate and reflect on its content. (Blumenfield, Soloway, Marx, Krajcik, Guzdial, & Palinesar, 1991; Kubitskey, 2006).

Implementation of Inquiry-Based Science. With Year 2 of the VISTA model nearing its close, the findings indicate that several factors need to be considered when elementary teachers apply their knowledge of inquiry in the classroom. The factors are scheduling of science at the school, curriculum pacing and standards, school barriers, support and resources, and the role of the coach. The VISTA teachers in this study were concerned that their ability to implement inquiry-based science was hindered by the amount of time allocated to science in their schedule. This supports the study by Appleton (2007) which showed science instruction is scheduled after mathematics and reading or literacy programs, if at all. Often, science is absent from the schedule or has only few minutes each week.

Feedback from instructional coaches indicated that teachers were slow to make use of their services. The coaches felt they could be of some use to help implement inquiry instruction

once they had established a rapport with the teachers. There is little research showing whether teachers perceive coaches to be beneficial. Our findings indicated that most teachers were wary of the coaches at first but did find their presence beneficial to them. This supports the findings of Vanderburg and Stephans (2010) that teachers find coaches helpful, but does not explain how the actions of the coaches change the delivery of teacher instruction.

Coaches were identified as a positive support factor that could help the teacher implement inquiry in the classroom. The VISTA model does include feedback and support to the teachers by providing instructional coaches in the classroom. Future research could examine if the instructional coaches are effective in providing constructive feedback to the teachers on inquiry-based instruction and improves teacher practice.

If teachers are teaching in a school district with a rigid curriculum pacing schedule, they may become overwhelmed when asked to implement new science programs (Bybee, 1993; Crawford, 2000). The VISTA teachers expressed concerns with curricular demands and demands of their school administrators as hindrances or barriers encountered during their implementation of the PBL unit. Drits (2011) found that school and personal factors can be barriers that prevent teachers from implementing changes in the classroom.

Professional Development. As the professional development for elementary teachers of VISTA completes its second year of implementation, several factors need to be considered when looking at professional development such as the importance of inquiry based science (PBL, NOS, hands-on science and inquiry), the role of the teacher, questioning and problem solving, connections to real world, the role of the coach, and establishment of support and professional learning.

Teachers in this study were confident in their understanding of PBL, NOS, hands-on science and inquiry-based science in their classroom after attending the ESI professional development program. However, the ESI teachers are facing problems with implementation of inquiry-based instruction due to time constraints, feedback limitations, and other barriers found at their own schools. Hauck (2012) believes that any understandings teachers gain during the professional development will not be sustained as it takes three years for this to happen. VISTA ESI professional development with continued support is only one year long. The ESI teachers also perceived that they had begun implementing NOS successfully in their classroom. Akerson and Volrich (2006) found that teachers who were trained in NOS do not introduce NOS in their instruction unless there is ongoing feedback to monitor their progress. It could be argued that the VISTA coaches could provide better feedback on teacher success incorporating NOS, but NOS is not the only focus of their observations and coaching duties.

Year 2 of this study indicates the VISTA ESI professional development model continues to change teachers' perceptions on how to teach inquiry-based science. The VISTA model gave teachers the means to experience inquiry and PBL development first-hand and to professionally grow as a science educator. The main goal of professional development programs is to improve student outcomes and to increase student achievement. Often professional development is ineffective as it is not focused on student outcomes and is unsupported at all levels of implementation. VISTA teachers become part of a professional development program that has the support of other teachers, coaches, principals, science coordinators and VISTA staff to promote student learning and achievement.

Future research (including three more years of the VISTA model with new sets of teachers joining the project) on teachers' perceptions of how to teach inquiry-based science will

enable researchers to understand in greater depth how teachers change instructional practices after professional development. Since much of this study is based on teachers' own perceptions and is self-reported, it would be interesting to research if the coaches' observations of teachers accurately match the perceptions of the teachers as they implement inquiry-based science in the classroom. If coaches are at the schools, then the coaches should facilitate the customization of the teachers' learning to maximize student achievement as suggested by McCombs & Marsh, (2009). During the last three years of the VISTA program, qualitative data on coach and teacher interactions and how the teacher utilizes the coach as a resource could be collected to determine the nature and magnitude of the impact of the coach on the classroom teacher's science instruction.

References

Akerson, V. L. & Abd-El-Khalick, F. (2003). Teaching elements of nature of science: A yearlong case study of a fourth-grade teacher. *Journal of Research in Science Teaching*, *40*, 1025-1049.

Akerson, V. L. & Volrich (2006). Teaching nature of science in a first-grade internship setting. *Journal of Research in Science Teaching*, *43*, 377-394.

Appleton, K. (2007). Elementary science teaching. In S. K. Abell & N. G. Lederman, *Handbook of Research on Science Education* (pp. 493-535). Mahwah: Lawrence Erlbaum Associates.

Banilower, E.R., Heck, D.J., & Weiss, I.R. (2007). Can professional development make the vision of the standards a reality? The impact of the National Science 226 Foundation's Local Systemic Change through Teacher Enhancement initiative. *Journal of Research in Science Teaching, 44*(3), 375.

Bell, R.L., Konold, T., Maeng, J.L.,& Heinecke, W.F. (2012). *VISTA research and evaluation annual report: Year 2.* Unpublished Report for George Mason University.

Berg, A, De-Marginalizing Science in the Early Elementary Classroom: Fostering Reform-Based Dilemmas Proquest Dissertations and Theses. Retrieved from http://search proquest.com

Blumfield, P. (1994). Lessons learned: How collaboration helped guide middle grade science teachers learn project-based instruction. *Elementary School Journal*, 94, 539-551.

Blumenfield, P. , Soloway, E., Marx, R., Krajcik, J. , Guzdial, M., & Palinesar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist*, 35, 149-164

Borko, H. (2004). Professional development and teacher learning: Mapping the Terrain. *Educational Researcher*, 33 (8), 3-15

Brown, J. L., (2004). *Making the most of Understanding by Design.* Washington, DC: Association for Supervision and Curriculum Development.

Bybee, R.W. (1993). *Reforming Science Education. Social Perspectives and Personal Reflections.* Teachers College Press, New York.

Chang, C.Y., & Mao, S.L. (1999). Comparison of Taiwan science students' outcomes with inquiry-group versus traditional instruction. *Journal of Educational Research,* 92, 340-346

Crawford, B. A. (2000). Embracing the essence of inquiry: New roles for science teachers. *Journal of Research in Science Teaching*, 37, 916-937.

Darling-Hammond, L. (1999). *Teacher Quality and Student Achievement: A Review of State Policy Evidence.* Center for the Study of Teaching and Policy, University of Washington, WA.

Desimone, L.M. (2009) Improving impact studies of teachers' professional development: Toward better conceptualizations and measures: *Educational Researcher*, (38), 181-199.

Drits, D. (2011). Elementary teachers' science practice, beliefs, and content knowledge during and following a reform-based professional development program. The University of Utah). ProQuest Dissertations and Theses, 246. Retrieved from http://search.proquest.com/Proquest Dissertations and Theses. Retrieved from http://search proquest,com

Drits, D., & Stark, L. (2011, April). The role of school context in advancing teacher change in the year following a science-based professional development program.

Paper presented at the AERA Annual Meeting, New Orleans, LA.

Fennema, E. , Carpenter, T. P. , Franke, M.L. , Levi, L. Jacobs, V.A, & Empson, S. B. (1996). A longitudinal study of learning to use children's thinking in mathematics instruction. *Journal of Research in Mathematics Education*, *27*, 403-434.

Fishman, B.J., Marx, R. W., Best, S., & Tal, R.T. (2003). Linking teacher and student learning to improve professional development in systemic reform. *Teaching and Teacher Education*, 19, 643-658

Hartshorne, R. (2005). Effects of integrating hypermedia into elementary science professional development on science content knowledge. *Journal of Science Education and Technology*, 14, 415-424

Hauck, N. (2012). Effects of sustained teacher professional development on the classroom. science instruction of elementary school teachers, Utah State University. Proquest Dissertations and Theses, 211. Retrieved from http://search proquest,com

Hiebert , J. , Fennema, T.P., Fuson, K. , Human, P. , Murray, H. (1996). Problem solving as a basis for reform in curriculum and instruction: The case of mathematics. *Educational Researcher,* 25,12-21.

Johnson, M.A. & Lawson, A.E. (1998). What are the relative effects of reasoning ability and prior knowledge on biology achievement in expository and inquiry classes*? Journal of Research in Science Teaching*, 35, 89-103.

Keys, C.W., & Bryan, L.A. (2001). Co-constructing inquiry-based science with teachers: Essential research for lasting reform. *Journal of Research in Science Teaching, 38,* 631-645.

Khlar, D., & Nigam, M. (2004). The equivalence of learning paths in early science instruction: Effects of direct instruction and discovery learning. *Psychological Science*, 15, 661-667

Kielborn, T.L., & Gilmer, P.J. (1999) Meaningful science: Teachers doing inquiry + teaching science. Tallahassee, FL:SERVE

Kubitskey, B. *Extended professional development for systemic reform* (2006). Doctoral dissertation, University of Michigan, Ann Arbor.

Lakshmanan, A., Heath, B.P. & Elder, M. (2010). The Impact of Science Content and Professional Learning Communities on Science Teaching Efficacy and Standards-Based Instruction. *Journal of Research in Science Teaching*, 48, 534-551

Loucks- Horsley, S., Stiles, K.E., Mundry, S., Love, N., &Hewson, P. (2010). *Designing professional development for teachers of mathematics and science. (3rd Ed.)* Thousand Oaks, CA: Corwin Press

Luft, J. & Pizzini, E. (1998) *The demonstration classroom in-service: Changes in the classroom.* New York: John Wiley.

McCombs, J.S., & Marsh, J.A. (2009). Lessons for boosting the effectiveness of reading coaches. *Phi Delta Kappan*, *90*(1), 501-507.

McDermott, L. C., & DeWater, L. S. (2000). The need for special science courses for teachers: Two perspectives. In J. Minstrell & E.H. van Zee (Eds), *Inquiring into inquiry learning and teaching in science.* Washngton, DC: National Academy Press.

Mensah, F.M. (2010). Toward the mark of empowering policies in elementary school science programs and teacher professional development. *Cultural Studies of Science Education*, *5*, 977-983.

Michaels, S., Shouse, A. W., & Schweingruber, H. A. (2008). *Ready, set, science! Putting research to work in K-8 science classrooms.* Washington, DC: NA Press.

Miles, M.B. & Huberman, A.M. (1994). *Qualitative data analysis.* Thousand Oaks, CA: Sage

Minstrell & E. H. v. Zee (Eds.), *Inquiring into inquiry learning and teaching in science*. National Academy Press: Washington, D.C.

Minuskin, S. O. (2009). *Effects of professional development on the knowledge and classroom practices of elementary school science teachers* (Doctoral dissertation). Available from ProQuest Dissertation and Theses database. (UMI No. 3385691)

Musheno, B.V., & Lawson, A. E. (1999). Effects of learning cycle and traditional text on comprehension of science concepts by students at differing reasoning levels. *Journal of Research in Science Teaching*, 36, 23-37

National Commission on Mathematics and Science Teaching for the 21st Century. (2000). *Before it's too late*. U.S. Department of Education . Retrieved from http://www.ed.gov/americacounts/glenn

National Commission on Science Education Standards and Assessment and National Research Council (1996). *National Science Education Standards.* National Academy Press: Washington, DC.

National Research Council (2007) *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. National Academies Press: Washington, DC. Retrieved from http://books.nap.edu/catalog.php?record_id=11463

National Research Council (2011). *A framework for K-12 Science Education: Practices, Cross Cutting Concepts, and Core Ideas* . Washington. DC: National Academic Press.

Next Generation Science Standards Draft, (2013): Retrieved from www.nextgenscience.org; www.nsta.org/ngss

Patton, M.Q. (2002). *Qualitative evaluation and research methods.* Newbury Park: Sage

Rice, D.C. (2005). I didn't know oxygen could boil! What preservice and inservice elementary teachers' answers to 'simple' science questions reveals about their subject matter knowledge. *International Journal of Science Education, 27*, 1059 – 1082.

Rosenfield, S., & Ben-Hur, Y. (2001). Project-based learning in science and technology: A case study of professional development. In *Proceedings of the IOSTE Symposium in Southern Europe on Science and Technology Education: Preparing Future Citizens, Greece, 2001*

Simon, M. A. & Schifter, D. (1991). Towards a constructivist perspective: An intervention study of mathematics teacher development. *Educational Studies in Mathematics*, 22, 309-331

Smith, T. , Desimone, L. & Ueno, K. (2005). "Highly qualified" to do what? The relationship between NCLB teacher quality mandates and the use of reform-oriented instruction in middle school math. *Educational Evaluation and Policy Analysis,* 27, 75-109.

Smith, T. , Desimone, L. , Zeidner, Dunn, Bhatt, Rumyanteseva (2007). Inquiry oriented instruction in science: who teaches that way? *Educational Evaluation and Policy Analysis,* 29, 169-199.

Steiner, L., & Kowal, J. (2007). *Instructional Coaching*. Washington, DC: Centre for Comprehensive School Reform and Improvement

Swars, S. L. & Dooley C.M. (2010). Changes in teacher efficacy during a professional school-based science methods course. *School Science and Mathematics*, 110, 193-202

Vandenburg, M., & Stephens, D. (2010). The impact of literacy coaches. What teachers value and how teachers change. The Elementary School Journal, *111*(1), 141–163.

Wallace, C. S. & Kang, N. (2004). An investigation of experienced secondary science teachers'

beliefs about inquiry: An examination of competing belief sets. *Journal of Research in Science Teaching*, 41, 936-960.

Windschitl, M. (2004). Caught in the cycle of reproducing folk theories of " Inquiry" How pre-service teachers continue the discourse and practices of an atheoretical scientific method. *Journal of Research in Science Teaching*, 41, 481–512.

Wise, K.C., & Okey, J.R. (1983). A meta-analysis of the effects of various science teaching strategies on achievement. *Journal of Research in Science Teaching*, 20, 419-435

Wu, H., & Krajcik, J. S. (2006). Inscriptional practices in two inquiry-based classrooms: A case study of seventh graders' use of data tables and graphs. *Journal of Research in Science Teaching, 43,* 63-95.

APPENDIX

Table 2*: Sample Schedule from VISTA site. (The actual times may vary but the instructional content and delivery of that content at all 3 VISTA sites is the same)*

Week 1- Learning the VISTA Model of Inquiry-Based Instruction Using PBL		
Day 1	8:30am –8:40am	Welcome and Introductions Getting to know you
	8:40am – 9:30am	VISTA Assessment # 1 Overview of VISTA Journaling
	9:30am – 12:30pm	Introduction to Inquiry in the context of PBL in a rich context Teachers experience the beginning process of how to solve a problem through inquiry instruction. The concept of using a question map is introduced with 3 levels of questions and how to identify solutions to a problem. Teachers discuss the implementation of this process and how they as learners felt during this inquiry-based activity.
	12:30 pm – 1pm	Lunch
	1pm – 1:45pm	PBL, Inquiry, Hands-on NOS (Linking the morning's activity to the VISTA definitions). Introduce Inquiry rubric and applications to the classroom.
	2pm – 3:45pm	PBL Camp Theme is introduced. Teachers then develop topics for possible scenarios through brainstorming in small groups or whole group. Identify problem, scenario, student role, culminating activity (assessment), and resources/materials. Consult with scientists and curriculum math specialists to determine scientific grounding and feasibility of scenarios Scenarios
	3:45 pm – 4pm	Overview of General Camp Schedule Exit Ticket
Day 2	8am – 8:30am	Welcome Back/Parking Lot Camp logistics
	8:30am – 9:30am	Nature of Science (instructional training)
	9:30am – 10:30am	Technology Fair (instructional training)
	10:30am – 11:30am	Initial Planning for Camp
	11:30am – 12pm	Lunch
	12pm – 2:15pm	Question Map Planning
	2:15pm – 4pm	Lesson planning with teaching team Exit Ticket/Reflection
Day 3	8am – 11:30am	Planning Share Lesson plans Gallery Walk

	11:30am – 12pm	Lunch
	12pm – 4pm	Planning Exit Ticket/Reflection
Day 4	8am – 9:30am	Lesson Review Finalize Supply list
	9:30am – 11:30 am	Planning
	11:30 am – 12pm	Lunch
	12pm – 4pm	Planning Exit Ticket/Reflection
Day 5	8am – 11:30am	Planning
	11:30am – 12 pm	Lunch
	12pm – 4pm	Camp Overview Presentations VISTA Assessment # 2
Week 2- Implementing PBL unit or Professional Development		
First Week of Camp with Students Teachers not teaching will actively participate in instructional modules and field/lab activities with scientists		
Week 3- Implementing PBL unit or Professional Development		
Second Week of Camp with Students Teachers not teaching will participate in modules and field/lab activities with scientists Last day of camp – Final Presentations of PBL / Parent Visitation Day		
Week 4- Planning a PBL to Implement at Participant's School		
Day 1	8am – 10am	Camp Debrief
	10am – 11:30am	Planning with school team
	11:30am – 12:30pm	Lunch
	12:30pm – 12:45pm	Sharing Session
	12:45pm –4pm	Planning with school team/VISTA Team Consulting
Day 2	8am – 9:30am	Best ELL practices in Science
	9:30am – 11:30am	ELL consulting
	11:30am – 12:30pm	Lunch
	12:30pm –4pm	Planning with school team/Sharing and Peer Feedback/VISTA Team Consulting
Day 3	8am – 9:30am	Best Practices with Special Ed students in Science
	9:30am – 11:30am	Special Ed consulting
	11:30am –	Lunch

	12:30pm	
	12:30pm –4pm	Planning with school team Groups Report Out/Peer and VISTA Team Review
Day 4	8am – 11:30am	Planning and Consulting
	11:30am – 12:30pm	Lunch
	12:30pm –4pm	Coach consulting
Day 5	8am – 11:30am	Peer teaching
	11:30am – 12:30pm	VISTA Assessment
	12:30pm – 1pm	Lunch
	1pm-4pm	Concluding Thoughts (Follow up info, VAST registration, Communication protocols)