

“Science happens between people”: teachers’ perspectives in a physics RET program

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RET summer programs are envisioned as spaces that can help bridge the gap between classroom STEM teaching and STEM research. Much research has focused on the impact of RETs on teachers’ beliefs about inquiry based learning. RET programs provide a unique setting where teachers, as short term visitors in the research lab space, encounter and engage with ideas about the practice of science itself. In this work in progress, we present the narratives constructed by two physics teachers about the doing of science and the doers of science in a quantum science summer RET program. Using a qualitative approach, we analyze teachers’ interviews over the summer and show how these teachers constructed their identities with regard to the doing of science. We demonstrate how both teachers, by the virtue of trying on these new identities, repositioned themselves as doers of science and challenged dominant ideas about the doing of science.

I. INTRODUCTION

Research Experience for Teachers (RET) programs aim to engage K-12 science teachers in research practices of scientists in university-based laboratory settings and bridge STEM research and classroom practice. Scholarship among science education researchers has focused on understanding how teachers experience STEM research in these programs and how their participation affects their beliefs about classroom science teaching [1–3]. Some scholars have utilized teacher identity as a construct to understand the changes that science teachers go through as they participate in RET programs [4,5]. Teacher identity is a powerful construct to situate and describe trajectories of teacher learning [6]. Thus, in this paper, we use teacher identity to show our preliminary results on how two high school physics teachers in a quantum physics RET program view the doing of science, position themselves as doers of science and try on new identities in this new space outside of their classrooms.

II. THEORETICAL BACKGROUND

In this section, we briefly review the extant literature on research on teacher experience in RETs. Next, we lay out the use of teacher identity as a lens to understand teacher change, and a few important studies in the RET context that used this lens. We then delineate some current perspectives on the meaning of doing science. Finally, we state how we wish to use the identity lens to explore how physics teachers in an RET program position themselves as doers of science in a research laboratory context.

A. Research on teachers' RET experiences

Since the widespread implementation of RETs as an important opportunity for in-service teachers' professional learning, much research has focused on evaluating the impact of these programs. Particular attention has been paid to how these programs affect teachers' views regarding inquiry-based science instruction. Work by Hughes and colleagues showed that participation in a summer RET program improved primary and secondary teachers' understanding of the scientific inquiry process [1]. In another instance, a summer RET program followed by a yearlong professional learning community shifted teachers' beliefs about science classroom practice from a teacher-centered approach to a guided or structured inquiry approach [3].

B. Teacher experience in RETs through the identity lens

Many scholars on teacher identity have centered the conceptualization of this construct around Gee's framework [7] of identity as “the kind of person one is

seeking to be and enact in the here and now”. Building on this, Beijaard and colleagues [8], in a literature review of teacher identity, identify that an essential feature of identity is that it is “an ongoing process of interpretation and reinterpretation of experiences” and that “it implies both person and context”. We align our analysis in this paper with Beijaard and colleagues' concept of teacher identity and focus on how teachers interpret and reinterpret their experiences in the context of an RET summer program to construct their identities as science practitioners.

We highlight important findings from previous work that has pioneered the use of the teacher identity construct in examining teacher experiences in RET programs. Varelas and colleagues [4] utilize teacher identity to understand how teachers make sense of their practices as scientists and science teachers and how they navigate the emergent tensions between their identities. In more recent work, Davidson and Hughes [5] investigate factors that influence teachers' level of belonging in the “community of science practice” and find that both program design factors such as research group structure, as well as personal factors such as teachers' sense of expertise in doing the research work are important.

C. Ideas about doing science

In understanding science teachers' identity construction, it is important to examine existing ideas about science and science teaching. Holton states, “[there] are two very different activities, both denoted by the same word, ‘science’: the first level of meaning refers to private science, the science-in-the-making... the second level of meaning refers to the public science, science-as-an-institution, textbook science, our inherited world of clear concepts and disciplined formulations” [9]. Holton's framing makes a distinction between ideas of science held by the general public as established and institutionalized versus a more tentative and constructivist idea of science held by practitioners such as scientists and researchers. Furthermore, a recent study by Warren and others [10] calls out this institutionalized science attributing it to the invisibilization of the “dynamic nature of disciplinary activity where disciplines are flattened and engaged with as if they are static, known and finalized domains”. In the context of science, they emphasize that this “settled” disciplinary knowledge is shaped by normative ideas about who is allowed to create scientific knowledge. In this paper, we refer to these individuals as doers of science.

It has been shown that discourses about science teaching (for example, traditional science teaching Discourse versus teaching science through inquiry Discourse) can influence what identity options are available to and are taken up by teachers [11]. We therefore conjecture that dominant ideas about doing science (e.g, science-in-the-making versus science-as-institution) can also influence the identities

available to teachers as doers of science in the research lab. Thus, in our preliminary analysis, we aim to understand how two physics teachers in an RET program construct their identities with regard to doing science, by positioning themselves and others as doers of science.

III. METHODS

A. RET program context

Our study examines two physics teachers participating in a paid six week summer RET program focused on quantum science, primarily based in an interdisciplinary science research center of a private research university. Participating teachers applied for the summer program in the preceding spring. Each participant was referred to as a teacher researcher, hosted by a research lab led by a faculty member and matched with a research lab member (graduate student, postdoctoral researcher or staff scientist) who acted as their research facilitator. During the first week of the program, teacher researchers spent most of their time getting oriented towards working in the labs and establishing relationships and planning projects with their research facilitators. In addition, they participated in “quantum bootcamp” where quantum science concepts were reviewed by a participating faculty member in a lecture format. Starting in the second week of the program, teacher researchers spent most of their time in research labs, with one morning per week dedicated to a curriculum development session, another morning per week dedicated to curriculum group work and one afternoon per week at a content instruction session delivered by a faculty member.

B. Participants and data collection

The main data source for this study was semi-structured interviews conducted with all five teacher participants at the beginning and end of the six week summer program. All interviews lasted around one hour and consisted of questions about teachers’ thoughts and feelings about the RET programming, their interactions with other teacher researchers, research facilitators and faculty members, and their experience navigating the research lab space. We analyzed interviews from two teacher participants in this preliminary stage of our work. Both Mr. Martin and Ms. Adam held degrees in physics and were physics teachers. Mr. Martin had 2 years of teaching experience, while Ms. Adam had 21 years of teaching experience.

C. Data analysis

All interviews were transcribed verbatim. We drew on the principles of phenomenological analysis, and analyzed the interview transcript data to make meaning of the teacher researchers’ experiences in the RET program. The unit of analysis was the teachers researchers’ reflection on a specific event or activity in the RET program such as doing

an experiment in the research lab or having discussions with the research facilitator. The first author composed multiple analytic memos on these individual descriptions to understand how these reflected participants’ underlying views on the doing of science and the doers of science. Finally, memos integrating thoughts from the two interviews from each teacher were written to understand how and why teacher researchers’ views evolved through the course of the RET program.

IV. FINDINGS

A. Mr. Martin: owning the teacher identity

Mr. Martin was excited for his research lab experience – the prospect of having hands-on experience with in the laboratory made him feel “over the moon.” In Mr. Martin’s first interview in the first week of the summer program, when asked about working together with his research facilitator, he expressed an interest in being as helpful as possible. He also mentioned his thinking on how he could be helpful in the research lab, saying:

“And they are all very keen on me coming in as a science teacher, not so much as a scientist, which I think is the entire point of the program. I need to sometimes switch that perspective in my brain, because sometimes I’m looking at things from the perspective of a researcher, not from the perspective of a teacher.”

First, Mr. Martin distinguished two different kinds of science practitioners he envisioned being in the research lab space – a science teacher and a research scientist. Interestingly, he also spoke of switching between these two practices, suggesting that he thought of them as mutually exclusive. Second, he got the sense in the initial days of the program that his research lab valued the science teaching skills he brought. We focus on these two threads in Mr. Martin’s first interview.

We first explore Mr. Martin’s ideas about the practice of science, and how his thinking was exhibited during his research experience in the summer program. In the second interview at the end of the summer program, Mr. Martin recalled that he was very curious to learn “the process of being a researcher.” In Mr. Martin’s account of his research activities, he described reading research articles, learning experimental procedures and fabricating a device that was used to obtain research data. Thus, ostensibly Mr. Martin successfully carried out all the research activities planned for him, and yet when he spoke of his feelings when swiping his ID to walk into the research lab, he said, “I felt very cool. [...] And I was like, “Y’all don’t even know. I have no idea what I’m doing.” What drew our attention is the contradiction in Mr. Martin’s description – despite the research work that Mr. Martin engaged in, it seemed hard

for Mr. Martin to feel like he belonged to the research space, perhaps like other members of the research lab, like graduate students. Another piece of data hinted at how Mr. Martin distinguished his science practice and his research facilitator's science practice:

“So there is definitely a healthy mix between my experience as a teacher and providing, and being the bridge to content and having that ability to translate that content to high school level. And then [research facilitator]'s expertise in knowing true physics, if that makes any sense, a true understanding of quantum concepts.”

Here, Mr. Martin was speaking about collaborating with his research facilitator to develop a curriculum module based on his summer research experience. We note that he referred to his research facilitator's expertise as “knowing true physics.” By positioning his research facilitator, a member of the research lab, as holding the “true” knowledge of physics, Mr. Martin drew on a dominant idea of normative science practice where only individuals who are engaged in science research in a laboratory at the graduate level and beyond are seen as truly doing science. Perhaps, this is why, in Mr. Martin's view, he felt like he didn't know what he was doing, because even though he was in the research lab space, he was still a science teacher and not a science researcher like his facilitator.

However, positively positioning himself as a science teacher in the research space is also what allowed Mr. Martin to challenge this dominant idea of normative science practice. Mr. Martin shared the experience that was central to this:

“In the beginning I came in and I was very anxious because I have not breached these higher tier scientific subjects in so long. I was thinking, “Well, I'm going to be coming in. And there's going to be an 18 year old who will blow me out of the water with their mathematical and physical physics expertise.” And then I come in and here I have some 18 year olds calling me, sir, and asking me about my expertise in teaching the subject. Because they are very clear in the idea that science happens between people. And if you can't explain what you're working on, you're not going to get anywhere. Nobody does a full project by themselves. They have to be able to correctly communicate what they're working on to people of various degrees of content knowledge. [...] But the part where they were actually interested in scientific communication was the part that made me realize like, oh wait, I have knowledge and skills that can be beneficial to the people in the lab.”

For Mr. Martin, members of the research lab respecting his expertise in communicating science as a teacher was crucial

to recognizing he had important skills to contribute to the research space. In fact, Mr. Martin told us that he saw his role in the research lab as someone that lab researchers could practice explaining scientific concepts to. The experience of being positioned as a science teaching expert by research lab members led to Mr. Martin thinking about doing science in a different way, where he saw conversations between people about scientific work as integral to the process. Thus, while Mr. Martin retained the distinction between science teacher and researcher, being in the research space with a strong teacher identity allowed him to challenge this binary and create a legitimate space of membership for himself in the research lab.

B. Ms. Adam: embracing a learner identity

Like Mr. Martin, Ms. Adam was excited to be in the research lab space. In her first interview at the beginning of the program, she told us that she felt privileged to be experiencing a “state of the art” science laboratory. At the same time, she was concerned whether she would be able to understand the quantum science content well and fit into the research lab. Ms. Adam's perception of the research lab members and in particular, the professor was illuminating:

“I felt the professor was going so fast, but it was for me so fast. He actually was really, I think this is the best that he can bring it to the public, and that's part of the communication. He's too much knowledgeable, and he is around so many smart students.”

Ms. Adam was reflecting on the professor's teaching in the quantum bootcamp. She positioned her research professor as “too knowledgeable”. She also positioned the other student members of the professor's research lab as “smart” and in another excerpt, as “very, very, very advanced”. In doing so, Ms. Adam constructed an idea of the research scientist, an individual capable of creating scientific knowledge, as a person with extraordinary, and even unattainable intelligence.

Very early on in the summer program, however, Ms. Adam had an interesting experience in the lab space that provided her a different perspective about who can be a scientist. Ms. Adam was assigned a desk in her host research lab and noticed the graduate student researchers' desks. She wanted to take pictures of these desks and share them with her students:

“And the clutter of the notes, and the coffee. It was like this is what the people have, so they can't see, relate, “Oh, a student is a student. Whether you are a grad, they have tests to do, they have activities. They have a nice thing. I think one had some of the KPOP poster or somebody. It was like, oh, those are normal. [...] And again, a lot of them that in the younger generation, so they can connect with my students. [...] Normalize them as a humans, and

just like- Someone is in the lab doesn't mean that they have just to be ... They may be nerd in their specialty and stuff, but that doesn't mean they don't have life, and they don't have interest, and things."

The everyday objects on the graduate researchers' desks, such as coffee, clutter, and posters, humanized the unimaginably intelligent scientists for Ms. Adam. She describes thinking in this moment "oh, those are normal." In the research lab space, Ms. Adam found a point of relatability with the graduate student researchers in that she saw them as just students and youths and, thus, similar to her own students.

Hearing Ms. Adam's account of her summer of research in the second interview, it became clear that this early encounter was important to her experience. Ms. Adam reflected on her general experience of being in the research lab saying, "it's put me on the feet of my students." Imagining what her students might feel like in the research space and what they might like to know and see about it may have been central in feeling like she was in her students' shoes. Additionally, Ms. Adam also told us that due to curriculum development work in the program, she was often thinking about how to share the content she was learning with her students. Such student-centered thinking, combined with being positioned in the lab as a research apprentice of sorts may have encouraged Ms. Adam to embrace and enact her identity as a learner in the research lab. Further conversation with Ms. Adam revealed her actions that crystallized into this identity:

"like when she [research facilitator] will give me a homework, read these articles and come with the three questions. And I will go and say, okay, in the article, in this paragraph, I saw this. What's that mean? So I felt it's like a homework. So I kind of put myself as a student. I need to learn these materials. I need to apply these activities. I need to participate with this, whatever she will tell."

Ms. Adam viewed the research lab as a flipped classroom, and herself as a student. She immersed herself into research activities facilitated for her and actively reached out to her facilitator with her questions. She even spent time outside of the research lab hours doing "homework" and reading research articles. At the end of the program, Ms. Adam felt settled into the research experience and told us that she saw it as a place where she could focus on her own learning. For her, working in the research lab became a routine where "everyday was something fun". Thus, by stepping into the identity of an enthusiastic learner, Ms. Adam established her membership in the research lab space.

V. CONCLUSIONS

Our preliminary analysis demonstrated how two physics teachers constructed two different identities (teacher and

learner) while navigating the summer RET program. These two identities, and more identities that we could not focus on, served as resources for them to reposition themselves as doers of science and legitimate members of the research labs in various ways. In doing so, they also challenged the notions of institutionalized science and reframed science as a more humanized enterprise that requires many different kinds of skills and centers human interactions.

In this study, the identity construct allowed us to notice the important learning teachers accomplished and the moments in which normative notions of science were breached. However, with the scope of our data, we cannot say whether this repositioning of science and doers of science was stabilized or not. Future studies should focus on how RET programs can be designed to allow and encourage this kind of repositioning and how the repositioning observed during the summer program impacts teachers' classroom practices.

Our study provides useful implications for the design of RET programs. First, we note that the social context of the laboratory were instrumental in teachers' repositioning. For example, Mr. Martin description of his lab colleagues' interest in learning from his teaching skills, or Ms. Adam's note about how the physical contents of the lab space made her feel. In the implementation of RET programs, it is thus important to attend to teacher-researcher relationships, encourage asset-based thinking about teachers' experiences and promote intentional inclusion of teachers in the social structures of research groups. Second, teachers' positioning of scientists and research practices was central to developing a deeper understanding of how scientific knowledge is produced and how there may be multiple ways to be involved in this process. Thus, it is important to realize that RET programs provide a space not just for the transfer of content knowledge, but also knowledge about the processes of doing science. RET participants are carriers of this knowledge to their high school classrooms. Attending to this aspect of RET programs allows further dispersion of knowledge to students in science classrooms who may be future doers of science.

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