On the Road: Effectiveness of an Experiential Professional Development Program on Teacher Perceptions of Self and Science

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This study investigates an experimental professional development program in which 15 teachers on a weeklong bus trip to science-intensive locations across three Western states. The goal of the program was to provide teachers with experiences that would foster a sense of excitement about, and a personal connection to, the nature of science, the process of conducting science and to scientists working in field locations. The research questions involved understanding teacher goals for the program, post-program teacher outcomes, alignment between teacher goals and outcomes, and alignment between teacher outcomes and leader goals. Data included pre- and post-program open-ended teacher surveys, open-ended leader surveys, and follow-up school year interviews with a sample of the participants. Our data describe teachers being particularly satisfied and enthusiastic about the program, especially due to the experiential nature of the trip and direction of the program's leaders. This work suggests a model by which to engage teachers in and foster more personal connections to science, potentially resulting in more meaningful science experiences for students in the classrooms.

Introduction

Teacher professional development in science is identified as a primary source of providing teachers with the necessary understanding and training to enact science teaching reforms and with updating content knowledge (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003; NRC, 1996; U.S. Department of Education, 2000), both of which are critical in preparing science literate citizenry. Professional development in science may take many forms. One type includes research experiences for teachers (RETs), where teachers experience conducting scientific research in science laboratories. Much more common are programs in which teachers are exposed to new content and/or new classroom activities and lessons in a classroom or workshop environment by science specialists, teachers, scientists, or other providers. The literature shows some consensus as to which components of professional development contribute to change and improvement in teachers' knowledge and practice. These include having a heavy emphasis on content preparation, long-term engagement, allowing time for peer collaboration, having a strong connection to classroom practice, and providing time for the examination of and reflection on teachers' knowledge and beliefs (Loucks-Horsley et al., 2003; NRC, 1996; Supovitz & Turner, 2000; Wee, Shepardson, Fast, & Harbor, 2007). Most professional development providers, however, "continue to rely on stand-and-deliver, one-shot workshops, and menu-driven conferences and conventions," which do not result in knowledge transfer (Duschl, Schweingruber, & Shouse, 2007, p. 314). While state offices, districts, and schools work on identifying and implementing the professional development programs that are most suitable and effective for the needs of local populations, other types of professional development, those with somewhat different yet complementary goals, are emerging.

One such approach to professional development involves taking teachers out of the classroom, workshop, or laboratory setting and exposing them to a broad range of personal, in-situ science-related experiences. The purpose of this work is to investigate the effectiveness of a pilot program in which a scientist and a science education professor led teachers on a weeklong bus trip to science-intensive locations (including research facilities, field experiences, and museum visits) in three states. The primary goals of the program were to provide teachers with experiences that would foster a sense of excitement about, and a personal connection to, the

nature of science, the process of conducting science, and scientists working in various field locations.

Research Objective and Questions

The overarching research objective in this study is to understand the overall effectiveness of this experiential type of professional development program. This preliminary investigation will inform researchers and program developers about the types of research questions that should be asked when studying programs of this nature, and the types of results that can be expected from such programs. Further, this study will create an initial list of effective elements of experiential professional development programs to inform designers and developers of future programs of this nature.

Although the program developers had a vision for the effect the experience would have on the participants, the research questions are broad in order to capture any possible effects the program had on the participants. The research questions are: 1) What were the teacher participants' goals for this program/why did they participate (teacher expectations)? , 2) What benefits did the teachers perceive as a result of the program (teacher outcomes)?, 3) How closely aligned were teacher expectations and teacher outcomes?, and, 4) How closely aligned were teacher outcomes to the program developers' goals for the program?

A teacher change theoretical framework, with a focus on change in beliefs, guided this study. This included the notion that belief systems guide behaviors, that opportunities to rethink practice and collaborating with other professionals during this process can create changes in belief systems, and that implicit and explicit beliefs affect the decisions teachers make in their classrooms (Loucks-Horsley et al., 2003; NRC, 1996).

Methodology

The participants in this research were 15 teachers from a school district in the Mountain West. We collected a variety of qualitative data to generate descriptions of teachers' experiences, expectations, and outcomes from the program, including open-ended pre-and post-trip surveys, field notes, and interviews. Interviews were conducted with six of the teachers during the school year following the program.

The Program

The program consisted of six full days of traveling by bus to science-related sites spanning a large portion of one state and portions of two neighboring states in the Mountain West. Indoor sites included laboratories, observatories, and manufacturing and testing facilities, and outdoor sites included lakes and canyons within State and National Parks. Researchers and other professionals at each location provided guided and interactive tours, as well as lectured on content and processes of conducting research in that field. Appendix A outlines the trip schedule.

The group leaders, a professor of astrophysics and a professor of physics education, further discussed the significance of the sites during the program. Visits spanned multiple scientific fields, including physics, aerospace and aeronautical engineering, archaeology, microbiology, geology, and astronomy. Other presenters included engineers and state science specialists who described opportunities for classroom visits by specialists and field trip resources for teachers. The trip also included teacher-lead discussion sessions about personal issues and frustrations with teaching science in the classroom. Trip leaders held discussions on the bus and during some evenings in hotels about topics in science education, such as scientific knowledge, scientific processes, philosophy of science, and the process of becoming a scientist.

Participants spent all day together, including site visits, bus rides, and meals, and all had unlimited access to the group leaders.

Participant Selection

An invitation was sent to teachers in one school district to apply to the program. Eighteen people were selected out of 26 applicants, based on answers on application materials and potential for bringing experiences to the classroom and to other teachers. After attrition, fifteen teachers participated in the trip. Approximately half of the participants were elementary teachers, beginning with kindergarten, and half were secondary teachers, through tenth grade biology. Participant teaching experience ranged from 1 to 21 years, with an average of 6.7 years and a median of 3.5 years. The number of college-level science courses taken ranged from 2 to 18, with an average of 8 courses and a median of 4 courses.

Data Collection

Data were collected from multiple sources: a) a pre-program open-ended survey that asked teachers why they decided to participate in the program and their goals for the program, how they perceive themselves as professional and effective teachers of science, and what they believe would aid them in their growth as teachers of science, b) a post-program open-ended survey that asked teachers to describe their favorite and least favorite aspects of the trip and suggestions for improvements, and what they will take away from the program in terms of classroom implementation, and professional and personal development, c) a mid-program open-ended survey that asked program leaders to describe their goals for the program, design rationale, and beliefs regarding factors that aid teachers in their growth as professional and effective teachers of science, d) field notes from the program, and, e) interviews with six of the participants aimed at further elaboration on questions posed in the post-trip survey.

Interview selection was based on achieving an array of grade level representation, years of teaching experience, and science content knowledge based on number of undergraduate science courses taken. The teachers were Brad (9^{th} and 10^{th} grade biology, 7 years taught, 27 science courses), Jillian (2^{nd} grade, 15 years taught, 4 science courses), Carrie (3^{rd} grade, 5 years taught, 5 science courses), Jon (9^{th} grade, 2 years taught, completed earth science major), Lara (7^{th} and 8^{th}, 3 years taught, 12 science courses), Kristin (5^{th} grade, 1 year taught, 3 science courses). Interviews were conducted in the fall of the school year following the program, and were audio taped and transcribed.

Data Analysis

Initially, one member of the research team reviewed all pre-trip teacher surveys and all post-trip teacher surveys and generated broad themes for each type of survey. The themes generated from the pre-trip and post- trip teacher surveys were then compared for similarities and differences. Next, the leader surveys were compared with one another and broad themes were generated. Themes generated in the leader surveys were then compared to teacher post-trip themes.

Another member of the research team reviewed the interview transcripts and defined broad categories from the initial patterns and perceptions found in the interviews. The researchers then together refined the interview-generated categories. The resulting categories were supported by evidence from field note data and allowed for the development of case studies to elucidate the findings generated by the surveys. Cross-case analysis was conducted to identify consistent themes and issues in changes in teachers' beliefs about science, changes in teachers' beliefs about self as teachers of science and, possibly, changes in behaviors in the classroom resulting from the program (Miles & Huberman, 1994).

Findings

A teacher change theoretical framework guided this study. The data analysis revealed two broad themes that span across the four original research questions. The first theme (Finding One) shows evidence of changes in teachers' conceptions about the scientific world, scientific practice, and the desire to share this with students. These changes align with leader goals for the trip but was a more substantial and deep change than what the teachers had expected to gain from the program. The second theme (Finding Two) describes three elements of the trip that seemed to have played key roles in creating the conditions for the teacher changes.

Finding One: Teachers Changed in Ways They Did Not Expect

The results show evidence for teacher change, however not in the ways the teachers themselves had expected. Teachers' initial interest focused on gaining content knowledge, gaining new lesson plan ideas for the classroom, and seeing new sites. Teacher outcome results, however, indicated that the teachers, to varying degrees, experienced a change in their conceptions of science and scientific practice, and an intent for change in their science teaching practice. What the teachers took from the trip were gains in understanding of the process and spirit of science, and feeling that science is an exciting enterprise that they would like to share with their students.

Initial teacher goals: Curriculum, science content, connecting to other teachers

Teacher goals for the program were consistent among most of the teachers. They sought to acquire new lesson plan ideas and topics to use in the classroom, with statements such as, "Learn more about rocks and fossils to fit into my curriculum" (Emily, survey1) and "Find some new topics to incorporate into my kindergarten science curriculum." (Jennifer, survey1) Teachers also wanted to learn more science content, explaining that they sought to, "Expand my content knowledge" (Rich, survey1) and "Broaden my knowledge of science—it's my weakest subject." (Jennifer, survey1) Teachers listed connecting with other teachers as another goal. For example, "Meet new people/networking" (Amy, survey1) and "Work with teachers of different grades to gain insight into teaching strategies." (Julie, survey1)

The other teacher goals were unique to experiential programs, with a variety of statements revolving around personal growth such as having new and fun experiences, including, "See new places" (Emily, survey1) and "It sounded interesting and fun." (Carrie, survey1) Only four of the teachers expressed an interest in developing skills and enthusiasm for making science enjoyable to students. These included, "To learn to be a more effective science teacher so I can help kids learn to love science, (Kristin, survey1) and "I hope to be able to get enough out of it to have a passion to teach it." (Uma, survey1)

Teacher post-trip outcome result #1: Changes in conceptions of science

The teacher outcome results indicate that the teachers' gains exceed their initial goals in many ways. In the post-trip data, teachers indicated experiencing outcomes such as changes in their conceptions of science and scientific practice, and potentially changes in their own practice as teachers of science. They made little or no mention of their initial focus on new lesson plans, activities, or improved content knowledge in their core curriculum area.

Comments included, "I gained a more complete understanding of the interconnectedness of many branches of science" (Aaron, survey 2) and "understanding more of the world around me." (Emily, survey2) In their interviews, Brad and Kristin explained, "I would say what I really got out of it was the understanding of the processes of sciences outside of what I teach" (Brad, interview) and "It changed my whole outlook about things and what exactly is science and what isn't science, it kind of defined that for me." (Kristin, interview) Brad, a 10th grade biology teacher, explained the effect of visiting Capitol Reef National Park on his teaching:

> [The geologist] was telling us, "you can't use the scientific method when it comes to geology, you know you can observe a problem but you really can't do an experiment and things like that on rocks that are so old and different rock structures, you can just look at what happened now and go 'well this is probably what happened up in back then.' … you can't do the same process with biology you can with geology… And I explained, you guys in geology you cannot use the scientific method the same way we do in biology for example, same with astronomy. (Brad, interview)

Lara, a 7th and 8th grade teacher, explained her changes in thinking about the nature of science:

> I think the thing that really struck me is when [trip leader] had mentioned that the whole thing about scientific method and it's not the step-by-step thing because in 7th and 8th grade we teach it as a step-by-step thing. So we have changed the curriculum a little bit so that we are teaching the scientific method at the end of the year and I am going to make sure that I let the kids know that even though they need to take the step-by-step process it doesn't always work that way and so I am going to try and make a point of giving examples of how it would work in real life, how they can use the scientific method in settings other than a classroom or lab. (Lara, interview)

Overall, teachers' comments seem to reflect a gain in their general understanding of the fields of science, the processes of scientific research, and science as explaining natural processes. Although we cannot ascertain the full extent or depth of these conceptions, these types of changes have the potential to result in more meaningful science learning for students.

Teacher post-trip outcome result #2: Teachers changed in their attitudes toward science

The results indicate that teachers changed in their attitudes toward science, which is another outcome the teachers did not initially seek. This outcome aligns closely with leader goals for the program, which included fostering more visceral, personal connections to science.

Leaders' goals revolved around exposing teachers to aspects of the nature of science. They wanted teachers to gain a broad understanding of the many disciplines of science, to experience the essence of scientific pursuits, to get teachers excited about the subject of science and to be able to relate this to students, to introduce teachers to scientific culture ("real people do science, but most people don't see it that way"), and to expose teachers to parts of the natural world they may not have seen previously. One leader explained, "I wanted to connect these teachers to science in a visceral way. I think that people learn more and get more excited when they are able to connect to individual local people and places. Learning about what's happening around you is much more interesting than learning about general principles in the context of a distant place. I also wanted to experiment with a large range of sciences and adventures to see what works."(leaders' survey)

The teachers' post-trip survey responses illustrate their differences in attitudes toward science, "I am so much more excited about learning science and interested in science topics, (Kristin, survey2,) "My entire morale with regards to science has turned into a positive notion…I have found my eyes to be more open and accepting of science now," (Jennifer, survey 2)" and, "This reminded me of why I began teaching and got me even more excited for the upcoming year." (Tara, field notes)

In her interview, second-grade teacher, Jillian, explained, "I am just so interested in it now, I am so interested in the formations and just what this geologist found out there." She went on to say,

> The night that we were all at the Grand Canyon and we were all back in our hotel and we went out and did this star gazing and she was pointing out stuff and I just sat there in awe of her thinking "how does she know all of this stuff?" So it made me excited so then when I came home and I sat outside with my oldest son I said, "this is this and this is this…" and I was able to point out things I was never able to." (Jillian, interview)

Kristin, a first-year fifth grade teacher explained her changes in attitude toward science:

> I am excited, a lot more excited about it, and that definitely affects, and I don't know, it did make me really excited about science…. Like the Grand Canyon, that was so overwhelming and cool, and it made geology seem so exciting, whereas before it was ok, not my favorite thing, but then I have thought a lot since then about how I can teach it in interesting and engaging ways. (Kristin, interview)

Jon, a 9th grade teacher, describes the effect the experiences of visiting the sites had on his enthusiasm level:

> You can read about that but to be able to actually go and see how they really build a rocket, that's just really cool you know, and right up close where you can almost touch it, but not quite because you're not allowed to touch it. But you know that kind of thing, because you can read about it, you can watch a video about it, that kind-of thing, but to be able to go and see and kind of get all of your senses involved in that, and that was just really cool.

Jon went on to say,

> You know, [our group leader] really got me excited about the history of science, and teaching kids about the history of science, and about scientists, you know that kind of thing. So I have taken a different approach to that. (Jon, interview)

While unexpected by the teachers, these changes in their attitudes toward science may have more far-reaching and deeper effects on the teachers and potentially their students than had only their initial goals been met.

Teacher post-trip outcome result #3: Teachers changed in the depth of what they wanted their students to gain and understand about science.

Another change reflected in the data is teachers' shift from seeking a science-based travel experience for their own benefit to wanting to share their experience with their students. Further, the reported wanting to share more than simply the sites they visited—they wanted students to feel the excitement and enthusiasm toward science that they themselves gained from participating in this program. The teachers, in other words, seem to have made a transfer in what this type of professional development program has offered them to how this experience can benefit their students.

While only four teachers mentioned gaining experiences to share with students in their initial goals, every teacher mentioned this desire after the program. In their post-trip surveys, teachers wrote, "I have a desire to share and provide my students with a firm foundation in science" (Gus, survey2), "I am even more excited about science, especially astronomy. I want to share these new things with my students," (Aaron, survey2) and, "I want kids to understand the connections between science and their lives." (Kristin, survey2) Second-grade teacher, Jillian, described her intent to teach science in new, more experiential ways:

> I have rocks in my curriculum and I can bring photos back and my enthusiasm back to them. There's rocks right here in Utah! I'd love to be able to take students to some of our local sites. (Jillian, field notes)

She continues in an interview, later:

> I am more comfortable in saying, "let's go out, let's go look at this leaf for a minute", or whatever because I know that I would rather take them out and let them walk around and see it. (Jillian, interview)

Ninth-grade teacher Jon explained,

> I think just taking a trip like that gets you get creative you know, get all excited about, "Oh this is really cool, oh we can really do that," you know. The whole week I am thinking, "how can I do this, how can I teach my kids some of the stuff I learned." (Jon, interview)

Third-grade teacher Carrie, described what inspired her to create a science word wall for the first time:

> Just the whole trip in general, me just trying to think more about science and teaching science at the level the kids need, I guess that's what the trip got me thinking about. (Carrie, interview)

She also described:

> I didn't realize that before, that [science] could connect in other ways except for "Ok, we are going to learn about science today," I can teach science and the kids don't even really know I am teaching science unless I tell them. (Carrie, interview)

Again, this outcome was unexpected by most of the teachers. Their intent to share their new enthusiasm toward science with students, like with the other outcomes, can potentially result in important changes in teacher practice.

Teacher post-trip outcome result #4: Nonevidence of change

Two of the teachers, both secondary, showed little or no evidence of change in gains in understanding of science. They still, however, expressed a gain of new knowledge and valuable experiences from the trip. Jon and Lara explained:

> I don't [see a change in my understanding of the process of science] because I have been in science forever, you know, what you do is be a scientist or be a science teacher, so I kind of knew that stuff already, you know. …No, I don't see a difference, it was interesting to go see what everybody else was doing and that's always good because we are in a vacuum, an educational vacuum, not doing actual science and trying to think of things for kids to do, so it was good to see real science people doing real science, but uh, no it didn't change my understanding of that at all. (Jon, interview)

> I wouldn't say I noticed a big change in that, just because I took so much science before, I kind of, of course I saw things I didn't know before, but I think I had a pretty good idea of what science is and what it stands for. (Lara, interview)

In each of the above cases, these teachers describe preexisting ideas about what science is and how it works. Whether their views were completely informed or not is not actually known from this research. However, what we can take away from these statements is that these teachers found value in the experience that went beyond "traditional" outcomes of professional development, such as content knowledge and understandings of the nature of science. Instead, they each emphasize other aspects of the trip as having an impact on their portrayal of science in the classroom.

Finding Two: Aspects of the Trip that Contributed to the Changes Described in Finding One.

Our data suggest that three aspects of the trip may have played key roles in creating the conditions for the teacher changes described above to occur.

Program aspect #1: Authentic contexts and sites

Teachers' statements suggest that being in the actual places—the sites and the contexts—may have played the most influential role in the teacher changes. Different teachers cited different locations as most influential and exciting for them, therefore no specific location can be listed as most important. However, teachers' statements indicate that it was seeing and experiencing new, science-related sites, rather than the presenters themselves, that created the outcome changes. For example: "I liked being able to see so much of the area. Each place was new to me and opened my eyes to new ideas" (Julie, survey2), "Like the Grand Canyon, that was so overwhelming and cool, and it made geology seem so exciting" (Kristin, interview), and, "I think the best thing was those [discussion sessions] and then just the different places that we stopped… the locations more than the [scientists at various sites]." (Carrie, interview)

In their interviews, Brad and Lara described the effect visiting the sites had on their science understanding and enthusiasm:

> At first I really didn't understand the whole point in going to the Linear Accelerator and then you know to the Grand Canyon, then to the Observatory…but then when they showed us how it was all, how they had a grand scheme in mind, … it kind of clicked for me. … I wouldn't have been able to make the connection without going to each of those places, I don't think. … it's nice to hear that stuff but without actually being able to see it you know it makes a difference. (Lara, interview)

> Having the people that work there and use the equipment to give us firsthand experience on this is how we do it, and this is how it works and this is why we do it…visiting the individual sites and talking to those guys, that was the best part of the trip. (Brad, interview)

Program aspect #2: Example of the trip leaders

The example of the trip leaders influenced teachers to gain in their understandings and attitudes toward science. Teachers described the leaders' deep understanding of and excitement about science and scientific pursuits as contagious, influential, and important in their own growth and understandings about science. Further, the example of the trip leaders seem to have fostered a desire to spread this spirit and attitude toward science to their own students. Examples include: "I really enjoyed being able to spend a week with knowledgeable people like [trip leaders] and being able to ask them questions and discuss various scientific ideas (Amy, survey2), and, "It was inspiring to hear how enthusiastic [trip leaders] are about science and it's good to be around people like that, rather than teachers with burn-out." (Lara, survey2) Jillian, Brad, and Jon described similar points in their interviews:

> The night that we were all at the Grand Canyon and we were all back in our hotel and we went out and did this star gazing and [trip leader] was pointing out stuff and I just sat there in awe of her thinking, "how does she know all of this stuff?' So it made me excited so then when I came home and I sat outside with my oldest son I said, 'this is this and this is this…" and I was able to point out things I was never able to, because of her excitement … got me excited. (Jillian, interview)

> [The trip leaders] being into what they teach so much rubs off on us and we can take that excitement and that enthusiasm into our classroom... just the enthusiasm they gave us and the stuff they taught us along the way was very beneficial I think. (Brad, interview)

> You know [trip leaders] were excited about going and doing everything so that kind of kept the excitement going. And it made it like, 'oh wow, these guys are excited about this stuff, maybe we should be too,' if you weren't already. (Jon, interview)

Program aspect #3: Interaction with other teachers (to a lesser extent)

The teachers reported enjoying and benefitting from interacting with the other teachers. It is unclear, however, whether these interactions contributed to changes in their conceptions or attitudes about science. Most of the teachers indicated the vexation/venture sessions—structured teacher-based discussions about issues in science teaching and education—as one of their favorite aspects of the programs. Examples include: "I got lots of good ideas from the [discussion] sessions" (Julie, survey2), "I love the experience, knowledge and getting ideas from other teachers, and making new friends around the district" (Brad, survey2), "I loved the bonds that were formed with each other, and the knowledge that was shared between everyone" (Mary, survey2), and, "But really the most I got from was talking to the other teachers and having [trip leaders] talk to us on the bus or afterwards, just that discussion." (Kristin, interview)

Program aspect #4: Non-examples—elements of the trip that did not contribute to teacher gains

The specific scientists and guides at the sites did not influence the teachers to any extent approaching other aspects of the trip described above. Several comments indicated that teachers liked and appreciated some of the presenters, however these were relatively few.

Further, no specific content areas are reported to be most influential. Different teachers reported different content areas interesting, enriching, or influential for them, but the results showed no consistent content area or lesson that was recognized as most beneficial or important.

The results also indicate that secondary teachers may require longer exposure to the sites and more background knowledge, as expressed in this statement, "not enough time at places, not enough background knowledge at each place (Amy, survey 2). Further, program leaders must ensure that presenters at sites are aware of the wide variety of backgrounds present in the group (i.e., teachers from kindergarten through 10th grade) and that they present information at appropriate content levels for the teachers. For example, one secondary teacher wrote, "Sometimes the presenters/guest speakers would talk way over our heads and lose half the teachers during the lecture. They need to be reminded that not everyone is an expert in their particular field and teach accordingly." (Lara, survey2)

Results Summary

Results from the post-trip surveys and follow-up interviews two months into the school year indicated that several changes occurred in the teachers' conceptions about science and in how they envisioned teaching in their science classrooms. First, teachers reported gaining new understandings about the processes and spirit of science yet did not mention their initial interest in gaining new lessons plans and content knowledge specifically in their core curriculum areas. The results suggest, instead, teachers changed in their beliefs about what was important to gain from the program from what they initially had sought. Second, the teachers showed a profound difference in their attitude and excitement toward science. Third, they gained the desire to bring back to their students their new appreciation and understandings about the science of the world outside the classroom.

Separating the experiences of the elementary and secondary teachers shows that most of the elementary school teachers had limited exposure and interest in science prior to this trip and they emerged with a deeper interest in and excitement toward science and science teaching. The secondary teachers had significant prior exposure to science, and two of the secondary teachers reported that they did not gain new conceptions about science processes. However, all of the secondary teachers reported that the trip created a rise in their level of enthusiasm and excitement toward science and science teaching; and in one case, a secondary teacher reported a renewed interest in her field.

Three main program elements may have contributed to the teacher changes. They are: visiting and experiencing authentic contexts and sites; the example of the trip leaders in their deep understanding of science and contagious enthusiasm toward science and scientific pursuits; and, to a lesser extent, interactions with other teachers, especially during the vexation/venture discussion sessions. The less effective program elements were the lectures or presentations by any particular scientist or guide and any specific course content.

Conclusions

As a pilot study open to a diverse set of outcomes, it was interesting to see the contrast between what teachers initially expected as "hoped for" outcomes versus what they actually reported as gains from the program. Even though many teachers had hoped for specific content knowledge and specific lesson ideas for their classes, these expectations were virtually forgotten

about. Rather, teachers emphasized aesthetic appreciations for science, enthusiasm for a variety of disciplines within science, and new contexts for placing science and scientific process. To us, it seems particularly interesting that these outcomes were had even as teachers anticipated different "best case" outcomes. In other words, the experiential nature of the program seemed to have "won over" the teachers and made them consider science education in new ways.

As a result of this work, we suggest that suitable goals for experiential programs may be gaining general understandings about the processes of science and the scientific world of nature and research. Less suitable goals for experiential programs may be achieving gains in content knowledge and specific lesson plans for use in the classroom. Further, our data indicate that programs such as the one described here may serve to complement "traditional" professional development programs. If high quality, both traditional and experiential programs can provide essential learning experiences for teachers that they can extend to their classrooms. Among the goals of many high-quality traditional professional development programs are increasing content knowledge, creating a shift in teacher beliefs about how students learn science, and creating a change in teachers' science teaching practice in the classroom to include elements of science reform, such as inquiry teaching and learning. As seen in this study, the leader goals and teacher outcome results of experiential programs appear to be different. Experiential programs such as this one seem to foster affective changes, beliefs about accessibility of real-world science, and a desire to share the excitement of science and passion of scientists with students.

We would imagine that *both* the understanding of more traditional, content knowledge *and* the affective dimensions must be cultured together. Pairing traditional with experiential professional development programs could offer teachers experience necessary for a balanced and informed science teaching practice. In fact, many teachers in this study suggested that their newfound enthusiasm for science would be a motivation to develop more science content in their courses, especially at the elementary level.

Implications

The results of this preliminary study can inform the design of future experiential professional development programs. These results indicate that experiential programs must include a compelling and authentic set of places to visit, strong leaders with an intent to stitch the trip together, and opportunities for the teachers to interact. The results also suggest that secondary teachers may require longer exposure and more background knowledge to the various sites, and program leaders must ensure that presenters at the sites deliver information at appropriate content levels for the teachers. Less important are specific scientists or presenters at the sites, and specific content areas.

While this initial attempt at an innovative professional development program seemed to find success in interesting ways, this research is ongoing. Follow-up work needs to be done to see how this experience affects classroom practice, as well as long-term teacher attitudes about science and science teaching. As teachers' own goals for the program seemed to change during the week, the notion of applying conceptual change theory to teacher practice (Feldman, 2000) seems an inviting theoretical framework for such work, but this has yet to be fully explored. Finally, future research should also be framed within the literature and contexts of other, similar experiential professional development programs.

In sum, this research has shown that experiential programs of this nature may serve to engage and excite teachers in the fields of science. They may also foster more personal connections to science and scientists, potentially resulting in more meaningful science experiences for students in the classrooms.

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Appendix A: Trip schedule.

Day	Site	Presenter
Day 1	Idaho State University (ISU), department of physics: lectures and of laboratory tours	Physics professors
	Linear Accelerator, Idaho Accelerator Center: Tour of facility	Laboratory faculty
	Laboratory experiences at ISU and Linear Accelerator (teachers choose between four laboratories)	Laboratory faculty, including graduate students
Day 2	ATK facility tour, Utah. Aerospace and defense facility. Tour consisted of portions of facility that manufacture booster rocket parts, fuel, and rocket assembly areas.	Facility tour guide
	Weber State University, Utah. Tour of on-campus field trip opportunities, such as the planetarium and greenhouse. Presentations about state-sponsored science educational curricula and speakers available to classroom teachers.	Governor's science advisor
	Weber State University, Utah. Presentation about science-related careers for students.	ATK engineer
	Vexation/Venture structured incubator sessions, in which teachers discuss their vexations about any aspect of science teaching education and propose solutions.	Teachers
Day 3	Antelope Island, Great Salt Lake, Utah Presentation about archaeology of area	Archaeology professor
	Antelope Island, Great Salt Lake, Utah Microbiology of the GSL: Presentation and data collection experiences	Biology professor
Day 4	Capitol Reef National Park, Utah Presentation and hike	Geology professor
	Night hike in Grand Canyon National Park, Arizona	
Day 5	Hike in Grand Canyon National Park, Arizona	
	Lowell Observatory, Flagstaff, Arizona Tour of facility, including historic observatories and other buildings, museum, planetarium	Observatory staff
Day 6	All-day travel home. Discussions and Vexation/Venture sessions	