The Efficacy of SciTrek in Solving the Transfer Problem and Supporting Teacher Enactment of the Next Generation Science Standards

Problem

Inservice teachers have to assume and often juggle multiple identities in order to implement the types of 21st century learning opportunities envisioned in new content standards such as the Next Generation Science Standards (NGSS;Lead States, 2013). For instance because K-8 students are expected to come away from their STEM schooling with an understanding of science content, context, and culture, teachers are asked to provide all students opportunities to meaningfully develop these understandings in ways that are authentic to the work of scientists (National Research Council [NRC], 2012; NGSS Lead States, 2013). However, research shows that elementary students often develop an incomplete understanding of the practices of science inherent in the NGSS, in part because their teachers have never themselves been exposed to the authentic doing of science (Davidson & Hughes, 2018; Gillies & Nichols, 2015). Some teachers are hesitant to even attempt to implement scientific inquiry in their classrooms due to their perception of not having the materials, resources or the professional development (PD) that they need in order to be successful (Silm, Tiitsaar, Pedaste, Zacharia & Papaevripidou, 2017).

Recent research shows that establishing PD opportunities for teachers to participate in science research to develop their own identities as teacher-scientists are needed so that teachers can increase their understanding of what doing science entails and confidence to enact this with their students (see for example Davidson & Hughes, 2018). Such research looking at the teacher's science identity often utilizes the Communities of Practice (CoPs) framework. Lave and Wagner (1991), define CoPs as a group of people who engage in a process of collective learning in a shared domain of human endeavor. They share a concern or passion for something they do and interact regularly within a well-established community to increase their knowledge and practice. One assertion of CoPs is that a participant learns through a method of guided cognitive apprenticeship in the practices of that trade, starting as a peripheral, new member and moving to a fully realized member of the community. (Lave & Wenger 1991). However, while research studies show that PD aimed at creating and fostering CoP's for teaching science can increase teachers' understanding of scientific teaching practices and efficacy to do science, teachers are then left to translate these understandings into opportunities for their students at their own school sites without assistance (Pop, Dixon & Grove, 2010). We assert that for a teacher to teach students how to understand and do science they not only need to develop their membership into the CoP of science teaching, they also need to figure out best practices to enact these processes with their students. We will refer to this as the transfer argument.

Others argue that teachers need opportunities to learn the new teaching practices needed to implement their understandings of science within their own school and contexts (Horr, & Heimlich, 2016; Margolis, Durbin & Doring, 2017). A popular model for this type of on-site situated PD is a Professional Learning Community (PLC). A PLC, is a group of educators that meets regularly, shares expertise, and works collaboratively to improve teaching skills for the purpose of improving the academic performance of students. According to Eaker and colleagues (2002). The attributes of a PLC are: (1) a shared mission, vision, values; (2) collaborative teams; (3) collective inquiry; (4) action orientation and experimentation; (5) continuous improvement; and (6) an outcome driven orientation. While a PLC does offer the teacher an opportunity to attempt to address the transfer problem stated above, and collaborate with peers about teaching practice for the purpose of increasing student achievement, what is often missing from PLCs is the presence of students during the PD. Margolis and colleagues (2017) suggest that PD for teachers is more effective when they learn new teaching practices in the context of their own classrooms *as they interact with their own students*. The purpose of this current paper is to report results from an evaluation research study of the SciTek program—a program that due to its unique design creates CoP, a viable PLC, and offers a solution to the transfer problem by using an apprentice model in the teacher's classroom. SciTrek is simultaneously a science program for 2^{nd}-12^{th} grade students and a PD opportunity for in-service teachers. For the elementary portion of the program (grade 2-6), teachers get a 1.5 hour individual or small group PD event (orientation) and then take the skills that they learn back to their classroom and implement them with SciTrek lead scientist support i*n real time with their own students.* This allows the teacher to learn to teach practice-based science in their own classrooms as their students actively participate in authentic science investigations.

In a SciTrek classroom the teacher collaborates with a team of five or six people from the university for 13-17 lessons to implement an introductory module and two practice-based science modules for their students. The team of scientists consists of one lead scientist (university faculty, graduate science student, or staff person with a science degree) and five undergraduate students. Many of the undergraduates are participating in CalTeach, a program in which students at the university can earn an undergraduate minor in Science and Mathematics Education. Each module focuses on one disciplinary core idea in the NGSS (NGSS, Lead States 2013), and centers on participants planning and carrying out their own science investigation. SciTrek borrows the apprentice model from the CoP framework and there are scaffolded levels of SciTrek to bring in the teacher as a full member of the teaching science community. For the teacher new to the program and perhaps to practice-based science teaching, the teacher works with three to five students as they go through the module, in addition, the teacher observes the lead scientist as they facilitate the module. As the teacher becomes comfortable with the content and processes within the modules (typically after one year with the program) they take on a co-lead role by leading some of the activities, with the lead Sci Trek scientist ready to step in and help scaffold the teacher as s/he facilitates and/or takes over the lesson. As the teacher gains confidence and develops expertise they take over full responsibility for implementing the module (typically after three years with the program) including the oversight and coaching of the undergraduates working with the student groups.

Prior evaluation research shows that elementary school students involved in SciTrek improve both their understanding of the processes and practices of science, and show increases in their positive attitude toward science. However the specific value of SciTrek as a PD opportunity for the classroom teacher has yet to be documented. SciTrek is designed to develop teachers' science teaching confidence and knowledge of associated classroom practices. This paper will explore the following questions: RQ: How does SciTrek develop CoP and PLCs to support teachers' implementation of practice-based science *in their classrooms (solving the transfer problem)*? RQ1: What are the teachers' experiences with SciTrek in gaining confidence for teaching science practices? RQ2: In what ways can a cognitive apprentice CoP model be used to describe teachers' learning process during SciTreks? RQ3: Are SciTrek practices incorporated into other non SciTrek related classroom activities?

Procedure

A case study (Yinn, 2016) was conducted during the 2019-2020 academic year in which 29 teachers in eight elementary schools participated in the program. Twenty-four of these teachers agreed to participate in the study (Table 1).

Table 1. *Participating Schools and Number of Teachers Taking SciTrek Roles*

District	Group lead (n=7) (0-2 year program exp)	Co-lead (n=10) (1-4 years program exp)	Lead (n=7) (3+ years of exp)
Heart District	7	2	3
SB District		2	
LP District		3	3
MC (Private School)		3	
CA (Charter School)			1

Data Sources

Questionnaires. Pre (Fall 2019) and post (Spring 2019) questionnaires were collected from participants: (1) to gauge change in teacher's knowledge and science teaching efficacy in terms of the processes of doing science and (2) to begin to understand the ways in which the program met their expectations for both the teachers PD and the impact on their students' learning. The post questionnaires consisted of four Likert scales as well as open ended reflective responses. The open ended responses asked participants to reflect on aspects of the orientation (outside the classroom before the school year begins), their SciTrek role (during the classroom apprenticeship), as well as changes to their assessment of their knowledge of effective practices and efficacy for science teaching as a result of their participation in the program. Data was analyzed using Excel for descriptive data and NVIVO for qualitative transcripts programs.

Observations. Observations of orientations (outside of class before the each module starts) and SciTrek modules (in class using the apprentice model) were conducted across a purposeful sample of SciTrek teacher classrooms. Observations were audio recorded and transcribed immediately after they took place.

Interviews. Five teachers with varying degrees of experience with teaching practice-based science agreed to respond to a further open-ended questionnaire, after their first module, and to participate in a thirty minute open ended interview toward the end of their SciTrek experience. This additional data was collected in order to trace the teacher PD process through the SciTrek experience. Interviews were recorded and transcribed immediately after they took place.

Findings and Analysis

Questionnaires were analyzed using descriptive statistics, and open ended data were analyzed qualitatively using two rounds of coding. Codes were assigned to meaningful chunks of text, and the first round used the descriptive method of coding (Salanda, 2013) using a combination of a priori codes, from the framework and emergent codes (Miles & Huberman, 1994; Saldana, 2015). The secondary coding used sub coding (Gibbs, 2007; Saldana, 2015), which is appropriate in studies in which there are a variety of data sources such as interviews, observations and documents, as well as when nuanced data analysis is indicated (Saldana 2015). For example many chunks of text could be coded as modeling, yet within these chunks were specific instances of what was being modeled and for what purposes. Once data was coded, themes were obtained by abstracting beyond the codes to the larger meaning of the data. The first set of findings (addressing RQ1) showed the majority of teachers increased their ability to incorporate practice-based science in their classroom (82%), increased their ability to engage students in scientific discourse (95%), and they learned more about what scientists do (77%). Of those teachers that had been with the program for two or more years 94% reported that they learned about incorporating NGSS based standards into their classrooms. A theme across open-ended data indicated that long-term benefits to teachers are cumulative and iterative.

> *This was the second year I have led this module, and I feel like I was more confident in the process...it felt more natural. I understood better what understanding we were hoping for the students to arrive at. I still find that sometimes I don't have the clear end point in mind that the UCSB SciTrek Leads do. I am still learning. They model how to direct the conversation in more efficient ways to get to the important points than I can.*

Participating in SciTrek modules also leads to teachers reporting greater confidence. Overall 88% of participants reported an increase in confidence in their knowledge and ability to teach practice-based science. Newer participants (group or co-leads), grew in their knowledge of science content and how to teach it. Yet the more seasoned SciTrek participants appreciated the continued learning of the processes that SciTrek models provided, and all seven lead teachers reported an increase in their confidence in one or more areas.

> *I feel this experience, going from group to co-lead helped me find confidence in teaching science. SciTrek always makes me a better science teacher.*

The second set of findings suggest that in general it was the teacher's own expectations for their own students' learning which motivated them to learn practice based science and to develop professionally and the SciTrek processes that allowed them to do so.

> *The difficulty truly was for me was what kinds of questions do I ask to get information and to continue their thinking, to develop their thinking without leading them too close to what I want them to discover? And that's what I wrote down was one of the things that was hardest for me.*

The SciTrek processes of explicitly articulating the implicit nuances of practice-based science during orientation, the modeling by the scientists in teachers' own classrooms and the scaffolding of teachers at critical junctures of their own implementation as they become SciTrek co-leads and leads that teachers felt facilitated their development. These processes of modeling, articulation and reflection made the tacit elements of expert practice-based science visible to participants and will be discussed in detail during the presentation.

> *I was nervous, really nervous. But the first time, I had Darby with me. I knew she would step in to help me if I missed anything, or needed to retrace steps, or spent too long on a certain point. It was pretty successful, but definitely a challenge for me.* [Kate, co-lead]

The third set of findings illustrates the ways in which some teachers took up practice-based science after SciTrek. In particular participants incorporated scientific vocabulary, argumentation and discourse practices into other lessons and were able to implement student questions and support scientific writing within their existing science curriculum. For instance:

> *When SciTrek isn't there I still incorporate the discourse and scientific language into other lessons. It is a process. First year it was frontloading. Now this vocabulary and discourse is incorporated into the classroom environment. i.e. claims, evidence, variables AND the practices or processes of science such as procedure writing.*

Contribution to the teaching and learning of science

The SciTrek cognitive apprenticeship in class model has many advantages over the lecture or knowledge-dissemination format of PD typically offered. SciTrek provides teachers the opportunity to learn the content and NGSS practices necessary to implement inquiry science in an authentic setting with an expert by seeing and doing *with their students*. The research experience for teachers (RET) model that allows teachers to participate in science research with scientists can also be considered a cognitive apprenticeship in science content and practices (e.g. Davidson & Hughes, 2018), yet the advantage of SciTrek is that the apprenticeship takes place in the teacher's own elementary classroom with their own students. It is thus truly in situ, and in context which allows teachers to make connections and integrate what they learned into other areas of their teaching.

Interest to NARST Members

In alignment with the 2021 NARST theme, this study examines the efficacy of a program that has the potential to change science classroom practice in ways that afford teachers the opportunity to learn the content and NGSS practices necessary to implement inquiry science in an authentic setting by seeing and doing. This is a viable solution to the transfer problem often seen with other PD opportunities for science teaching and can lead to more equitable outcomes for all students to learn science.

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