Design and Implementation of Professional Development Seminars in Coordination with Research Experience for Teachers (RET) and Focused on Professional Practices of Scientists and Engineers

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ABSTRACT

Many programs promote professional development for teachers in laboratory settings. In fact, some research has shown these experiences can improve student achievement. However, it is unclear what aspect of the laboratory experience helps bring about this effect. In order to ensure all teachers participating in Stanford’s Research Experiences for Teachers program received maximum benefit from the laboratory experience, supplementary seminars were delivered that emphasized a variety of skills and tasks required of career scientists and engineers. Teacher feedback indicates that participants found these seminars valuable, but that they would prefer additional time for peer interaction and curriculum development.

INTRODUCTION

National Science Education Standards established by the National Research Council in 1996 suggest that science teachers “encourage and model the skills of scientific inquiry, as well as the curiosity, openness to new ideas and data, and skepticism that characterize science” [1]. Exposing students to this expansive representation of science is expected to improve their skills as technical workers and as thoughtful citizens. It is also thought to improve students’ attitudes toward and perceptions of science, though the mechanism of altering each may differ.

Research suggests that teacher participation in laboratory-based professional development can help student achievement in a variety of measures [2],[3]. However, one comprehensive study suggests that teachers participating in the National Science Foundation’s Research Experiences for Teachers (RET) may not actually be conducting hands-on research [4]. In order to ensure all teachers participating in Stanford University’s RET program were aware of the variety of skills and characteristics possessed by career scientists and engineers, we developed and delivered supplementary seminars that highlighted and reinforced professional practices. These seminars were thematically organized around the following professional practices of scientists and engineers:

• Analyzing and synthesizing research literature, including planning experiments and writing proposals;
• Collaboration, specifically the skills required to navigate diverse backgrounds, distributed tasks, and individual goals but shared resources;
• Synthesizing data and communicating results, including formal and informal mechanisms.

By creating approximations of these professional practices for teachers to engage in, we hope to create a more authentic experience for all teacher participants that can then be brought back to the classroom.
THEORY

As mentioned above, national expectations require teachers to convey an expansive view of science and scientific inquiry to their students. Many studies since have sought to explore ways that training and development programs cultivate habits in teachers that promote a broad and inclusive depiction of science beyond mandated content. Richardson and Simmons established a widely-used survey, the Teacher Pedagogical Philosophy Inventory, to examine teachers’ beliefs about their training and subsequent teaching philosophy [5]. Studies done with this instrument show that discontinuities exist between teachers’ understanding of the skills characteristic of scientific inquiry (embodied in “professional practice” above) and their ability to promote said skills in the classroom [6].

Recent studies suggest professional development in a laboratory setting, such as the RET program, may be one way to overcome these discontinuities. Teacher professional development in laboratory skills has been found to advance students 44% higher in grade level using the National Assessment of Educational Progress compared to students of teachers who had not received similar professional development [2]. Another study found a 10% improvement in student pass rates on the New York Reagents’ Exam for students of teachers participating in Columbia University’s RET program [3].

While data linking professional development in laboratory settings with student performance exist, few data sets help explain this connection. However, pedagogical theories offer some suggestion as to this mechanism. Grossman et al. suggest that without firsthand participation and orchestrated opportunities for application, teachers and other learners find it difficult to translate theory into practice [7]. They deemed these opportunities for application “approximations of practice.”

The National Science Foundation instituted Research Experience for Teachers (RET) with the goal of “involving teachers in engineering research and helping them translate their research experiences and new knowledge of engineering into classroom activities” [8]. However, not all those who have participated in RET actually have been involved in research. While over 80% of teachers worked on classroom plans and observed research activities during the RET program, only 50% collected or analyzed data to answer a research question [4]. Thus, only half of the teachers participating in the RET program actually have a chance to perform approximations of practice, running the risk of inadequate transfer of knowledge into practice.

In order to ameliorate this potential problem, we have designed and implemented an eight-week seminar series to enrich the RET program by scaffolding for teachers the translation of theory and observation into their teaching practice. The seminars are designed to engage teachers in approximations of practices they witness in Stanford science and engineering laboratories and consider ways to incorporate appropriate approximations of practice into courses they teach at the secondary level. By focusing on approximations of practice, the desired impact is two-fold. First, by engaging teachers in approximations of practice as a group, we hope to create a more authentic experience for teachers not engaged in first-hand inquiry in their respective laboratories. We also involve teachers in a wide variety of practices—like grant writing and poster presentations—that are not necessarily part of a standard inquiry experience. Second, we hope that this pedagogy provides a more tangible framework for teachers to translate their laboratory experience into the classroom.
RESULTS AND DISCUSSION

To articulate the approximations of practice we presented to the teachers, we have detailed below the activities and assignments done with the cohort of 21 teachers involved in Stanford’s RET in the Summer of 2009.

Exposure to the laboratory setting and introduction to approximations of practice

To help teachers acclimate to the laboratory environment, they were provided with select chapters of a laboratory manual before they arrived on campus [9]. Additionally, we asked each mentor (typically a professor or graduate student) to provide us with background reading for the teacher. The mentors typically responded with articles from technical literature, which were forwarded to the teachers along with a worksheet providing tips on reading technical literature. While teachers indicated that it was overwhelming to receive assignments prior to their first day, they indicated that they particularly liked the readings from *At the Bench* [9].

In addition to discussing the readings during the first seminar, we also discussed the pedagogy of approximations of practice mentioned earlier. In order for teachers to relate this to their teaching, we conducted an interactive activity where teachers were asked to share approximations of practice they already use in their classrooms. Blank poster boards titled with one of the three professional practices were posted around the room. Teachers were asked to write activities they use that are approximations of these practices, as well as list problems they encounter while trying to complete these activities, as they rotated around the room. Teachers reported that they enjoyed the opportunity to share ideas with other teachers in this manner.

Analyzing and synthesizing research literature

To begin the discussion of reading research literature, we asked teachers to review a journal article and popular magazine article written about the same technology. This was used to instigate a discussion about the differences and similarities between the two genres and how each may or may not be appropriate for the classroom. Teachers were also asked to “reverse engineer” their thinking in answering questions about the papers. They realized that by simply asking personal questions about the content, e.g., “Would you want this technology in your home?”, they could make the material relevant to the students. Teachers mentioned, though, that they would have liked to spend more time translating these ideas into actual curriculum components they could use in their lessons.

We also spoke with teachers about the role synthesizing literature plays in designing experiments and proposing new ideas, namely in grant writing. In order to provide an approximation of grant writing practices, teachers were given a mock grant assignment with guidelines to write a grant on whatever they desired. A few excited teachers outlined scientific grants related to their summer research, but more teachers took the practical route of planning activities for their classrooms. The seminar leaders provided extensive feedback to all teachers who participated and prizes were awarded for the most well written grants.

Collaboration

We created a cooking activity for the teachers to stress the importance of collaboration. The teachers were split into groups, and a Principal Investigator (PI) was designated (not from volunteers) for each team. The PIs were given a recipe that was written in French, and each
group member was given the translations for only a certain portion of the recipe thereby enforcing communication and teamwork. Furthermore, the teams were not given enough cookware to finish their recipes independently, thus they had to coordinate sharing equipment with other teams, much like a real-life laboratory. During the race to be the first team to finish cooking, many authentic conflicts were created. This provided a powerful, shared experience for teachers to begin discussions of how to modify classroom group work to constructively mimic some of these dynamics. In debriefing the session, we asked teachers what they would bring back to the classroom from the experience. They mentioned the value of appointing leadership roles, rather than always taking volunteers, and of having their classes communicate with one another, perhaps providing each other data or working on separate aspects of related problems.

Another realistic aspect of collaboration we wanted to stress to the teachers is the diversity of personalities and skill sets present in a research setting. We asked teachers to interview their mentor about their background and experiences in the lab. We also spent time as a large group discussing the variety of roles witnessed in the laboratory. Teachers reported that this broadened their perspective on the role of a research scientist, which was a welcome result. Out of the diversity of skill sets we were hoping to highlight, we spent an entire session specifically on creativity. In a reflective activity, we asked teachers to consider the nature of the work they and their mentors were undertaking and whether it matched the work they ask their students to do in the classroom. The teachers then discussed in small groups how to incorporate more creativity and higher order thinking skills into their assignments.

**Synthesizing data and communicating results**

To paint a broader picture of the how scientific discoveries are communicated to society, the teachers heard from the Stanford Office of Technology Licensing. This presentation, along with personal anecdotes from one of the authors (C.S.) about her experience with patenting an invention, instigated much discussion. Teachers were particularly interested in how to encourage their students to pursue inventions and understand the patenting process, as well as laws that govern fair use of multimedia in the classroom.

During the last meeting of the summer, teachers were also asked to participate in a conference-like poster session as an approximation of practice related to data analysis and communication skills. Teachers viewed each other’s posters, gaining exposure to research in other fields, and presented their own, gaining practice at communicating advanced scientific concepts. Preparing the poster also gave many teachers practice working with PowerPoint and other software packages they may not normally use.

**Presentations from Office of Science Outreach and curriculum component with IISME**

In keeping with the theme of communicating results of scientific inquiry, the Office of Science Outreach coordinates science-oriented presentations from faculty across the university. Many talks and field trips occur over the course of the summer, and teachers appreciate this exposure to research occurring across the university. Additionally, Stanford pairs with Industry Initiatives for Science and Math Education (IISME) to work with RET teachers over the summer. IISME requires teachers to develop a curriculum unit, an “Education Transfer Plan,” that corresponds to California State Standards in their subject. IISME’s support via a peer coach and online infrastructure were also important components of the teachers’ experience, ensuring that their laboratory experience was taken back to the classroom in concrete form.
Table 1. Sample responses from teachers who had been at Stanford for two RET summers with and without supplemental seminars. The top row lists a mixed comment, characteristic of the majority of the six responses, with suggestions for modifying future seminars. The second row lists the most positive review received and the third row, the most negative.

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<th>Do you feel the seminars offered in 2009 enhanced or detracted from your research compared to previous summer(s)? Please elaborate on your answer.</th>
<th>Do you feel the seminars offered in 2009 enhanced or detracted from your teaching and curriculum development compared to previous summer(s)? Please elaborate on your answer.</th>
<th>Would you recommend these seminars be included as part of the Stanford-IISME program in the future? If so, why? If not, what is your hesitation?</th>
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<td>I think it was somewhat useful for the research, mainly in how I thought about my research lab. But then again, my research situation was also quite a bit different than my previous experience.</td>
<td>In the sense that they crowded out time to work on lesson plans with other teachers and share lessons we have on certain subjects, it detracted quite a bit. …I never quite got to the point where I felt like I had fully formed ideas on how to integrate more &quot;real&quot; science into my classroom as actual lessons.</td>
<td>One idea I had was perhaps it could be every other week? And on the off weeks people could get together in subject areas and discuss ways they teach specific subjects? …Also, if the seminars could focus a bit more on ways teachers could use them in the classroom, or ways to create lesson plans, that would make it more interesting and useful long-term.</td>
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<td>I feel that overall Chelsey’s seminars enhanced my research compared to previous summer experiences. The content complemented my experiences in the lab and provided me with a more in-depth look into the different facets of research.</td>
<td>I feel that my teaching and curriculum development have been enhanced. Some of the content we covered reaffirmed why I have students engaged in a certain activities…Also, knowing about the hierarchy in the lab helped me to better identify individual roles during lab activities and the emphasis on reviewing research to make more informed decisions has helped me identify more effective teaching practices.</td>
<td>I would recommend the seminars, but I think they need to be somewhat different from year-to-year for fellows returning to their labs. Also, it would be beneficial to incorporate more time for teachers to discuss their own practice with other fellows and share ideas about how to integrate seminar content into classroom activities.</td>
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<td>For the most part, Chelsey's seminars detracted from my research. I learned little about teaching science and turning students on to learning.</td>
<td>Compared to previous summers, it was about the same in terms of value to my teaching.</td>
<td>I recommend the seminars be led more by teachers helping teachers. Sharing labs is, for me, a better approach. It gets right to the heart of what we are doing as teachers and opens our minds to how we can improve our curriculum.</td>
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Feedback from returning teachers

Teachers who had participated in the Stanford program previous summers were asked by email about their 2009 experience that now included these supplemental seminars. Their responses are summarized in Table 1.

CONCLUSIONS

Overall, we were pleased with the results of our pilot experiment with supplemental seminars. As you can see in the representative feedback we received, teachers highly value time
to interact with one another and work on concrete lesson plans they can take back to the classroom. Transferring ideas back to the classroom remains the most salient concern of teachers, and we still believe there is great value in centering these energies around approximations of professional practices by making explicit for science and math teachers the skills and abilities professional scientists and engineers rely on implicitly. With our supplemental seminars, group discussions help teachers to articulate the technical and interpersonal skills required of scientists and engineers. By writing grant proposals and creating conference posters, teachers have firsthand experience with the intricacies of planning experiments and communicating results. Furthermore, team activities reinforce the need for classroom experiences that incorporate collaboration and opportunities for creative thinking. The seminar series helps teachers acknowledge the complexities and ‘non-linearity’ of laboratory research and broaden teachers’ notions of skills and abilities valued by career scientists and engineers. In the future, however, we hope to build more opportunities into the seminars for teachers to interact with one another about lesson plans and in-class labs.

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REFERENCES