Becoming Science Teacher Leaders:

Challenges and Opportunities

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Abstract

Through a partnership with 12 school districts, the University of Florida science education program prepared 35 school/district Science Teacher Leaders to lead a transformation in science education through the study and enactment of a reform-based science curriculum in their classrooms. Bounded by the parameters of a particular program, this case study reveals how the STLs enacted their training experiences within their school and district contexts, and their strategies for working as leaders among their peers.

Introduction

The University of Florida, in collaboration with Florida school districts and with grant support from the National Science Foundation (NSF), developed a job-embedded graduate program, *University of Florida Unites Teachers to Reform Education in Science* (U-FUTuRES) designed to prepare two cohorts of middle school science teachers to (a) implement the inquiry-based *Investigating and Questioning our World Through Science* (IQWST) curriculum, (b) provide support to school science colleagues and lead professional learning communities (PLCs), and (c) design and facilitate professional learning opportunities for other teachers in their districts. Through a partnership with 12 school districts, the University of Florida science education program prepared 35 school/district Science Teacher Leaders (STL) to lead a transformation in science

education through the study and enactment of a reform-based science curriculum in their classrooms.

Methodology

This investigation constitutes a case study. That is, the parameters of the investigation are bounded to a particular program and its stated goals (Creswell, 2013; Hatch, 2002). The interviews were structured for researchers to understand more clearly the ways in which U-FUTuRES STLs (a) made sense of their U-FUTuRES program experiences in the context of their daily teaching in schools and to (b) ascertain the extent to which they perceived themselves as working toward the goals of implementing IQWST and inquiry-based science; developing collaborative, transformative relationships with their colleagues; facilitating PLCs within their schools; and providing professional learning opportunities for science teachers in their schools and districts.

Data Collection

Participants. Of the 35 U-FUTuRES graduates, 25 participated in the face-to-face interview portion of the study. Of the 25 respondents who participated in the interviews, 23 were middle school science teachers, two were district level administrators. Three school- and district-level administrators who supported the STLs were also interviewed.

Interviews. Face-to-face interviews with U-FUTuRES graduates working in one large south Florida and 11 north Florida school districts were conducted during the 2015-2016 academic year. A pre-determined protocol served as a guide for the interviews, with follow-up questions and probes added, as needed, to elucidate or extend participants' answers. Participants were assured that their responses were anonymous. That is, their

individual comments would not be identified for the U-FUTuRES faculty or staff or in publications regarding U-FUTuRES without their consent.

The interviews were held in the afternoon when the school day had ended. We met in teachers' classrooms or administrators' offices. The interviews lasted approximately forty-five to ninety minutes. All interviews were transcribed. We met with teachers in their classrooms where they taught IQWST. A small portion of the school day was also observed prior to each interview. During the interviews teachers often referenced the IQWST lesson for the day, the adequacy of the facilities, and the posted Florida Next Generation State Science Standards for the lesson taught that day.

Data Analysis

Transcripts were reviewed, line by line, to discern initial categories of interests. Initial categories included "Things Teachers Say About Inquiry-based Science," "Kinds of Things Teachers Say About Student Achievement," "Kinds of Things Teachers say about Administrators," and so forth. Categories were developed as they emerged from teacher comments. After categories were established, we searched for common themes within categories, comparing and contrasting comments within the categories, and establishing additional levels of categories. We also searched for themes across categories (Creswell, 2013; Hatch, 2002; Lincoln and Guba,1985; Spradley, 1979).

Participants were assigned a numerical code. The code consisted of two numbers. The first number indicates whether the participant was in Cohort 1, interviewed in fall 2015, or Cohort 2, interview spring 2016. The second number in

the code represents the teacher. For example, in (1:11), the 1 represents the first round of interviews; the 11 represents the number assigned to the teacher.

Bronfenbrenner's ecological systems theory (1979, 2005) was used as a guide to make sense of themes emerging from the data sets. In Bronfenbrenner's ecological system theory, nested contexts are not discrete, but rather are fluid, interacting continually as events unfold over time. The interrelated and interactive contexts of classrooms with schools and districts, as well as state and national policies, influence and are influenced by the ways individuals interacted with and responded to these varied contexts.

Preparing U-FUTuRES Science Teacher Leaders

The U-FUTuRES Science Teacher Leadership Institute (STLI) was a job-embedded graduate program co-facilitated by the university's College of Education and science partners from the College of Liberal Arts and Sciences. The two-year institute included graduate-level science content aligned with state and national standards, science-specific pedagogy, and leadership courses focused on PD practices and Professional Learning Communities (PLCs). Coursework for the program included: (a) nine credit hours of science content (physics and chemistry, biological science, and earth and space sciences for teachers); (b) 12 credit hours of science education focused on inquiry-based science teaching, reformed-based science curriculum, assessment, and best practices for engaging underrepresented populations; (c) three credit hours of leadership training; and (d) six credit hours of a capstone project organized around teacher inquiry. The science courses were co-developed by science and science education professors along with graduate students from both the College of Liberal Arts and Sciences and the College of

Education. Two courses in the STLI, *Inquiry-based Science Teaching* and *Science Curriculum Development,* were designed to immerse teachers in the practices and principles that informed the development of the IQWST curriculum (a middle school evidence-based science curriculum). Throughout the project, teachers attended monthly cadre meetings, which built upon topics introduced in the formal courses and allowed for further reflection on practices toward effective implementation of the curriculum and inquiry-based science.

The Reform-Based Middle School Science Curriculum: Investigating and Questioning our World through Science and Technology (IQWST). The IQWST curriculum is designed to actively engage sixth through eighth grade students with scientific phenomena and scientific practices as they collect data and make evidence-based arguments. Each year, students engage in four units of study (physics, chemistry, biology, and earth systems) organized around driving questions designed to support coherence within and across grade levels. IQWST was developed through ten years of support from NSF to develop the next generation of science materials that would engage students in learning the big ideas of science (Krajcik, McNeill, & Reiser, 2008). IQWST promotes engagement in scientific practices that allow students to experience how scientists develop their knowledge and in the process develop deeper understanding of both the science practices and the content being addressed. In addition, the IQWST curriculum acknowledges the varying levels of students' exceptionalities and diverse needs; therefore, it includes materials and resources that allow teachers to connect to students' real-world interests and experiences and provides opportunities for specific and general differentiation.

Case Study Findings

Our theory of action was built upon the simple logic model that professional development increases teacher knowledge and skills, leading to changes in teaching practice that result in improved student outcomes. Further, we believed that by increasing the knowledge and skills of our STLs and supporting their work as STLs the knowledge and skills of their science teaching colleagues would also be impacted. We understood that all project activities, teaching practices, and student learning were nested within layers of influence—school culture, district directives, state standards, testing, and national concerns (Elmore, 2007). Any effort to influence teachers' knowledge and skills, and as a consequence teaching practice and student achievement, would not occur in isolation. Therefore, the project included specific strategies for working with school and district leaders to align the various layers of influence to create sustainable support for reform-oriented science teaching practices and collegial collaboration through PLCs. Our findings are organized in three sections: (1) STLs definitions of reform-based science teaching; (2) STLs working definitions of what it means to be a STL; and (3) layers of support and challenge to STLs.

How do STLs' Define Reform-Based Science Teaching?

Enabling Students to "Do Science"

In the IQWST curriculum, one of the teacher's initial strategies is to discern students' misconceptions regarding the concept under study. In U-FUTuRES, we followed a similar process; we tried to discern teachers' understandings of teaching science prior to entering the U-FUTuRES program. According to our participants, studying science had consisted of content lectures facilitated by Power Point

presentations, an occasional lab experience to illustrate the lecture (demonstrated by the teacher with some participation by students), a list of science vocabulary words, and a formal assessment.

> It was like I was in a Charlie Brown cartoon and I was the teacher going, "Wah, wah, wah." I would just make a PowerPoint and have no connection to the real world. And then, with IQWST, I was able to do the labs and say, "Okay, this is what we're doing, here's some background information. Have at it. You make the discovery." It was something that I enjoyed. The last three years teaching IQWST has been great. (2:8)

Interestingly, STLs said that their students shared similar notions about middle school science class prior to the implementation of reform-based science practices.

In U-FUTuRES classrooms, STLs and their students began to define their inquiry based science classes as opportunities to "do science." STLs explained that their preparation in U-FUTuRES had "flipped the traditional approach to teaching science." The inquiry-based practices they had learned empowered their students to search for answers to questions posed by their teachers, using investigatory methods. STLs described how their students were learning to act and think as though they were scientists.

> For me, the number one change was, "I don't have to be in control of everything in my classroom, I can put my students in control." That was a huge change in how I taught before. I'll give an example. In the physical science unit, we had a can that rolls back and forth, because it has a rubber band and a weight inside. It stops at a certain point and rolls back, and we talk about elastic energy. But at the

> beginning when the kids see that, they ask, "How does that work? Can you explain it to me?" And my first instinct would have been, "Let me explain it to you." And U-FUTuRES taught me to step back and say, "Let's figure it out. I want you, without opening it, to try to think about all the science that we're learning and try to explain it." So, it's trying to turn them into scientists or learners instead of listeners of the teacher. IQWST puts them in the seat of their own personal learning. (1:3)

U-FUTuRES STLs reported that their students demonstrated greater engagement, enthusiasm, and understanding of concepts. Off-task behavior decreased as student interest increased. STLs believed their students were learning. They said,

> We have made huge gains in student understanding and student achievement. You walk into the classroom, listen to the kids, and you can tell that it's just leaps and bounds beyond what it was like last year. It's just amazing what these kids can do. They can speak science, they can do science, and they can discuss science. I'm excited about that. But they may not be able to test well. We just don't have those big pieces of data. But when they leave here, what matters most is what they know, so I'm excited about that. (1:1)

Changing school culture and moving toward inquiry-based learning also meant "trying to change the culture with students." An STL explained that students are surprised that they are not being given the answers. They, too, must adjust to in inquiry approach. STLs said,

> Students have been conditioned at a young age to sit quietly and work independently on a worksheet or read a section in the book and answer questions, so leading them to think about these scientific principles and

> thinking about how it's happening and looking at the natural phenomenon is an adjustment. (2:3)

STLs, however, were clear that students did more than have "fun" doing hands-on labs.

Using the IQWST or inquiry approach to teaching science required a systematic approach to learning concepts. STLs presented a driving question board and set up hands-on investigative experiences for the students. As they work in cooperative groups, students pose additional questions. Eventually, students are asked to explain scientific phenomena—to make a *claim*; present specific data, *evidence*; and provide logical, science-based reasons for their claim, *reasoning.* The *claim*, *evidence, reasoning (CER)* framework provided teachers with a rigorous approach to insure students made sense of and could articulate the science concepts learned.

> U-FUTuRES … opened my eyes to a different way of thinking—in terms of letting students do the investigations, let them ask the questions, let them explain what's happening. And I think it really helped change my perception of my role as an educator. It's about putting the students first, putting them in student-centered groups, and then taking a step back and just observing and asking questions. There were times before (IQWST) if a student asked me a question, I would always give an answer. With U-FUTuRES, I learned that you keep them thinking, to ask them, "Well, why do you think that's happening? What's causing this?" And I think it really allows them to take it one step further in the way they were thinking in their own minds about science. (2:3)

Teachers are more likely to change their practices and sustain those practices when they observe changes in student learning (Guskey, 1989; 1986). STLs believed that most of their students were learning. They observed changes in what their students said and did during labs. Sustained change over time coupled with observable growth in students' classroom performance, resulted in teachers' continuing commitment to inquiry-based learning. The changes, however, were not easy and not all students flourished.

Teaching Students in Poverty and with Special Needs

STLs noted the challenges of working in classrooms with students from poverty and students with special needs. Some of these students exhibited weaknesses in reading and writing; some exhibited inappropriate behaviors. Some STLs noted, however, that despite students' weaknesses in reading and writing, they were strong in science. Many STLs were concerned that on standardized assessments students would not have the opportunity to demonstrate what they had learned in science due to their limited proficiency in reading and writing,

> We are using IQWST with students at Reading FCAT Level 1 or Level 2. They have gone from sleeping through the lectures, to actually being involved. With our lower level kids, you see the kids making those connections who are going, "Well, why does this happen?" "Well, we did this, this, and this. And we get this." I'm like, "Yeah!" And, they're like, "Oh!" They would make that connection, they would see that light bulb. (2:8)
>
> It's making a difference in my kids. The kids know the science content. But I have a new hurdle to overcome. My kids are the 76% non-proficient readers.

> … They can discuss science, they can do the labs, and they can orally give you claim, evidence, reasoning for anything they are doing but they cannot reproduce that on an assessment. So now we have a mismatch of what we know the students are capable of and what the students can produce in the standardized assessments. (1:1)

U-FUTuRES participants believed, based on their classroom observations of students, formative assessments, and student learning journals, that their students had a greater understanding of scientific principles as well as scientific approaches to inquiry. STLs also believed that they had better insight into how their students were making sense of scientific concepts. These teachers hoped, but wondered, whether student learning would be captured in standardized assessments.

What is a Science Teacher Leader?

U-FUTuRES prepared teachers to become change agents advocating for inquiry-based practices. One component of U-FUTuRES preparation was intended to develop participants' capability to provide professional development for their colleagues through coaching, modeling IQWST lessons, facilitating PLCs, leading summer workshops, and working with school and district leaders to enact change. In the school context, STLs definitions of leadership evolved.

I am a Teacher, Just Like You

U-FUTuRES teachers expressed reluctance to use the title of STL. They were concerned that the title, STL, would set them apart from other teachers, implying that, in some way, they were superior to other teachers. Some U-FUTuRES STL noted that in their districts "STL" is an administrative position that had already been established. Most

U-FUTuRES STLs began their efforts with offers to help other science teachers in whatever ways teachers felt comfortable. Initially, STLs wanted to reassure their peer teachers that their leadership role did not include a formal supervisory role. The STLs reassured teachers that they were also teachers, just like them.

How Can I Help?

U-FUTuRES STLs maintained an open-door policy and invited teachers into their classrooms to ask questions and observe inquiry-based lessons. Most STLs described their role as a resource person for teachers trying to implement IQWST or other inquiry-based lessons. STLs said that they were available to answer questions, from early in the morning until late at night.

> I unlock my door before and after school. I can have anywhere from two to ten people in my classroom in the mornings during my planning time. It's very chaotic. I get questions like, "How do I put this lab together?" "I didn't ask these discussion prompts and I'm worried that the kids don't understand this. How do I backtrack?" "The standard says, I'm supposed to use this vocabulary, but it's not in the IQWST lesson, what do I do?" Things like that. And, I get phone calls, texts, at suppertime, anytime. I have never been so popular. (1:5)

Almost all of the U-FUTuRES STLs offered variations on the theme of someone who could help other teachers in a variety of ways, with an open-door, accessible policy. STLs facilitated their colleagues' learning in ways that were comfortable to them within the context of their schools. Most STLs did not observe other teachers in the classroom, as a coach, unless they had the support of the school level administrator in facilitating the

observation. However, STLs invited other teachers to observe them modeling IQWST in their classrooms to provide assistance to teachers learning inquiry-based practices.

Come to My Classroom: Modeling Inquiry

U-FUTuRES STLs modeled IQWST labs to help teachers understand the process of inquiry-based science methods. As one STL noted,

> A teacher asked, "Can I watch you teach?" And so we've taught together for two years now and there'll be times where she'll say, "I'm really confused about this lesson. Can we tag team one class period so I could watch you do it and then I'll do it with the rest of my students?" (1:5)

Some STLs combined their classroom with another classroom. The other classroom teacher assisted and observed while the STL facilitated the laboratory experience, while using IQWST curriculum strategies such as CER, the DQB (Driving Question Board), and other inquiry-based strategies. For these STLs, modeling labs made sense to them as an important step in facilitating the professional learning of other teachers.

Teaching Science Content to Colleagues, Unobtrusively

U-FUTuRES STLs noted that other science teachers struggled with understanding science content. Prior to U-FUTuRES, many STLs had also struggled with science content. They were aware, from their own backgrounds, how weak many teachers are in science content knowledge. However, telling other teachers that they needed a better understanding of science content was awkward. U-FUTuRES teachers did not know how to tell teachers what they needed to know without “insulting their intelligence.” STLs described their efforts to communicate science knowledge while explaining or modeling a laboratory experience. As one teacher explained, “I did the lab with [a less

knowledgeable teacher] and I [realized] that you can tell someone how to do a lab, but then as you're doing it you're also teaching them science at the same time" (1:12). Addressing peer teachers' lack of content knowledge was not easy.

***Coaching*.** Coaching observations, when they occurred, were facilitated by school principals. One STL's principal organized a round of observations in science classrooms. The teacher noted that the administrator helped facilitate U-FUTuRES goals.

> [The science teachers] were asked to observe each other by our administrators. At first, we all videotaped ourselves once in nine weeks, and starting this second semester, the administrators are giving us a substitute so we can actually go in and sit in the other teacher's classroom. And, that teacher is also going to get to come in and sit in my classroom. All four teachers are going to do that. We'll rotate around so every one of us can watch every other teacher and vice-versa. … My recommendation was that the videotapes weren't working, they weren't doing what you the administration wanted them to do. So, I asked, "Why can't we just sit in the class, even if it's for only half a class or something?" Our principal liked it, so we're going to do it. (1:11)

The support of the administration was clearly an important factor in coaching another teacher in the school. The administration funded the substitute teachers to facilitate observations and coaching. Very few U-FUTuRES STLs had that level of administrative support.

Need Resources? Managing Laboratory Materials

U-FUTuRES teachers also described their roles as "librarians" of the IQWST lab materials—keeping track of equipment and materials and their safe return to their appropriate place in the IQWST closet. U-FUTuRES teachers also took the lead in submitting requests for laboratory supplies through school and district offices. Sometimes, they arrived in a timely manner; other times, they did not. Most schools did not have sufficient materials for each teacher to conduct inquiry-based lessons. The STLS at the schools assumed the responsibility of managing and scheduling effective use of limited supplies.

Science Teacher Leadership: Opportunities and Challenges

When is a PLC a Professional Learning Community?

U-FUTuRES STLs were prepared to facilitate PLCs in their schools to provide sustainable support and encourage collegial collaboration for implementing inquiry-based science practices. As facilitators of PLCs, U-FUTuRES STLs became acutely aware of obstacles within their schools to teacher change. STLs said that their first objective regarding their PLCs was to educate teachers and administrators about the importance of teacher voice and teacher leadership within PLCs. STLs needed to teach administrators and colleagues that the science PLC would need to function differently from science department meetings or other faculty meetings. It was not easy when pre-existing PLCs in their schools were not working well. It was not easy when teachers had different levels of experience and interests. Teachers' and administrators' misperceptions regarding PLCs meant slow progress toward establishing an effectively functioning PLC. Some STLs

noted that typically, teachers were not accustomed to working together and described school cultures operating within traditional norms of isolation (Little, 1990).

> Everybody's compartmentalized at this school. It's pretty hard to get people out of their little cubbies and into a common arena, into a common thought or think-tank. People just keep to themselves emotionally and socially, and physically. And I, for myself, have been very isolated here over the past few years. (2:2)

Other STLs noted that teachers liked to "whine" when they get together. Nevertheless, a few PLCs facilitated by U-FUTuRES STLs, moved past the complaining stage and began to focus on professional practices.

> We have, for the most part, stopped the complaining sessions and the griping sessions. That was a huge hurdle to overcome in itself, so now the meetings are getting more and more beneficial and more and more focused as we move through them. So, we're making progress everywhere, not as quickly as I would like, but I am definitely celebrating our progress. (1:1)

Teachers' and administrators' misperceptions regarding PLCs meant slow progress on facilitating a professional learning community. Confusion regarding the purposes of common planning time seemed to be an obstacle as well. U-FUTuRES provided funding to support time for PLCs. Most principals, however, did not continue the practice of finding time and additional funding for PLCs.

Teachers' Resistance to Change

STLs also encountered resistance from their school colleagues as they endeavored to "make the shift" to an inquiry-based science curriculum. Veteran teachers resisted

changing methods they had used for years. Novice teachers had multiple, multifaceted concerns as they began their new careers. Some teachers preferred traditional teacher-directed, textbook-driven instruction rather than inquiry-based practices.

Veterans and Novices. Veteran and novice teachers presented different challenges to U-FUTuRES STLs trying to effect change to a student-centered, inquiry approach.

> I think that it was two sets of teachers who did not want that to happen. There were veteran teachers who had their own way of doing things and definitely did not want to give up control of the classroom. And then there were the brand new teachers who were like, "Oh, my gosh. What'll happen if I let go of the classroom? (2:2)

STLs said that veterans were cynical about another reform effort that may not last. STLs expressed the view that many veteran teachers did not intend to invest the time and energy necessary to implement large-scale changes in their classrooms when they were just a few years away from retirement.

STLs also met resistance from novice teachers. STLs were reluctant to add any additional pressures to the stress experienced by many novice teachers as they acclimate to their new role in a new school. Echoing other STLs, one noted that, “Right now these poor dears are just trying to tread water. The last thing they need is something else on their plate. Just, trying to survive.” (1:5) Nevertheless, some STLs said it was important to give the new teachers opportunities with inquiry-based approaches.

Resistance to Inquiry-based Teaching. STLs noted that it takes time and support to make such a substantial change in practice, from traditional teacher-centered, textbook-based practices to student-centered, inquiry-based practices. U-FUTuRES

teachers expected to find some resistance from teachers in their schools, because they knew, from their own experiences, that change is difficult. One STL noted that teachers are motivated when they see students learning, but that takes time, effort, and support.

> It takes a few years for the teachers to really see that kids are really learning. Teachers are used to something they can open up and here's a worksheet and we're going to go over the answers. You know, it's been just, memorize and regurgitate. It's the age we live in. Having kids ask you tough questions is something that middle school teachers aren't used to. ... One teacher told me that she was like, "I'm not used to kids asking me why the sky's blue. I didn't know what to say." All of a sudden you have to admit that maybe nobody has all the answers, including you, and you have to figure out how to work through it in a different way. Not just let's see what the answer key says."

STLs also realized that they had been able to make significant changes due to the education and support they received from U-FUTuRES, a comprehensive long-term professional development project. STLs also noted that administrative support was necessary to enabling reform.

Providing Professional Development

Most STLs were involved in providing professional development for teachers in their districts. STLs worked with University of Florida faculty and graduate students to provide summer workshops giving teachers opportunities to practice inquiry methods and learn science content (T^2S). These workshops typically involved IQWST curricular materials.

Generally, STLs felt that the summer workshops were satisfactory. One STL described her most recent workshop.

> We (two U-FUTuRES STLs) did a summer workshop for our county based on the Earth. … It was a three-day workshop mostly geared toward Earth science. That is one of the weakest areas in our county. Graduate students came from the University of Florida to help and assist and answer content type questions. We taught 3rd through 6th. We taught all kinds of concepts on erosion, weathering, deposition, conversion, radiation, conduction – all the main principals. … We gave them little, short activities that they could do within their classroom that were basically quick and easy things to demonstrate a concept, and help the kids understand. We had them practice, ironed out all the kinks, so they could see any mistakes and fix them. We got great responses. Some were veteran teachers and some were newbies. But all the teachers have told me that they have used those activities in their classroom. (1:12)

Nevertheless, STLs expressed concerns that enthusiasm during the summer may fade as the school year begins. One district administrator noted, however, that even short experiences with inquiry-based practices can make a difference. A summer workshop in inquiry-based lessons is the first step to "become more confident and competent with inquiry strategies, primarily." (1:3)

Listening to Teachers: The Importance of School-based Administrative Support

STLs who had administrative support within their schools were clearly in the best position to implement inquiry science and serve in a leadership role in their schools.

IQWST, or inquiry-based lessons, pose challenges that teachers can only overcome with the assistance of their administrators.

Willingness to Learn About Inquiry-based Science. U-FUTuRES STLs were clear about the importance of school level support, or more importantly, administrators' willingness to listen and learn regarding an inquiry-based approach to science. U-FUTuRES participants did not believe it was possible to implement an inquiry-based science approach without administrators' willingness to learn the essentials of inquiry-based science. Without school-based administrative support, U-FUTuRES STLs said that implementing IQWST or inquiry-based science would not happen. One U-FUTuRES trained district administrator noted, "Asking teachers to change their practices with or without principal support, is hard." (1:4) Another STL noted the difference when administrators had been in the inquiry-based classrooms.

> I think the principals [in our district] were highly supportive. They liked what they saw when we started teaching IQWST, the students were highly engaged and could talk about the science at hand, and then they would go into other classrooms where there was lecturing and a lot of workbook pages. ... the principals really, really liked the engagement in an IQWST classroom. (1:4)

Other STLs also described supportive principals who noted the changes in student engagement in the science classroom and assisted them in their efforts to enact reform.

Creating Time for Teachers to Meet. Administrators were essential for creating time for teachers to meet and to support teacher collaboration.

> The support has to come from the teacher all the way to the superintendent. … It has to start with the teacher in the classroom, and then it has to involve all of the teachers at the school, or at least most of them. And the principal has to be sensitive to the needs of those people. They have to be able to collaborate. And, I know a lot of our training involves the development, formation, and function of a professional learning community, and it's a great idea, in concept, but it has to be allowed to happen. (2:2)

STLs said that the administration has to understand how to implement an inquiry-based curriculum and actively facilitate teacher learning at their schools.

***Insuring Adequate Resources and Facilities*.** School administrators needed to ensure that resources were available and laboratory facilities were functional. Teachers' access to laboratory facilities varied greatly, both within schools and across schools and districts. Participants said that implementing IQWST, or inquiry-based practices, required an adequate laboratory space that included counter tops, sinks, electrical outlets, natural gas, glassware, safety goggles and eyewash stations as well as a myriad of materials for specific labs. Lack of laboratory facilities was a significant obstacle to changing practices. One STL noted that inadequate facilities made a difference in colleagues' willingness to change their practices. Teachers in traditional classrooms with tablet desks persisted in teaching science in traditional ways.

Flexibility with State Standards and Standardized Assessment of Students and Teachers. The IQWST curriculum is not overtly aligned with Florida's Next Generation State Science Standards. In addition, IQWST lessons do not neatly conform with commonly used teacher observation protocols required by the district and state.

Nevertheless, some STLs found principals who were willing to be flexible with their interpretations of meeting the state standards and evaluating teachers on a standardized observation protocol. For example, one principal listened closely to an STL as she explained how her inquiry practices "fit" the teacher observation protocol. In response, the principal changed the STL's observation evaluation to a more favorable rating than she had assigned previously. A few other principals also adapted to the challenges that inquiry-based learning posed to traditional teacher observations and evaluations, and standardized student assessment instruments. In turn, the school level administrators needed to work with district level administrators to facilitate their flexibility as well.

When Administrator Support Is Missing. Many STLs had examples regarding the lack of knowledge or flexibility among their school administrators. Without the support of administrators, STLs had difficulty accessing IQWST workbooks or materials. Some U-FUTuRES STLs said that they were unable to coach or mentor new teachers. Without active intervention and support by administrators, at the school and district level, STLs met resistance from other teachers who did not want to attend PLC meetings or learn to use IQWST or other inquiry-based practices, even though the school may have adopted the IQWST curriculum as a condition of district participation in U-FUTuRES. Lacking principal support, several STLs transferred to other schools. They did not believe it was possible to teach IQWST or inquiry-based approaches without a supportive school administration.

The Importance of District Support and Collaboration

In a few districts, STLs said that they received support from district staff as they endeavored to implement inquiry-based science. Two STLs were moved to the district

office to facilitate science reform. In these settings, multi-faceted efforts – with teachers, principals, and district administrators – became a powerful influence for change.

Openness to Inquiry-Based Approaches to Learning. Teachers said that to make school level change requires support "all the way to the top." STLs believed that district support was essential to successful implementation of IQWST. Administrators who had seen students in inquiry-based science classrooms were typically supportive. Seeing student engagement led to conversations about the approach and how to effectively document student learning.

> We are explaining to [the administrators] how we have met our goal: the kids learning science by doing science. ... You could walk into the room, listen to the kids and tell that it's just leaps and bounds beyond what it was last year when we were using an online curriculum. It's just amazing what the kids can do. Our classroom tests are super rigorous. And they are way harder than anything that the kids have had to do before. … Now our new role is going to be finding a way to help the students test better so that they can show what they know. We just don't have those hard pieces of data that they want to see. We have a mismatch of what we know the students are capable of and what the students can produce on tests. Our administration understands that, too. (1:1)

However, the challenges of documenting student learning on standardized state testing instruments was an ongoing issue. Some STLs had the support of their school and district administration in trying to make sense of student progress if students' test scores did not reflect what their teachers believed regarding their students' classroom performance.

Aligning IQWST with the State Standards. District support was invaluable as teachers tried to align their inquiry-based science curricula with the state mandates. One of the U-FUTuRES trained district administrators put it this way,

> Choosing IQWST for a science curriculum comes with problems. … If you want a district to take on IQWST—a curriculum that's not based on state standards, does not have the same scope and sequence that state standards have, that does not follow the evaluative tools that state uses—then you have got to have some sort of way for the district to guide the administrators in how to address those issues. (1:4)

STLs, who were using IQWST, faced the task of aligning IQWST with the Florida's Next Generation State Science Standards. U-FUTuRES teachers, who did not have district support, were frequently frustrated by the demands to meet standardized protocols.

Another STL, who worked at the district level, said that district administrators needed to educate principals so that teachers were not constantly frustrated with their school administrators. Principals and other administrators needed to know what problems were created by IQWST and inquiry-based practices. Nevertheless, she also noted that she was empathetic to district administrators who face the pressures exerted by state mandates. STLs argued that the currently mandated assessments were inappropriate assessments for *all* students regardless of the curriculum.

District Flexibility for Teacher Evaluations. U-FUTuRES district administrators conducted formal observations with teachers, but also did informal observations when invited to visit a teacher's classroom. One district administrator noted that STLs wanted

to demonstrate some aspect of IQWST they were doing well or to ask for help from the district. Both types of visits resulted in teacher growth. She said,

> Teachers have invited me because they need help with something, or where they want to showcase something. Even if it's showcasing, it can open up the conversations with how to push or how to even go a little bit further. But, they also honestly will tell you when they struggle, too. They'll call up and say, "I'm not at all comfortable with this, but can you model this lesson for me?" (1:3)

District administrators had multiple responsibilities in providing support for the growth and development of teachers implementing an inquiry-based science program. Those responsibilities included being responsive to teachers who were taking risks to change their practices.

District Support for Facilities and Resources. Some district leaders described the paucity of equipment and materials available to teachers in their districts. One of them described her district this way.

> I walked into ... classes with not a single beaker on the shelf. Earth science: where's your globes? Didn't see any. Environmental science, where's your soil test kits? Where is ??? ... I've been in classrooms where all they have are desks, and there's no sink. (1:4)

According to this administrator, district level staff needed to "reach out to the facilities people and convince them to get sinks in science classroom where there weren't any." (1:4) Clearly, district support for enhanced science facilities would facilitate adoption of inquiry-based practices. Teachers in traditional classrooms, with slanted top desks, no

sinks, few electrical outlets, and limited laboratory materials, were more likely to resist change and continue teaching in traditional textbook-driven ways. One district administrator said that she did not believe she could ask teachers to change their practices without sufficient supplies and equipment. She found ways, however, to purchase materials to facilitate change. Acquiring external funding to support inquiry-based learning was necessary to continue progress toward reform.

Districts' Discontinuing IQWST and Disregarding STLs Experiences. STLs, whose districts were discontinuing IQWST, expressed frustration. STLs in these districts had put forth effort to learn a challenging curriculum and support other teachers in their schools. STLs were disappointed that the district did not take advantage of their experiences with IQWST in choosing textbooks for the coming years.

> I'm not sure my district even understands yet how U-FUTuRES prepared us to be leaders, what we are there for, or how we can be used. So as far as the district calling on me to say, "I need your help doing this," or, "because you're an STL," I really haven't felt that they recognized my involvement in U-FUTuRES. (1:10)

STLs believed that their experiences with inquiry-based science practices would have been useful in discussions regarding science curriculum.

STLs had acquired greater content knowledge, changed their practices, reached out to help others transform their practices, managed laboratory materials, and improved facilities. They had many conversations with school and district administrators to mediate between inquiry-based practices and state mandates. The multitude of tasks was exhausting. Many of them said that they worked at least 12 hours a day at school, just to

manage the IQWST labs. The position of supporting colleagues and facilitating PLCs added to the daily demands. Some teachers found it extremely rewarding; others wondered about time spent on school instead of their families. Due to their individual contexts, teachers tried maintain their commitment to the goals of U-FUTuRES while maintaining some balance in their lives. When school and district support was lacking, they turned to the U-FUTuRES staff and their cohort members. The support they received from U-FUTuRES staff and cohort members helped them maintain their focus on achieving the goals of the project.

U-FUTuRES Staff and Cohort Support

Throughout the interviews, participants repeatedly praised the support they had received from U-FUTuRES faculty and staff at the University of Florida. One STL said as her interview ended,

> There's one other point I wanted to make and that is U-FUTuRES has a unique professional development model. I've been involved with [another university program] which offer great summer professional development model, followed with conferences. But it's lacking the longevity. … A lot of great content knowledge and lab science practices are learned, but it ends. But U-FUTuRES had a different model, sustained learning and sustained change. (1:4)

U-FUTuRES participants received professional and personal support from UF faculty and staff while taking coursework as well as working in schools. Teachers also noted that through their relationships with cohort members they were able to receive a variety of perspectives—from other teachers across the state—on how to become more competent

and confident as they solved their problems of practice. Participants spoke of other members of the cohort as though they were close friends. They had developed bonds during the first summer, when the science content coursework was exceedingly challenging for some of them. The bond continued throughout the years. Participants said that the communication across schools helped them to make sense of the goals of U-FUTuRES as progress unfolded across different settings. The cohort group became STLs collaborative model for PLCs. U-FUTuRES teachers realized the advantages of having multiple perspectives, discussing practices, and collegial collaboration as a consequence of their cadre experiences.

Conclusion

Teacher change is notoriously difficult. The teachers who participated in this study were enthusiastic about the changes they had made in their practices and the differences they observed in their students. U-FUTuRES participants changed their practices with great effort accompanied by sustained, long-term support from the U-FUTuRES faculty and staff and their cohort colleagues. U-FUTuRES teachers developed competency and confidence with inquiry-based science practices. Eventually, they observed the fruits of their labor: students engaged in their science lessons, exploring questions, making claims, finding evidence, sharing their reasoning, and making sense of the concepts embedded in the lesson. U-FUTuRES participants reported that they were able to persist with their change efforts in many respects due to the support and instruction received from the project throughout the five years. At times, they were able to convince school level administrators to give them flexibility when the curriculum

deviated from state standards or district assessments that were misaligned with the curriculum.

STLs expected or hoped for similar changes among their colleagues. Such changes, however, would require the same extensive, sustained support they experienced. In supportive settings, colleagues and principals observed inquiry-based lessons and were enthusiastic about the impact on student learning and engagement. STLs who began to see change in their schools cited several factors as supporting the change process:

- Principal openness and support for change;
- Principal-supported time for teachers to meet, observe, and model practices;
- Supportive school-based peers who embraced an inquiry-based approach and began the long process of reform; and
- District administrator openness and support for change.

Multiple circumstances intervened to obstruct change:

- Classrooms overloaded with students demonstrating behavioral and academic challenges;
- Schools with an influx of new students and new teachers each year;
- Peer teachers with inadequate content knowledge or pedagogical knowledge;
- Peer teachers who were novices, and overwhelmed by beginning teacher concerns;
- Non-supportive and, at times, hostile school administrators;
- Non-supportive district administrators;
- Substandard facilities; few resources; and inadequate funding.

Our findings highlight the complexities of the layers of influence that surround classroom teaching practice and reform-based curriculum implementation. To accomplish a sustained commitment to reform-based science teaching in middle schools requires direct support and assistance from school and district administrators to maneuver and align district and state policies regarding state standards and teacher evaluation protocols. Teachers need overt support from their districts to access adequate facilities and supplies. Teachers need both incentives and ongoing support if they are to change their practices. Incentives are driven by teachers' belief that the change effort will quickly result in better student outcomes. STLs who had made progress in transforming their classroom practices recognized that real change would be slow and arduous, and benefitted from continuous project support for their learning and transformation. How can those dedicated to school transformation insure that teachers have continuous, high level, quality support? STLs who were able to initiate reform in their schools did so with willing, supportive, and open-minded administrators in their schools and district offices. The challenge for teacher educators is to develop strategies for working with school administrators and district leaders to align the various layers of influence on classroom practice to support teacher change. Change is further complicated by an excessive emphasis on state mandates and assessment procedures for teachers and students. How can universities work more effectively with school and district administrators to transform schools in an era of high stakes, public accountability? Some administrators in this project found ways to be flexible and supportive; how can the research community better support *both* teachers *and* school/district administrators in reframing policies and requirements to support changes that result in better learning opportunities for all students

over time? U-FUTuRES began by establishing working partnerships with school and district leaders. Quarterly meetings were organized to immerse administrators in inquiry-based science practices and to collectively articulate the potential benefits for students. Meetings were also devoted to providing assistance in aligning state-required teacher observation instruments to support the reform-based curriculum. Project resources were devoted to drafting and providing alternative measures of student learning aligned with the IQWST curriculum. That is, project leaders were acutely aware of the various influences surrounding teacher practice and implementing a reform-based curriculum and therefore sought to provide direct support and learning opportunities for administrators. Perhaps what is not as well understood is the powerful influence of state policy and administrator instability on school and district leaders, and as a consequence, teachers. How might universities strategically strengthen their partnerships with school and district administrators to support a much needed transformation in science education? How might university partners work directly with school and district administrators to design structural and systemic support for emerging teacher leaders who are dedicated to leading from their classrooms through thoughtful collaboration with their colleagues? More research is needed to understand the complexity of the layers surrounding teacher change and school improvement in this era of high stakes, public accountability.

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