**Session Title:**
Modifying Program Implementation and Addressing Sustainability Issues to Improve Research Experiences for Teachers

**MSP Project Name:**
Minority Student Pipeline MSP

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**Project Session**

**Strand 1**

**Summary:**
The recruiting strategies and implementation of a year-long professional development program using authentic research experiences to promote explicit nature of science instruction in the classroom evolved to better address the needs of program participants, and the partnering school system, as well as, lay the groundwork for future program sustainability. Changes to the recruiting strategy included broadening accessibility of the program, encouraging repeat participation, and encouraging development of cohorts within individual schools. Changes to programmatic implementation led to developing enrichment and extension activities for repeating participants, and providing and encouraging leadership opportunities for repeating participants. Additionally, relationship building with the partnering school system helped guide program modifications to create a useful product for both teachers, and the system as a whole.

**Section 1: Questions framing the session:**
1. What are the best practices for encouraging adult learners (with many other professional and personal commitments) to actively participate in professional learning communities that require substantial self-reflection and independently driven learning?
2. In what ways can implementation strategies be modified to meet the individual needs of program participants, and to encourage professional growth and development?
3. In what ways can program sustainability be encouraged, in order to meet the needs of the partnering school system and support other strands of the grant?

**Section 2: Conceptual framework:**
The body of knowledge that describes and defines what science is and how it is generated is referred to as the nature of science (NOS). Lederman (1992) defined NOS as "…the epistemology and sociology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development". Ensuring students possess

informed views of nature of science is important for several reasons. Current science education standards emphasize understanding NOS as a specific content goal in and of itself. For example, content standard G of the National Science Education Standards (National Research Council 1996) states that "as a result of activities in grades 9-12, all students should develop understanding of science as a human endeavor, nature of scientific knowledge, and historical perspectives (pg. 200)." Similarly, the National Science Teachers Association states "all those involved with science teaching and learning should have a common, accurate view of the nature of science" (National Science Teachers Association 2000). Developing informed views of nature of science in students will serve to increase their understanding of how science works, thereby allowing them to be better able to evaluate science as a member of society. Further, exposing students to the way science is actually performed in authentic settings can increase student interest in science, particularly for those who might otherwise view science as only a collection of facts, with most knowledge already known and nothing new to discover.

If NOS instruction is a content goal, then science teachers themselves must have an adequate understanding of NOS as content as well as pedagogical content knowledge to be able to teach it (Shulman 1986; Abd-El-Khalick and Lederman 2000; Lederman 2006). Teaching methods of NOS can be grouped into three main approaches (Khishfe and Abd-El-Khalick 2008) that include 1) implicit teaching of NOS through inquiry 2) explicit teaching of NOS (often, but not always through inquiry or science process skills) and 3) use of history of science lessons. Implicitly teaching nature of science is often done by having students take part in scientific inquiry activities. It is assumed in this approach that because students are engaged in asking and answering scientific questions that will be come to accurate understanding of nature of science concepts. However, research has shown that this is not the case (Carey and Smith 1993; Lederman, Schwartz et al. 2001). History and historical examples have also been used in attempts to teach nature of science. However, the evidence for improved student understanding of nature of science based on the historical approach is inconclusive (see Khishfe and Abd-El-Khalick 2008 for review). An explicit, reflective approach means that teachers explicitly address specific components of nature of science knowledge through reflective questioning of students. Explicit approaches have been shown to be an effective means in increasing nature of science knowledge (Shapiro 1996; Abd-El-Khalick, Bell et al. 1998; Akerson, Abd-El-khalick et al. 2000).

In order to be able to effectively teach students about NOS through the explicit, reflective approach teachers need to have a strong foundation and an informed view of what NOS is, as well as the pedagogical content knowledge to deliver that information to their students (Shulman 1986; Lederman 2006). To that end, we have designed a professional development experience for high school science teachers that couples an authentic summer research experience (128 hours) with a year-long learning community (136 hours over 11 months). The summer research experience places teachers in research labs, working side-by-side with faculty members, post-doctoral candidates and graduate students. These types of experiences for teachers have been shown to increase student achievement in science (Schwartz, Lederman et al. 2004; Silverstein, Dubner et al. 2009).

Research has shown however, that simply 'doing' science is not enough to increase understanding of the nature of science (Schwartz, Lederman et al. 2004), therefore we have coupled the authentic research experience with a year-long learning community. The learning community is a forum in which teachers can explore their own understanding and thoughts on nature of science, using their experiences in the research lab as a context for that reflection, as well as discuss and learn the necessary pedagogical content knowledge for teaching nature of science in their classroom.

Recruiting strategies and goals, implementation of the year-long learning community, and strategies for developing sustainability have evolved significantly from Year 1 to Year 5 of the program to meet the needs of both individual participants and the partnering school system. Initially we expected to have cohorts of first-time participants each year; however, each cohort after the first consisted of a mixed group of both first-time participants and repeaters. The presence of repeat participants provided an opportunity for us to encourage the repeaters to recruit other teachers from their schools to participate in the program which led to the creation of smaller cohorts within the larger cohort. The success of these smaller cohorts' influence on the way NOS was approached in these schools led us to modify our recruiting strategy to further encourage participation of multiple teachers from the same school. Additionally, recruiting efforts were modified to include a broader range of participants including those who were otherwise unable to participate in the full five-week research experience, and making the program available to both middle and high school science teachers. Expanding the program was in part due to suggestions from school officials that the content of the program was valuable to teachers in the system and therefore should be more readily available.

Due to changes in our recruiting efforts to include program repeaters and broaden the reach of the program, we had to modify the original program implementation plan to address the needs of these participants. The changes include creating a new and shorter version of the professional development experience, and re-evaluating our program and as a result re-designing program activities to engage repeaters and provide opportunities for them to grow as teacher leaders either within the program or in their schools. We have also the scaffolding techniques used with both repeaters and new participants to better guide them through self-reflection, and development of their understanding of NOS.

To increase sustainability of the program we determined after many conversations with our school system partners it would be beneficial for teachers to be trained to facilitate discussions about NOS with their colleagues. As a result, we have engaged in this type of training with selected program alum. Working closely with the school system and having many frank conversations has been incredibly helpful in determining what is and is not useful to teachers individually and the system as a whole. As a result sustainability efforts are likely. One example of this is the increase of NOS strategies being added to the county curriculum as a result of previous participants serving on the county curriculum writing team. All of these changes have occurred throughout the progression of the program. They were not intended at the onset, but have evolved because of needs that developed.

**Section 3: Explanatory framework:**
We are in the fifth year of our 5-year grant and are currently working with our fourth cohort of teachers (1 cohort/year). Our fifth cohort will begin in July. Throughout this experience one insight we have gained is the need for focused, in-depth and on-going professional development programs for teachers. Insights from our experiences with our first cohort led us to implement several programmatic changes in our second, third and fourth cohorts to help us meet our goal of increasing understanding of nature of science in high school teachers and students. These changes include:

- Increased specificity in program content and goals. Initially, our focus was on inquiry in science. This broad topic did not allow us to focus in-depth on any specific subject. For the following cohorts, we have tightened our focus to exploring the nature of science, with specific emphasis on the following nature of science aspects: tentativeness, creativity, subjectivity, theory-ladenness, the scientific method and the differences between theories and laws.

- Increased time in the learning community. In response to a need perceived after completing the first cohort, we added a 4-day 'bootcamp' for teachers in our subsequent cohorts, thereby increasing the amount of time spent in learning community activities by as much as 30%. During this bootcamp, teachers were given the opportunity to explore, reflect on, and discuss their conceptions and understanding of the nature of science. By holding the bootcamp in the beginning of the summer, prior to teachers entering their research lab placement, we were able to better prepare them for using the research experience as a context for discussion of ideas related to the nature of science. We found this to be extremely successful in preparing teachers to consciously and actively reflect and think about the ways they, faculty mentors, post-docs, and graduate students were conducting science.

- Increased focus on pedagogical content knowledge. Feedback from our first cohort suggested that despite focusing on, discussing, reflecting on and exploring nature of science concepts for over eleven months, they still felt inadequately prepared to teach these concepts in the classroom. Looking back, this was not surprising as self-mastery of a subject does not automatically allow one to teach that subject effectively (Shulman 1986). As a result, we have added a significant pedagogical content knowledge component to the program being delivered to our second cohort. We have increased our focus on providing them with examples of how to explicitly teach nature of science in the classroom. In addition to reading about examples others have used, we continually challenge them to develop, implement and share their own techniques and ways of explicitly teaching nature of science. The major assignment for teachers during the school year learning community is to videotape themselves teaching and create a 10-minute video that highlights their attempts (both successful and unsuccessful) to explicitly teach nature of science to their students. There are four main purposes of the video presentation 1) to give an individual teacher a structured opportunity to view and reflect on their explicit teaching of NOS 2) to allow other teachers in the learning community to view other teachers explicit teaching of NOS 3) to allow an opportunity for learning community members to

provide constructive feedback on each other's explicit NOS teaching efforts and 4) to allow the facilitators (researchers) insight into what is actually happening in the classroom.

Another insight that was gained was the importance of working with the school system to ensure programming met the needs of both the school system and teacher participants. With the school system's support our program was modified to include a broader number of participants. These changes included making the program available to both middle and high school science teachers, and creating a shorter program that includes a year-long learning community but excludes the summer research experience. This shorter program provides an opportunity to reach teachers who may not be able to commit to a 5-week summer research experience and therefore would not otherwise be able to participate. We have also modified recruiting strategies to encourage teams of teachers from the same school to participate in programs in order to create cohorts within the larger cohort. We have learned that doing this creates additional space to continue discussion an practice of new techniques.

We have also worked to increase sustainability by providing leadership opportunities for repeat participants who were interested in continuing their development. It was important to the school system that teachers be trained to coach or facilitate their colleagues on NOS. We have provided opportunities for this and as such have developed "NOS experts" in the county. These individuals will have the skills to continue this work after program funding is over. Additionally, past program participants working on the curriculum writing team have included NOS in the county science curricula. These connections are improving future sustainability.

**Section 4: Discussion:**

We have learned how invaluable an effective learning community can be in providing teacher participants with the support necessary to enable them to fully benefit from a professional development experience. We realized teachers need a great deal of time to practice new ideas, a lot of feedback before they become comfortable with those new ideas, and in some instances need to be taught how to be reflective. Knowing this, future programs will have the necessary supports embedded in the program from the onset. Additionally, we have learned that the impact of this type of professional development experience is amplified if multiple teachers from the same school participate in the program. Flexibility is imperative in order to meet the needs of all participants. Participating teachers should have the ability to grow and develop professionally while participating in the experience. This includes providing leadership opportunities for repeat participants who have been successful and would like to take their learning experience to another level. The facilitators should create an environment that meets teachers where they are and pushes them to next level, being aware that most likely all participants will not begin or end the program at the same level and being flexible enough to develop specific activities and opportunities for teachers to reach the highest goal.

These insights can be shared with others to encourage an environment where change and modification of teacher professional development experiences for the benefit of the

participants is expected and encouraged. Additionally, it is important to consider that while a research experience for teachers may be beneficial it may not be practical for all teachers. We must consider alternate ways to provide meaningful experiences to all teachers.

**Section 5: How will you structure this session? What is your plan for participant interaction?**

The session will begin with participants breaking into small groups to discuss a predetermined questions related to recruiting or implementation strategies, and program sustainability. Participants will then share their thoughts and ideas about the question with the whole group. The presentation will follow this brief discussion and presenters will share how these issues were addressed in this particular project.