USING A STEM WORKFORCE DEVELOPMENT PROJECT FOR RESEARCH THAT THE SCIENCE EDUCATION COMMUNITY CAN HEAR

Juanita Jo Matkins
College of William and Mary

Vexation

I became involved with a project funded by the Department of Defense almost immediately following my move to my current institution. The project was initiated very quickly, and rapid performance was expected. There was no time for setting up a research study, nor was there a lot of guidance and support for research. There was an explicit long-term goal of recruiting students for the Armed Forces research initiatives that seemed so critical to national security, and the short-term goals were undefined (!!). It became clear that the branch of the Armed Forces that we were working with – the Navy-- functioned from an approach similar to the King of Siam (so it is written, so it shall be done) or possibly the Field of Dreams (if we say it, they will do it). The alpha males in the group were convinced that all that was needed to convince students to go into STEM careers (and into the "Naval research enterprise") was to take the students to a base and shoot off the big guns. (Boom! Boom! "That would do it!"). The start-up was bumpy. Who would be the target group of K-12 students? What would be done with the target group? Start-up was complicated by the push from the Navy to get in the schools and do something practically immediately. The project would be implemented that spring.

The really amazing thing was that it worked. We put together a project for middle school teachers and kids that used Lego robots and problem based learning in science, mathematics, social studies, and language arts. Scientists, engineers, and mathematicians (S&Es) from a nearby Navy lab co-taught and served as mentors. After four years, our records show that over 3000 middle school students, 80 teachers, and nearly 50 S&Es have participated in program activities, both in regular classes during the academic year and in summer camps. To the present day, despite the exigencies of federal funding – monies were "pulled" in total in the third year of the project, monies returned in the fourth year – the schools, teachers, and administrators continue to implement the project, and more school systems are coming on board. The data collected included survey data from teachers and engineers, asking for judgments about effectiveness, and also focus group interviews with students, teachers, engineers, and administrators. Trained observers used a classroom observation rubric to show implementation fidelity. We designed our own instruments to determine content knowledge gain, and used a variation of the STEBI-B for teacher efficacy. We get feedback that is almost uniformly positive.

There is something very good about this project. From my perspective in the K-12 classroom (18 years) and in the university setting (16 years), this is one of the best projects I've been involved with. Nonetheless, the research community needs information that is focused and tied to a research base that is recognized in the community. That's how we decide whether and how much to pay attention to something. I believe this project has some important messages to tell, messages that can support similar projects in other settings. I need help in figuring out how to glean those messages from the mass of information I have. My vexation is distilling what I know about this project into information that the research community will hear and benefit from. How might I obtain data from the project or how might I turn the data from this project into such information?

Here's some information that might help. An area that yielded undeniably positive results from students, teachers, and administrators was the use of cooperative learning groups. In focus groups, students offered comments such as: *"I learned to cooperate with people who are different." And "The point is to get everyone to work together on it. By the end of the 2 weeks, you could adapt and work with other groups of people or people that you do not really know."* Teachers defined the success of the project by the ability of students to work together*, "When the greater majority of students learned to cooperate with people they don't know or normally get along with",* and by their own ability to use cooperative groups*, "I learned to trust the students to find the information on their own. It was scary not to answer, for me and the kids! I'm a better teacher as far as using cooperative groups more often."* Structured observations of classes during the implementation of project activities showed *"A remarkable number of students on task."* There were indications that issues of gender bias and isolation of students with special needs and of students whose primary language was not English were successfully dealt with in the context of working through the group tasks. There were also indications that students who were habitually truant attended class regularly during project activities; and students who were behavior problems purposefully stayed out of trouble so they wouldn't miss the activities. It's unclear whether it was the group work or other aspects of the project (or a combination) that yielded these results.

The topic of the use and impact of cooperative learning groups is one line of inquiry I could pursue, from student, teacher, administrator and other perspectives. I could ask about the impact of the use of cooperative learning groups on socialization of students, on attendance, or on achievement. I could ask about the impact on

Juanita Jo Matkins
College of William and Mary

teachers. How do teachers use what they've learned and applied in this project to classes that are not part of this project?

We had an interesting outcome in a small subset in student achievement in the context of this project. Pre- and post-test results for content knowledge for one class of seventh graders (23 students) in Portsmouth, a high-needs, high minority urban school system, yielded statistically significant gains at the .001 level in science, mathematics, and robotics. These results were further analyzed for a breakdown by minority or majority and revealed that both minority and majority groups had significant gains on all three tests. On two of the tests, mathematics and science, minority students showed greater gains than majority students, indicating the activities helped to narrow the achievement gap.

A content-based assessment instrument set similar to the one used in Portsmouth was also administered to a larger group of King George students. King George is a small rural school system. Again, extremely statistically significant gains were achieved. The content results from these two settings indicated that students are learning science (and mathematics and robotics) as a result of project activities. The science test for both groups was on coral reefs, and was a 10-item fill in the blank test with a word bank provided. I'd like to know what other probes and measures could be used to complement this, to get at the question of what students are learning and what aspects of their experiences supported their learning. Of course, an intriguing question embodied in Table 1 above is why there was greater gain for minorities, i.e. what aspects of the project (or other contextual factors) supported the differential and encouraging gains in the this group?

Another aspect of the project is the embedding of a problem-based learning scenario into the curriculum. Some teachers are saying they can never go back to teaching the way they used to teach, and they're going to use the problem-based approach in all their classes. The research on cooperative learning that was summarized in the newest *Handbook on Science Education Research* (Treagust, 2007, pp. 383-384) focuses on "how" cooperative learning is used, and emphasizes that these group strategies require rich curricula if they are to encourage cognitive, social, and affective development of students. The problem-based learning scenarios we developed provided a rich context for the activities, and may explain in part why the results seem so positive. I could focus on change in teacher practice, and might operationalize teacher practice by their use of cooperative learning groups and problem-based learning, recognizing full well that "cooperative learning groups" and "problem-based learning" will likewise need to be thoroughly described.

Forming the heart of the in-class component of the project were robotic challenges that required the solution of programming and building problems using LEGO MINDSTORMS™ equipment. We know that the use of the robots contributed much to the level of student and teacher engagement in the project lessons. It provided a context for authentic group division of labor and for involving the S&E's in a meaningful way in the classroom, since the S&E mentors were extra adults available to help and advise student groups during the programming and building. We also saw in our classroom observations and heard in focus group interviews with teachers and students that the presence and participation of S&E mentors enabled all the teachers to challenge the student groups to a higher level of accomplishment and satisfaction. Thus, there's the aspect of the use of robots and the additional aspect of the involvement of the S&E's in the classroom. How did the use/manipulation of robots and the presence of STEM professionals influence students' perception of science? (The Navy would like to know how much the S&E's really contributed to the outcomes, particularly because these professionals are a pricey commodity in the grant's budget.)

For the short term, I see that it will be important for me to narrow the focus and start with an aspect of the project that I can describe. It's also important to me to work with aspects of the project that I find interesting. I'm not particularly interested in how many students become scientists, engineers, or mathematicians, but I am interested in changes in students' knowledge, skills, and attitudes in the context of these experiences. I'm also interested in change in teachers' practice.

I've already begun to narrow things down, and have proposed a poster presentation at NARST on cooperative learning in the context of this project. This project is on-going and my involvement continues, making it very feasible that more data could be collected in any aspect of the project that shows promise. I'm looking forward to the next steps.