SEPs in RETs: Design and Development of an Observation Protocol

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Program Abstract: 350 Characters

Come learn about the design and refinement of an observation protocol for science & engineering practices employed to capture the activities of teachers in a NSF-funded Research Experience for Teachers (RET) site. Where previous RET studies have focused on self reported data, this protocol adds insight to program evaluation and research endeavors.

Proceedings Abstract: 2100 Characters

This study describes the design and development of an observation protocol for science and engineering practices (SEPs) experienced by teachers working in research laboratories under the auspices of Research Experiences for Teachers (RET). Development has proceeded iteratively through two-cycles of use and refinement based upon the observation of K-5 teachers working in engineering research laboratories as part of an NSF-funded RET site (EEC-1711543). This protocol offers the potential for looking inside the blackbox of apprenticed professional practice in the context of a research laboratory, which for K-12 teacher participants, has been previously only described through self-report. Data derived from this method, which can be viewed holistically or chronologically, can be used to triangulate and enhance other forms of data, for defining new processes or explaining outcomes and ultimately for enhancing programmatic functions.

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Introduction and Problem Statement

This study describes the design and development of an observation protocol for science and engineering practices (SEPs) experienced by teachers working in research laboratories under the auspices of Research Experiences for Teachers (RET). Development has proceeded iteratively through two-cycles of use and refinement based upon the observation of K-5 teachers working in engineering research laboratories as part of an NSF-funded RET site (). This protocol offers the potential for looking inside the blackbox of apprenticed professional practice in the authentic context of a research laboratory, which for K-12 teacher participants has been previously only described through self-report (Storm and Lichtenstein 2019). Data derived from this method, which can be viewed holistically or chronologically, can be used to triangulate and enhance other forms of data, for defining new processes or explaining outcomes and ultimately for enhancing programmatic functions.

Program Background

The Next Generation Science Standards (NGSS), released in the spring of 2013, provide "an ambitious and complicated vision for K-12 Science and education in the US" (Lederman and Lederman 2014, p. 143) intended to serve as a guide to reforming science teaching across the nation. One challenge in the successful implementation of the NGSS has been the need expressed by teachers for preparation in engineering (Haag and Megowan 2015; Trygstad 2013). The PROGRAM (blinded for review) is a 7-week summer experience, part of an NSF-funded RET site, in which K-5 teachers are embedded as **contributing members** of engineering research teams. The professional development goals of the program for teachers as well as graduate student researchers (GRs) are (1) increasing knowledge of STEM concepts and practices, (2) fostering mentoring relationships among researchers and teachers, and (3) guiding the translation of the laboratory experience into K-5 classrooms.

The programmatic goal of having teachers as contributing members implies some form of a first-person experience with SEPs in the professionally authentic context of a research laboratory. The assumption, which is inherent to all RETs was based upon NSF's previously established Research Experiences for Undergraduates (REU) program (Russell 2007) and the subsequently documented positive effects of such experiences on persistence in STEM degrees (Olivares-Donoso and González 2017; Hunter et al. 2007), is that there is some expectation that placing teachers alongside researchers at the cutting edge of science and engineering will positively influence their capacity as science educators. With the focus on participating in professional research practice as a mentored experience involving graduate student researchers and professional scientists and engineers as Principal Investigators, we chose to use cognitive apprenticeship as the theoretical framework for our design.

Theoretical Framework

Donovan & Bransford (2007) define cognitive apprenticeship as "the process through which a more experienced person assists a less experienced one, providing support and examples, so the less experienced person gains new knowledge and skills" (p.363). Experts are not born with special abilities; they are developed with access to information, support, mentoring, and focused intensive practice (Ericsson et al. 1993). This implies that mentors need to be reflective about learning goals, methods of learning, the sequence of activities, and the optimal learning environment (Collins 2006). The cognitive aspect of the theory implies that the thought processes as well as skills to solve complex problems within a domain are made explicit by mentors so that they may be studied and acquired by learners in an interactive and systematic fashion. In addition to declarative and procedural knowledge, these thought processes include heuristics, mental models and habits of mind. Such apprenticed learning involves four dimensions: (a) content – the types of knowledge for expertise, (b) method – the ways to promote the development of expertise, (c) sequencing – the order of events, and (d) sociology – the social characteristics of the learning environment. These dimensions are further divided into 16 components, such as sociology: cooperation, methods: coaching or content: heuristic strategies. This perspective and detailed framework provided the basis for understanding and interpreting the intent for aspects of the observed experience of teacher participants.

So as to enhance the practical utility of the protocol for the ultimate goal of impacting the teaching practice of the teacher participants, we further drew upon the SEPs delimited in the Framework for the NGSS as a practical framework (National Research Council 2012). The eight practices identified as essential include (p. 382):

1. Asking questions (science) and defining problems (engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (science) and designing solutions (engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Although previous reviews have characterized learning as a result of laboratory experience (e.g., Hofstein and Lunetta 2004; National Research Council 2005), the corpus of research evidence focuses on cognitive or skills-based outcomes, as opposed to practice-based or process activity. Our review of the literature for an existing instrument or method produced examples of observation tools for teaching practice in K12 contexts (Capobianco et al. 2018; Wheeler et al. 2019) as well as higher education (Eddy et al. 2015; Smith et al. 2013), including the context of undergraduate laboratory (Velasco et al. 2016; Kyle et al. 1979), but nothing involving engagement, demonstration or experience with SEPs.

Methodology

Our methodology for development and validation is based upon existing heuristics in the published literature (Smith et al. 2013; Capobianco et al. 2018; DeMonbrun et al. 2015). The steps involved a) preliminary protocol development (version 1), b) initial trial, c) review and revision (version 2) and d) first round pilot testing (version 3). Future plans include another round of pilot testing focused on reliability.

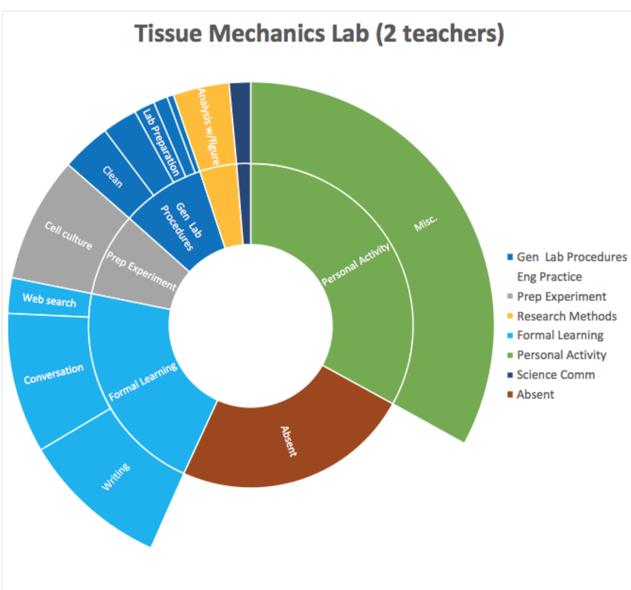
Preliminary protocol development involved using our frameworks to brainstorm an initial set of anticipated behaviors based upon our experience and knowledge that the initial round of participants would be placed in one of two laboratories that focused on either tissue or cell mechanics as a general research focus. It was determined that a single observer would rotate among the laboratories approximately every one half-hour, observe the participants briefly at work, then record the exact time and date as well as the following in a spreadsheet for each teacher participant:

- **Activity**, what they are doing (e.g., buffer preparation, preparing a cell culture, collecting data)
- **Social Arrangement**, who they are working with (e.g., whole group, small group, with a partner, etc.)
- **Level of Behavioral Engagement**, degree of involvement on a 5pt scale (e.g., 1-Minimally; demonstrates no apparent involvement with the activity; 4-Extensively; appears thoroughly involved with activity.)

An initial list of 23 activities was developed based upon the following six SEP categories: general laboratory procedures, engineering activities/applications, setting up an experiment, data analysis, learning through study/reading or conversation, personal activity and others. These activities and practice categories were reviewed and revised based upon feedback from mentors in each laboratory.

Initial Trial: Steps b-c

Teacher participants were four local-area K-5 teachers with very limited background in STEM who applied and were accepted for the RET based upon their interest and intent to complete all of the program requirements. Observations with the protocol indicated different experiences, which varied by laboratory assignment (Figures 1&2).



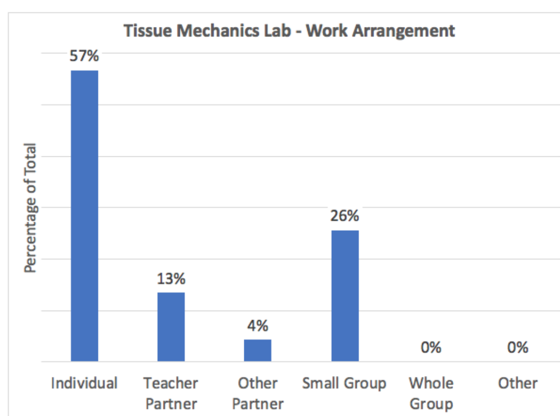
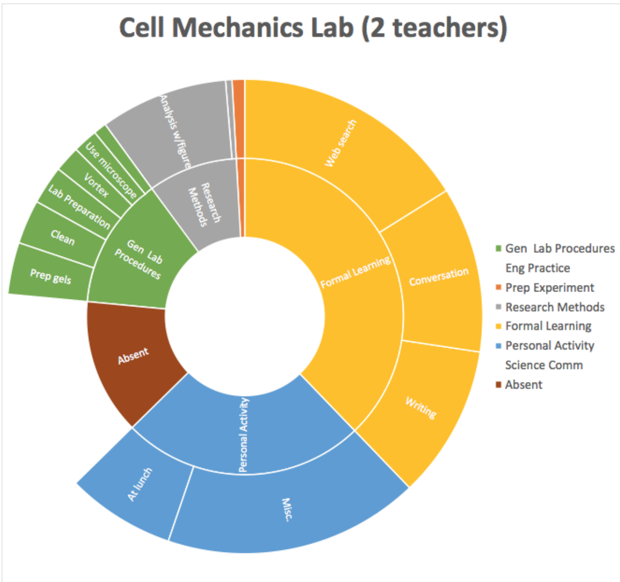


Figure 1: Overall teacher participant activity and work arrangements in a tissue mechanics research laboratory. The sunburst diagram at left is ready clockwise with the most observed practices and activities appearing first, then in descending order.



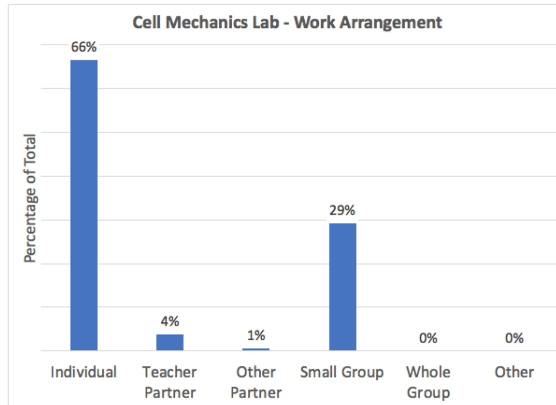


Figure 2: Overall teacher participant activity and work arrangements in a cell mechanics research laboratory. The sunburst diagram at left is ready clockwise with the most observed practices and activities appearing first, then in descending order.

Results revealed that teacher participants spent the majority of their time in either personal activity (tissue mechanics laboratory) or formal learning activity (cell mechanics laboratory) and for each, most likely working alone. The activities recorded as 'other', resulted in >15 previously unanticipated practices. A member checking review of these results with participants indicated general accuracy for the method as well as programmatic design issues such as the lack of shared understanding with mentors about start and end times for work as well as overall expectations for responsibilities. It was also noted that the observation of participants absent from the laboratories often was indicative of work in another area of the building. These results resulted in important feedback to the program as well as significant revision to the activities and practices component of the protocol, which were then applied in the first round of pilot testing as version 2.

First Round of Pilot Testing: Step d

Version 2 of the protocol involved a two-tier hierarchy for SEPs. The top tier was eight major practice categories, including the addition of Science Communication—the explicit process of translating scientific or engineering knowledge to a general audience (Figure 4). Each category was further broken down into observable activities that represented the second tier. Similar to the first round of testing, the observation data was again recorded by a single observer. However, for this trial the person was an advanced pre-service science teacher. In addition to the rating scheme, the observer took detailed notes to support their evaluations and was in continuous discussion with the other researchers about the nature of the observations as well as the practice tier of the taxonomy.

Within each of the participating laboratories, teams consisted of one pair of K-5 teachers and one or two GR's. Each team was observed at least once an hour between 9:00 a.m. to 3:00 p.m. Monday through Thursday. Observations rotated through each lab continually throughout the day. The five laboratories were in four separate buildings that could be reached on foot or bicycle. A Google form was generated and used for each observation to record the name of the lab, teachers' names, working arrangement, the level of engagement of the teachers and GRs, and the activities observed according to categories based on the NGSS science and engineering practices. Additional activities were added as "other" as needed during observations. Results indicated a diversity of difference in experienced practices across the different laboratories that were deemed related to the general research focus (Figure 3).

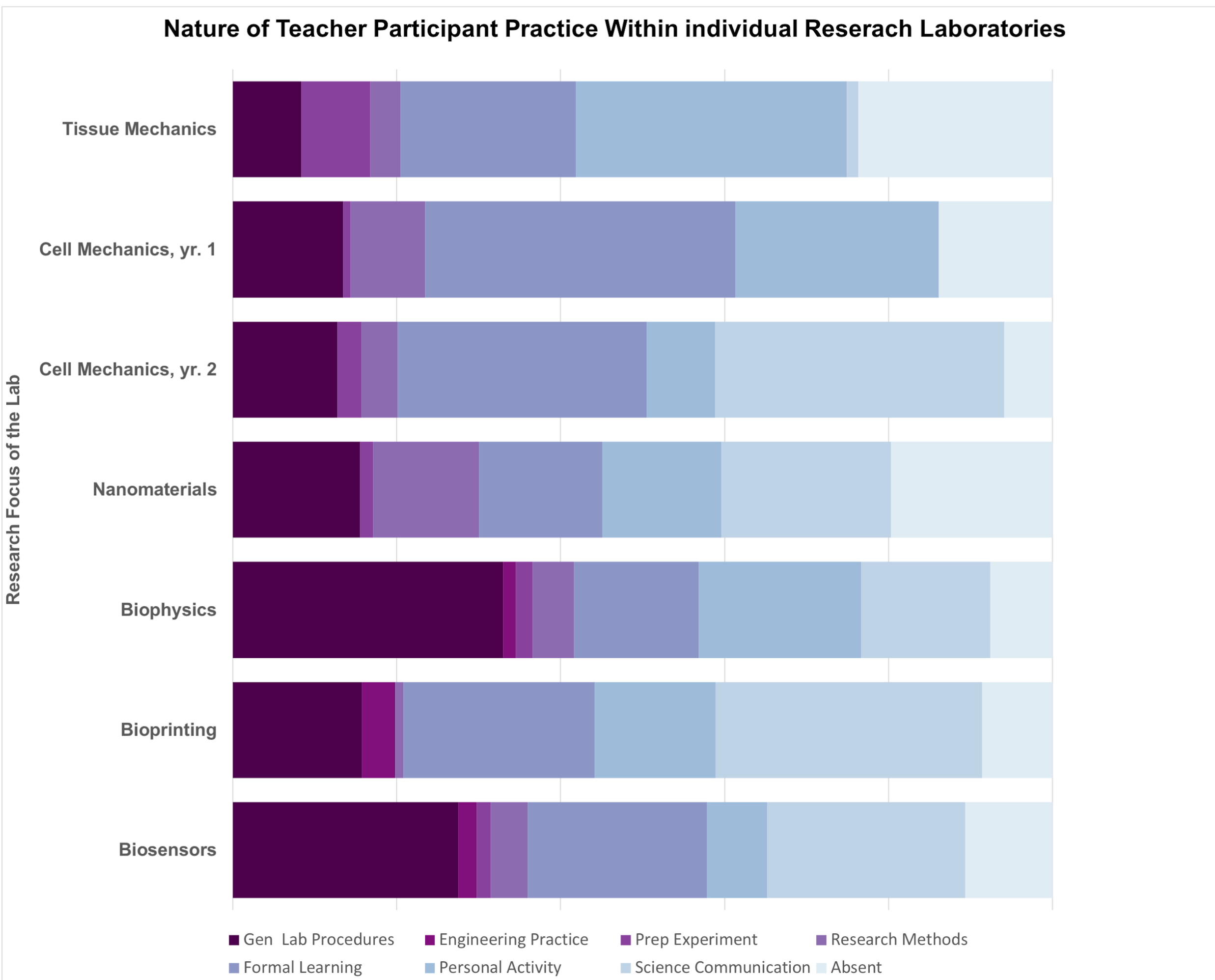


Figure 3. Nature of participant practice by research laboratory and practice category.

At the conclusion of the professional development, the research team met to refine and member check the classification of activities, creating new categories as needed, and resulting in the version 3 of the Observation Taxonomy (Figure 4).

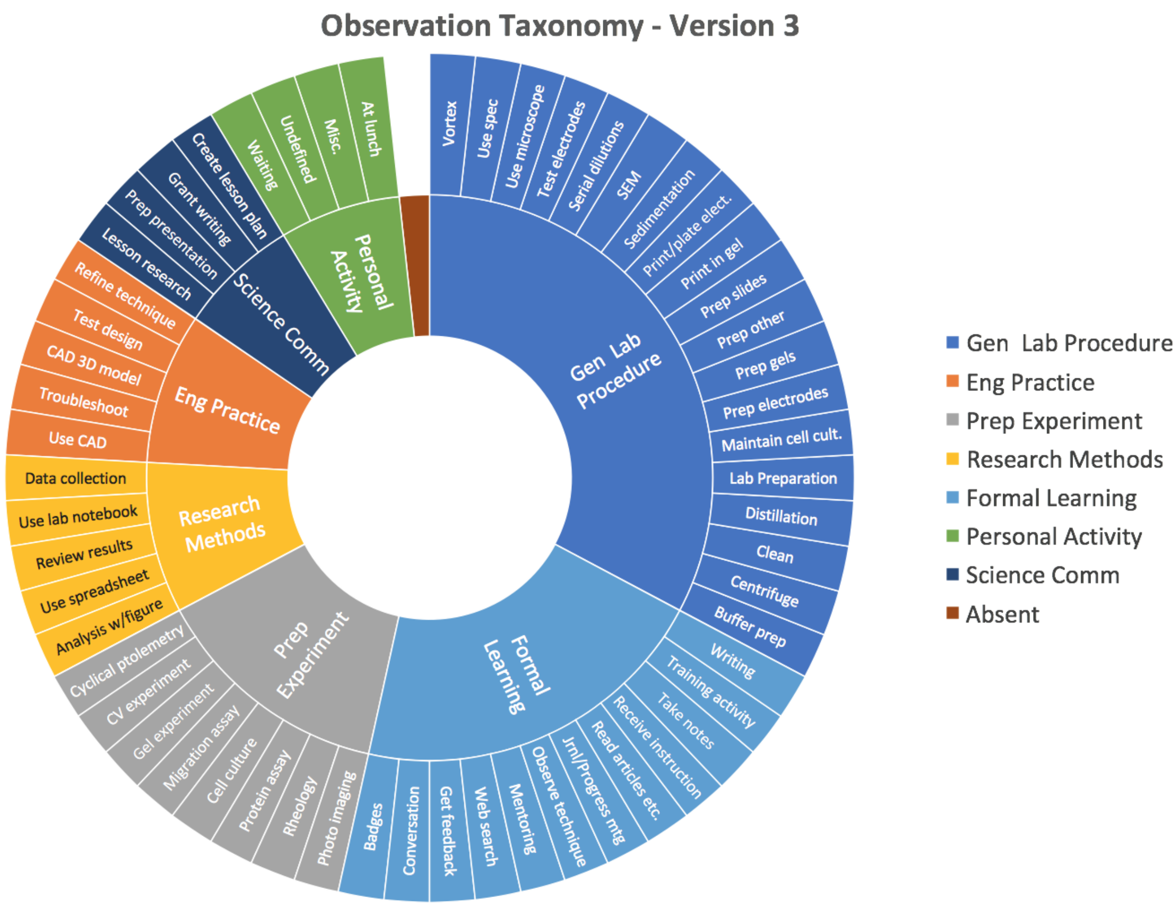


Figure 4. The current two-tiered observation taxonomy (version 3). The inner ring is the practice tier, which includes eight major categories. The practice categories are further broken down into the activity tier (outer ring), which consists of individual activities that can be observed.

Conclusion

Our data show teacher participants engaging in both collaborative and individual work across all laboratories although the experience varied. General laboratory procedures and science communication activities stand out as the categories in which participants were most engaged, however, all laboratories showed teachers taking part in research methods including data collection and analysis. All laboratories also showed participant engagement in formal learning activities in which they were spending time doing Internet research, reading academic articles and engaging in conversation about their work in the lab. Surprisingly although situated in engineering laboratories, the activities within category of engineering practices were among the least frequently observed. Overall, we saw teacher participants engaged in first person experiences with science and engineering practices as defined in the NGSS framework. This evidence supports achievement of the program goal for K-5 teachers to serve as contributing members of an engineering laboratory research team and verifies it as a realistic expectation.

This protocol offers the potential for looking inside the blackbox of apprenticed professional practice in the authentic context of a research laboratory, which has been previously only described for K-12 teacher participants through self-report (Storm and Lichtenstein 2019). Data derived from this method, which can be viewed holistically or chronologically can be used to triangulate and enhance other forms of data, for defining new processes or explaining outcomes and ultimately for enhancing programmatic functions. Future work will involve an additional round of pilot testing focused on reliability.

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