

Using Science to Take a Stand: Action-Oriented Learning in an Afterschool Science Club

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**Abstract**

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This dissertation study investigates what happens when students participate in an afterschool science club designed around action-oriented science instruction, a set of curriculum design principles based on social justice pedagogy. Comprised of three manuscripts written for journal publication, the dissertation includes 1) Negotiating community-based action-oriented science teaching and learning: Articulating curriculum design principles, 2) Middle school girls' socio-scientific participation pathways in an afterschool science club, and 3) Laughing and learning together: Productive science learning spaces for middle school girls. By investigating how action-oriented science design principles get negotiated, female identity development in and with science, and the role of everyday social interactions as students do productive science, this research fills gaps in the understanding of how social justice pedagogy gets enacted and negotiated among multiple stakeholders including students, teachers, and community members along what identity development looks like across social and scientific activity. This study will be of interest to educators thinking about how to enact social justice pedagogy in science learning spaces and those interested in identity development in science.

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## **Dedication**

To my family and friends

## Chapter 1. Introduction

Other than a few studies, as a field we know little about how to effectively engage students in taking action with their science knowledge (Calabrese Barton, 2003; Calabrese Barton & Tan, 2009, 2010; Moje et al., 2004; Moje, 2007; Thompson et al., 2015; Windschitl, Thompson, Braaten, & Stroupe, 2012). Coupled with this uncertainty about what action-oriented science looks like, is a need to articulate both a vision and set of workable design principles that can be used across both in and out of school science education settings. Currently, teachers who wish to enact rigorous action-oriented science enact through trial and error rather than based on a set of evidence-based effective tools and practices. Furthermore, inequities for minority students continue to persist in science education, and more so for minority females in science education, calling for further investigations into how minority females develop identity with and in science (Brickhouse & Potter, 2001; Calabrese Barton, Tan, & Rivet, 2008; Calabrese Barton et al., 2012; Carlone, 2004; Carlone, Haun-Frank, & Webb, 2011; Holland, Skinner, Lachicotte, & Cain, 1998; Thompson, 2014). Aiming to address the uncertainties of what action-oriented science looks like and work towards equitable opportunities for all students, this dissertation works within the theoretical construct of social justice pedagogy that moves beyond providing equitable opportunities for students and aims to help students learn how to use knowledge to make transformative changes in their community (Moje, 2007).

Reframing instruction and curriculum as action-oriented science, I drew from literature that focuses on using students' assets as building blocks of science, critiquing and expanding canonical knowledge, using science to engage in action, and using community members as teaching and learning resources to develop a set of design principles. Using these design principles, I examined how students, teachers, and community members engaged and

participated in, across, and on the margins of scientific and social activity in an afterschool science club called Students Tackling Authentic and Relevant Science (STARS).

### **Summary of Study Design**

In this qualitative study, I investigated action-oriented science curriculum and instruction, female identity development in and with science, and the role of human everyday interactions as students do productive science. On a biweekly basis for one school year a community—middle school students, university science educators, two school science teachers, and multiple community members—worked together to learn, participate in, and take action with science in STARS. Findings were drawn from data sources that were collected across activity and artifacts produced in STARS: Video recordings of afterschool club meetings, video recordings of teacher and community member planning and debrief meetings, student and teacher interviews, journals, scientific explanatory models, nature walk signs, and a documentary film. Findings illustrate what it means for students to engage and participate in, across, and on the margins of action-oriented science activity. Aiming to contribute theoretically to understandings in science education, I investigated the following research questions:

- 1) How are students', teachers', and community members' ideas and resources considered and used to negotiate action-oriented science curriculum?
- 2) How do middle school girls author themselves in STARS? To what extent does their development of relationships with others in STARS intersect with this authoring (scientific or not)?
- 3) How do the girls participate and engage in, across, and on the margins of the various activities in STARS (investigations, scientific model groups, scientific action groups, documentary film production)?

- 4) How are everyday social interactions that make science discourse like everyday discourse used as resources that create an intimate bond that students can then leverage when working together to make progression on science ideas?

### **The Dissertation**

The dissertation is presented in three stand-alone articles, two empirical and one practitioner article prepared for post-dissertation publication in appropriate journals. In the following chapters, I examine research across three areas: 1) Action-oriented science teaching and learning, 2) Middle school girl identity development in an afterschool science club, and 3) The role of everyday social interactions in productive science learning spaces. In this section, I provide an overview of each of the studies presented in upcoming chapters.

#### **Chapter Two. Negotiating Community-Based Action-Oriented Science Teaching and Learning: Articulating Curriculum Design Principles**

The paper in chapter two features a design-based study that examined how a group of middle school students, teachers, and community members negotiated curriculum to raise awareness about a local, toxic lake. The curriculum was based on four action-oriented design principles: Students' assets as resources, critiquing and expanding canonical knowledge, using science to engage in transformative action, and community members as teaching and learning resources. Data included afterschool meetings, planning and debrief meetings video, artifacts, and individual student and teacher interviews. Analysis of discourse and artifact data revealed how stakeholders negotiated three problems of practice that emerged as action-oriented curriculum was enacted: Finding a shared understanding of what it means to "take a stand" in the community, broadening the definition of science to include social content, and being responsive to how students built science and social action-oriented ideas. This study adds to the

conversation of ways in which multiple stakeholders' ideas can be considered when designing community-based curriculum and proposes three amendments to the design principles with key ideas from the study.

### **Chapter Three. Middle School Girls' Socio-Scientific Participation Pathways in an Afterschool Science Club**

The paper in chapter three focused on how middle school girls drew on multiple identities as they authored themselves in an afterschool science space. Middle school is a time for forging and trying on identities and afterschool spaces can be places for continuing to work on identities and the relationships, such as friendships, which are important to how girls author themselves in science spaces. This study aimed to understand how a specific type of social activity, relationship formation activity, an activity that naturally occurs alongside science activity for middle school girls, intersected or did not intersect with science activity. Data sources included interview and video records of participation in the afterschool club for nineteen girls. I investigated the situated nature of the girls' identity trajectories by examining how girls participated in various activities within STARS. I focus on four case studies representative of the nineteen and examined identity trajectories in terms of: participation in activity, expression of ideas with each other and the community, and working towards a future image of what is possible. Each girl had a unique trajectory for foregrounding work on building relationships and on science ideas, or both. In terms of activities, it seems that having a range of activities that supported working together was important. For some, specialized activities, such as conducting investigations, were important for authoring. For other, the full range of activities was important. Findings problematize the situated nature of identity trajectories in activities and question whether a trajectory can be positive or negative when participation is so extremely different for each student.

## **Chapter Four. Laughing and Learning Together: Productive Science Learning Spaces for Middle School Girls**

Chapter four is an article that is written for a practitioner journal. Providing children with opportunities to use personal experiences and background knowledge in dialogue with peers is critical for making sense of scientific phenomena. This paper is a reflection on the types of activities that supported robust scientific learning for a group of nineteen middle school girls in an afterschool science club called STARS. I describe four forms of everyday social activity important for supporting student learning in afterschool spaces: Fun and laughter in science spaces, comfort in sharing ideas in an all-female space, sense of belonging with each other, and feeling proud of yourself. My hope is that this paper sparks further conversation about social interactions important to learning in afterschool spaces.

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Chapter 2. Negotiating Community-Based Action-Oriented Science Teaching and Learning:

Articulating Curriculum Design Principles

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## Abstract

With an increasing number of STEM related after-school clubs the field could benefit from a better articulation of design principles that orient students to taking civic action. This design-based study examines how a group of middle school students, teachers, and community members negotiated curriculum to raise awareness about a local, toxic lake. The curriculum was based on four action-oriented design principles: Students' assets as resources, critiquing and expanding canonical knowledge, using science to engage in transformative action and community members as teaching and learning resources. Data included seventy-one hours of afterschool meetings, twenty-five hours of planning meetings, and twelve hours of debrief meetings video, artifacts, and twenty-two hours of individual interviews. Analysis of discourse and artifact data revealed how stakeholders negotiated three problems of practice that emerged as action-oriented curriculum was enacted: Finding a shared understanding of what it means to "take a stand" in the community, broadening the definition of science to include social content, and being responsive to how students built science and social action-oriented ideas. This study adds to the conversation of ways in which multiple stakeholders' ideas can be considered when designing community-based curriculum and proposes three amendments to the design principles with key ideas from this study.

## Chapter 2. Negotiating Community-Based Action-Oriented Science Teaching and Learning: Articulating Curriculum Design Principles

### Introduction

Currently teachers have little guidance on how to connect classroom-based curriculum to the goings-on in the very communities the schools are situated in; this means classrooms often fail to build-on and strengthen students' ties to their local communities as they engage with disciplinary concepts. In contrast, afterschool clubs are often sites that engage students in community-based and action-orientated projects, yet in-depth disciplinary learning is often sidelined (Bell, Lewenstein, Shouse, & Feder, 2009; Rose & Calabrese Barton, 2011). Both classrooms and afterschool clubs could benefit from a better articulation of design principles that orient students to taking civic action in their communities by utilizing and building on relational and situated community-based knowledge *and* disciplinary content knowledge. Clarity of design principles is particularly important in STEM fields; the number of STEM related afterschool clubs is skyrocketing and there are few mechanisms to understand how these environments generate knowledge of teaching and learning.

This study examines how a group of middle school students, teachers, and community members negotiated curricular aspects of an afterschool science program. Framed as an action-oriented project, STARS (Students Tackling Authentic and Relevant Science) aimed to build scientific explanations for why a local lake was becoming toxic and take action in the community (Banks, 1999; Bell et al., 2009; Cochran-Smith, 2008; Gay, 2000; Grant 201; Hagenah & Thompson, 2013; Rose & Calabrese Barton, 2011; Thompson, Hagenah, Kang, Stroupe, Braaten, Colley, & Windschitl, 2015; Williamson, Rhodes, & Dunson, 2007; Windschitl, Thompson, J., Braaten, M., & Stroupe, 2012; Zeichner, 2009). While there is ample

evidence to support the idea that action-oriented science projects enhance important forms of learning for students (Bang et al., 2014; Bang & Medin, 2010; Calabrese Barton, 2003; Calabrese Barton & Tan, 2009, 2010; Rose & Calabrese Barton, 2011; Medin & Bang, 2014), less is understood about the design process and the various ways multiple stakeholders (students, teachers, and community members) develop and adapt curriculum.

### **Literature Review**

In the literature review, I describe how I developed an initial set of design principles using theoretical constructs from social justice pedagogy (Figure 1). I then describe what is known to date about how curriculum is negotiated in projects involving multiple stakeholders.

#### **Social Justice Pedagogy**

Social justice educators advocate for equal participation for all students by explicitly addressing and overcoming current oppressions found within social, economic, and political norms that govern how education exists in our society, in schools, and in classrooms (Banks, 1999; Cochran-Smith, 2008; Gay, 2000; Grant 2012; Williamson, Rhodes, & Dunson, 2007; Zeichner, 2009). Working for social justice means working against institutionalized domination and oppression of traditionally marginalized groups in education (Freire, 1970; Nieto & McDonough, 2011; Young, 1990). Oppression, preventing some from learning in social settings, and domination, forcing others to act according to power-defined roles, vary by individuals and groups in relation to assigned social roles and interactions between people. The aim of this study is to work against oppression by empowering students marginalized by race, class, and gender to engage in the expansion and use of science knowledge to take action in their community (Cochran-Smith, 2008; Gay, 2000; Gonzalez, Moll, & Amanti, 2005; Grant, 2012).

Acknowledging that the ideas within social justice education are extremely broad, I focus on a

specific slice of social justice education called social justice pedagogy that is based on students using knowledge to take action in and with their community.

Action-oriented science teaching focuses on producing a more just and equitable society through students learning and using rigorous science knowledge to take action in their lives and communities for an issue they care deeply about. In this study, I borrow Moje's (2007) distinction between socially just pedagogy and social justice pedagogy and refer to social justice pedagogy as action-oriented teaching. Socially just pedagogy is equitable and ensures "that all youth have equitable opportunities to learn" (Moje, 2007, p. 3). This is akin to equitable teaching practices that allow all students to share ideas, ask questions, and learn rigorous content knowledge (Thompson et al., 2015). In contrast, social justice pedagogy moves beyond providing equitable opportunities for students and aims to help students learn how to use what they learn and apply knowledge to make transformative changes in society. In social justice pedagogy students are not only taught in socially just ways but are taught to critique and expand upon a discipline and use it to transform (take action) their world. "Social justice pedagogy should...offer possibilities for transformation... and demands that youth learn to question and perhaps even offer changes to established knowledge" (Moje, 2007, p. 4). Social justice pedagogy allows students to learn, critique, and use knowledge in ways to make change in their lives or those around them. In the next section of the literature review I describe the four design principles for action-oriented curriculum used in this study.

### **Design Principle One: Students' Assets as Resources**

The first design principle is based on using students' assets, their funds of knowledge, as teaching and learning resources to shift who holds the knowledge and ideas from authoritative figures to students that are used to make progress in science. This principle is based on research that has

shown positive increase in learning, interest, and efficacy in science when students' lives are considered and leveraged in learning and teaching (Basu and Calabrese Barton, 2007; Calabrese Barton & Tan, 2009; Calabrese Barton, Tan, & Rivet, 2008; Carlone, Haun-Frank, & Webb, 2011; Moje et al., 2004; Moll, 1992; Rosebery, Ogonowski, DiSchino, & Warren, 2010; Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001).

Student learning is most effective when students engage resources from multiple lived experiences and from their community; resources frequently referred to as students' funds of knowledge. Funds of knowledge is a construct that refers to "historically developed and accumulated strategies (skills, abilities, ideas, and practices) or bodies of knowledge that are essential to a household's functioning and well-being" (Gonzalez, Moll, & Amanti, 2005, p. 92) and as "the historical and cultural knowledge of a community" (Basu and Calabrese Barton, 2007, p. 468). Studies have provided a general picture of the positive effect of the use of students' funds of knowledge on student learning and engaging providing insight to how funds of knowledge can be used as a resource for student engagement (Moll, 1992). For example, Moll's (1992) study on how the use of students' funds of knowledge enhanced bilingual instruction was based on the idea that classrooms are always socially and culturally organized settings, with the teacher playing the essential role of getting to know students' outside-of-school lives and connecting outside knowledge and experiences with instruction. When the teacher got to know the student Carlos in Moll's study, the teacher came to know the student as a "whole person" (p. 133) and was able to genuinely incorporate part of that students' ways of living into classroom learning. Based on getting to know Carlos and other students in the school, teachers designed a unit on candy that ultimately led to learning experiences with the community and new questions around other types of candy in different cultures (Figure 1, subprinciples 1a & 1b; Moll, 1992).

When students' stories get told as part of disciplinary learning, students' stories become newly legitimized resources in learning spaces. The idea is that students begin to see the relevancy of disciplinary constructs to their lives (Figure 1, subprinciple 1c). When students' stories are used in the classroom as the basis of reasoning with science, the focus of who holds knowledge shifts from the teacher to the student. The students come to see themselves as experts, ones who can reason with, share, and construct new knowledge. Studies argue that students' funds of knowledge are essential components of science learning as they "broaden(s) the classroom culture over time, making new spaces for new kinds of discourses, knowledge, and identities to potentially emerge" (Calabrese Barton, Tan, and Rivet, 2008, p. 94). In Barton and Tan's (2009) study on the use of students' lived stories in the science classroom they found that when students' stories and ways of living were explicitly used in a unit on food and nutrition, power dynamics shifted and students' roles changed from receivers of knowledge to the science experts as students connected food from their everyday life with science.

Knowing that students' assets are a resource in disciplinary teaching such as science teaching and learning, what the practice looks like to incorporate these assets in connection with community assets remains ambiguous (Braaten & Windschitl, 2011; Thompson et al., 2015; Windschitl et al., 2012). This study aims to add to the established value of students' assets in science education by framing science curriculum around phenomena that are not only relevant to students' lives, but also phenomena that students care to investigate, communicate to a larger audience about, and take action for or against. This study draws from the outlined studies and uses the design principle of using students' assets as building blocks of rigorous science as one part of action-oriented science teaching and learning (Figure 1, subprinciples 1a, 1b, & 1c). In

the next section, I outline the studies that guided the construction of the second principle, critiquing and expanding canonical knowledge.

### **Design Principle Two: Critiquing and Expanding Canonical Knowledge**

The second design principle is based on teaching and learning that aims to critique and expand canonical knowledge. This principle is based on research that states that critical and expansive learning and teaching allows students to question power structures, critique established science, consider multiple perspectives of science, and expand the idea of who holds science knowledge (Basu & Calabrese Barton, 2007; Bouillion & Gomez, 2001; Calabrese Barton & Tan, 2009; Freire, 1970; Grant, 2012; Roth & Calabrese Barton, 2004). Due to limited examples around students expanding science knowledge and little to no examples about students critiquing canonical science knowledge in science education literature, I borrow ideas and examples offered in mathematics education as a means of constructing this design principle.

Using Freire's (1970) theory of the relationship between education, social change, and developing critical consciousness, research in mathematics started to focus on how students could use mathematics knowledge to challenge economic, political, and social structures in the 1980's (Frankenstein, 1983; Gutstein, 2003, 2007; Ladson-Billings, 1997; Martin, 2003; Matthews, 2005). Calling for educators to situate math in a way that helps marginalized students think about how math impacts their lives and is connected to larger social and structural contexts Martin (2003) stated:

Equity discussions and equity-related efforts in mathematics education should extend beyond a myopic focus on modifying curricula, classroom environments and school culture absent any consideration of social and structural realities faced by marginalized

students outside of school and the ways that mathematical opportunities are situated in those larger realities. (p. 7)

This idea of extending curriculum to include critical consciousness was taken up and investigated by Gutstein (2003, 2007) when he studied students in his mathematics class as they used their mathematics knowledge to critique a community-based issue. Gutstein (2003, 2007) found that when he based his curriculum on providing space for students to co-create problems that are relevant and meaningful to them, analyze and question each other, consider multiple perspectives to help build on each other's ideas, and take action where and when appropriate, students became the knowers and users of mathematics knowledge. He argued that "students must be given the opportunity to name their own realities", so students can begin to define their role in their worlds and know where math knowledge may be able to help them (Gutstein, 2007, p. 55). An example of this in practice was when his students questioned mortgage-rejection rates that were based on race in Chicago, the city where the students' resided. The problem belonged to the students as they discussed who amongst themselves owned homes in the class and personal stories regarding parents not being able to get mortgages. Students analyzed the race-based mortgage data and based their mathematical solutions within a discussion on individual versus institutional racism. In this example, students critiqued the given data and expanded the meaning of using mathematics as a tool to question a race-based issue that was relevant to their lives.

Drawing on the critical pedagogical mathematics research, principle two is based on developing curriculum that provides students with opportunities to critique given science knowledge and shape the progression of in-depth science with their evidence-based ideas (Figure 1, subprinciples 2a, 2b, & 2c). More work is needed in science education that provides clear

examples of how to bolster students understanding of science and engage in critique. This principle asks for teaching and learning to be about not accepting canonical, given knowledge, but question it and seek answers based on new questions that are relevant and meaningful to students in their community. In the next section, I review studies that were used to construct the third design principle, using science to engage in transformative action.

### **Design Principle Three: Using Science to Engage in Transformative Action**

The third design principle is based on using science to engage in transformative action. The research that supports this states that social justice pedagogy needs to not only raise awareness of complex science issues, but also have students to take action with knowledge to make just changes in their world (Calabrese Barton, 2003; Cochran-Smith, 2008; Gay, 2000; Gonzalez, Moll, & Amanti, 2005; Grant, 2012). Expanding upon design principle one based on planning curriculum that is relevant to students' lives, this third design principle implies that in-depth discipline content needs to focus on a scientific phenomenon that is relevant and has action components. I advocate for not just taking action, but taking informed action based on disciplinary principles. This shifts the focus from planning curriculum around science events that are nominally related to students' lives, to diving into curriculum focused on issues that are relevant *and* need transformative action (Figure 1, subprinciple 3a). For example, one study that helped youth convert an abandoned lot into a community garden was based on the value that "science ought to contain elements of action and change...it is about interacting with the world" (Calabrese Barton, 2003). In the case of the community garden, science as content and process skills and science as a tool for change concepts could be learned and applied when making the garden. Turning the abandoned lot into a beautiful garden space made students feel like part of a scientific community as they engaged in scientific practices and with part of their own

community. Like the work in the community garden, action-oriented science means that those involved are aware of one's role in making transformative change (Calabrese Barton, 2003).

In an action-oriented science space both the teacher and students are aware of their roles in using rigorous science explanations to take action in society (Bouillion & Gomez, 2001; Calabrese Barton, 2003; Cochran-Smith, 2008; Grant, 2012; Roth & Calabrese Barton, 2004). Awareness of these roles can be shaped with the careful planning of and use of participation structures that explicitly discuss roles in terms of using knowledge to make change in a community (Bouillion & Gomez, 2001; Thompson et al., 2015; Figure 1, subprinciple 3b). For example, in Bouillion and Gomez's (2001) study with a fifth grade classroom, the fifth grade classroom students were aware of their role of being language liaisons as they worked with multiple community members to restore a polluted riverbank. In their role as language liaisons, students bridged communication between English-speaking partner organizations that were needed to help clean up the riverbank and the students' Spanish-speaking community by recording and writing in all information in both Spanish and English. With students aware of this unique role in helping clean up the riverbank, communication between the partner organizations and students was a success.

In action-oriented science new knowledge that is built should be acted upon across personal, local, and global dimensions of students' lives (Bouillion & Gomez, 2001; Moje et al., 2004; Roth & Calabrese Barton, 2004). Moje et al. (2004) found that students are connected beyond their local communities and are connected globally to others across the world on a daily basis via technology. Mimicking the science community, science knowledge and action with this knowledge needs to be used on this broader, global level. A sense of social agency should extend beyond the local issues and into larger issues that may have global impact. This design principle

means that a period of learning in a science setting is not finished after students construct a full evidence-based science explanation, but rather the action component of “How do we use our science knowledge to engage in transformative action?” has just begun (Figure 1, subprinciple 3c). Implications for curriculum include the idea that in-depth discipline needs to be connected to real world issues with action components, students need to be aware of their role in an action-oriented space, and students focus on applying their knowledge to their outside-of school worlds (Cochran-Smith, 2008; Grant, 2012). In the next section I outline studies that guided the fourth design principle based on using community members as teaching and learning resources.

#### **Design Principle Four: Community Members as Teaching and Learning Resources**

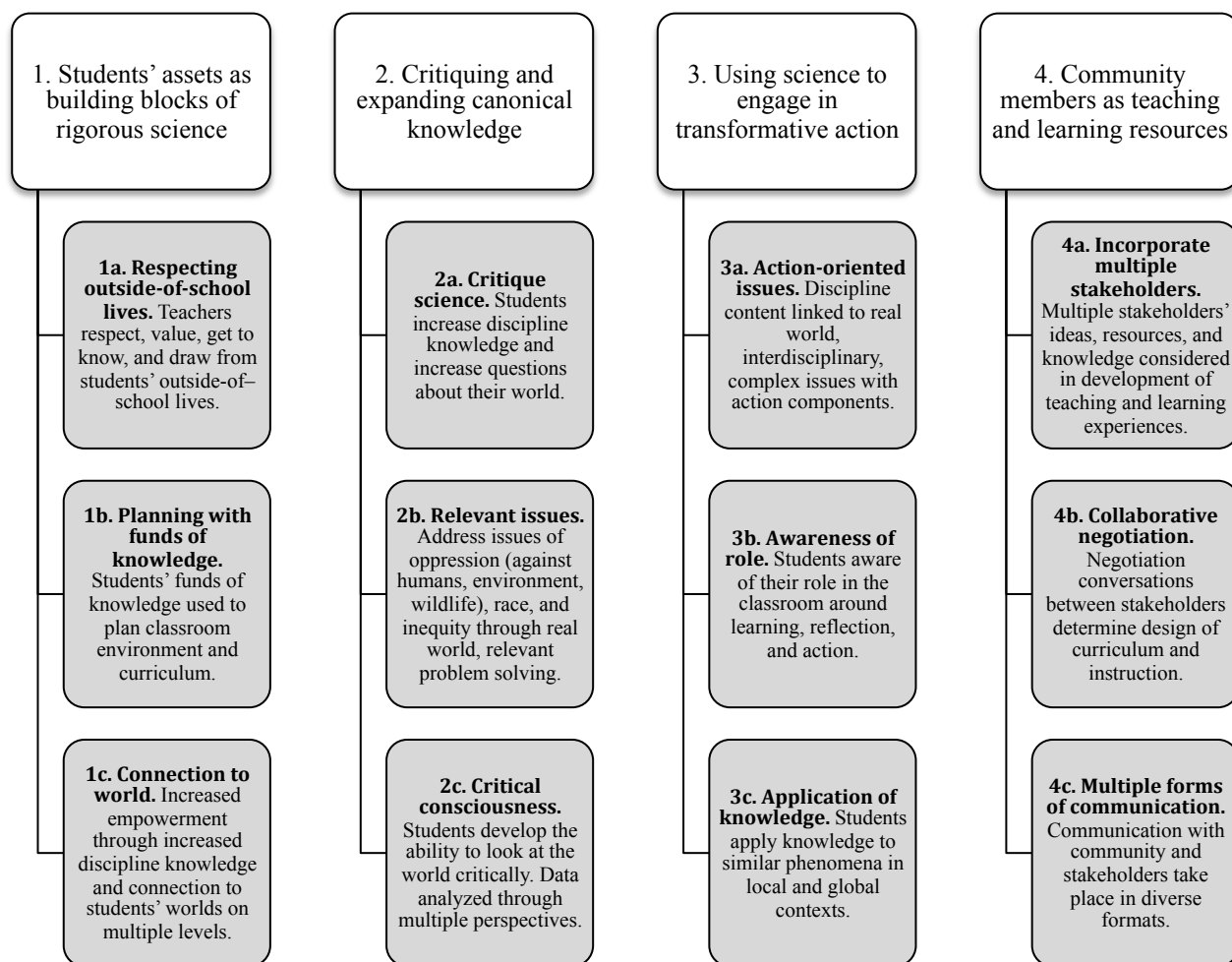
The fourth design principle is based on using community members as teaching and learning resources. Borrowing from design based implementation research (DBIR) studies that incorporate multiple stakeholders, the fourth design principle relates to the negotiation of curriculum by students, teachers, and community members (Penuel & Fishman, 2012; Penuel, Fishman, Cheng, & Sabelli, 2011). This fourth principle requires that action-oriented curriculum and instruction be responsive to ideas and resources available when multiple stakeholders collaborate in iterative conversations.

A few studies have investigated how and what it means when the community members participate in developing curriculum. Bang and colleagues (2010, 2012) worked with indigenous communities to develop “community-based ways of knowing” to deepen students’ understandings and connections with indigenous ways of knowing (Bang et al., 2012; Bang & Medin, 2010). Studies that focus on “community-based instruction” describe the central role that community can play in the design of science curricula that is meaningful and relevant to a community’s needs and ways of living (Bang et al., 2014; Bang & Medin, 2010; Medin & Bang,

2014). Community-based instruction aims to capitalize on and be responsive to the social, material, and human resources found within and across multiple stakeholders. What is known about community designed instruction is about the negotiation of intended curriculum, not the enacted curriculum (Bang et al., 2014; Bang & Medin, 2010; Medin & Bang, 2014). In Bouillion and Gomez's (2001) study focused on cleaning up the riverbank, community members were a key resource in terms of identifying and organizing the riverbank cleanup. It was through collaboration with other community members who had a stake in benefitting from a clean river, benefits including low river pollution and green space for community, that the fifth grade classroom was able to productively study and benefit from using their ideas to take action in their community. In this study there was an increase in learning, interest, and efficacy in science when these students connected with the community and community members. It is in the co-design between multiple members in these studies that the community was a valued part of the entire experience from design to reflection (Figure 1, subprinciples 4a, 4b, & 4c).

What remains unclear from studies that use community resources is clarity on the practices of determining what and how an action-oriented phenomenon should be taught and learned. In other words, how does issue-based phenomenon curriculum get negotiated between multiple stakeholders? In this study, I am interested in the specific practices that occurred between students, teachers, and community members to study a science and social issue that is relevant to students. This study extends the idea of using students funds of knowledge and using community resources to thinking about how teaching and learning decisions are negotiated when students' lived experiences and ways of living, teachers' ideas, and community members' ideas are considered when designing curriculum that is based on a set of social justice teaching and learning principles (Figure 1).

Figure 1.

*Action-Oriented Teaching and Learning Design Principles*

This study aims to provide a descriptive picture of how the action-oriented science curriculum designed around a set of social justice teaching principles came to fruition through a series of negotiation conversations that took place between students, teachers, and community members. The research question for this study was: How are students', teachers', and community members' ideas and resources considered and used to negotiate action-oriented science curriculum?

### **Methods**

Using a design-based approach this study examined the negotiation of action-oriented science curricular aspects of an afterschool science program between middle school students, teachers, and community members (Bell, 2004; Design-Based Research Collective, 2003; Gonsalves, Rahm, & Carvalho, 2013; Kincheloe & Berry, 2004). Aiming to work with those involved, design-based research calls for iterative cycles of collaborative design, enactment, reflection, and redesign as a result of reflection. A design-based approach in this study is appropriate because one purpose of this study is to “orchestrate innovative learning experiences” by examining how the four design principles are negotiated to develop action-oriented science curriculum (Bell, 2004, p. 244; Bruner, 1999; Design-Based Research Collective, 2003; Penuel & Fishman, 2012; Penuel et al., 2011). In this section I describe the participants, data sources, data collection, and multiple iterations of data analysis.

### **Research Context**

Science STARS was a formal out of school program for middle school students (see Table 1 for overview of activity). The program operated under the umbrella of the Mountain Schools Collaboration (MSC), which was funded by outside sources and ran separate from the middle school it was hosted in. The MSC regulated how students were recruited for afterschool

programs, timing of afterschool programs, attendance procedures, discipline of students, report out mandates, and transportation for students. Two teachers co-led Science STARS, one middle and one high school science teacher, along with the author and another university researcher as a participant, co-leader, and researcher.

STARS took place twice a week at Mountain Middle School on Tuesday and Thursdays. Tuesday meetings focused on design and production of a professional documentary film. At the Tuesday meetings, four to ten of the overall nineteen students would work with myself and a professional videographer to storyboard, write scripts, record audio, take video and pictures for stop-gap animation film, critique, and edit the film. Tuesday film production was based on what science, questions, and actions that were taken on the previous Thursday STARS meeting (Thursday meetings described next). The film was a planned part of STARS, but what the film was about was up to the students to decide and design with assistance from the videographer. Thursday meetings focused on activity around constructing an evidence-based scientific explanation around a local issue. All nineteen students attended the Thursday meetings from 3:00-4:30, with up to five girls absent on various weeks for various reasons. The students participated and engaged in science sense making activities, evidence-gathering investigations, and discussions to construct an understanding around a local science issue and how they could take action to help it.

### **Participants**

**Middle School students.** Nineteen middle school students from ages eleven to fourteen participated in STARS from October 2013 to June 2014. The middle school students were recruited through the MSC recruitment process that included advertising during lunch and at parent curriculum night. One of the lead teachers recruited some students from her science class

that she taught. All of the students in STARS attended a high poverty school, Mountain Middle School, with a free and reduced lunch rate of 86 percent. Mountain Middle School hosted over 583 students that spoke over twenty different languages, with 21 percent of the students designated as transitional bilingual.

**Lead teachers.** Recruitment of the lead teachers included letting teachers that we have worked with in the past know about the program and asking for teachers potentially interested in leading the formal out of school science program. The two teachers who responded, Collette and Emerson, were teachers that I had worked with for three years on three other research studies around ambitious and equitable science teaching (Thompson et al., 2015). Emerson, the middle school science lead teacher, was the science teacher of many of the STARS middle school students and hosted the program in her classroom every week. Collette, the high school science lead teacher, taught at one of the feeder high schools that many middle school students from STARS could apply to go to upon graduation from middle school. The school that Collette taught at focused on the health sciences and was built around the concept of small schools, meaning that she knew each of her students very well. Collette taught many of the middle school students' older siblings and was able to engage in conversation with many of the STARS students about their siblings. The lead teachers participated in weekly planning, instruction, and debriefing meetings from September 2013 to June 2014. A version of the action-oriented teaching and learning principles were shared with the lead teachers.

**My role.** I took on the role of research participant in this study. Along with another university researcher I co-planned, co-led, participated, and co-debriefed all STARS meetings with Collette and Emerson and community members.

**Community members.** Multiple community members were an intricate part of the planning, instruction, and reflection process throughout the entire STARS program. Community members included: park personnel, multiple scientists and engineers from the county's stormwater department, undergraduate chemical engineering and restoration ecology majors, community environmental stewards, local newspaper and television organizations, and local businesses. Community members were involved in evaluating student artifacts and providing connections to numerous community resources including archived maps, historical knowledge, experts, and resources for taking action.

Lead teachers and university researchers met with different community members on a weekly basis throughout the afterschool program. The main community collaborators in order of presence in planning and debrief meetings, email and phone communication, and review of students artifacts were: 1) the county senior limnologist (a version of the action-oriented teaching and learning principles was shared with the county limnologist), 2) undergraduate chemical engineering and restoration ecology majors, 3) park personnel, 4) community environmental stewards, and 5) other local stormwater and microbiology scientists. Other community members attended meetings and/or participated in some planning, but not on a regular basis.

### **Data Sources and Collection**

Multiple sources of data were collected to answer the research questions about how a group of stakeholders, middle school students, teachers, and community members, negotiate curricular aspects of an afterschool science program and how students', teachers', and community members' ideas and resources were considered and used to negotiate action-oriented science curriculum. Data sources included artifacts, video recordings of weekly STARS meetings, lead teacher planning and debrief meetings, and student and lead teacher interviews,

and emails with lead teachers and community members. Sections of video recordings of meetings, both lead teacher planning and debriefing and weekly meetings with students, were transcribed and stored for data analysis to triangulate with artifacts, emails, interviews, and other communication with lead teachers and community members (Wolcott, 1997; Yin, 2009).

Validity was ensured of all data through member checks both formally in final interviews and informally during weekly meetings (Merriam, 2009). This approach allowed for the gathering of multiple pieces of data to analyze the negotiation of action-oriented science curricular and instructional decisions between multiple stakeholders.

**Artifacts.** Various artifacts that resulted from interactions were collected and analyzed. Student work including journals, explanatory models, and film narratives were collected and analyzed. Community resources that were produced by community members, such as field notes and models drawn during planning sessions, were collected and analyzed. Lead teacher and community member planning documents were collected. This included multiple planning documents around the what, how, why, and action needed in relation to the overall phenomenon. Student-produced artifacts included scientific explanatory models from weekly afterschool sessions and a professionally developed documentary film produced by a videographer and the middle school girls. Table 1 shows an outline of when the different student-produced scientific explanatory models and actions taken were constructed over the course of the STARS program.

**Weekly STARS science and film production meetings.** Video recording and artifact gathering occurred on a biweekly basis from September 2013 to June 2014. Every Tuesday and Thursday of each week, the middle school students would gather to learn about the science behind why a local lake, Lake Evergreen, was polluted and why it is taking so long to clean it up. Discourse and activity focused on learning rigorous science explanations, constructing scientific

explanatory models, deciding upon how they would take action in their community, taking action in their community, and communicating the science with the larger community (see Table 1).

Sections of these weekly meetings were transcribed and used to answer both research questions.

Table 1.

*Scientific Explanatory Models and Actions Taken in STARS (See Appendix D for pictures of student-produced scientific models)*

October	November	December	January	February	March	April	May
<p><b>Take a Stand posters:</b> Small group interviews on what does it mean to take a stand</p>	<p><b>Pollution explanation model drafts:</b> Formation of small pollution explanation groups; design investigations to gather evidence</p> <p><b>Pollution and solution hypotheses model:</b> Whole group sharing of pollution and solution hypotheses on whole group model</p>	<p><b>Pollution explanation model drafts:</b> Investigations and evidence gathered</p> <p><b>Whole group pollution and solution hypotheses model:</b> Whole group sharing of pollution and solution hypotheses</p>	<p><b>Pollution explanation model revision through negotiation with larger community</b></p> <p><b>Pollution and solution hypotheses model:</b> Whole group sharing</p> <p><b>Whole group scientific and social pollution synthesized model:</b> Combined layers of phenomenon</p>	<p><b>Taking action interviews:</b> Small group interviews on how to use knowledge to take action in community</p> <p><b>Solution expert groups:</b> Formation of new small solution expert groups</p>	<p><b>Solution expert groups:</b> Consultations with community members</p>	<p><b>Whole group communication and action in community:</b> Construction and installation of nature walk signs and community film showing of documentary film</p>	<p><b>Reflection on pollution and solution models</b></p>

**Weekly STARS planning and debrief meetings.** The lead teachers and university researchers participated in a planning meeting every Monday and a debrief meeting after every Thursday after the STARS meetings. Community members joined the lead teachers for many of the planning meetings and debrief meetings if they attended the Thursday meeting. These meetings were transcribed and used to help answer both of the research questions.

**Email correspondence between university researchers, lead teachers, and community members.** All email correspondence between university researchers, lead teachers,

and community members were collected, stored, and analyzed as evidence for how the curricular decisions were negotiated.

**Interviews.** STARS students and the two lead teachers were interviewed twice—once in the beginning of STARS and once at the end.

*Student interviews.* The first student interview took place in the fall and was based on how students think about taking a stand for something they believe in, for someone, or for something. Interviews took approximately forty-five minutes and were conducted in a semi-structured, open-ended interview format with groups of three to four students (Patton, 2003). Each interview was video recorded and notes were taken to help modify and adjust questions as necessary. Sample questions that were asked included (see Appendix A for full set of student interview questions):

- 1) Tell me about a time when you stood up for yourself, a friend, or a family member.
- 2) Tell me about a time when you stood up for one of your ideas (big or small idea, in or out of school, in family, or/and with friends).
- 3) What are some important issues or ideas that are shared in your families?
- 4) What is a time in science that you really enjoyed learning about science?

Groups of students being interviewed were encouraged to add on to each other's ideas and ask each other questions. Following the interview, each group of students were asked to synthesize the shared ideas about what it means to take a stand and design a poster to share with the whole group. These synthesized ideas and posters were then shared with entire afterschool STARS whole group.

The second student interview took place after the completion of the weekly meetings and after the final showing of the film to the community. Interviews were approximately forty-five

minutes and were conducted in a semi-structured, open-ended interview format with individual students (Patton, 2003). Each interview was video recorded and I took notes to help modify and adjust questions as necessary. Sample questions that I asked were (see Appendix B for full set of student interview questions):

- 1) How has STARS impacted your life?
- 2) How has your participation in STARS impacted your desire to take science courses in school?
- 3) What were your favorite parts of STARS this year?
- 4) In what ways were you a leader in STARS this year?
- 5) Give me an example of how you used your science knowledge to take action on this science issue.
- 6) How will you take action for or against something in the future? In high school? Next year in eighth grade?

*Teacher interviews.* Lead teachers were informally interviewed in September to establish the collaborative nature of work in this study. The four design principles were shared with the teachers and used in our planning meetings. The two lead teachers were formally interviewed at the end of STARS to inquire about their role in the iterative teaching and learning process (see Appendix C for full set of teacher interview questions).

### **Data Analysis**

Data was analyzed to gather evidence around how a group of stakeholders— students', teachers', and community members'—ideas and resources were considered and used to negotiate action-oriented science curriculum. Employing an ethnographic approach, analysis involved

multiple iterations of analysis of activity in STARS (Calabrese Barton et al., 2012; Merriam, 2009).

**STARS activities and foregrounded action-oriented principles.** Upon the completion of STARS in June 2014 I first listened to and watched all post-STARS interviews, then initial STARS interviews, then all video from all student, teacher, and community meetings, and finally the documentary film. As I listened and viewed these videos I began to form a matrix of time and key events across STARS that mapped the activity that occurred in each meeting, the design principles that were foregrounded, and the artifacts that were produced (Table 2).

It was in the formation of this initial matrix of activity and artifacts that I noticed that action-oriented curricular practices were being negotiated in multiple interactions and conversations between students, teachers, and community members. Ideas that were brought up by students in STARS meetings were carried into planning meetings, debrief meetings, and in email correspondence between teachers and community members. The exchange between teachers and community members would then carry over into upcoming student meetings. This pattern continued throughout STARS, not in a linear fashion, but as needed in response to particular curricular questions, problems of practice, or tensions around the science or community actions needed. What was unique about this cycle in STARS was the attention to how new ideas and unanswered questions around the toxic lake would emerge that required all stakeholders to work with each other to think about both the science explanation and actions needed in order to plan next steps in the curriculum. In other words, teaching and learning around this issue-based phenomenon required iterative conversations between the multiple stakeholders. To connect these conversations with activity, I then examined what artifacts were produced from each activity and who was involved in the planning, enactment, and reflection of

the action-oriented teaching and learning. To further investigate these initial patterns of how the curriculum was negotiated I then turned to coding for activity around these negotiation conversations to see what themes of negotiation would emerge.

Table 2.

*STARS Activity, Science, Foregrounded Design Principles, and Artifacts*

Week	Activity & Science	Foregrounded Design Principle(s)	Artifact(s)
1	Introduction and welcome to STARS Introductions and why we came to STARS Small and whole group conversations about science in our lives Survey of issue-based science interests: environmental, brain-based, music	1a, 1b, 4b	“Getting to know you” surveys and bingo game
2	Elicitation of incoming ideas on local science based issues Small and whole group conversations about science in our lives: what issues around you call for action and are science based? Communication of science ideas with others-share out of small group ideas	1a, 1b, 2b, 3a, 4b, 4c	Film storyboarding & scripts Journals
3	Elicitation of incoming ideas on local science based issues Survey of teachers and community members about local science issues of concern Small and whole group conversations about science in our lives Communication of science ideas with others- share out of small group ideas	1a, 1b, 2b, 3a, 4b, 4c	Film storyboarding & scripts Survey data of school and community knowledge
4	Take a Stand small group interviews-where have you taken a stand for something, someone, and a science issue?	1a, 1b, 1c, 2a, 2b, 2c, 3a, 4c	Take a Stand posters
5	Take a Stand poster share-out Whole group discussion around what it means to take a stand for (or against) something What we want to take a stand for decision: Local Lake Evergreen pollution problem Examining local watershed area data	1a, 1b, 1c, 2a, 2b, 2c, 3a, 3b, 4c	Journals Take a Stand posters STARS Take a Stand Message Film storyboarding & scripts Sense making ideas/questions about watershed data
6	Mapping external and internal sources of lake pollution Water testing investigation-focused on measuring amount of phosphate in water Whole group sense making discussion	1a, 1b, 1c, 2a, 2b, 3a, 4a, 4b	Maps of local watershed and sources of pollution Water quality data Film storyboarding & scripts Journals
7	Field trip to Evergreen Lake Observations of Evergreen Lake—Recording of observations and questions in journals Whole group conversation around Lake observations and questions	1a, 1b, 1c, 2b, 2c, 3a, 4a, 4b	Maps of local watershed and sources of pollution Water quality data Film storyboarding & scripts Journals
8	Formation of Evergreen Lake explanation expert groups: nutrient overload group, cyanobacteria group, floating island group Examination of local data Whole and small group discussions of Lake observations, questions, and evidence needed to answer questions	1a, 1b, 1c, 2b, 2c, 3a, 4a, 4b, 4c	Water quality data Film storyboarding & scripts Journals Explanation group draft models
9	Expert group science investigation design-testing phosphate amount on plant growth, plants ability to soak up phosphate, and bacterial growth in different amounts of phosphate induced agar Evidence-based small group conversations	1a, 1b, 1c, 2b, 2c, 3a, 4a, 4b, 4c	Film storyboarding & scripts Journals Explanation group draft models Explanation group investigations
10	Expert group science investigations (see week 9) Small group expert group conversations-making sense of investigation data and meaning to science explanatory model and pollution/solution hypotheses	1a, 1b, 1c, 2a, 2b, 2c, 3a, 3b, 4a, 4b	Film storyboarding & scripts Journals Explanation group draft models Explanation group investigation designs, hypotheses, data, conclusions Whole group share-out scripts and questions
11	Whole group pollution and solution hypotheses mapping and sense making discussion Expert group science investigations	1a, 1b, 1c, 2a, 2b, 2c, 3a, 3b, 4a, 4b, 4c	Film storyboarding & scripts Explanation group draft models Explanation group investigation

	Small group expert group conversations Preparation for female scientist interviews: Expert groups chose one local female scientist to visit to gather information and evidence for working model		designs, hypotheses, data, conclusions Pollution and solution hypotheses List of questions for scientist interview day
12	Female scientist interviews-lakes and streams ecologist, restoration ecologist, limnologist Brief whole group sense making discussion of knowledge and evidence gathered from interviews	4a, 4b, 4c	Film storyboarding & scripts Ideas and questions generated post interviews
13	Expert group final science explanation model formation Small group expert group conversations: preparing for presentation, roles, and narrative to be shared with whole group	2a, 2c, 4a, 4c	Film storyboarding & scripts Explanation group models Share-out preparation sheets
14	Expert group science explanation model share-out with whole group Local female scientists invited and participated in whole group discussion of expert models	2a, 2c, 4a, 4b, 4c	Film storyboarding & scripts Explanation group models
15	Whole group model construction: All three expert group models were combined to form synthesized whole group model Whole and small group sense making conversations Whole and small group conversations and role playing around what needs to be communicated to community and how it should be communicated	1c, 2a, 2b, 2c, 3a, 3b, 4a, 4b, 4c	Film storyboarding & scripts Explanation group models Whole group science explanation model
16	Take Action interviews: Small group discussions around how to use science knowledge to take a stand Communication from local scientists on what is needed to help reduce Lake pollution Use of whole group model to think about how to take action to help Lake Evergreen's pollution problem Whole group share-out and synthesis of take action ideas	4a, 4b, 4c	Take action interview responses and brainstorming pictures (small and whole group) Film storyboarding & scripts Whole group science explanation model
17	Solution expert group formation: Four expert groups to make four nature walk signs based on introduction to Lake pollution problem, solutions for animal lovers, solutions for kids of all ages who play near Lake, and future solutions for Lake pollution	1c, 2a, 2b, 2c, 3a, 3b, 4a, 4b, 4c	Nature walk sign brainstorming posters Film storyboarding & scripts
18	Solution expert group sign design Communication with local scientists and park manager	3a, 3b, 3c, 4a, 4b, 4c	Nature walk sign brainstorming posters Nature walk sign drafts Film storyboarding & scripts
19	Solution expert group sign design Communication with local scientists and park manager	3a, 3b, 3c, 4a, 4b, 4c	Nature walk sign brainstorming documents Nature walk sign drafts Film storyboarding & scripts
20	Solution expert group sign design Communication with local scientists and park manager	3a, 3b, 3c, 4a, 4b, 4c	Nature walk sign brainstorming documents Nature walk sign drafts Film storyboarding & scripts
21	Solution expert group sign design Communication with local scientists and park manager: Drafts of nature walk signs emailed to scientists and park manager for critique	3a, 3b, 3c, 4a, 4b, 4c	Nature walk sign brainstorming documents Nature walk sign drafts Questions fro communication with community members Film storyboarding & scripts
22	Solution expert group sign finalization Communication with local scientists and park manager: Changes made based on feedback from scientists and park manager	3b, 3c, 4c	Nature walk sign brainstorming documents Responses/feedback from community members Nature walk final signs Film storyboarding, scripts, final edits
23	Lake Evergreen field trip Solution expert group share-out at Lake Evergreen	3b, 3c, 4c	Nature walk signs Film storyboarding, scripts, edits
24	Documentary film showing event preparation	3b, 3c, 4c	Nature walk signs Whole group science model Assignments/Jobs for film night
25	Documentary film event: Middle School girls, families, teachers, administrators, local scientists, university faculty, community members attended film event (Event was hosted by middle school girls)	3b, 3c, 4c	Community ideas and questions on how to help Lake Evergreen
26-29	Individual post-STARS final interview	1a, 1b, 1c, 2a, 2b, 3b, 4a, 4c	Girls' responses to interview questions

**Coding for action-oriented curricular negotiations.** For the second round of analysis I used video analysis software, Studiocode, to analyze all interview, teacher planning and debrief, and afterschool meeting video for both curricular and instructional decisions and activity (Emerson, Fretz, & Shaw, 1995; Derry et al., 2010; Saldana, 2009; Yin, 2009). I coded the data marking all curriculum conversations that focused on action-oriented design principles and subprinciples that guided this study (Figure 1: Students' assets as building blocks of rigorous science, Critiquing and expanding canonical knowledge, Using science to engage in transformative action, and Community members as teaching and learning resources). In this second round of coding I noticed that there was significant overlap between all of the design principles across conversations between the multiple stakeholders. Aiming to find themes across stakeholder conversations, I coded for who (student, teacher, community member) was in conversation around content that pertained to a specific subprinciple (Table 3). I marked these conversations for curricular themes or ideas. I then triangulated these conversations with the artifacts (journals, scientific explanatory models, and film) that were produced in STARS meetings. I connected what action-oriented principles were foregrounded in conversations, what stakeholder was involved in conversation, and what themes or ideas were taken up and potentially carried across stakeholder conversations. From these connections, three problems of practice emerged that were the focus of negotiation conversations between students, teachers, and community members: Finding a shared understanding of what it means to "take a stand" in the community, broadening the definition of science to include social content, and being responsive to how students built science and social action-oriented ideas. Conversations that were based on these problems of practice were marked for selective transcription for a third round of analysis.

Table 3.

*Coding Scheme for Stakeholder Conversations*

Stakeholder/Design Principle	1 Students' assets as building blocks of rigorous science	2 Critiquing and expanding canonical knowledge	3 Using science to engage in transformative action	4 Community members as teaching and learning resources
Students	1a Respecting outside-of-school lives	2a Critique science	3a Action-oriented issues	4a Incorporate multiple stakeholders
Teachers				
Community Members				
Students	1b Planning with funds of knowledge	2b Relevant issues	3b Awareness of role	4b Collaborative negotiation
Teachers				
Community Members				
Students	1c Connection to world.	2c Critical consciousness	3c Application of knowledge	4c Multiple forms of communication
Teachers				
Community Members				

**Deep dive into three problems of practice.** Keeping in mind my research question around how students', teachers', and community members' ideas and resources are considered and used to negotiate action-oriented science curriculum, I selectively transcribed themes and ideas that were tagged within the three problems of practice: Finding a shared understanding of what it means to “take a stand” in the community, broadening the definition of science to include social content, and being responsive to how students built science and social action-oriented ideas. Through analysis of transcribed discourse and triangulation with artifacts a descriptive picture of what negotiation conversations around these problems of practice looked like emerged. In the next section, I elaborate on and illustrate the three problems of practice and provide evidence for how they were negotiated among the multiple stakeholders.

### Findings

Analysis of data revealed evidence about the local translations of curriculum and the legitimate participation of three important stakeholders—students, community members, and

teachers—in negotiation conversations of action-oriented science curriculum. There were three problems of practice stakeholders needed to negotiate to help students make progress on ideas about how to take action in their community. The negotiation of these problems shaped the content and curriculum of the afterschool club at key times over the course of the year. In this findings section, I provide evidence for how stakeholders negotiated three problems of practice: Finding a shared understanding of what it means to “take a stand” in the community, broadening the definition of science to include social content, and being responsive to how students built science and social action-oriented ideas.

### **Problem of Practice One: Finding a Shared Understanding of What it Means to “Take a Stand” in the Community**

One point of negotiation that emerged when working with the STARS group was determining a viable and worthy issue that *students* would want to and could take action on in their community. This problem of practice emerged early on in the school year as we considered one of the central design principles: using students’ assets as building blocks. In this section I discuss two types of negotiation that supported finding a shared understanding of what it means to take a stand. Each subsection is organized around interactions among role actors. In the first section, I discuss how students and teachers developed shared language for ‘taking a stand.’ Then, I discuss how teachers and community scientists developed a dual focus on taking action and focusing on relevant content knowledge.

The challenge was how to elicit the students’ ideas about a practical problem that might engender a sense of pride for tackling the issue. In pre-STARS lead teacher meetings, multiple issues including how drugs affect the middle school student’s developing brain, how and why music evokes emotion and its role in the school, and the energy costs of the events at Mountain

Middle School were tested and put up for survey with our STARS students. It was quickly identified that in order to tackle this problem of practice the teachers needed to understand what the students thought ‘taking action’ meant, as they were excited about these initial ideas, but there lacked a general consensus of what our purpose together was when it came to taking action for something we care about. So rather than focusing on “what” content would encourage students to take a stand we focused on “how” students described the act of standing up for ideas they believed in. Attending to this need for clarification on what taking a stand meant to the group, the lead teachers interviewed the students about ‘taking a stand’ in multiple dimensions of their lives. What follows is a description of how students decided to take a stand for Lake Evergreen and how these ideas were taken up and negotiated among teachers and community members.

**Students and teachers developing shared language for ‘taking a stand.’** Early in the year lead teachers interviewed the students about times they had taken a stand. Students reported taking a stand for people in their lives, ideas they were passionate about, and (for some) science issues that cared about. Social issues ranged from standing up for gay rights, questioning acts of racism, and acting against bullies. Many students related to standing up against bullies. Saia, for example, shared her personal story about standing up against bullying of her friend when no one else did.

(S=student, LT=Lead Teacher)

S: I had a friend who got bullied. I take a stand for bullying. So I took a stand for him and I said you are just being a bully. And, um, pretty much I studied bullying in elementary school and why they bullied each other and pretty much most of the people they got bullied and then they became the bully. Or they just live like, or their parents aren’t good

together. Bullies will stop if you stand up and be the bigger person, so I said you are just being a bully.

LT: What was it like to stand up against this other bully?

S: You know, I felt like I was doing the right thing because when I got bullied, I was born with a cleft pallet and people couldn't pronounce my name, my name, my nickname is Skipper. And they couldn't pronounce it. And so, um, I like stood for them because no one stood up for me.

LT: That is a powerful story. Thank you for sharing.

These personal and social stories led to a focused conversation of what science issues they or close friends or family took a stand for or against. Similar to social issues, a variety of science issues arose including health care issues, environmentally friendly choices, and animal rights. For example, Darlene shared "One thing that makes me soft is like shark fin soup. Animal endangerment. Like other cultures using animals as food and in Spain with bull fighting. Those catch my attention." Other students expressed family rules about considering environmentally friendly choices, "We go to the park a lot and walk, my family loves to walk. We don't drive cars because it's not good for the environment. My aunt is kind of an environment freak, she loves to walk everywhere." What was interesting about the range of both social and science issues that the students took a stand on was that they all echoed the idea of standing up for others, especially those that cannot speak up for themselves and doing the right thing and sometimes feeling uncomfortable about the situation.

The lead teachers reflected on the importance of these common messages in a teacher debrief session. Each teacher worked with different small groups in the take a stand interview, yet upon reflection in this debrief meeting teachers revealed similar conclusions about what it

meant for this group of students to take a stand for or against something. The following is an excerpt from the debrief meeting after the take a stand interviews and sharing out of take a stand posters:

LT1: We want science that is responsive to students, I heard, as Darlene stated, 'this is what makes me soft' that they want to take a stand for animals.

LT2: A ton of students said taking a stand for animals and I heard a lot about that they care a lot about the environment. They stated 'when we are gone this has to be our stamp of what we leave for other people. Like the environment can't talk for itself.' To me they sound like a group of environmentalists and animal activists. These are the two things they are willing to take a stand on.

LT3: Yeah, I heard Janet say 'It's like I have to speak up for someone that can't speak up for themselves. Like with animals I have to speak up for them because they can't speak up for themselves.'

LT1: That is like Lai who was saying that 'I have a deaf cousin that I have to speak up for because he can't, so I have to.' She has a lot of family in Africa that are blind and she has a beautiful way for speaking up for those that can't.

LT4: Gloria and many others were talking about being 'proud of myself.' 'Taking a stand means being confident and proud in yourself.'

It was through the small group interviews, whole group share-out, and teacher debriefs that the teachers were able to work with the students to construct an overall message about what it meant for the whole group to take a stand, landing on the following:

To take a stand for or against something means that they were committed to speaking up for those that can't speak up for themselves, whether that be animals, the environment, or younger or future generations of organisms.

**Teachers and community scientists developing a dual focus on taking action and focusing on relevant content knowledge.** From this synthesized take a stand definition the group inquired into science issues in the community they cared about. All role actors, students, teachers, and community members, came to value the building of science ideas and fleshing out the type of impact they would like to make in the community.

Multiple students in STARS brought up the idea of investigating a toxic lake that was located right outside of our afterschool classroom's window. It was the same lake that many of them frequently visited and walked through to both come to school and go home after school. There was excitement around exploring this lake and when it was decided a few students even shouted "woohoo!" in delight over our focused question of "Why is it so hard to clean up polluted bodies of water?" This delight was around exploring a lake they all cared about and wondered about. They wondered why it was a dead lake, why it was so polluted, and why people were not cleaning it up.

The lead teachers realized that in order to plan action-oriented instruction around this phenomenon, they, the teachers, needed to know more about why it was polluted and what needed to be done to help it. The first step was to contact the county limnologist, Lisa, who studied water quality in inland water systems. The lead teachers invited her to plan with the teachers as a content expert but she ended up pushing them to think more about the action the students could take.

LT: In our afterschool program we are going to focus on Taking a Stand for Lake Evergreen and water quality issues (on a personal, local, and global level) and ultimately build a professional science investigation-based documentary video that we will show to the whole community in April in a local theatre. I am interested in learning more about Lake Evergreen from you and any other key people. We are interested in what data is being collected with the new floating islands and if our group could be a resource for the community.

Lisa, Limnologist: I am happy to talk with you to see if there is something that could work out, as I understand the concept that you may be able to inspire students by active participation in a project. (Email communication)

The initial contact with the county limnologist had a domino effect as she then reached out to multiple watershed scientists and undergraduate restoration ecologist students. She emailed two undergraduates who installed floating islands in Lake Evergreen (the floating islands had plants that filtered the water in an effort to reduce the amount of phosphate in the lake). What was interesting about her contact with other community members was that her initial communication was framed around taking action. This is evident in her email connecting with other community members:

They (STARS students) are interested in putting together a water quality project for the girls that deals with Lake Evergreen and its water quality challenges. I suggested that a possible project could involve designing and possibly even construction of a pilot water quality wetland facility (like a bioswale) along the channel that carries stormwater into the park from the north, depending on permission from MC Parks. If not actual construction, they might be able to put together a design and then estimate how effective

it would be at treating pollutants, thus introducing them to modeling concepts ...something similar to what you did in the Green Hopeful Workshop, only on a simplified scale adjusted to grade level. (Email communication)

It was through the learning and planning meetings with the county limnologist that the lead teachers were able to focus the phenomena to be about the biochemistry behind the lake pollution, its effects on animals, and how to clean the water up. These first emails were followed up with multiple planning meetings. Prior to planning with the limnologist, the lead teachers sent her a planning tool based on unpacking the what, how, why, and taking action with knowledge behind the polluted lake phenomenon along with discussing the four design principles in the first planning meeting. Using the what, how, why, action document as a point of reference, planning sessions focused on construction of a detailed science explanation and how the students could research, investigate, and take action on specific parts of the phenomenon. In one planning meeting, the county limnologist challenged the lead teachers to think both about the depth of science that the students would learn and the lead teachers listened and responded with questions around how to connect action to helping this polluted lake.

(CL=County Limnologist, LT=Lead Teacher)

CL: One thing that struck me, um, is that you should include, you know when you say 'become polluted' kind of like what does that mean? It is the same thing as saying the lake's health, are you talking about algae, toxins, no plants, what are you talking about? What I would do is, yes, of course phosphorus is important because it is generating algae blooms, but why do we care. They are stinky and they are not very pretty, but is that a problem? Well, it is a problem because they are producing toxins. I think you should get

that in here (your planning). There is nuisance algae and healthy algae, not only would you want to research phosphorus, but you would also want to research algal blooms.

LT: That is important. We were hoping to focus on the algal blooms in a group of students thinking about the cyanobacteria problem (points to cyanobacteria reference in planning tool). Also, I have a question for you. Our students are interested in taking a stand for those that can't take a stand for themselves, so what specific species are you focused on at Lake Evergreen? Or what species do you know that exist in Lake Evergreen?

CL: You could have them focus on any animal such as amphibians. They could think about how could you encourage those animals to come back to the lake and that is where the constructed wetland comes in. There is currently no way for them to live there. There may be some in the little wetland next to the lake, the wetland may have some frogs, but we are not sure.

LT: We saw turtles there and tiny fish.

CL: We know of two kinds of fish in the lake that are not native. Carp and pumpkin seeds. They are warm water fish and they can survive the conditions.

Framing the problem through the lens of a solution, the limnologist suggested that the students focus on constructing a wetland to filter the water entering the lake. This was one idea suggested by the limnologist, with many other action ideas to surface in other planning and STARS meetings.

It was through iterative content and action-oriented conversations that dual conversations became a norm between the teachers and community members (see Appendix D for science explanations). Synergy around the mutual goal of helping clean up Lake Evergreen fostered the

development of a shared language around the focused content and needed actions to help the lake. Through the sharing and negotiation of ideas offered by students, teachers, and community members this shared language was “owned “ by all stakeholders who cared to clean up this space in their community.

**Summary of area one: Finding a shared understanding of what it means to “take a stand” in the community.** Deciding upon a phenomenon that was viable and worthy of using science to take action was not a process that involved a surface consideration of what was meaningful, relevant, or part of students’ lives. Instead, a deep consideration of and planning for time to consider what individuals and the group as a whole cared about in terms of taking a stand socially and scientifically was needed in order to spark further planning with community members. The phenomenon that was chosen, the polluted lake next door to their school and frequented by students became the phenomenon of focus for all stakeholders.

This problem of practice and its two lines of discourse around how students and teachers developed a shared language and meaning for what it means to take a stand and what to take a stand for meant that the teachers and community members had to carefully consider where the students lived, problems in their community that could be acted upon, and how to have collaborative conversations that allowed for negotiation of enacted practice. Developing a shared language around what it meant to take a stand called for consideration of students’ funds knowledge, connections to their world, relevant science issues, action-oriented issues, and incorporating multiple voices (design principles 1a, 1b, 1c, 2b, 3a, 4a, 4b). Focusing both on the content and taking action involved careful consideration of what phenomenon students cared to investigate and take action on, along with teachers and students asking new questions about the science behind this issue (design principles 1b, 1c, 2a, 2c, 3a, 4a, 4b, 4c). In the next section, I

discuss problem of practice two where stakeholders negotiated the definition of scientific and social rigor that was used by the students to construct scientific explanatory models of the polluted lake phenomenon.

### **Problem of Practice Two: Broadening the Definition of Science**

A second point of negotiation that emerged when working with the STARS group was how to leverage knowledge and resources from students, teachers, and community members to broaden the definition of science to include social aspects of content. This problem of practice meant sewing together social elements of the lake such as student and community members' experiential interactions with and intergenerational stories about the lake with aspects of rigorous science content. In this section I discuss three types of negotiations that supported the broadening of the content. Each subsection is organized around interaction among role actors. In the first section, I discuss how the experiential and intergenerational social stories and ideas brought in by the students were incorporated into the curriculum. For simplicity, I refer to these stories as social stories in this section. Then, I discuss the incorporation and negotiation of how social ideas played a role in a scientific explanation and broadening the knowledge that makes up an action-oriented issue reframed how the teachers planned for scientific rigor as seen in Table 4.

#### **Incorporation of experiential and intergenerational aspects of science explanation.**

With the lake being part of students' social lives, planning the causal explanation of why Lake Evergreen was polluted and why it takes so long to clean up naturally called for the incorporation of social aspects of why the lake was polluted. Social aspects of the explanation were any parts of the lake story that were not based on evidence-based science knowledge, but rather social interactions, ideas, or folklore. Many of the students walked to and from school by the lake,

visited the lake on weekends with family, or watched the lake activity outside of their school windows.

An example of how science was broadened to include social ideas was through the incorporation of stories that the STARS students heard from their families and neighbors. Parents shared stories of jumping into Lake Evergreen for a swim after Mountain Middle School let out each day. Grandparents shared stories of having picnics by the lake, fishing in the lake, and walking out on the dock in the lake. As these stories trickled into STARS conversations around the science behind the phenomenon, tension around how the lake “used to be” versus its present condition arose with both the students and the teachers. These stories painted a completely different picture of the lake that existed at the time of STARS; with past stories about a place of recreation and beauty and present day conditions consisting of a lake with no dock, no signs of wildlife, and no picnicking.

Stories of the lake in the past reinforced the students’ wonderments about why the lake was polluted. There was a sense of “it not being fair” that the lake used to be a place of recreation and now it was a dead lake surrounded by signs warning of toxicity. Urban legends and not-so-urban-legends around cars being at the bottom of the lake, a horse trying to swim across the lake and dying, and past and present drug/criminal activity surfaced up in conversations as stories around why students and the community were no longer able to enjoy the lake recreationally. Katie, an eighth grade student, would frequently come to STARS with new stories about Lake evergreen in the past. In between meeting times, she would share with her family what they did in STARS and in return her family would share stories of their past interactions with Lake Evergreen. Her father was the one who shared swimming in it after school, when weather allowed. The teachers used this information in a debrief meeting to think

about implications for broadening what was known about this scientific phenomenon, not just for the students, but also community-wide.

LT: And you know, Katie, that conversation was all about her dad and he used to go to Mountain Middle School and he would go jump in the lake after school and he remembers when he stopped going because it was too gross. There are all these myths about the lake, back in the day a horse tried to swim across the lake and he didn't make it so he drowned. So everyone is like oh. Then she added to it, yeah, someone told my dad that there is a big hole in the bottom of the lake and it drains to Mountain Sea, so there is so much folklore about this lake. Interviewing people about the lake, which is based on non-informed sources, and letting the students educate them about the science behind it. That is why nothing is happening in this lake, because people like Lisa (county limnologist) don't talk to people like Katie's dad and they have no idea what is really going on.

It was in this debrief meeting conversation that the tension around the separation of knowledge held by one group, students' families and neighbors, and knowledge held by a different group, community scientists and environmental stewards, was recognized by the teachers. This gap in communication or sharing of the social and scientific knowledge was recognized, as was the lack of the connection between the science and social stories in thinking about phenomenon. Tensions recognized by students and teachers around this gap motivated the group to think about how communication about the science behind Lake Evergreen needed to include the social ideas and interactions with the lake to dispel myths, inform the community, and ultimately open communication between families and neighbors and scientists working with the lake about the real reason behind the lake pollution.

Addressing these gaps between community-based knowledge and scientific knowledge of pollution, led teachers and community scientists to plan for a variety of ways of communicating the science in concert with students' and their families lived experiences. Teachers worked with students and community members to fold in social aspects into the scientific explanation. As seen in Table 4 (social ideas in bold and italicized for emphasis), social aspects of the scientific story behind the polluted lake became part of the overall science explanation. Specific social elements that students ended up discussing and including in their scientific explanatory models included: observations of who used the lake and the surrounding park, how the park was used by the community, what structures surrounded the park, how pets interacted with and left waste in the park, the use of excess lawn fertilizer by surrounding schools and houses, and the lack of knowledge of old sewer pipes that were still entering the lake.

**Leveraging community-based knowledge and resources to broaden uncharted science knowledge.** Planning the curriculum around why Lake Evergreen was polluted meant that the teachers were planning curriculum for an unmapped phenomenon in terms of curriculum. There were no textbooks, websites, or resources that explained the complete explanation behind why it was polluted and very little around actions that were needed to help clean it up. It was through conversations with multiple community members, the uptake of their ideas and resources that enabled teachers and students were able to construct and understand a complete picture of the pollution behind Lake Evergreen.

An example of this was in planning one part of the overall science explanation around how floating islands, built and installed in Lake Evergreen to filter water, were installed and how they worked to filter the lake water. Lead teachers and students consulted the county limnologist, a watershed scientist, and two ecological restoration undergraduate majors. It was through

communication with these scientists in planning and after-school meetings that the lead teachers and students were able to construct ideas and a full explanation of the role of the floating islands in filtering the lake water. In an after-school meeting one ecological restoration undergraduate student, Elena shared new-to-us information behind the floating islands that was not previously known to the afterschool group. In this excerpt she refers to how the floating islands were designed with the concept of biomimicry in mind, a design and production of man-made systems that are modeled from biological processes. The floating islands mimic other biological phenomena that float and naturally clean up water.

I think the concept of biomimicry is fascinating. If you look at these pictures (refers to computer which has pictures of plants floating in water) you can see plants that are floating, they are just floating in the water using nutrients. Fire ants are amazing because they will all grab each other and float across the water; they have this oil that makes them float on the water. These are natural floating systems, so we look at these to then develop a floating wetland as a means to clean up water in a way that is also more natural instead of dumping more chemicals.

Other new knowledge that was not available via websites, newspaper articles, grant reports was what was the detailed construction of the floating islands. Elena was able to provide firsthand knowledge about the floating islands because she was part of the installation team and had studied them in her undergraduate courses.

This is called a dynamic media column, we hang them under the floating islands and they play a big role in taking up the nutrients, because it is not necessarily all the plants that grow that takes up all the nutrients, but there are bacteria, this biofilm that takes up nutrients too. You can think of it as a layer of organisms taking up nutrients. These

columns, there are 20-40 under each column and the bacteria will continue to grow and take up nutrients.

This information about the dynamic media columns was added to the student models and also prompted students to think about other natural ways that the lake could be cleaned up.

Table 4.

*Four Levels of Scientific and Social Action-Oriented Rigor*

	<b>Level 1 What happened explanation</b>	<b>Level 2 How/partial why something happened explanation</b>	<b>Level 3 Why or causal explanation</b>	<b>Level 4 Communicating and using casual explanation to take action</b>
<b>Depth of Explanation</b>	Student describes what is scientifically and <i>socially observable</i> or measureable in an issue-based phenomenon.	<p>Student tells a one-step “cause and effect” story.</p> <p>Student describes but does not explain relationships between variables, or differences between experimental groups, or trends over time or qualitative observations.</p> <p>Student predicts the way some natural systems will behave, based on previously collected data, but without talking about unobservable events, processes.</p>	<p>Student can trace a full causal story for why an issue-based phenomenon unfolded the way it did and hypothesize potential solutions.</p> <p>Student uses powerful science ideas that have unobservable/theoretical components that link to observable scientific events.</p> <p><i>Student seeks further knowledge behind the unobservable/theoretical components from community members including scientists or community experts.</i></p> <p><i>Student uses social ideas that require seeking knowledge from outside resources including community members or local scientists/experts to explain observable social events.</i></p> <p>Explanation is about a system of scientific and <i>social evidence-based</i> events and processes that are linked.</p> <p>Students work with peers and community members to construct a multi-layered explanation that requires different members of the group to hold and be experts of knowledge that collectively constructs a holistic science explanation.</p> <p>Explanation connects casual explanation to personal, local, and global stories.</p>	<p>Students will use evidence-based causal explanation to determine steps to take action for or against a scientific and <i>social issue</i>.</p> <p>Students will design solutions that meet student-set criteria and define constraints on solutions.</p> <p>Student can communicate causal explanation and <i>needed actions through a variety of ways to community members in connection with making changes in their community</i>.</p> <p>Student can use action-oriented casual explanation to determine uncertainties with canonical science knowledge.</p>

County and undergraduate scientists critiqued and helped all small explanation expert group models construct a deeper understanding of the unobservable and observable entities within the phenomenon. For example, in the cyanobacteria group Lisa, the county limnologist, helped students in the cyanobacteria group understand how cyanobacteria outcompeted all other organisms in the lake. The conversation started when students stated that the “cyanobacteria killed everything (in the lake).” This statement prompted the limnologist to engage in a conversation that ultimately led to a deeper understanding of what it meant for the cyanobacteria to outcompete other organisms.

CL: Cyanobacteria in lakes can actually control where they are in the water, ok, they can make gases that allow them to rise to the surface and these are the ways in which they can compete with algae. Because they can rise to the surface and shade out other algae. So yes, when you get enough cyanobacteria that rise to the surface, they will shade out the sunlight and that allows them to do better than the algae, gives them an advantage.

S: So, yes, it can kill other plants besides algae?

CL: Well, when you get enough of them, it's like nobody is all bad or all good, cyanobacteria are not all bad or good. If you get too much of them, yes they can have bad effects...cyanobacteria were the very first creatures on Earth and when they started evolving there was no oxygen on Earth.

LT: The other thing we have on our poster is the decomposers sucking up all of the oxygen.

CL: Yes, that's right. The cyanobacteria have a short life cycle, so when they die the bacteria at the bottom decompose them. So it isn't the cyanobacteria using all of the oxygen, it's the bacteria that are decomposing that use all the oxygen.

S: Ah, so the fish, they die because they don't have any air, I mean oxygen.

CL: Yes. Oxygen in the water comes from the air above it, aquatic plants, and algae...

From this conversation, the six students and two lead teachers that made up this small expert group were able to clarify what it meant for cyanobacteria to outcompete and how the lake became eutrophic, meaning a body of water with no oxygen or life. More significantly this altered how the students represented this on their explanatory model and the information they shared with the whole group.

**Summary of problem of practice two: Broadening the definition of science.**

Significance of this area of negotiation lies in the evidence around navigating new territory in terms of what the science explanation was for the Lake Evergreen phenomenon. It was through the asking of new questions, critiquing known knowledge and seeing where new knowledge was needed, and the desire to make new community-based connections within a local issue that the science had to be restructured to incorporate new ideas and ways of thinking.

This problem of practice and its two lines of discourse around how the experiential and intergenerational social stories and ideas brought in by the students were incorporated into the curriculum and these were negotiated to broaden the knowledge that makes up an action-oriented issue meant that teachers had to reframe how they planned for scientific rigor. Reframing required the incorporation of experiential and intergenerational aspects offered by both students and community members. This restructuring required using students and community ideas and resources to broaden the definition of science to incorporate social ideas and an expansion of science knowledge. There was a deep respect and use of stories that students brought into the after-school space to help redefine what it meant to consider social aspects of a scientific phenomenon (design principles 1a, 2b, 2c, 4a, 4b, 4c). It was through being upfront about not

knowing on the teacher and students part that led to the use of community ideas and resources to really (design principles 1a, 1c, 2b, 3a, 4a, 4b, 4c). In the next section, I provide evidence for how the practice of using science to take action was negotiated by the stakeholders.

### **Problem of Practice Three: Being Responsive to How Students Built Science and Social Action-Oriented Ideas**

The third problem of practice that emerged was about being responsive to building student knowledge in connection with taking action in their community. Designing curriculum around an action-oriented issue called for teachers to be responsive to ways that students could discuss and plan for transformative action as they constructed a rigorous science explanation. Addressing this problem of practice happened at different levels of interactions in and outside of the classroom: 1) Elevating student ideas from small group conversations to whole class discussions of solutions and 2) Negotiating students' design solutions with community members.

**Elevating student ideas from small group conversations to whole class discussions of solutions.** Across activity in STARS, students became experts of one part of the overall science explanation by focusing on one layer of the complex polluted lake phenomenon. Students were broken up into three pollution expert explanation groups in activity and focused on one of three layers to construct an evidence-based scientific explanation model. These small groups focused on one chunk of the science story: 1) Excess nutrient expert group, 2) cyanobacteria group, and 3) water filtration group (see Appendix D for small group scientific models). It was common practice across small group activity to design investigations, gather evidence, and engage in hypothesis-forming conversations around why the lake was polluted based on what their small group knew. In small groups, students would practice what they would share with the other small groups and what questions they had for the other small groups. This role-playing and the use of

small group scientific models as tools for whole group conversations elevated ideas for the whole group to be responsive to.

Ideas from small group conversations and models were then carried into whole group conversations where students would share out the evidence they had for why Lake Evergreen was polluted and their respective hypothesized solutions. An example of this was seen in the following excerpt when multiple pairs of students from the different small groups shared pollution and solution hypotheses with the whole group. As the pairs shared, they taped their solution hypotheses onto a picture of the lake to show the targeted location of their solution.

PH=pollution hypothesis, SH=solution hypothesis

**Pair 1**

PH: Although we have floating islands it will take awhile for nature to catch up and really clean up the water.

SH: If we stop putting stuff in Lake Evergreen then the plants may be actually able to clean up the lake, they might be able to keep up with the stuff and not be overloaded or find something to help the plants the filter the water

**Pair 2**

PH: We will go next because our pollution hypothesis connects to your solution hypothesis. Lake Evergreen is polluted because it is difficult to clean up polluted water. It is hard to clean up because of...it continues to get polluted, stuff just keeps coming in.

SH: So, we need more people to help us, help us clean it. We need to tell pet owners because their pets will drink the water. We (small group) were trying to think about who uses the lake the most and we decided that we needed to talk with pet owners because they use it the most.

**Pair 3**

PH: Lake Evergreen is polluted because there is no natural filtration system or outlet for the polluted water to go.

SH: Our solution is to make a bioswale, a bioswale is an indent filled with plants and rocks, the water runs through to filter it. A bioswale could be placed somewhere else as an outlet too.

Sharing these hypotheses prompted a whole group conversation about “getting others to care about the lake pollution and cleaning it up.” As Nina stated, “There are not enough people to help clean up the lake, cost a lot of money-you don’t have the people or the money-what are we going to do?” This same concern of how to make community members care was raised by Saia and her cyanobacteria small group. Responding to this genuine worry about who will listen and who in the community will help clean up the lake from students prompted the formation of new questions for community scientists that we would be joining us in our next meeting. It was through this type of elevating of ideas in small groups to whole group discussions that the student ideas would be elevated again to the community level.

What was interesting about this pattern of idea elevation was that the synthesized whole group ideas would then be elevated to a discussion with community members. For example, when the students were grappling with how to help those that do not care begin to care, the following week Rida, an eighth grade student, asked a watershed scientist who was visiting our group how to get other to care about this too. “How people can help it? People don’t care about it because if they did they would have done something about it earlier. We need to gather people and petition the government to have local citizens clean it up.” What was interesting about Rida’s prompt was that the watershed scientist responded with a compromising way of

negotiating both this feeling that the group was having and how it could be tied to action. The watershed scientist responded with a story about how sometimes the “community doesn’t yet know what they might be concerned of and that is why your group’s work is so important.” And “It’s our work to inform others. Those that don’t care may not end up caring, but there might be part of that group that ends up caring because of what you have informed them about.” The watershed scientist’s idea helped the students decide the value, the difficulty, and the need to continue taking actions even if they could not get all community members involved or interested. In the next section, I describe how the community took on a significant part of shaping how the students ultimately chose to take action with their knowledge in the after-school program.

**Negotiating students’ design solutions with community members.** Lead teachers and students looked to community members as consultants on how to use students’ solution hypotheses ideas to take action on the lake. When brainstorming solution hypotheses on how to clean up the water in Lake Evergreen the lead teachers consulted with the county limnologist about various solution hypotheses that students had raised in meetings. For example, early on in STARS after examining county collected data on the amount of toxic cyanobacteria in the lake, one student proposed that the lake be filled with dirt. Although this sounded like an extreme solution or way to take action, the lead teachers asked the county limnologist about her insights on this idea.

LT1: One of our students suggested just filling up the lake so it was no longer a toxic water site. What do you think of that idea? Has that been an option you have considered?

CL: I think there has been a lot of neglect in regards to Lake Evergreen. I think it is important to ask what could you do with this lake? What would you like to see happen? Sure you could fill it in and then it wouldn’t be a hazard anymore. But what else could

we do. Maybe someday it could be something useful for animals and the community if we cleaned up the water. What would happen if it was filled in? You still would have the stormwater with excess phosphates. I would suggest being right up front about why should we care?

LT1: Important to think about what are you working towards? Two main goals-be safe for people to swim in it and be able to eat fish out of it. Very practical goals that everyone can relate to.

LT2: It makes me think of this water system in China and people swimming in the cyanobacteria as you (CL) talked about.

LT1: Asking them ‘when you are 63 what do you want Lake Evergreen to look like?’

It was through conversations such as these that actions toward solutions were tossed around in conversation, negotiated, and remained the focus of all work. As the students worked on their science models, shared their models, and synthesized the whole group model of the phenomenon they decided to focus on designing a nature walk that used four signs posted around the lake to inform the community about the lake’s condition and what actions were needed by the community to better Lake Evergreen’s future.

Through communication with community members and verification that the signs were a viable option in terms of taking action, students took up the nature walk sign design process. This idea to design signs originated from a planning session with the limnologist three months prior to the students deciding to focus on it. She suggested that the students design signs with warnings and needed actions for all ages, “Some of them aren’t appropriate for children, but you know with this group do a child’s version of this. Here is what adults can do and here is what kids can do. Have them (students) brainstorm a kid’s version of this.” In multiple meetings based

on negotiating and brainstorming using knowledge to take action, the students decided that four signs that combined all of the knowledge and action needed would be the best “first step” in taking action.

LT: What solutions do you think you would like to pursue? We have talked about connecting to youth, designing a sign to help the community learn about the condition of the lake, connect with community by holding a party, and build a model of the bioswale that is needed to clean the water.

S: I think we need the bioswale because we have to clean the water-actually we should do the youth one and the sign one. The fourth one, the bioswale, will take a lot of approval and a lot of time, so we could think of the first one, the signs, as the first thing to do.

S2: It would be our first thing to do, which could hopefully lead to a bioswale.

Throughout the sign-making design process students set criteria for how the signs should be constructed and what key information and images should be included on each sign. As drafts of the signs were produced according to set criteria, drafts were sent to community experts for verification of information, quality, and adherence to county regulations. In email correspondence with the Park’s Department Manager about the student-produced nature walk signs, he suggested that the students revise particular parts based on his knowledge of human interactions in and with the lake. (See Appendix E for pictures of nature walk signs and description of signs).

Very cute signs with some real science. I like it. The fourth sign needs a little verbiage change. Change to “Your dog can safely play in the water” swimming would imply off leash dog use. Change to “You can safely enjoy the lake”. Mountain County doesn’t plan on making this lake a swim beach, in fact just the opposite we would like to see a more

natural lake with less human activity and more wildlife activity. We have selectively planted out areas of the old swim beach to decrease human access to the lake. There is also currently one bioswale installed by Parks from the small pond to Lake Evergreen. So I assume you're talking about the drainpipe that comes out from the street and goes untreated into the center parking lot wetland/seasonal creek. I would love to see a bioswale installed there and as to improve the center parking lot wetland. Thanks for all the hard work and I look forward to the next steps. Any questions let me know. (Email from Park Manager)

Students edited their signs based on feedback from the park manager and limnologist and then shared them with the whole group by finding the location near the lake where they wanted their sign to be posted. The park manager posted the signs.

Communication with the community was also tackled through the production of a professional documentary film. In the documentary film, that the students showed the community about how to better the future of Lake Evergreen. Although at the start of STARS a film was a planned product, what the film was about and what the film would say to its audience was up to the students in STARS. Narrated around the idea that they (the students) were “just a small group” and could only do so much on their own, they decided that the film would tell the story around the science behind Lake Evergreen and what their group decided to do to take action. Through film storyboarding and scripting, the students shared that their first steps were to inform community about the condition of the lake and what the lake could be like if the community took certain actions and a bioswale was designed.

If we stop focusing on the bad about the lake and start thinking about the good then we can start to accomplish our mission to clean up the lake. We decided to create a walking

tour that consists of four informational signs. Each sign has information and ways for individuals to take action. (Film)

**Summary of problem of practice three: Being responsive to how students built science and social action-oriented ideas.** Significance in negotiating this problem of practice was in how the ways that the students worked with ideas for action and deciding to take action was about having negotiation conversations with the community. It was through multiple conversations between students, with teachers, with community members that hypotheses could be shared, revised and connected to action on a relevant issue (design principles 1c, 2a, 2b, 2c, 3a, 3b, 3c, 4a, 4b, 4c). Being responsive to students as they built a science action-oriented understanding required responsiveness on the teachers part to plan and foster the sharing of all hypotheses, responsiveness on the students part to ask and respond to community members' ideas, and responsiveness from the community to help students (and teachers) build an understanding of the value of making change and the difficulty in making changes in a community.

**Summary of findings.** Findings from this study suggest that action-oriented science teaching and learning practices involve planning, enacting, and reflecting in a rigorous and responsive manner with multiple resources and stakeholders. It is through negotiation conversations based on the emergence of problems of practice with multiple stakeholders that rigorous and responsive science teaching and learning morph into relevant, authentic, complex, and transformative action. Rigor as set by canonical standards in science education grows to include consideration of social evidence and using an explanation as a tool to make change in a community. Responsiveness extends beyond being responsive to just students' scientific ideas to

being responsive to all ideas that come and go from conversations with multiple stakeholders involved with the problem-based phenomenon.

Embracing action-oriented science as a series of planning and enactment negotiations provides meaning for what it means to teach and learn about a phenomenon that does not possess a predefined science explanation. Issue-based phenomena, such as how Lake Evergreen became polluted and why it takes so long to clean it up, call for a determination of what is the issue and what the given group of students can take on to help solve. With the middle school students in this study, this was about “getting people to care” and “speaking up for those that can’t speak up for themselves.” If a different group of students and community members were to take on this same question, negotiate how to investigate it, and take action, the science explanation would most likely be different as would be the negotiated actions to make change. What would not be different would be the necessary multiple negotiation conversations with multiple stakeholders to decide curriculum for the action-oriented science.

### **Discussion**

Although researchers have described the ways in which multiple stakeholders’ ideas can be considered when designing community-based curriculum, little is known about how curricular decisions are negotiated as the curriculum itself is being enacted (Bang et al., 2012; Bang & Medin, 2010; Penuel & Fishman, 2012; Penuel et al., 2011). In this study, I described the problems of practice that arose as a group of stakeholders—middle school students, teachers, and community members—negotiated curricular aspects of an afterschool science program. In the discussion, I amend the design principles with key ideas from this study and discuss implications of findings on designing curriculum for action-oriented and social justice pedagogy. Finally, I suggest areas for future research.

## Negotiation of Action-Oriented Design Principles

Undergirding the problems of practice that were negotiated were three important ideas that have bearing on the design principles. First, is the idea that *stakeholders shared a common object of work yet incorporated different perspectives*. In this study, all stakeholders had legitimate interest and concern over the polluted lake next door to Mountain Middle School and they all could find ways to map their interests and concerns onto a common project. The root of interest and concern in the lake was different for each stakeholder, with these differences nurturing the same issue, but in very different ways. Student interest and concern was rooted in the desire to make the lake a place of safe recreation for all organisms. Teacher interest and concern was rooted in helping students use in-depth science to make a worthy change in their community. Community member interest and concern was rooted in collaborating with a new group to help clean up the lake and help inform the community of the issues and actions needed to clean up Lake Evergreen. It was through negotiation conversations that these roots came together to design responsive curriculum that adhered to the design principles.

Second was the idea that *multiple design principles were in play simultaneously*. Negotiation of action-oriented science curriculum did not mean that planning meetings were based on checking off what design principles we wanted to foreground or not in a meeting. Rather, the use of the design principles meant that at different moments of time in STARS different principles were foregrounded as a natural part of designing curriculum that was responsive and relevant to the students and their surrounding community. For example, in the first problem of practice when negotiating what it meant to take a stand, students' assets as building blocks were foregrounded followed with the use of community members' ideas as resources for designing the curriculum for STARS. In this problem of practice the design

principles based on critiquing canonical science and using science to take action were backgrounded, yet still very present in terms of how the stakeholders were negotiating what it meant to take a stand in the community.

Third, was the idea of a *cascading effect of responsiveness beyond the intended curriculum*. Designing action-oriented science curriculum with multiple stakeholders required a keen sense of responsiveness, humbleness, and curiosity by all parties involved. Responsiveness was broadened in action-oriented science from teachers being responsive to students to all stakeholders being responsible to all ideas regardless of stakeholder's role as student, teacher, or community member. An example of how responsiveness cascaded was when the student suggested filling in the lake with dirt the teacher was responsive to this idea by asking the community member about its validity in terms of taking action for the lake. The community member in turn elaborated on this idea offering a new thread of discussion in STARS about the limitations and benefits of all actions. Students then responded to the community ideas about weighing out benefits and limitations for any proposed solutions. This cascade of responsiveness flowed into negotiation conversations as the stakeholders decided together what and how students would use rigorous science knowledge to take action for the lake's future. In sum, negotiating action-oriented curriculum as it was being enacted meant that the stakeholders compromised and were ready and willing to nimbly shift ways of thinking about the lake phenomenon.

### **Future Research**

**Unsettling science.** An unsettling aspect of action-oriented science is that at the end of a unit of instruction the explanatory model that the students construct and use to take action is not finished. Investigating an issue-based phenomenon means that students construct the knowledge

that is used to make first steps towards solving a problem. Part of the learning process is that when designing criteria to solve a problem, the criteria and solutions all have limitations and may not solve a problem completely; they serve the purpose to inform others about needed steps and perhaps solve a small part of the overall puzzle on either a short or long term scale. At the end of STARS students reflected upon how the Lake Evergreen problem was not solved, rather “we are a small group of students and this is what we chose to do to help” and these were our “first steps” towards a solution. Future research should focus on what it means to empower students to use scientific knowledge to take action in their community and know that taking action with science is not about necessarily fixing a problem, but rather weighing benefits of possible solutions to make necessary changes in the world. This study used specific design principles to think about how to tackle the problem around students using knowledge to take action and future studies could design new studies exploring how effective action-oriented curriculum and instruction could take place across various contexts in helping students take “first steps” in their communities.

**Expanding the voices of enacted curriculum.** In this study multiple stakeholders included students, teachers, and community members. Further research is needed that expands this circle of stakeholders to include students’ families. Literature on community-based designed instruction has described examples of how families have been involved in the planning, but we need examples of how family voices become part of the negotiation process in enacting action-oriented science curriculum and instruction (Bang et al., 2014; Bang & Medin, 2010; Medin & Bang, 2014). In this study, family stories that were brought in by students were capitalized upon in terms of using them to reframe rigor in the second problem of practice, but family voice in

action-oriented science needs to be highly present if we are to fully explore what using science to take action means in students' communities.

**Action-oriented pedagogy in formal science classrooms.** From a design perspective, articulating a set of principles for curriculum of action-oriented science projects is a classic theory-to-practice problem (McDonald, 2007, 2008, 2010; McDonald, Kazemi, & Kavanagh, 2013; Nieto & McDonough, 2011). Findings from this study suggest that if a goal in science education is to develop science teaching core practices that are relevant, authentic, and present complex phenomena for K-12 students to construct rigorous science explanations about (McDonald, Kazemi, & Kavanagh, 2013; NGSS Lead States, 2013), then as a field we need to provide clear practices that can help science educators have the conversations with multiple stakeholders to determine what is relevant, authentic, and complex in specific contexts. Systemic support is needed to further articulate what these practices look like in the form of planning tools, sense making tools, and instructional reflection tools. As an education field at large we continue to strive for education that is equitable *and* socially just, but if we continue to just teach about in teacher education programs and talk about these as a stance to hold onto, rather than build practice-based tools that support enactment of socially just education, we will not see it come to fruition across informal and formal education contexts.

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Chapter 3. Middle School Girls' Socio-Scientific Participation Pathways in an Afterschool

Science Club

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## Abstract

Drawing on literature that focuses on intersections of female students' funds of knowledge, positioning, agency, and identity trajectories in science activity, this study focused on how middle school girls drew on multiple identities as they authored themselves in an afterschool science space. Middle school is a time for forging and trying on identities and afterschool spaces can be places for continuing to work on identities and the relationships, such as friendships, which are important to how girls author themselves in science spaces. This study aims to understand how a specific type of social activity, relationship formation activity, an activity that naturally occurs alongside science activity for middle school girls, intersected or did not intersect with science activity. Data sources included interview and video records of participation in the afterschool club for nineteen girls. I investigated the situated nature of the girls' identity trajectories by examining how girls participated in various activities within STARS. This approach stands in contrast to other studies that have examined afterschool clubs as a type of activity separate from school science. I focus on four case studies representative of the nineteen and examined identity trajectories in terms of: participation in activity, expression of ideas with each other and the community, and working towards a future image of what is possible. Each girl had a unique trajectory for foregrounding work on building relationships and on science ideas, or both. In terms of activities, it seems that having a range of activities that supported working together was important. For some, specialized activities, such as conducting investigations, were important for authoring. For others, the full range of activities was important. Findings problematize the situated nature of identity trajectories in activities and question whether a trajectory can be positive or negative when participation is so extremely different for each student.

## Chapter 3. Middle School Girls' Socio-Scientific Participation Pathways in an Afterschool Science Club

### Introduction

This study investigates how middle school girls participate in and shape learning opportunities for themselves and others in an afterschool science club. Specifically, I examine identity development in the science club as the girls take on roles that position themselves as productive knowers and doers of science as they develop identity around science and in their relationships with others (Brickhouse & Potter, 2001; Calabrese Barton, Tan, & Rivet, 2008; Calabrese Barton et al., 2012; Carlone, 2004; Carlone, Haun-Frank, & Webb, 2011; Holland, Skinner, Lachicotte, & Cain, 1998; National Academies, 2007; Thompson, 2014). Several studies have investigated the intersection of female students' funds of knowledge, positioning, agency, and roles in science spaces, analyzing how students author themselves as they engage with scientific practices; noting if the identity trajectory is positive or negative, productive or unproductive (Banks et al., 2007; Bell, Lewenstein, Shouse, & Feder, 2009; Bouillion & Gomez, 2001; Carlone, 2004; Moll, 1992; Price & McNeill, 2013; Roth & Calabrese Barton, 2004). What remains unclear from these studies is an understanding of the intersection or lack of intersection of relationship formation activity (the interactions among girls such as building friendships, sharing family stories, sharing ideas based on lived experiences with others, having fun together) that naturally occurs alongside the science activity that shapes participation and identity development in science learning.

I refer to identity development in terms of trajectories that unfold over time and are shaped by a set of social interactions and discourses “situated in historically contingent, socially

enacted, culturally constructed ‘worlds’ ” (Holland et al., 1998 p. 7). For example, in this study the girls’ discourses about themselves are social; they are rooted in many communities that constantly inform the girls about what it means to be female, a daughter, a refugee, and/or a student who is learning English or science. I am less interested, however, in the naming of types of categories and forms of membership and more interested in how these discourses shape (and are shaped by) the girls’ participation in the science club over time. Identities are constantly shaped and reshaped in culturally constructed social worlds, with various actors working in the figured world influencing one’s identity both in an individual and collective manner (Holland et al., 1998). This study looks at the affordances of particular activities (investigations, scientific model groups, scientific action groups, and documentary film production) in an afterschool science club, Students Tackling Authentic and Relevant Science (STARS). STARS was intentionally designed to be a scientific, social, cultural, and an informal learning space where the middle school females could engage in rigorous science activity. Drawing upon sociocultural processes that are central to learning and the figured worlds framework to outline a research agenda to study female participation in a science space (Holland et al., 1998; Nasir & Hand, 2006; Nasir, Rosebury, Warren, & Lee, 2006; Rogoff, 2003), my central research questions were:

- 1) How do middle school girls author themselves in STARS? To what extent is their development of relationships with others in STARS intersect with this authoring (scientific or not)?
- 2) How do the girls participate and engage in, across, and on the margins of the various activities in STARS (investigations, scientific model groups, scientific action groups, documentary film production)?

## **Theoretical Framework**

In this study I draw upon sociocultural perspectives of learning and participation to frame the analysis of identity development of the girls in STARS activity (Esmonde, 2009; Holland et al., 1998, Nasir and Hand, 2006; Rogoff, 1995; Urietta, 2007). In this section, I unpack aspects of identity development as participation pathways and then discuss the idea of authoring, as agency, positioning, and working within cultural expectations. In both of these sections I attend to the role of developing relationships with others as an important dimension of how the girls in this study viewed themselves coming into STARS and during STARS.

### **Identity as Participation Pathways**

This study focuses on identity trajectories of female students across time in an afterschool science learning context when they are provided with opportunities to do authentic, relevant science (Calabrese Barton & Tan, 2010; Calabrese Barton et al., 2012). An identity trajectory considers the historical development of identities and girls' ideas about how they would like to act in the present and the future. Identity trajectories build over time and unfold as the girls make decisions about their lives and which activities to act upon or not (Brickhouse & Potter, 2001; Carlone, 2004; Thompson, 2014). By examining the girls acts of participation, I can take a critical look at the multiple dimensions of how the girls draw on their existing identities and use them to shape and make a new self in the STARS setting.

Important to the development of trajectories are interactions with peers and teachers (Calabrese Barton et al., 2012; Thompson, 2014). In this way identity trajectories are a “constellation of relations,” meaning that one’s self in time and space has multiple influences that define how one makes sense of herself, the world, and her place in the world (Holland & Lave, 2001; Nasir & Saxe, 2003; Olsen, 2011, p. 266; Sfard & Prusak, 2005; Urietta, 2007). I

hypothesize that interactions between the girls and others in this study will “play a key role in learning and development” as “learning is constituted by changing relations in these social relationships and the social world” (Nasir & Hand, 2006, p. 459). Constellations of activity for the girls in this study pulled from both scientific and relational activity that took place over time in STARS. Understanding the girl’s trajectories in this study means to understand how the girls positioned themselves with others, how they are positioned, and how they acted with agency within cultural expectations.

### **Agency and Authoring Oneself Against the Backdrop of Cultural Expectations and Social Positioning**

To understand the situated nature of identity trajectories within activities I use the idea of “figured worlds,” or interpreted spaces of being “in which a particular set of characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others” (Holland, Skinner, William, & Cain, 2001, p. 52). Girls participate and author themselves in multiple figured worlds such as in the science classroom, on sports teams, in clubs, community gatherings, when hanging out with friends, or at family events (Barton & Tan, 2007; Calabrese Barton et al., 2012; Urietta, 2007). It is through actions and interactions in figured worlds that shifts in identity trajectories emerge. “Through participation in figured worlds people can reconceptualize who they are, or shift in who they understand themselves to be, as individuals or as members of collectives” (Urietta, 2007, p. 120). It is through participation in figured worlds that people act with agency in and across figured worlds (Calabrese Barton & Tan, 2010). Acting with agency means people can interpret who they are in a space in response to the activity that is taking place with others. It is with agency, the ability to act within one’s

world and influence others' agency within that world, that the girls in this study acted, improvised, in the figured world of STARS (Barton & Tan, 2010; Moore, 2007).

**Agency in the context of cultural expectations and positioning.** Understanding agency and act of authoring oneself to others requires individuals to make sense of their context and the cultural expectations and positioning within that context. Cultural expectations and positioning result in roles that people take on or the roles that they are assigned or given by others (Calabrese Barton & Tan, 2010; Holland et al., 1998; Urietta, 2007). An example of this can be seen in Skinner and Holland's (1998) ethnographic study of caste groups in Nepal when a lower caste woman decided to scale a three-story house to enter the balcony where she was to be interviewed, rather than walk through the kitchen where food was. The act of climbing the house instead of walking through the kitchen was response to discourses about social caste and gender in this society. These discourses, or cultural expectations, are inscribed on people personally, interpersonally, and institutionally. This extreme action of scaling the wall by this woman was a result of learned embodied cultural behavior about the significance of others, those of a higher social caste, not wanting her in their kitchens due to her socially positioned caste that was determined by a set of cultural expectations set by the world in which she figured herself.

The woman's improvisational climb up the wall represents products of collective social history that ultimately guided her actions, which can be likened to the actions of the girls in this study (Holland et al., 1998). "Improvisations are the sort of impromptu actions that occur when our past, brought to the present as *habitus*, meets with a particular combination of circumstances and conditions for which we have no set response" (p. 17-18). Improvisation is what prompts change in identity and change within individuals and groups that are in activity in a given figured world. "Individuals and groups are always (re)forming themselves as personal and cultural

materials created in the immediate and more distant past” (p. 18). Her improvisational act of climbing the wall was an attempt to reconcile what she saw and knew herself as in her religion and society *and* her need to speak with the interviewer about herself and her positioning-speaking up about it, making others aware of something that was silently put upon her. She was constructing a new identity, a self that could speak out, while working within the expectations that were set upon her.

The girls in this study had opportunities to (re)form themselves as they improvised in the sociocultural context of the STARS space based on who they were in other parts of their lives, who they were in the STARS space, and how they were positioned. In terms of cultural expectations, the science learning spaces are not historically places that support students in authoring ideas. It is often a socially constructed place where students and teachers take on roles of giver and receiver of knowledge, with actions guided by historical institutional norms, students’ past and present everyday experiences in and out of school, and discipline specific norms of teaching and learning. Furthermore, Carlone et al. (2011) described how school science is configured for particular types of identities such as those that are deemed by others as a “smart science person” (p. 462).

A figured world of prototypical school science learning is often one where only those who have access to and find interesting afterschool science experiences (summer camps, after-school programs, museum visits, dinner table conversations about science and nature) and resources (science trade books, computer programs, television shows) get defined as ‘smart science students.’ Over time, actors become more and more familiar with the practices and rules of a figured world and eventually author themselves within (or against) the world. (p. 481)

In order to address this “historical association of elitism and inaccessibility” in the school science figured world, students either have to conform or resist the historically defined role of who is a smart student in the science classroom (p. 481). Although not situated in a school science classroom and not focusing on who is smart or not in the science classroom, the STARS space was a structured science learning space that took place in the same room that many of the girls had school science in each day. Exploring what practices and roles guided their identity development, how they authored themselves, in this afterschool space has implications for this study as it would in a school science classroom.

**Authoring of identity.** Authoring oneself in a space means that one is acting within and across multiple identities (Johnson, Brown, Carlone, & Cuevas, 2011). This study takes on the assumption offered by Johnson et al. (2011) that “there is more to our participants than simply the *moment-to-moment identities* they attempt to author” and rather authoring is about patterns and new uses of identities in figured worlds and can be viewed as “identity in process” (p. 345). This process of identity development in a science learning setting is shaped by how students are positioned, what resources are taken up, and what opportunities are available for access by students (Calabrese Barton & Tan, 2009, 2010; Tan & Calabrese Barton, 2010).

Identity is made evident through what individuals say and do, how a student and their work is recognized and by whom, by the resources they access and activate to do so, and by how they position themselves in relation to others and to the object of the activity while taking particular roles. (Calabrese Barton et al., 2012, p. 43)

Using identity in process or authoring oneself as a construct to understand science participation means recognizing the ongoing negotiation with the resources—ideas, knowledge, material objects—that are available to students and how students and others leverage these

across space and time. When resources from across students' figured worlds are accessed and positioned as learning resources in learning settings, students are repositioned as experts in the figured world of science and their identities are transformed. "Creating different figured worlds in a science classroom that allow a broader range of funds of knowledge and discourses potentially opens different routes for students to gain authority in science" (Tan & Calabrese Barton, 2010, p. 52). School science as a figured world that considers students' lives and ways of being as resources provides opportunities for students to see themselves as one that can be in and work with science. This study uses an afterschool space to further explore the questions of how it is possible for students to see themselves as doers of science.

### **Methods**

Using a multiple-case study approach, this study examined identity development of the middle school girls in this study over time over the course of STARS. Discourse, both talk and non-verbal actions in video of meetings, student interviews, and student artifacts were examined to see how the girls participated in STARS (Calabrese Barton, Rivet, & Tan, 2008; Gee, 2011; Yin, 2009). A case study approach in this study is appropriate because it provided an opportunity for an in-depth description of the different ways in which the girls participated and identified with and in science (Green, Camilli, Elmore, 2006; Rogoff, 2003; Yin, 2009). This method of qualitative research allowed for in-depth analysis of the Discourse that occurred between the STARS participants as they interacted with each other in, across, and on the margins of activity. In this section I describe the participants, the data sources and means of collection in the specific research context, and multiple iterations of data analysis.

## **Participants**

**Middle school girls.** Nineteen middle school girls from ages eleven to fourteen participated in STARS from October 2013 to June 2014. The middle school girls were recruited through the MSC recruitment process that included advertising during lunch and at parent curriculum night. One of the lead teachers also recruited some students from her science class that she taught. All of the girls in STARS attended a high poverty school, Mountain Middle School, with a free and reduced lunch rate of 86 percent. Mountain Middle School hosted over 583 students that spoke over twenty different languages, with 21 percent of the students designated as transitional bilingual. Participants in this study are not described by their ethnicities nor are their cultural differences treated as traits; rather they are described as the participants they were in the cultural activities that took place in STARS (Gutiérrez & Rogoff, 2003, Rogoff, 1995).

**Lead teachers.** Recruitment of the lead teachers included letting teachers that we have worked with in the past know about the program and asking for teachers potentially interested in leading the out-of-school science program. The two teachers who responded, Collette and Emerson, were teachers that I had worked with for three years on three other research studies around ambitious and equitable science teaching (Thompson, Hagenah, Kang, Stroupe, Windschitl, & Colley, 2015). Emerson, the middle school science lead teacher, was the science teacher of many of the STARS middle school participants and hosted the program in her classroom on a weekly basis. Collette, the high school science lead teacher, taught at one of the feeder high schools that many middle school students from STARS could apply to go to upon middle school graduation. The school that Collette taught at focused on the health sciences and

was built around the concept of small schools. Collette taught many of the middle school students' older siblings.

**My role.** I took on the role of research participant in this study. Along with one other university researcher, I co-planned, co-led, participated, and co-debriefed all STARS meetings with Collette and Emerson.

### **Data Sources and Collection**

To answer the research questions of how the girls authored themselves in STARS, to what extent their development of relationships intersected with this authoring, and how they participated and engaged in, across, and on the margins of the various STARS activities I collected multiple data sources. Data sources included videos of weekly afterschool meetings, video of group and individual interviews, and student-produced artifacts. Sections of video recordings for case studies presented in this study were transcribed and stored for data analysis to triangulate with interview transcripts, and student-produced artifacts (Wolcott, 1997; Yin, 2009). Validity was ensured of all data through member checks both formally in interviews and informally during weekly meetings (Merriam, 2009). This approach allowed for the gathering of multiple pieces of data to analyze what identity development looked like for the girls as they participated in STARS activity.

**Video of bi-weekly meetings.** Science STARS was an afterschool program for middle school girls. The program operated under the umbrella of the Mountain Schools Collaboration (MSC), which was funded by outside sources and ran separate from the middle school it was hosted in. The MSC regulated recruiting students, timing of after school programs, attendance procedures, discipline of students, and transportation for students. STARS took place twice a week at Mountain Middle School on Tuesday and Thursdays. Tuesday meetings focused on

design and production of a professional documentary film. At the Tuesday meetings, four to ten of the overall nineteen girls would work with myself and a professional videographer to storyboard, write scripts, record audio, take video and pictures for stop-gap animation film, critique, and edit the film. Tuesday film production was based on what science, questions, and actions were taken on the previous Thursday STARS meeting (Thursday meetings described next). The film was a planned part of STARS, but what the film was about was up to the girls to decide and design with assistance from the videographer. Tuesday meetings were video recorded.

Thursday meetings focused on activity around constructing an evidence-based scientific explanation around a local issue and deciding how to take action to help it. All nineteen girls attended the Thursday meetings from 3:00-4:30, with up to five girls absent each meeting for various reasons. Every Thursday meeting was video recorded and sections were transcribed for data analysis. The girls participated and engaged in science sense making activities, evidence-gathering investigations, and discussions to construct an action-oriented scientific understanding around why Lake Evergreen, a lake next door to their school, was polluted and why it takes so long to clean it up. As the girls learned the science behind the lake pollution, they hypothesized possible solutions to help the lake. The question of how to help the lake and how to inform the community about the lake was a central question that guided how the girls decided to use their science knowledge to take action in their community. They decided that they would take action to help clean up the lake by communicating with the community through their documentary film and constructing a nature walk around the lake that would tell the story about why the lake was polluted, who and what is affected by the pollution, and what further actions were needed to ensure a healthier lake in the future.

**Interviews.** STARS participants were formally interviewed twice—once in the beginning of STARS and once at the end. The first interview took place in the fall and was based on how students think about taking a stand for something they believe in, for someone, or for something. Interviews took approximately forty-five minutes and were conducted in a semi-structured, open-ended interview format with groups of three to four students (Patton, 2003). Each interview was video recorded and I took field notes to help modify and adjust the next question if necessary.

Sample questions that I asked were (see Appendix A for full set of questions):

- 1) Tell me about a time when you stood up for yourself, a friend, or a family member.
- 2) Tell me about a time when you stood up for one of your ideas (big or small idea, in or out of school, in family, or/and with friends).
- 3) What are some important issues or ideas that are shared in your families?
- 4) What is a time in science that you really enjoyed learning about science?

Groups of students being interviewed were encouraged to add on to each other's ideas and ask each other questions. Following the interview, each group of students were asked to synthesize the shared ideas about what it means to take a stand and design a poster to share with the whole group. These synthesized ideas were then shared with the whole group.

The second interview of the girls in STARS took place after the completion of the weekly meetings and after the final showing of the STARS film. Interviews were approximately forty-five minutes and were conducted in a semi-structured, open-ended interview format with individual students (Patton, 2003). Each interview was video recorded and I took field notes to help modify and adjust the next question if necessary. Sample questions that I asked were (see Appendix B for full set of questions):

- 1) How has STARS impacted your life?

- 2) In what ways were you a leader in STARS this year?
- 3) Give me an example of how you used your science knowledge to take action on this science issue.
- 4) How will you take action for or against something in the future? In high school? Next year in eighth grade?
- 5) How has STARS changed you personally?

**Student-produced artifacts.** Various artifacts that resulted from interactions in, across, and on the margins of activity were collected and analyzed. Student-produced artifacts including journals, explanatory models, film scripts, nature walk sign brainstorming posters, nature walk sign drafts and final versions, and the final documentary film were collected and analyzed. Journals were not only for recording scientific information, but were also used as an art sketchbook with the girls adding in personal drawings, pictures of themselves and each other, and shared messages to each other as they worked in STARS activities. The scientific explanatory models were used as a tool for modeling, drawing and writing, evidence-based scientific explanations that the girls then used as tools for having sense making conversations with each other and with community members. The explanatory models also served as a tool to guide sense making conversations around how to use science knowledge to take action in their community. Multiple drafts and versions of scientific explanatory models were developed and used in and across multiple activities in STARS (see Appendix D). Draft and final scripts that were written by the girls to narrate their stop-gap animation film were collected, as were pictures of storyboarding ideas that were drawn out on whiteboards. In addition to the documentary film as one method to communicate with community and take action to help the future of the polluted lake, the nature walk signs were engineered by the girls in collaboration with teachers and

community members (see Appendix E). The scientific explanatory models were used as tools to help decide what to include on the signs as a way of communicating with a large part of the community needed to know. Community members installed the signs around the lake at sites selected by the girls where the girls felt the message of the sign would be most impactful in terms of who would be in certain areas of the park in relation to the lake.

### **Data Analysis**

Data was analyzed to gather evidence around how the girls participated in activity in STARS to answer the question of how the girls authored themselves in various activities in STARS. Using an ethnographic approach to data analysis, I analyzed and looked for triangulation between data sources through multiple iterations of analysis of activity in STARS (Calabrese Barton et al., 2012; Merriam, 2009). Focusing data collection on how identity is enacted in and through “language together with other stuff” I focused on Big “D” Discourse that includes the “talk, actions, interactions, ways of thinking, believing, valuing, and using various symbols, tools, and objects” that the girls engaged in and with through social and scientific activity (Gee, 2011, p. 28-29). Through data analysis I aim to illustrate “the dynamic patterns of individuals' participation” to problematize what it means to positively or negatively identify with or in science by examining where and how identities in relationship formation intersect with science identity development (Rogoff, 2003, p. 23).

**STARS activity across time.** In the first round of analysis I reviewed all data sources from the entire study to hear and see the data in a holistic manner. I first listened to all post-STARS interviews, then listened to initial STARS interviews, watched all video from meetings, and finally viewed the documentary film. As I viewed these videos I began to form a matrix of time and key events across STARS (Table 1). I reread all data memos that I had written

throughout STARS and noted in the matrix more specific information about activities. I then examined student-produced artifacts—scientific explanatory models—both small and whole group drafts and revised versions, journals, nature signs, and investigations—to add to my matrix of STARS activity and key events. After this initial round of data viewing, I noted two central themes that described the participation of the girls—scientific activity and relationship formation activity.

Table 1.

*STARS Science Activity & Relationship Formation Activity*

Week	Science Activity & Relationship Formation Activity	Artifact from Activity
1	Introduction and welcome to STARS Introductions and why we came to STARS; getting to know each other games Small and whole group conversations about science in our lives Survey of issue-based science interests: environmental, brain-based, music	“Getting to know you” surveys and bingo game
2	Elicitation of incoming ideas on local science based issues Small and whole group conversations about science in our lives: what issues around you call for action and are science based? Communication of science ideas with others-share out of small group ideas	Film storyboarding & scripts Journals
3	Elicitation of incoming ideas on local science based issues Survey of teachers and community members about local science issues of concern Small and whole group conversations about science in our lives Communication of science ideas with others- share out of small group ideas	Film storyboarding & scripts Survey data of school and community knowledge
4	Take a Stand small group interviews-where have you taken a stand for something, someone, and a science issue?	Take a Stand posters
5	Decorating journals with pictures, stickers, drawings Take a Stand poster share-out Whole group discussion around what it means to take a stand for (or against) something What we want to take a stand for decision: Local Lake Evergreen pollution problem Examining local watershed area data	Journals Take a Stand posters STARS Take a Stand Message Film storyboarding & scripts Sense making ideas/questions about watershed data
6	Mapping external and internal sources of lake pollution Water testing investigation-focused on measuring amount of phosphate in water Recording of data in journals Whole group sense making discussion based on water quality and meaning of what it means for group to take a stand for lake	Maps of local watershed and sources of pollution Water quality data Film storyboarding & scripts Journals
7	Decorating journals with pictures, stickers, drawings Fun and informative field trip to Evergreen Lake Observations of Evergreen Lake—Recording of observations and questions in journals; mapping questions and sources of incoming water onto map of lake and surrounding park Whole group conversation around lake observations and questions	Maps of local watershed and sources of pollution Water quality data Film storyboarding & scripts Journals
8	Decorating journals with pictures, stickers, drawings Formation of Evergreen Lake explanation expert small groups (4-7 girls/group): nutrient overload group, cyanobacteria group, floating island group Examination of local watershed data Whole and small group discussions of Lake observations, questions, and evidence needed to answer questions	Water quality data Film storyboarding & scripts Journals Explanation group draft models
9	Expert group science investigation design-testing phosphate amount on plant growth, plants ability to soak up phosphate, and bacterial growth in different amounts of phosphate induced agar Small group conversation around hypotheses and evidence needed to answer expert group questions	Film storyboarding & scripts Journals Explanation group draft models Explanation group investigation designs
10	Expert group science investigations (see week 9) Small group expert group conversations-making sense of investigation data and meaning to science explanatory model and pollution/solution hypotheses	Film storyboarding & scripts Journals Explanation group draft models

	Preparation and practice to share small group ideas out with whole group-selected what and who would share key evidence with whole group, practiced, and brainstormed questions that they needed to ask other expert groups	Explanation group investigation designs, hypotheses, data, conclusions Whole group share-out scripts and questions
11	Decorating journals with pictures, stickers, drawings Whole group pollution and solution hypotheses mapping and sense making discussion Expert group science investigations Small group expert group conversations Preparation for female scientist interviews: Expert groups chose one local female scientist to visit to gather information and evidence for working model	Film storyboarding & scripts Explanation group draft models Explanation group investigation designs, hypotheses, data, conclusions Pollution and solution hypotheses List of questions for scientist interview day
12	Female scientist interviews-lakes and streams ecologist, restoration ecologist, county limnologist Brief whole group sense making discussion of knowledge and evidence gathered from interviews	Film storyboarding & scripts Ideas and questions generated post interviews
13	Expert group final science explanation model formation Small group expert group conversations: preparing for presentation, roles, and narrative to be shared with whole group	Film storyboarding & scripts Explanation group models Share-out preparation sheets
14	Expert explanation group science explanation model share-out with whole group Local female scientists invited and participated in whole group discussion of expert models	Film storyboarding & scripts Explanation group models
15	Whole group model construction: All three expert group models were combined to form synthesized whole group model Whole and small group sense making conversations Whole and small group conversations and role playing around what needs to be communicated to community and how it should be communicated	Film storyboarding & scripts Explanation group models Whole group science explanation model
16	Take Action interviews: Small group discussions around how to use science knowledge to take a stand Communication from local scientists on what is needed to help reduce Lake pollution Use of whole group model to think about how to take action to help Lake Evergreen's pollution problem Whole group share-out and synthesis of take action ideas	Take action interview responses and brainstorming pictures (small and whole group) Film storyboarding & scripts Whole group science explanation model
17	Solution expert group formation: Four expert groups to make four nature walk signs based on introduction to Lake pollution problem, solutions for animal lovers, solutions for kids of all ages who play near Lake, and future solutions for Lake pollution	Nature walk sign brainstorming posters Film storyboarding & scripts
18	Solution expert group sign design Communication with local scientists and park manager	Nature walk sign brainstorming posters Nature walk sign drafts Film storyboarding & scripts
19	Solution expert group sign design Communication with local scientists and park manager	Nature walk sign brainstorming documents Nature walk sign drafts Film storyboarding & scripts
20	Solution expert group sign design Communication with local scientists and park manager	Nature walk sign brainstorming documents Nature walk sign drafts Film storyboarding & scripts
21	Solution expert group sign design Communication with local scientists and park manager: Drafts of nature walk signs emailed to scientists and park manager for critique	Nature walk sign brainstorming documents Nature walk sign drafts Questions fro communication with community members Film storyboarding & scripts
22	Solution expert group sign finalization Communication with local scientists and park manager: Changes made based on feedback from scientists and park manager	Nature walk sign brainstorming documents Responses/feedback from community members Nature walk final signs Film storyboarding, scripts, final edits
23	Lake Evergreen field trip Solution expert group share-out at Lake Evergreen	Nature walk signs Film storyboarding, scripts, final edits
24	Documentary film showing event preparation	Nature walk signs Whole group science explanation model Assignments/Jobs for film night
25	Documentary film event: Middle School girls, families, teachers, administrators, local scientists, university faculty, community members attended film event Event was hosted by middle school girls	Community ideas and questions on how to help Lake Evergreen
26-29	Individual post-STARS final interview	Girls' responses to interview questions

**Coding for scientific and relationship formation activity.** For the second round of analysis I used video analysis software, Studiocode, to code all interview and meeting video for both scientific and relationship formation activity (Emerson, Fretz, & Shaw, 1995; Derry et al., 2010; Saldana, 2009). My goal in this round of analysis was to mark science activity and relationship formation activity for each girl in STARS to see what patterns and themes emerged. Relationship formation activity (RFA) was coded as anything that was not specifically related to science talk or actions (i.e. drawing or writing on scientific explanatory models) and was based on interactions or talk around a relationship in STARS or outside of STARS. Relationship formation activity included girls laughing and chatting about non-science topics or issues that may or may not have been prompted by the focused science work and informal, side conversations that took place in the beginning of meetings about family stories, during transition times between activities, and at the end of meetings. Scientific activity (SA) was coded as anything related to sense making in science. This included all science talk and scientific interactions during observations, hypothesizing, investigations, small or whole group sense making talk, and in the drawing of scientific explanatory models. Relationship formation and scientific activity data were coded for all participants across all video recorded activity including meetings (seventy-one hours of video) and interviews (twenty hours), with the note that they could occur concurrently or just scientific or relationship activity happening at one point in time.

From this second round of analysis, four patterns of participation pathways emerged across all nineteen girls scientific and relationship formation activity: Centered science activity and sidelined relationship formation activity, interwoven science and relationship activity, foregrounding science over relationship activity, and foregrounding relationship over science activity. This second round of analysis provided me with an idea of what girls participated in

what ways in STARS, but I needed to do a deep dive in each of these patterns in order to understand what identities were at play in the scientific and relationship activity within each of these patterns in order to answer the question of how girls author themselves in the STARS activities such as investigations, scientific model groups, scientific action groups, and documentary film production.

**Coding for positioning, agency, and cultural expectations in activity.** To gather evidence around specific activity, in the third round of analysis I chose to focus on four girls, one from each of the four participation pathways that emerged in the second round of analysis, to do a deep dive analysis into their scientific and relationship formation activity. The four girls I chose to feature as case studies were chosen because they were present for nearly every STARS film production meeting on Tuesday and for every Thursday STARS meeting. In this round of analysis I focused on Discourse analysis, coding for all specific aspects of scientific and relationship activity around positioning, agency, cultural expectations, and making sense of science and taking action across all STARS activity. I tagged how the four case study girls positioned themselves, were positioned, how they interacted with others, how they communicated their ideas, how and when their cultural expectations were part of activity, and how they made sense of the science in science activity (Table 2). Using video analysis software, Studiocode, I selectively transcribed coded sections and noted body movements and facial gestures in tagged scientific and relationship activity for each of four case study girls to construct cases around what identities emerged as they engaged in science and relationship activity. This coding with, in, and across activities revealed three themes about how each girl authored herself in this afterschool science club. In the next section, the findings section, I describe the four participation pathways based on these three themes that emerged: participation in activity,

expression of ideas with each other and the community, and working towards a future image of what is possible.

Table 2.

*Coding Framework: Positioning, Agency, Cultural Expectations, and Scientific Activity*

Coding Category	Coding Subcategories	Who was in activity?		
		Individual girl in STARS activity	Two or more girls in activity	STARS in activity with larger community
1 Positioning	1.1 How they positioned themselves	<ul style="list-style-type: none"> <li>• Leader</li> <li>• Science expert</li> <li>• Social</li> <li>• Change agent</li> </ul>	<ul style="list-style-type: none"> <li>• Leader</li> <li>• Science experts</li> <li>• Social group</li> <li>• Change agents</li> </ul>	<ul style="list-style-type: none"> <li>• Responsible for social change</li> <li>• Economic positioning</li> <li>• School science vs. STARS</li> </ul>
	1.2 How positioned by others	<ul style="list-style-type: none"> <li>• Leader</li> <li>• Science expert</li> <li>• Social</li> <li>• Change agent</li> </ul>	<ul style="list-style-type: none"> <li>• Leader</li> <li>• Science experts</li> <li>• Social group</li> <li>• Change agents</li> </ul>	<ul style="list-style-type: none"> <li>• Leaders</li> <li>• Science experts</li> <li>• Social group</li> <li>• Change agents</li> <li>• Unique recognition</li> </ul>
	1.3 Interactions and shared stories	<ul style="list-style-type: none"> <li>• Cultural, ethnic, family sharing</li> <li>• Social outings</li> <li>• Informal science chat</li> <li>• Kindness &amp; fun</li> </ul>	<ul style="list-style-type: none"> <li>• Cultural, ethnic, family sharing</li> <li>• Social groups/sharing</li> <li>• Science groups/sharing</li> </ul>	<ul style="list-style-type: none"> <li>• Seeking information:</li> <li>• STARS group contacted by outside group</li> </ul>
	1.4 Unique role, positioning, or action	<ul style="list-style-type: none"> <li>• Confidence</li> <li>• Resilience</li> <li>• Positive encouragement</li> <li>• Gender related talk</li> <li>• Future talk</li> </ul>	<ul style="list-style-type: none"> <li>• Confidence</li> <li>• Resilience</li> <li>• Positive encouragement</li> <li>• Gender related talk</li> <li>• Future talk</li> </ul>	<ul style="list-style-type: none"> <li>• Confidence</li> <li>• Resilience</li> <li>• Positive encouragement</li> <li>• Gender related talk</li> <li>• Future talk</li> </ul>
2 Shaping and making sense of science	2.1 Communication of ideas	In small group In whole group Lived experiences Family story Science ideas	Questions asked to each other Adding on to other ideas Encouraging responses from each other Active listening Social talk activity	Film Signs around lake Interviews with scientists Out of stars talk about stars-with friends, other teachers, or families
	2.2 Sense making of science and taking action	Communication of science: Film, signs, telling family or friend about stars Science practice: investigation, modeling, revision of model Data/evidence: using data make sense of science Materials/tools	Explicit use of scientific practice(s) (talk or action) Shared lived experience (community summit, interviews with scientists) Data/evidence Materials/tools	Work /influence with/by community members/other actors STARS as influence of community future Local scientists Park department Other interested parties

### **Findings: Scientific and Relationship Formation Participation Pathways**

What stood out in the data was the variation in the ways the girls participated in different activities; each girl had a signature way in which they developed scientific explanations and worked on formed relationships in STARS activities. I organize the findings around four participation pathways that represent identity trajectories in STARS. To illustrate these pathways I describe four cases of how girls authored themselves in STARS by describing their work on science explanations and relationships with others. For some girls their work centered on doing science investigations and they sidelined the building of new relationships, for others their work on science activities was interwoven with the formation and maintaining of relationships with peers, other girls invested themselves in doing science and relationship activity fell to the background, still other girls invested heavily in building relationships and science fell to the background. Each case is a rich description of how one middle school girl used agency and positioning within cultural expectations to figure themselves in STARS and how STARS figured them. Each case is divided into four subsections: 1) Introduction to the focus girl, 2) How the girl engaged in, across, or the margins of activity (investigations, scientific model groups, scientific action groups, and documentary film production), 2) How the girl expressed ideas in STARS with each other and the community, and 3) How the girl worked towards a different future.

#### **Romeesa—Centered Science and Sidelined Relationship Formation Activity**

The first case of authoring features Romeesa's participation pathway and exemplifies the participation pathway where girls had centered scientific activity and sidelined relationship formation activity. Romeesa's scientific activity did not take place on the sidelines and was centered on how she positioned herself and was positioned by others as a leader in the use of scientific practices. On the other hand, her relationship formation activity played out on the

margins or the sidelines of STARS activity and focused on her family, both in the United States and back in the Middle East, and on her desire to make female Muslim friends both in and out of STARS.

**Introduction to Romeesa.** Romeesa, a seventh grader, came from the Middle East to Evergreen Mountain City a year and a half prior to joining STARS. Leaving behind her “big family” she was forced to flee the Middle East with her Mom, Dad, and brother after having her apartment, located above her Dad’s place of employment at a mall, bombed in the middle of the night. She recalled waking in the middle of the night in a room she shared with her mom and baby brother to a “Boooooom” and running to the kitchen to see what happened. She claimed that the curtains in the window “saved us” because they caught the debris and “mud” from coming in. Her journey to Evergreen Mountain City came after “lots of appointments and appointments and appointments” for two years in another country, eventually making her way to Evergreen Mountain City as a refugee.

Romeesa shared this story multiple times with the STARS teachers in one-on-one conversations in the beginning or at the end of a STARS meeting, usually in conjunction with her struggle to confidently maintain friendships with other Muslim girls in and out of STARS. These conversations would occur on the margins or sidelines of the main activities of the meetings. Romeesa’s sharing of these deeply personal stories occurred at separate times from Romeesa’s activity in science. During science activity, Romeesa was exceptionally focused on doing and learning science in STARS for the greater purpose of going to college. She made it clear that her the relationship formation activity and activities around learning were not to intersect.

You should know that I came to America for a future, not to just play. And mess up with things and fight with someone. And I just like came to get A+ and have a good future and be a doctor...My only wish for coming here is to get to college. (Post-STARS interview)

**Positioning in and across multiple STARS activities.** Romeesa positioned herself as a leader of scientific practices in and across multiple types of scientific activities in STARS and authored a new self as a leader in scientific practices. The ways in which she positioned herself and how others positioned her as a leader in scientific practices had a domino effect, meaning that when she took on one lead role in one scientific activity another lead role would soon follow as she engaged in and across various forms of scientific activity.

During science investigations, Romeesa diligently wrote down the procedures and data for each science investigation in her journal. In the meetings she carried her journal with her at all moments of investigations, recording all steps, data, and questions. This action differed from other girls investigation practices in STARS as although all girls were prompted to do similar recording in their journals by lead teachers, many girls made the choice not to and instead relied upon only a few students such as Romeesa to attend to this recording. This positioning by herself, her peers, and teachers as being dedicated to the essential scientific practice of appropriate procedure and data recording resulted in a role of the communicator of procedure and data, a role that she carried throughout STARS. She was the person that the teachers and peers would go to for specific data needed to support claims around why Lake Evergreen was polluted and how it needed to be cleaned up. What was interesting was that when Romeesa would talk about the evidence her role would then shift yet again into the hypothesizer about what the evidence meant. This domino effect of roles nearly always resulted in further whole group discussion about the meaning behind the data and what questions remained unanswered.

This scientific leader position extended into her work when co-constructing an expert scientific model of how the floating islands in Lake Evergreen were trying to clean up the excess phosphorus. With her entire expert model group, Romeesa took the lead on the evidence of how the lake was being cleaned up. She was asked by her group to draw the model of the floating islands on the whiteboard, a model that became both their working model and final version that Romeesa ended up presenting to the entire STARS group during the expert group share out time when all of the scientific explanations from three expert groups were brought together. Her role of scientific practice leader while investigating positioned her as a lead communicator of a third of the overall science explanation.

Her positioning by self and others as a science leader continued into her work on taking action with science knowledge as she worked with other girls in both designing nature walk signs and in the production of the documentary film. She was positioned by her expert solution group to coproduce a future solution to the lake pollution that consisted of a chart that explained what a bioswale was and how it could work in their local park. During film production meetings Romeesa was positioned by the videographer and herself as a narrator of the science activity in STARS and what STARS meant to her:

Hello, I am so proud that I am in STARS where we stand up for science. We start by standing up for Lake Evergreen. We can't fix the whole world because we are a small group. I learned that standing up for things is amazing. You will be so proud of yourself when you help or stand up for something. That's it! (STARS documentary film)

As Romeesa testified in this segment from the STARS film, she was extremely proud of her science activity in STARS and was not afraid to state how proud she was of herself and how proud her family was of her for being part of STARS and being featured in the documentary

film. The roles and the activity that Romeesa engaged with in STARS were a result of the various ways that she was positioned as she engaged in and across activity.

What is interesting about Romeesa's engagement in and across activity is that her activity with these science identity-forming activities did not intersect with her relationship activity. Her relationship activity remained sidelined in regards to her scientific activity. In the next section I discuss how Romeesa's expression of science ideas were directly linked to a deeply engrained story of Romeesa's, cultural expectations around gender that guided much of how Romeesa spoke up in STARS.

**The freedom to express herself and science ideas.** The first day that Romeesa walked into STARS she immediately decided to take her hijab off and let her hair down. The other females in STARS that identified as Muslim responded to this action and quickly stated to Romeesa that they were keeping their scarves on and so should she. Romeesa immediately responded by wrapping her white scarf around her hair and neck. As others got to know Romeesa in STARS, it was realized that she was always eager to remove her scarf in our all-female science space for it was her routine to remove her scarf immediately after school at home. When professional pictures were taken for the documentary film Romeesa posed for multiple pictures with her hair being restyled for and displayed as full as possible in each frame. When she produced her final piece for the STARS film, she had her hair down and reassured the lead teachers that her mom was ok with her being shown on the film, a film in which would shown and made available to the public.

Cultural norms, such as wearing a hijab and being able to take it off in the presence of all females, were cultural norms that mediated Romeesa's actions in and out of STARS. Romeesa's

mom, Lamis, wrote a note on Romeesa's start-up packet that needed to be signed and returned in order for Romeesa to join STARS:

To Ms. Carter and the other teachers:

I want to say that Romeesa really love science that why I get her in stars because I want to eprove (improve) her science more and more and I let her join this group jas (just) because it only gurls (girls) and her frind (friends) are in it I did not let her join any group expet (except) for that one because it only girls and thank you guys for making this science star I am so proud and like this group of girls.

Thank!

Romeesa's mom-lamis

The fact that STARS was an all-girls space fit within Romeesa's norms and made it ok for her to be there after school. When asked in her post-STARS interview about why she joined STARS Romeesa stated:

Romeesa: I joined STARS because it's just for girls, that's one reason I joined it. Because like it's a big reason because my mom—I was going to go to the club where we dance and things but then I just changed. My mom was like, "We don't like dance, you know that." And then I was like okay, it's my religion. We can't dance. So I choose STARS because it's just for girls. I also choose it because my friend Lan was here. And I also choose it because I'm not good at science and then I figured out that I just love science.

Author: So tell me more about just being girls. Why was that important to you? And then maybe talk about why it was important to your mom also. With STARS.

Romeesa: Because of my religion.

Author: So tell me more about that.

Romeesa: Actually I don't like sitting with boys. Just...I don't like it. I just like being with girls.

Author: How come?

Romeesa: Because I like taking off my hijab so I join girls, because if I'm joining a club that you have to wear your hijab that's a little tricky because I don't wear it after school.

Author: So you'd rather take it off after school.

Romeesa: Yeah, yeah.

Both Romeesa and her mother, Lamis, made it clear from the start of STARS that being an all girl group meant something different to them because of their religion. For Romeesa, it meant a free space to express herself, free of culturally-set gender constraints. In Romeesa's final STARS interview she referred to "sharing in STARS as freedom." To her sharing in STARS was different than sharing in science class because of mixed gender versus an all girl space. "I think that's different between is...there are people that are nice in STARS and in science it's not really nice because there are—I told you that there are the boys in there." The figured world of STARS for Romeesa was a place without gender constraints. Without this she was free to take on the roles that resulted from the positions she was given and the ones she gave herself.

Although Romeesa's science activity and roles continued to thrive with one role generating a new lead scientific role, her relationship activity with friends represented a struggle and seemed to remain in a static position. The sense of freedom in this all girl space was a space that Romeesa tried to find herself friendships with other Muslim girls. The other eight Muslim females in STARS were all eighth graders and according to Romeesa were not always nice and would "bully" her. Romeesa would unhappily confide with the lead teachers on how she was

trying to get her other friends from her seventh grade science class to come to STARS telling them how much she loved going, but they did not come. One lead teacher attested to Romeesa's struggle with finding friendships with other Muslim girls in STARS and in school.

Lead teacher: Romeesa said some of the girls are bullying her and she said 'yeah, some of the girls are bullying me and I just want to take my scarf off and some of the girls from the Middle East are like making fun of me.' She was going back and forth between here and science class so I asked her do you mean STARS or science class and she said 'both.'

As mentioned in the very beginning of this section, her discourse around the struggle for relationships in STARS was a frequently visited social story that would only come up during non-science times in the beginning or at the end of STARS meetings. It was also frequently tied to her story of making it to Evergreen Mountain City as a refugee. In this activity, her focus was only on these two topics and although support was offered and norms were revisited in STARS with all of the girls, this position of needing more friends and truly desiring them continued throughout STARS. What was most striking about this was instead of letting this get in her way of flourishing in science, this story would be set aside in all science activity and it did not shift her focused science activity in any noticeable manner.

**Working with family towards a different future.** For Romeesa being a member of STARS meant an opportunity for a better future for herself, a better future because she would be educated and had more opportunities to choose from in the future. Being a member of and doing science in STARS represented an opportunity to be different than her cousins back in the Middle East, cousins who were her age and getting married. Romeesa's lead role and focus on scientific practices were positioned outside of STARS when her father took her STARS journal to the Middle East to showcase her scientific work to her entire extended family that she left behind.

Her STARS journal held significance to her and she frequently talked in her post-STARS interview about “being proud and thinking about science when I am holding my journal.” When her father shared her STARS journal with her family in the Middle East they said “ ‘Oh, that’s so cool. I wish I can come. I wish I can come to America and join that group.’ ” To Romeesa, her father showing them her STARS journal made sure her family back in the Middle East knew she was different than her cousins.

Romeesa: They are my cousins. And like they all married like early. None of my cousins, boy or girl, have a good future. None of them, none of them finished even elementary school. My friend, she stopped going to school at 5<sup>th</sup> grade.

Author: What does that mean to you?

Romeesa: That means they’re child, like their mind is childish. I don't like doing that. I want to grow up, my future I want to be a doctor. I don’t like marrying early. Too early. It’s too early. Really too early. ((laughs))

Author: And what does—how do your parents think? What do they think about that? That you want that?

Romeesa: My mom wants—that’s what my mom wants. So my mom is proud of me that I think that.

Romeesa carried this position of being different than her cousins into the STARS space and acted with agency to reshape who she was in this gender-restriction free space. She participated in STARS and positioned herself as free to learn, express her ideas, and think about future opportunities could be different because she was not in the Middle East. This free will of

Romeesa's was apparent as she participated in activity around taking action with science knowledge.

Taking action with science in STARS meant that Romeesa was also a part of making a change with her STARS peers to build a different future for the larger community. Two times in her film narrations, written on two different film production days separated by five weeks, Romeesa wrote and stated on the film "we can't fix the whole world," but expressed in multiple settings including her film narration that they can stand up for things together and it "is amazing to take a stand." When Romeesa was planning how she would like to take action with her science knowledge she brainstormed with a group of peers how they could interact with elementary students to help them see how the lake could be cleaned up for them to use and enjoy. Romeesa took a lead in brainstorming the four signs that would become the sign walking tour for all community members to be part of. These actions were similar to her relational positioning of herself as different than her cousins back in the Middle East. She could not change them, but she could change herself. Similarly in STARS, she could not "fix the whole world" using her science knowledge, but she could change one part of it.

**Summary of Romeesa's participation pathway.** Romeesa authored herself in STARS as a place to forge a new identity as a scientific leader but also as a place where it was difficult to build friendships (Figure 1). In this female-only afterschool science space she was immersed in a space where she was free to define who she was as a knower of science who can freely express all ideas, take lead roles across group activities and be one that is depended upon by others as the knower of the science. The absence of males in this science space meant that she could act with agency to decide how she was positioned as a doer and knower of science. Relationally she struggled to form friendships with the girls she felt she could form friendships with, other female

Muslim girls. It is important to note that while I describe Romeesa's way of authoring, her participation pathway, describing her relationship activity as sidelined to her central scientific activity it is likely that her relationship activity was at play, but not observable from evidence gathered in this study.

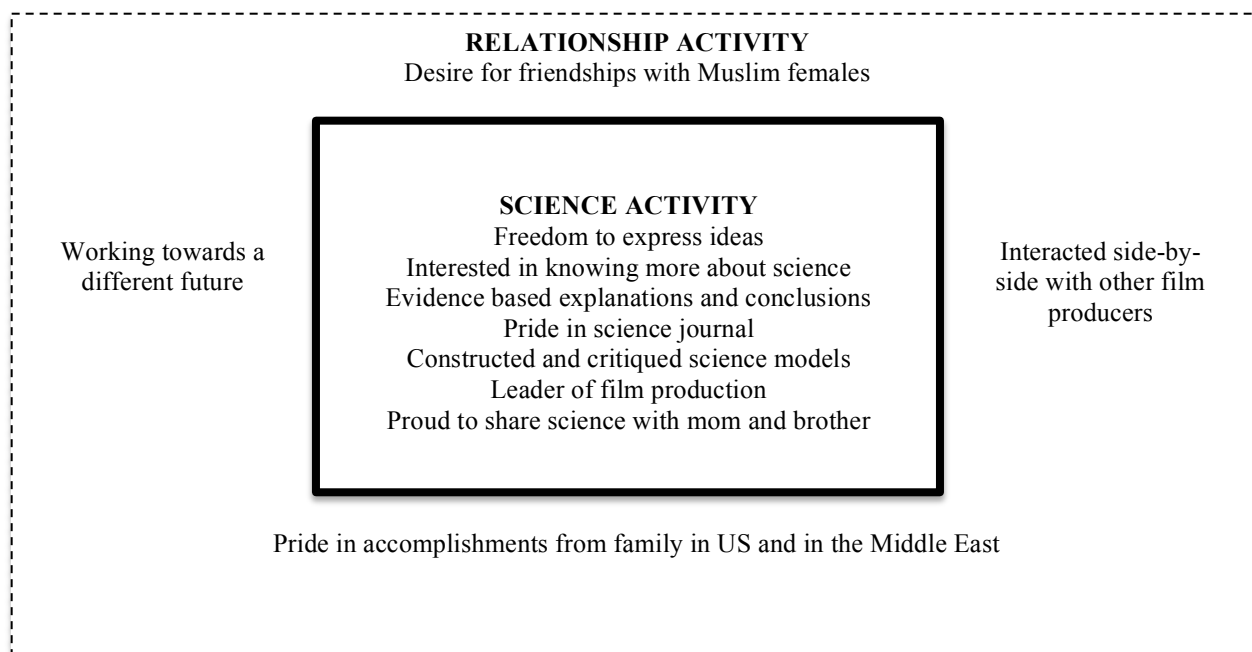


Figure 1.

*Romeesa's Participation Pathway.* Scientific activity remained at the center and relationship formation activity remained on the sidelines of science activity.

### **Gabriela—Intersecting Science and Relationship Formation Activity**

The second case of authoring features Gabriela's participation pathway and exemplifies the participation pathway where girls had intersecting scientific activity and relationship formation activity. Gabriela's scientific activity was carefully intertwined with her social activity. In this section I describe how Gabriela positioned herself as a leader in scientific activity as she developed strong relationships with other girls in the club.

**Introduction to Gabriela.** Gabriela, an eighth grader, lived with her family of eight and joined STARS to explore science in an out-of-school space. “It like got my attention about science...I’m interested in science and I wanted to do it out of school because I think you can do more stuff...because in school you have to be more strict because of the rules.” In the beginning of STARS Gabriela shared that she “tried to get to stay home sick from school but usually can’t because they (her parents) won’t be able to go to work and we won’t have money” because at school “we do boring stuff. Like the teachers are boring. Like we don’t have fun.” Reflecting upon STARS in her post-STARS interview she stated that “we did projects and science and cool stuff like I never knew nothing about (in STARS). I wish school was funner like STARS. Like if it was funner I’ll like it more.” Similar to Romeesa’s retelling of her story to the United States, Gabriela would retell this story around being bored in school, yet always attending STARS and always in full participation. An important note about Gabriella was that she was extremely quiet in STARS. It was through her subtle body movements and facial expressions along with what was initially little talk did she author herself in this afterschool club.

**Positioning in science and filmmaking activity.** Gabriela’s activity with most activities was through body and face movements and not talking in the first half (meetings 1-14) of STARS. In her science investigation activity, Gabriela would work side-by-side with peers and lead teachers doing science and collecting data, only responding to questions when asked and sometimes just gesturing to answer a question. She ended up working in most of her expert model group and solution expert group work with the same peer who came to routinely ask Gabriela “what do you think?” throughout all of STARS. This prompt gave Gabriela permission to speak up and share her ideas, otherwise when engaged in science activity she would continue working diligently on the task at hand. All video of her in science investigations, which took

place early in the first half of STARS, showed a neutral face throughout all activity. She did not smile or change expression as she worked on a task, nor did she ask for help. She looked on eagerly as others talked to her or each other about the science and appeared to be soaking in all of the talk and activity that surrounded her. Although she was silent, she was extremely productive in science activities. She was a leader in setting up investigations, recording data, and listening to others reason about the data. Her silent-productive role carried through into her expert scientific model group, where she became a key player in drawing her model, a silent key-player with only responding if called upon. Although her silent-productive role remained relatively static for over one half of Thursday STARS meetings, it began to shift at the mid-point of STARS when Gabriela became active in Tuesday film production meetings.

Gabriela attended every film production session with two girls, Nina and Carla, who over the course of STARS became Gabriela's good friends. Nina and Carla were described by other STARS girls as "the popular girls" and enjoyed STARS in an extremely social way. Nina and Carla, like Gabriela, spoke primarily Spanish and were both of Latin American descent. Gabriela did not have classes with either of them during the school day and STARS became their time with each other. In Tuesday film production meetings, Gabriela was able to use the science knowledge she listened to in STARS meetings to write scripts and simultaneously was able to form a deep bond with Nina and Carla. Gabriela was extremely focused and productive when on task in film production and while working would listen to and enjoy hearing Nina and Carla talk about non-science and non-film production ideas and experiences. When she listened to them while working she would smile and at times respond to them in Spanish. It was in these film-production meetings when Gabriela's laughter and quiet expressions of joy were first observed. This blossoming friendship spilled over into Thursday STARS meetings very quickly. Gabriela

relied upon the STARS space, both on Tuesdays and Thursdays, as the time she would see, hear, and interact with her new friends. “Because like I barely even talk to them in school...so I got to be more around with them in STARS.” After developing these friendships in film production days Gabriela began to talk and smile more in STARS Thursday meetings. At most times, she remained silently productive when engaged with learning resources, but slowly shifted to asking other group members about her or their ideas and frequently interacted with her two new friends while doing science if they were near her (as they happened to wander from group to group) or if they were in her group.

Gabriela’s lead role in film production consisted of writing, narrating, managing audio recordings and equipment, and producing animation for the film. She had a keen interest in how the film was made.

Because I wanted to know how they do the videos. Like it brought my attention to it. It was cool how they put like...like they would move letters to make this cool thing. Like when you see the video the letters come in and it’s very cool so it got my attention. And that’s why I came. Making it was very long and you have to take fifty pictures just to like put one part of it (stopgap animation), which is like very frustrating. Frustrating like...yeah but I really liked it though. I liked how it came out at the end. It made me feel very proud because I was in there and I helped a lot and I tried my best. So yeah, it made me feel really good. I’m proud of myself, yeah. (Post-STARS interview)

Due to Gabriela’s curiosity and quick ability to pick up production skills the videographer made Gabriela one of the lead audio equipment handlers and film narrators. She was able to handle the equipment and teach other STARS producers how to use it if the videographer needed her to. Although her voice was rarely heard over the of STARS Thursday

meeting video, Gabriela's voice and scripts made up nearly one quarter of the film. When asked what being in STARS meant to her she stated:

All of this time I have been in STARS. I have learned a lot about Lake Evergreen and all the bad things that are in Lake Evergreen. For example, all the nutrients in Lake Evergreen. I really like learning new things that can help me in my future. I really enjoyed learning about Lake Evergreen and I hope to learn more.

Gabriela wrote this statement in Spanish and narrated it in Spanish for the film. In this clip she starts out with a small smile as she speaks about STARS. Her mention of learning four times in this short statement was significant because as discussed in the next section it was important to Gabriela to understand the content in order to feel confident to take on lead roles.

**Finding her way to share science ideas.** Being able to express ideas orally in STARS meant that Gabriela needed to feel confident with her ability to share and with what she shared. Gabriela only voluntarily shared her ideas out twice with the whole group in Thursday meetings over the first fourteen weeks. The first time Gabriela's science ideas were shared with the whole STARS group they were shared by Emerson, a lead teacher, following a pair-share activity in our pollution hypothesis and solution activity during week seven. When Emerson shared Gabriela's ideas, Gabriela stood next to her and maintained a look of uncertainty as Emerson spoke. When the group responded with acceptance by responding to Gabriela's idea, Gabriela added on her solution hypothesis "To clean the lake we need more people to help us and tell pet owners to pick up pet waste because pets can get sick from lake water." Her second share out with the whole group would not come out until week fourteen, but was a significant audience to share out to. Gabriela was the first person in her expert model group to share out their explanation to the entire group and local scientists. Gabriela was encouraged by the lead teacher with Collette

saying “you will be fine, you will do great.” Throughout Gabriela’s explanation she fidgeted with her shirt and looked extremely nervous, but was able to take on this new role of reporting out to the entire Thursday STARS group.

OK, so, here is um, a before and um after picture with trash and here is the floating islands with plants and there are roses and, um, other stuff in here. (group members and lead teacher speak out to support her sharing what plants are on the floating islands- “hedges, grass”) Um, yes, which makes the water clean. And that’s it. (Gabriela’s piece of expert model share out to whole Thursday STARS group)

After Gabriela’s expert group finished, the entire group applauded in appreciation. Gabriela was not required to present and did not have to be the first group member to present. She chose this role. What is most interesting about this moment of oral communication is that it intersected at week four of becoming friends with Nina and Carla in film production. This could be the moment that Gabriela became more comfortable in speaking her ideas after finding her comfort socially in this group on both days of the week.

After this experience Gabriela did not begin to share out loud frequently, but what did change was how she worked in her small solution expert group to construct her sign for the walking tour. Gabriela’s silent productive role throughout most of STARS helped Gabriela construct a deep understanding of the science behind Lake Evergreen. Learning the content was essential for Gabriela and primed her to be ready to work on these action-oriented signs. Gabriela relied on working with others because then she did not have to worry about not understanding something, feeling like there would be others to help her learn it if needed. She felt that if she learned the content then she could help someone else learn it to. When asked to describe her role in STARS she described herself as a leader who could help others understand.

Like just to be like a leader to help...like if I don't know something maybe the person can help me and like I can learn from that person and show somebody else. Like it was to like help each other. Like for example if somebody didn't know what to do I would explain to them because somebody would explain to me. So I would take what they told me and tell them. And like I would help them all. Like for example if they didn't know about the molecules I can explain to them and tell them it's this and that. It made me feel like proud of myself because I know I'm helping somebody. Like you know what I mean, right?

(Post-STARS interview)

Her description of herself as a leader is fascinating as I hypothesize that she was allowing others to be leaders throughout most of STARS so she could build an understanding. Gabriela's comfort with the content was quietly flourishing in her silent productive role, her relational role was flourishing and allowing her to find a space of belonging were eventually she was able to lead her expert solution group in designing their walking tour sign. In the brainstorming session, she quietly wrote ideas on the poster and she took on the role of lead illustrator throughout the sign making process for five weeks. She did continue to verify ideas with her group members and get agreement by all if she added something, but she was the one who ultimately decided where pictures would go and what words were added. Gabriela did not speak loudly or hardly at all, but her science ideas were loud and clear on her sign and in the film.

**Working together towards a different future.** Gabriela's activity in STARS changed as she participated in building both scientific and relationship identities within the group. Her ideas, though not shared much in STARS, were expressed in a more permanent manner in her sign and in the film. She came into STARS not liking science in school and at the end of STARS stated how STARS changed her personally:

Well it changed about, what it changed me was it like at first I thought science was boring. Like I didn't like it. But now I got into it and I started liking it because I learned new things. And maybe those things can help me in my future. And I thought that was very cool because I never knew nothing about science. And like I started liking it so that changed me a lot. (Post-STARs interview)

What was most apparent about Gabriela was the way that she was smiling in her interactions in STARs meetings in the last four meetings. In video she no longer held a neutral face of expression, but there were smiles. She would be the one to ask her group for verification of an addition to their product in STARs meetings and was a continued leader in producing the film that would ultimately be made public and held much power for changing how many people thought of the lake's future. In our second to last meeting when the expert solution groups shared signs Gabriela spoke second in her group with confidence, smiling and almost laughing at times:

And here we have a after picture and we have dead fishes because there is like no air going in, only a little bit of oxygen (moves her hands in a swirling down motion and smiles, crowd laughs in appreciation, Gabriela produces a huge smile). And there are no plants and people are walking away from it. And it is healthier here (points to picture of lake in past).

As she presented she looked around to the other members and appeared to be having fun while speaking out loud to the whole group.

**Summary of Gabriela's participation pathway.** Gabriela's participation pathway was initially about subtle, silent productive activity with multiple people and through her engagement with various identity forming activities and people that how she interacted with others changed. It could be said that Gabriela "came out of her shell," but I think she was always out of her shell

and just waiting for the moment for others to recognize her as such. This recognition, which in her case was the leadership roles in film production and forming deep friendships with other Latina girls, literally changed how she stood up in front of others and gave her “permission” to not have to be asked for her ideas, but rather share them as she felt like it.

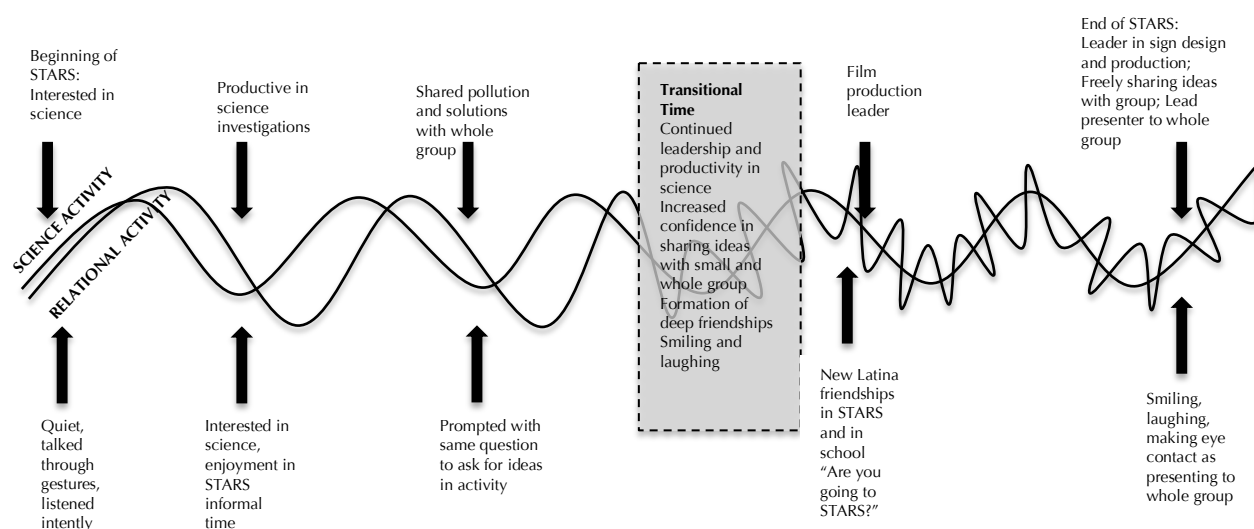


Figure 2.

*Gabriela’s Intersecting Science and Relationship Formation Activity.* Note the key transitional time for Gabriella as she formed deep friendships with two other girls in the science club.

### **Lily—Foregrounding Science over Relationship Formation Activity**

The third case of authoring exemplifies the participation pathway of foregrounded scientific over relationship formation activity in STARS. Lily’s scientific activity was foregrounded, meaning that it was the main activity that was coded for, and her authoring in scientific activity shadowed her relationship formation activity. In this section I describe how Lily positioned herself as a lover of all things science from the start of STARS and had an extreme desire for learning more science facts so she could tell science stories to other people in her life.

**Introduction to Lily.** Lily, an eighth grader, lived with her Mom, Stepdad Bob, and with her three younger brothers three, six, and twelve years old. She traveled every other weekend to stay with her biological Dad in Oregon. Lily loved everything about stories—both reading and telling stories. She was so passionate about stories that it was one of her biggest missions in life to get her younger brother ready to read, and even more so for him to love reading as much as she did. Lily’s passion, as told by herself, for stories was based on knowing the facts that make up a story. She explicitly related this love of stories to learning in new science ideas in STARS.

In STARS I like being able to do the experiments and do hands-on stuff and I’m also just kind of one of those people who will go and learn random facts and then memorize them and then will go and tell those random facts to anyone who will listen. Because it's cool. So generally little tidbits of facts you learn come from a story and I really like stories and so being able to memorize those means that I can tell something about it and it makes it easier to tell. (Post-STARS interview).

Lily read and learned facts about every topic so she could retell them to others. She sought out audiences, both younger and older, but not kids her own age to tell her fact-filled stories to. “Not like kids in class because I tend not to do so well with kids, like kids my age. Lily shared that she was pushed “to be more like an adult” by her mom when she was seven and so “in that year I matured...ended up getting so used to taking care of my little brothers and helping keep the house running and do the dishes and stuff and like—reading also.”

To Lily, STARS was a world in which everyone was there to learn science so they could retell it to others. “I’ll go home and I’ll spurt out random information at my six-year-old brother because I thought it was really cool... like almost anyone, almost everyone in STARS was interested in science and that’s why they were there.” Lily needed STARS to gather the facts for

her science story, her identity that was about gathering facts for stories, stories that she depended upon in her life. It was with these stories in which she could then communicate with others in her life, those that meant a lot to her.

**Positioning in scientific explanation building activity.** Scientifically, Lily positioned herself as a gatherer of data and facts. “There was the science story and so being able to learn how this caused this, caused this, helps...like sticks in my mind.” When doing science investigations, Lily was on a mission to complete the task at hand, to gather the data, and to move on to the next science learning task. When investigating the level of nitrates and phosphates in the stream water that entered Lake Evergreen she precisely went through each step and upon completion would state, “Ok, after we clean this up we will perform the next test.” This moving on to gather more information activity was characteristic of not only when she was investigating, but also in small group conversations based on learning the facts behind the current polluted condition of the lake. Lily was curious. So curious that she could hardly wait to learn about, really memorize the facts about, why the lake was toxic and needed cleaning up.

In her first expert explanation small group meeting Lily became hooked on the facts about the toxins that the cyanobacteria were producing in Lake Evergreen. These facts about Anatoxin-A and Microcystins became part of a bucket of “Lily’s facts” that she would retell dozens of times throughout STARS to anyone who was around her. “Anatoxin-A is also known as ‘very fast death factor’ because it kills an organism so fast,” was one of her favorite parts about learning about cyanobacteria. When she and her small group peers were provided with newspaper articles and data to take home after this first expert meeting as optional reading, just in case they wanted to read more about the cyanobacteria before meeting again next week, Lily started to read it as soon as she had it in her hands. Immediately upon dispersal of these

resources, Lily started reading them aloud for her group to hear as they started to draft their expert group scientific model on poster paper. Most group members listened to her read; with a few members packing up as the STARS meeting was over and parents were picking kids up. While reading aloud Lily did not look up to see who was listening and upon finishing the article about one hundred elk dying from drinking water with cyanobacteria in it, she stated to the remaining members of the group “this paper confirms that Anatoxin-A is really bad.” Then smiled. At the end of this first expert group meeting, Lily volunteered with the videographer to capture what her group started to think about. Her ride was waiting to pick her up, but she was eager to share this information in this official manner, captured on film.

It’s mostly a problem because the cyanobacteria in the lake produces two main toxins.

Anatoxin A is one of them and the big thing about Anatoxin A is its nickname is very fast death factor because it’s a nerve toxin and basically if it gets inside of your body it goes to your central nervous system and shuts it down. So you can’t breath and heart stops pumping and your brain shuts down and you die. (Script for documentary film)

She chose to focus on the toxins in this script and like many other science fact-based scripts that she narrated, she shared these narrated stories time and time again when she felt they were needed bits of information to build the scientific story. The girls in STARS also depended upon her to share these stories, these facts. She built an identity around being the fact-sharer in STARS, with an initial focus on cyanobacteria followed with facts around a bioswale that could filter water to inhibit growth of cyanobacteria. Lily had immediately positioned herself as a fact gatherer, a role she maintained and a role that her peers and teachers continued to position her in in all STARS science activities.

Lily's role of as science fact leader in STARS meetings carried across into film production activity. At one point in STARS the videographer shared that "Lily was becoming *the* science voice of STARS" when it came to what was being learned in the scientific explanations and the videographer needed to make sure that all girls' voices were heard on the film. Lily was able to tell her science story in the film while taking on the tri-leadership role of writing film scripts, acting out parts of scripts, and producing pieces of the film. When asked if she wanted to express on the film what STARS meant to her, she stated:

Hi my name is Lily and I was in STARS this year. STARS didn't really change how I thought about science because I already really loved it but it did give me access to be able to do science, which was really cool. It was also really cool to be able to see all of the kids who like science who were just like sprinkled in every class that I had be able to come together and do science together and be able to find out really cool things. And it was also really cool to be able to share what I was learning with my family. Especially with my Stepdad because my Stepdad is really sciencey and it was cool to actually talk about things that I felt were more like his level. (STARS documentary film)

For Lily, the film represented her scientific story about Lake Evergreen. Through this film she was able to share a story with multiple science facts with an audience larger than she ever had before. Unfortunately, none of Lily's family came to watch the film at the community film showing event. She stated, "because everyone else (in her family) was already doing something or didn't care enough. My stepdad had to work late. And then my mom doesn't—didn't really want to come because she didn't want to have to load all the kids in the car and take them. But it was okay." She followed this statement with a shrug. Lily expressed that on the night of the film, which was a Tuesday, she was supposed to have girl scouts and instead of

holding the meeting her Girl Scout Leaders decided to come to the film night. Her Girl Scouts Leaders were the ones that brought Lily to film night. Lily was excited about her Girl Scouts Leaders being there, along with some of her teachers. She stated, “and a bunch of the teachers came, which was cool because I managed to convince a bunch of them.” Although Lily’s family was not able to come, Lily felt a sense of satisfaction that her story about Lake Evergreen and its toxicity would be shared with other important adults in her life.

**Expression of all and any science facts.** Two main goals existed for Lily in terms of science facts-learning them and telling others about them. Her initial self-positioning continued throughout all small group activity with her peers and the lead teachers positioning her as the bearer of facts by providing her with a stage to tell these facts. What was interesting was the respectfulness that her middle school peers had for her as she shared these facts time and time again. Peers provided the space for Lily to speak out in every setting. There was no eye rolling or head shaking when Lily spoke up, as she did in response to every question or in any discussion. Instead, she was given the space, the space to speak and tell her ideas and know that her STARS peers received her voice openly. Lily never focused on forming friendships in STARS, with before or after STARS meeting interactions usually occurring with lead teachers.

Lily did not stop telling the science story at the end of STARS. Lily was supposed to ride the bus home after STARS, which meant that she was supposed to leave promptly at 4:15 when the bell rang. Many times the lead teachers had to remind her numerous times that she needed to leave before the bus left her with one time her missing the bus because she wanted to stay at STARS and continue sharing science ideas. When she did make the bus she would immediately go home and tell her Stepdad about STARS because he had Thursdays off, our STARS meeting day.

I came home and luckily for me Bob always has Thursdays off and so I would run from the bus stop home and then I'd be like, 'Bob Bob Bob Bob Bob Bob Bob Bob Bob, guess what we did today?' He'd be working on something and so I'll end up following him around for like twenty minutes trying to tell him what we did. And then Bob will like answer back, because he knew what I was talking about for the most part, or he'd like ask me to explain something more because he didn't know about it yet. And then I'd normally get cut off because I had to go do the dishes. And he'd be like, 'Alright, you need to stop talking and go do dishes now'... And then I'd try to yell at him through the house.

STARS provided Lily with more facts in her world of stories, both in STARS and out of STARS, science facts. This world of science, in her world where everyone was in STARS because of loving science, her job to tell the world how to use science to take action was an easier job.

**Working together towards a different future.** Working as a collective group for Lily meant that the job of telling the scientific story behind Lake Evergreen was easier. Unlike in doing science in her science class, she did not have to convince everyone in STARS to “get interested in science” because “almost everyone in STARS was interested in science.” Related to Lily's role in doing science prolifically, she relished in being productive with a group of peers that were also focused. This prolific role was not only apparent in her film production but also in how she designed her sign for the walking tour. “And so it was kind of cool being able to take a step back and not having to be the leader and not having to like, “Come on, let's get this done you guys.” Because that's not something I generally get to do. And so it was cool being able to work with a bunch of people who came here to do stuff.” For Lily, taking action with her science knowledge was easier because she could work with other productive peers. It was not as much about who she was taking action for, although she did have her stories for her stepdad and

brothers, in STARS it was about productively using the knowledge to tell the story in film and signs with other peers.

**Summary of Lily's participation pathway.** Lily, a lover of science and storytelling, a caretaker, a fact-finder was in her space in STARS. "We are all here because we love science" was how she entered the space and finally felt she was able to share all of her ideas as freely as possible and absorb as many new facts as possible. What was unique about Lily was that she was ready for more relationship formation activity (Figure 3). She recognized the limitations on her ability to form relationships with others, especially those her own age. In her post-STARS interview she revealed a deep sense of these aspects about her and her activity and also expressed a sense of yearning for more fact learning, more spaces to share ideas and stories-both in and out of school. In the next section a case of the participation pathway in which the relationship formation story is foregrounded will be described.

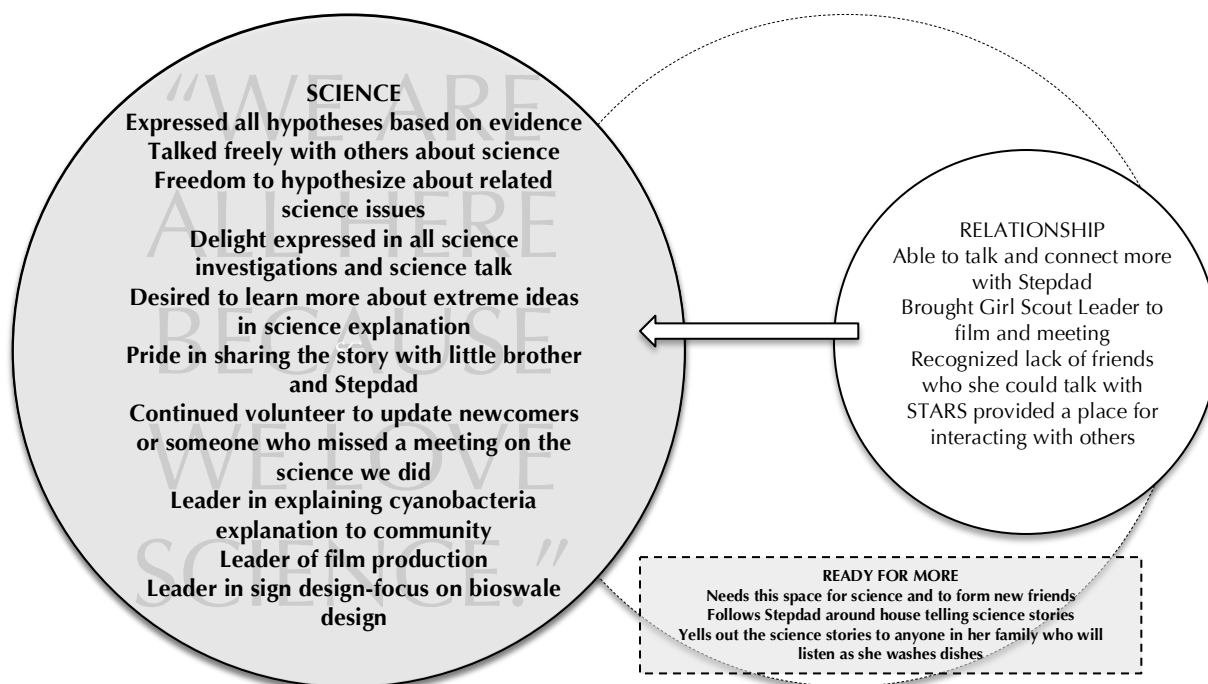


Figure 3.

*Lily Foregrounded Science Activity over Relationship Formation Activity.* Lily foregrounded science over relationship formation activity yet she was “ready for more” relationship activity.

### **Nina—Foregrounding Relationship Formation over Science Activity**

The fourth and final case of authoring exemplifies the participation pathway of foregrounded relationship formation over scientific activity in STARS. In this section, I feature how Nina traveled across various science activities to socially engage with multiple girls in STARS. As she engaged in science activity to strengthen and build new relationships, she found a new comfort in expressing some scientific ideas in the English language.

**Introduction to Nina.** Nina, an eighth grader, moved from South America one year prior to STARS and did not know any English when she moved to Evergreen Mountain City. She spoke of the experience of what it was like to speak up in class right after moving to Evergreen Mountain City:

And they’re [other students] all like, ‘What is she saying? I didn’t have any idea what she was saying.’ And then sometimes she picked my name from the class, I was just getting red and I didn’t know what to say. And then I just started talking in Spanish and then everyone was like looking at me like, ‘Why is she speaking Spanish? We’re in America. We’re not in the home country.’ I was like wow. I was getting really sad. But then I have like other class, English classes, and then I started to meet other people and tell them how they feel and they feel like the same way as me. And then I make new friends and tell them if they can help me about classes and they said they could. (Post-STARS interview)

I start with this part of Nina’s story because finding people to help her with her language and finding a way to share her ideas in English and Spanish was a big part of Nina’s activity and way of authoring herself in STARS.

Nina came to STARS and participated in STARS with her best friend, Carla, another Spanish speaking eighth grader of Latin American descent. They walked into both film production and STARS meetings every week appearing to almost be glued at the hip, always cracking up about something, checking their hair in their phone's photo booth app, texting friends and various boyfriends that came and went in STARS—whom we all shared opinions on—needing to go to the bathroom together in every meeting, and being in charge of music in small group meetings. Nina claimed to have come to STARS to learn about science with the addition of being with friends

[I came to STARS] Because I wanted to experience a new, like, a new thing about science because I didn't like science and I wanted to know more about science. Because like in my home country it [was to] learn about how plants and all that stuff. We didn't seem like, seem fun. And I want to try something new. And I don't know, I just choose science. Because with STARS and like science is kind of fun, if the way you want to take it. Like if you take it with your friends it's going to be like kind of fun. (Post-STARS interview)

**Positioning across multiple activities to get to know everyone.** Nina positioned herself as a social person when in activity with learning identity resources in STARS meetings. Her work with science investigations, expert science models, and walking tour sign groups is difficult to describe because she, as in others in this pathway, floated throughout groups during most meetings. She would wander from group to group gathering a sense and contributing socially to what others were working on. This social position would shift drastically in some whole group share-out times when we were hypothesizing or brainstorming together. For example, in a whole group share out time about how we could take action Nina shared, “we need to get the trash out

of there, the lake and get people to help.” This phrase carried significance because while she worked with her cyanobacteria expert model group, her designated group that she spent minimal time with she referred to the excess phosphorus as “trash” and repeatedly expressed concern with “having to get other people to help clean it up.” She had gained a sense of the science behind our phenomenon by wandering to different groups, but never used the science activities as a means to share her learning.

In film production Nina found a space to share her social life with peers, lead teachers, and the videographer. Producing a stopgap animation film meant that hours of film production was based on moving small pieces of paper for animation small distances and taking hundreds of pictures to ultimately make moving animation on film. It was during these stopgap animation design periods where Nina would talk with us about her life with her mom. Her mom never believed that she even went to STARS twice a week because she did not believe that Nina could care about something besides herself. As we all sat very still around a table moving pieces for the animation Nina would talk on and on about her struggles with her mom not caring and we would all listen.

I did (share about STARS) with my mom but then she didn't believe me that I was like staying at STARS and helping the lake. She was like, 'I don't believe you because you don't really care about somebody else. Or help others.' I was like, 'Mom, you don't really know me. I like to help others. If you don't believe me why don't you call the school and ask them if I'm staying or not?' and she was like, 'Okay, I'm calling.' Then she called and it turned out I was staying after school. And she was like, 'Wow, I never knew that about you.' And like parents don't really know more about their kids. (Post-STARS interview)

This part of Nina's story came up four times in four different animation design sessions.

In the film production sessions Nina was a leader in narrating the film. She did not write the scripts, but was always willing to read them to record for audio. In our last film production session where the girls spoke their native language to discuss what STARS meant to them, Nina's mom did not let her go as her punishment for something was being grounded from going to STARS. This saddened Nina and furthermore the fact that her mom did not come to the film that she took a lead in producing made her feel "bad." She was sad to miss the opportunity to show others that you do not have to know English to make a difference with the lake.

I wanted other people to show that we have to clean that lake. We have to do solidarity. And then when you guys say that we have to speak our language and I was getting excited because I can show people that it doesn't matter if you don't know that much English, you can get anywhere you want. (Post-STARS interview)

In Nina's wanderings to other groups she befriended other girls. One significant result of this was Nina's befriending of girls that she did not know or take the time to talk to before STARS. She became good friends with many of the Muslim girls in STARS and would frequently try to engage them in social business during STARS meetings. At the end of STARS she expressed how she learned about their culture in STARS

Nina: I learned about Somalian's religion. Some like they just have to show their hair to other girls and their husbands. And I never even knew that they have to show their hair to their husband. Well the girls and I asked them why do they have to wear that and then they tell me because it was part of their religion that they just have to show their beauty to other girls or to their husbands.

Author: And so what do you think of that?

Nina: I think it's kind of cool. I mean like the boys don't just like you because of your looks. Because of your personality.

Nina and Carla would try on the other girls' hijabs throughout STARS with the Muslim girls helping them and at times laughing at Nina and Carla for wrapping them the wrong way. The STARS space became a space where one of the Muslim girls, Lan, not only apologized for bullying Nina the prior year, but also became a good friend to Nina in STARS as they found out that they were both very much alike.

**Finding the English words to express science facts.** Nina's way of expressing herself in STARS was connected to her ability to find English words, find help with translation, and build confidence in sharing ideas. Tied to her experience shared earlier about when she first came to her new school and spoke in Spanish, Nina was surprised at how accepting her STARS peers were when she expressed her ideas.

It changed me because you (STARS) just make me comfortable about talking to others. It doesn't matter how do I sound when I speak English. It also helped to learn about how to pay attention with when others are talking instead of talking with my friends. Because every time I talk and share my ideas you guys were like, 'Oh, Nina that's really awesome,' and then you guys were starting to ask me questions. (Post-STARS interview)

The comfort in sharing ideas extended into Nina's school science classroom. Sharing ideas in STARS made her less shy in science class during school, "because I wasn't shy to talk anymore. And then I used to like know how to explain others and I can use some words that we used in STARS too."

**Working together towards a different future.** Being in STARS for Nina meant that she got to help others change the lake by using science, and she got to do this with friends. Nina was drawn to STARS for the science, but yet was extremely social in STARS.

Author: What did being in STARS mean to you?

Nina: It means like a lot because you know I can have with my friends but also I can learn science and help others with their science. And show others what can you change with science. I mean like it helped us to help others so they can feel like a better place to hang out. I know that it doesn't matter if you're short or small, you can do whatever you want. If you want to...just work on it

Nina viewed her progress in being able to share ideas in STARS in connection to her future. She recognized her reliance on Carla in translating for her and that Carla would not always be there to help her with that:

She's [Carla] my best friend and we really like to do things together, every time. Because I'm kind of shy talking in front of a whole people. It doesn't matter if they're like ten or five. I just get shy. But then I just like, I just can't talk but then when I came to STARS now I can talk in front of everybody and I'm not shy because I knew that I didn't have to have my best friend always because she's not going to be there forever. In my life. (Post-STARS interview)

Potentially tied to Nina's development in confidently speaking her ideas was her thinking forward to learning more science. She wanted people to know about "the gross things that are in the lake, how those affect humans and animals and all the people who live around." Looking forward she thought about what she would carry forward with her from STARS

Author: From STARS what will you carry forward with you into high school?

Nina: Hmm. I will care because it will be more easy to learn science. Because I have those experiences.

Author: So more easy to learn science. Anything else?

Nina: Also I can talk with other people and I can be—I am not shy because I'm talking in front of the girls in STARS. ((laughs))

Author: So you feel more confident in front of other people now too! That's awesome. So what about helping others in the community make changes or take a stand?

Nina: Maybe and like you can have a group of people that just speaks Spanish but then you can help them to translate in every class, I guess.

Nina's identity development in STARS was linked to her social activity linked with her comfort in using her language abilities to express ideas and then linked to science. Her agency and positioning left Nina with thoughts toward the future that she would be able to learn science, express her ideas, and help others learn about issues like the lake too, no matter what language they spoke.

**Summary of Nina's participation pathway.** Nina, a middle school girl new to the United States and English language, authored herself in the science space as one who was becoming more comfortable in using and expressing her ideas in a way that was "accepted" by others (Figure 4). In her post-STARS interview she revealed surprise that other students and teachers "actually listened to my ideas" and asked more questions about them. The fact that she was allowed her to express her ideas in Spanish on the documentary film meant that she was given a space, her space, to express her ideas how she was able to in a safe and welcoming space.

Nina was “ready for more” science at the end of STARS. She left STARS feeling more confident in sharing her ideas in English and desired for others to know that they could get help to feel this way too. Her relational activity did trump her science activity throughout STARS, but there was a larger purpose behind it. Nina was building a new identity for herself around feeling comfortable sharing ideas in English and much of this took being social with others to feel know that this was a safe place to try ideas out whether in Spanish or English. Although her science activity was significantly less than her relational activity, she did indeed make great strides in science through her increase in confidence in sharing ideas with others in English.

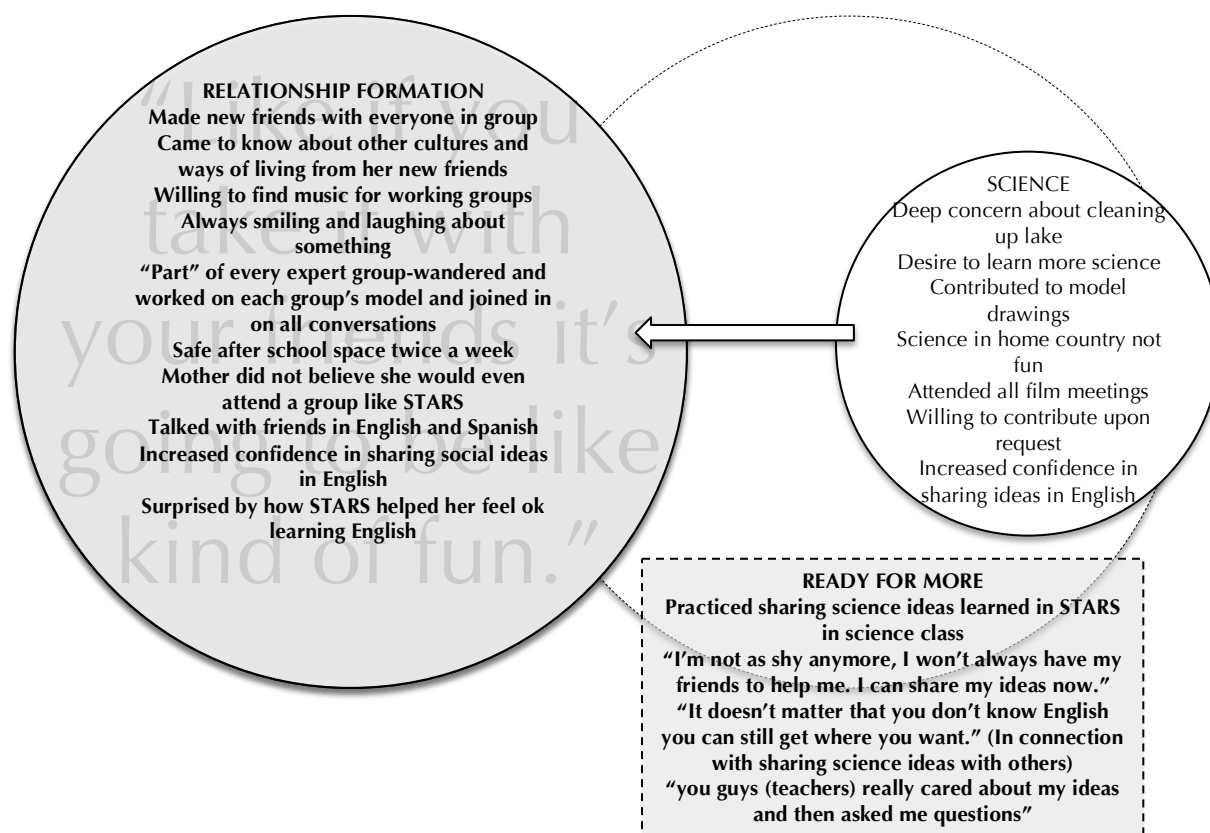


Figure 4.


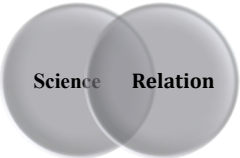


*Nina Foregrounded Relationship Formation over Science Activity.* Nina foregrounded relationship formation activity over science activity in STARS.

## Summary of Findings

Findings provide a deep description of four middle school girl's participation pathways that represent the scientific and relationship formation activity that each girl engaged in as they authored themselves in a formal after school science program designed for and by them. In the second round of data analysis the four case study girls were categorized into one of four general participation pathways (see table 3) and upon analysis of their moment-to-moment science and relationship activity new, detailed participation pathways blossomed. The general participation pathway no longer suffices as a representation for these girls and if used could potentially be an insult to the activity they engaged with in STARS.

Table 3.

### *Multiple Pathways of Participation*

Participation Pathway	Number of STARS Girls	Names of girls	General Pathway Representation
Centered science and sidelined relationship formation activity	4	Romeesa Saiqa Carmen Insha	
Intersecting science and relationship formation activity	7	Gloria Gabriela Sonya Hannan Elizabeth Paulina Gracie	
Foregrounding science over relationship formation activity	4	Lily Rida Lan Selena	
Foregrounding relationship formation over science activity	4	Nina Carla Lina Sanika	

Each of the girls in the four case studies authored themselves in unique ways by drawing on their existing identities as they engaged in, across, and on the sides of STARS activities and constructed a new identity based on who they were in the figured world of the STARS afterschool science club. For Romeesa, Gabriela, and Lily authoring themselves in scientific activity meant a position of leadership, and although different for each girl each of them were able to carry an identity as a science leader in and across STARS activity. Nina grabbed pieces of science as she constructed an identity around being comfortable in sharing any science ideas at all in English. Relationally, Nina and Gabriella capitalized on the social aspects of the STARS world and acted with agency to make this a space where they became new and good friends with those around them. Romeesa struggled to find where this could intersect. For Lily, building relationships was “less important” to her than identifying as the leader of scientific facts. These roles carried into STARS and they acted within those roles, yet throughout STARS there seemed to be a sense of “ready for more” when it came to either more science or more social activity. Lily, a storyteller, was looking for facts to share and build her stories with. Nina, an English Language Learner, was looking for practice and comfort in sharing ideas in English—in a supportive environment. These four pathways reveal extremely different glimpses into ways of authoring that four different girls embarked upon as they developed their identity in the scientific and relationship spaces of STARS.

### **Discussion**

This study explored how middle school girls authored themselves in an afterschool science club with specific focus on how they authored themselves scientifically and in relationships as they engaged in, across, and on the margins of activity. Using the four cases featured in this study I argue that identity development for girls is a dance between how the girls

are positioned and how the girls act with agency in both scientific and relationship formation activities. This study upsets the notion that one path of authoring in a science learning setting is good, not good, productive, or unproductive, but instead suggests that in science learning spaces we need to take a careful look at the intersection or lack of intersections between key social aspect of doing science, such as forming relationships in, across, and on the margins of science activity. It is through unique ways of authoring that each girl comes to see herself as part of a science learning space with multiple identities from in and out of school at play as they form new identities for themselves in the science space.

Science learning spaces are highly social spaces and understanding the role of such interactions as relationship formation could shed light on how to capitalize on the social aspects that naturally occur in learning settings. Studies that focus on identity discuss the relationship formation aspects of identity development and trajectories, but fail to focus on this part of the social aspect of doing science when collecting data and analyzing what it means in connection with science activity and identity development. Calabrese Barton et al. (2012) describe identity work as “actions that individuals take and the relationships they form (and the resources they leverage to do so)” (p. 38) noting that identity is shaped as students engage in activity and relationships. Brickhouse and Potter (2001) describe the social nature of girls and the complex relationships that form, urging the field to think about how to attend to the social aspects to enhance the overall learning community. Carlone et al. (2011) describe how both social and science identities can be leveraged in the science classroom. Calabrese Barton et al. (2008) mention how girls in their study take up playful identities meaning there “was a degree of lightheartedness that was attached to the trying on of a new identity” (p. 87) noting that these identities “did not neatly fit into who the girls were in science class...they often reflected

dimensions of the girls' lives that were active outside the boundaries of science class" (p. 87). The authors noted that when they were allowed to play with these identities "they were granted opportunities to explore new science-related identities without eclipsing other aspects of their identities" (p. 90). By not ignoring the relationship formation aspect of the activity that occurs in a science space findings show a new vision of the dance that middle school girls do when authoring themselves in a science space.

### **Creating both Productive and Positive Science Learning Settings**

Findings from this study show that it is important to create science spaces that are both productive and positive learning settings for students. Historically, productive science spaces have been ones in which students form a positive or productive identity trajectory as they participate and engage in science learning. This study disrupts the notion that positive or productive science spaces are only about science learning or becoming a science expert on a topic. It disrupts the idea that science learning spaces are void of emotion, cultural expectations, but are indeed integral to the process of learning for all students. For example, Gabriela could have easily been dismissed as a quiet, potentially unengaged student in a science space. Her observed ways of being a productive science leader in the first half of STARS could have easily been dismissed as a student who does not participate productively in a science learning setting. Yet in careful analysis of her Discourse, she was a silent productive participant and it was only through the attention to the relationship aspects and the nurturing of these friendships in this space did she begin to smile, share ideas with others verbally, and overall allow her to construct this identity that was extremely productive and positive when it comes to being a science learner and a good friend.

It is important to consider the different ways that youth take up learning settings and the different ways they navigate them. This study provides a glimpse into the lives of four middle school girls as they authored themselves in a science afterschool club. They acted with agency to construct who they were in this space, both scientifically and relationally. This authoring did not occur without the constraints of cultural expectations and social positioning. The girls had to work within and against these expectations and positions to make themselves. For example, Romeesa acted with agency in a space with only females to practice being the leader of scientific practices. She was free to share any and all ideas to construct a science explanation, with no cultural restraints holding her from having this freedom to act and learn in the way she chose. Interestingly these same cultural expectations around being Muslim and being friends with other Muslim females was a struggle in this space as she had difficulty navigating this as she authored herself scientifically.

### **Consequences of Positioning and Identities Taken up**

How students are positioned is crucial and has deep consequences for how students learn and what identities they take up. How students are positioned and how they position themselves has deep meaning for the identities that are taken up in science spaces. It is through positioning that the girls in this study improvised, or acted with agency, to construct who they were in and across the activities that occurred in STARS. For example, when Nina was positioned as one with scientific ideas and it was a surprise to her that people “actually listened” and questioned her about her science ideas, she was able to construct a new identity around feeling safe to share any science idea at all. Although this was not her central way of authoring herself in STARS, it was a significant piece in terms of how she saw herself as an able science idea sharer.

## **Future Research**

Afterschool spaces are not automatically places where girls can work on all dimensions of their identities. Future research is needed to ask questions of how we can support the social dimensions of learning as students engage in both social and scientific activity. This study attempted to tease out how one aspect of social interaction, forming relationships, shaped middle school girls in a science space. Future studies should also explore this naturally occurring aspect of middle school girls interactions as they engage in any learning setting. The field should also consider other relational and social aspects of identity development in a science space as it intersects with activity around the role of fun and laughter, music and art interactions, and the role of families in doing productive science.

**Humanizing research in science education.** While working with the middle school girls in STARS I frequently had overwhelming feelings of gratitude for being able to work with them on the authentic problem based on the toxic lake near their school. The girls in this study were not participants, although that is how they are described in this research paper. They were humans, who I had the outmost pleasure to work with in this science space. Paris and Winn (2014) discuss efforts toward humanizing research where research is no longer void of emotion and human connection and portraying such in the writing that we do as academics. In this study, I tried to adhere to such humanizing constructs by intentionally steered away from generalizing or assuming any cultural ideas that were not explicitly stated by the girls in this program as the girls' and their families volunteered to share their lives with me to think further about girls in science education. Future research needs to be done that captures what I call this human side of what occurs in productive science spaces. In chapter four I write a practitioner-based article that starts a conversation about the role of what I call human everyday interactions in productive

science, but more attention overall to the struggles around, the tensions, the voices of students and families about the purpose of and ways of doing science need to be shared and heard.

With more research that takes a look at the finer aspects of such sociocultural learning spaces as STARS we might begin to walk away from just saying we support the social and cultural aspects of learning science and begin to attend to them as valued ways of learning and doing science.

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Chapter 4. Laughing and Learning Together: Productive Science Learning Spaces for Middle

School Girls

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### Abstract

Providing children with opportunities to use personal experiences and background knowledge in dialogue with peers is critical for making sense of scientific phenomena. This paper is a reflection on the types of activities that supported robust scientific learning for a group of nineteen middle school girls in an afterschool science club. I had the pleasure of running a yearlong afterschool club called STARS, Students Tackling Authentic and Relevant Science. I describe four forms of everyday social activity important for supporting student learning in afterschool spaces: fun and laughter in science spaces, comfort in sharing ideas in an all-female space, sense of belonging with each other, and feeling proud of yourself. My hope is that this paper sparks further conversation about social interactions important to learning in afterschool spaces.

## Chapter 4. Laughing and Learning Together: Productive Science Learning Spaces for Middle School Girls

Science lessons are not one-sided in their emotional tenor, merely serious, but take on aspects of life in general. It is precisely when science lessons take on the same characteristics as life more broadly, when they are serious and humorous, when they embody the generative principles of life, that they reflect a greater truth than they are one-sidedly serious. (Roth, Ritchie, Hudson, & Mergard, 2011, p. 455-456)

Multicultural and science education theorists advocate that children need to have opportunities to use personal experiences and background knowledge in dialogue with peers as they make sense of phenomena in the natural world (Banks et al., 2007; Thompson et al., 2015). Practically, this is a challenge to orchestrate—both in classrooms and in out-of-school learning spaces—as teachers and learners navigate the personal, interpersonal, and structural components of talk. Science is a serious discipline that requires serious thinkers and makers of new knowledge, but science is not void of emotion and everyday social interaction (Roth et al., 2011). What is not well understood, are the multitudes of social interactions that support rigorous, responsive, and fun talk. What is the role of humor? Of pride? Of becoming friends? How are everyday social interactions that make science discourse like everyday discourse used as resources that create an intimate bond that students can then leverage when working together to make progression on science ideas?

In this paper I examine how a group of nineteen middle school girls in an afterschool science club built on shared histories of being girls, being ethnic minorities, and being classmates in school. Important to their learning space was the way they fell into naturally occurring forms

of friendship-talk as they learned science concepts and learned to take a stand for a toxic lake next door to their school. I examine physical activity in the afterschool club, student voice, and pictures to explore the connection between everyday human social activity and productive science. I describe patterns of strangely familiar forms of friendship, and how they were instrumental in constructing a nature walk and an animated film about saving the local lake for community members. I first describe the afterschool space in which the nineteen girls engaged, followed with an examination of four forms of everyday social activity: fun and laughter in science spaces, comfort in sharing ideas in an all-female space, sense of belonging with each other, and feeling proud of yourself.

### **STARS, Students Tackling Authentic and Relevant Science**

STARS was an afterschool space where nineteen middle school girls came to do science and produce a documentary film about how they decided to use their science knowledge about a local issue to take action in their community. STARS was not a predefined space, as it was open to who the girls were and what science they cared about taking a stand for. In STARS the girls were the knowledge experts and negotiators of how they would use their science knowledge to take action in their community on an issue that they cared deeply about.

The girls in STARS decided to investigate why Lake Evergreen, a lake they could see outside of their science classroom window and located in a park many of them walked through when coming to and from school, was polluted and why it was taking so long to clean it up. The girls cared to speak up for those in and around the lake that could not speak up for themselves—the environment, wildlife, and future generations. Sixty years ago the lake was a place where the community gathered to picnic, swim, and fish. Presently, the lake contained little to no life and was monitored for toxic cyanobacteria blooms in the warm summer months. The lake was a

place of urban legend with many stories flying around including that there was a dead horse on the bottom of the lake and a guessing game about how many cars were on the bottom of the lake. The surrounding park was known for its drug activity and crime, with many students expressing the feeling of being unsafe as they walk through and by this park everyday. These stories of wonderment were framed by the desire for the lake to once again be a place of recreation. STARS meetings were filled with activity around constructing a deep understanding of the science behind Lake Evergreen's pollution and ways the girls could help engage the community in taking steps towards a better future for the lake and all those that use it.

In upcoming sections, I use descriptions of teaching and learning activity, student voice, and pictures from STARS to illustrate how four elements of social interaction— fun and laughter in science spaces, comfort in sharing ideas, sense of belonging with each other, and feeling proud of yourself—were leveraged to make progress on science ideas and taking action in their community.

### **Fun and Laughter While Doing Serious Science Work**

Laughter and fun infused all aspects of science and social activity in STARS. Laughter was shared between students and with teachers. Laughter and fun formed a bond that became about working together to understand the science behind the polluted lake as they inserted jokes, performed dances, sang the song of the day, and viewed investigation mistakes as hilarious mishaps. An example of this took place in the small expert explanation group that focused on why there was so much excess nutrient phosphate in Lake Evergreen. Many different factors cause too much phosphate to enter Lake Evergreen including use of fertilizer, dog waste, sewage waste entering lake, and excess waterfowl feces. The fact that excess waterfowl feces, poop, was a significant contributor to increased phosphate levels in the lake became a focal point of

laughter for this group of middle school girls. In the following excerpt one teacher is working with five students in constructing a scientific model of what the external sources of phosphate are. There is a piece of poster paper in the middle of the table that the girls are drawing their scientific model on as they discuss a reading from the county about how phosphorus enters Lake Evergreen.

(T=teacher, S=student)

T: It (phosphorus) helps the plants grow. How does it help plants grow? What do we know about it?

S1: Let's see, it (referring to reading) says that phosphorus is in...poop.

T: Yeah (laughs), basically.

S2: Yep, it's in the poop.

(Whole group laughter)

S1: It says it is in poop and in wastewater.

S3: Is there poop in the lake?

(Whole group laughs)

T: Oh yeah. That's why we did a bird survey last year because they (the county) wanted to know where the birds hung out and pooped.

(Laughter)

S2: (Laughing) You're kidding right?

T: No, the county asked us to survey where the birds were because where they are is where they poop. They don't walk to a bathroom like we do, they just poop where they are. (Whole group laughter)

Following this excerpt, Lan (student two) volunteered to draw the geese and poop on their scientific model, showing how the phosphate from the poop gets into the lake, with student three drawing in wastewater that carried the feces into the lake. This laughter-filled conversation about bird poop and its significance in the overall scientific story started here and seeped into future meetings when the phosphate source of bird feces would come up in conversation. Lan, who originally volunteered to draw the bird poop on the scientific model, became known as the “poop advocate” in both small and whole group settings. Whenever the topic of pet or bird waste arose there was always an undertone of laughter in the whole group and Lan especially made sure that the poop problem in relation to the pollution problem was never forgotten.

The use of laughter and fun while doing serious science work was not only shared between students, but also between students and teachers. Teachers felt they could be more “fun” in the afterschool space and the girls noticed the more relaxed, humorous nature of teachers in STARS. For example, the lead teacher Emerson, who was also the school science teacher of many of the girls in STARS, stated, “I liked STARS so much because I sort of got to take on a different role with many of the girls and it was just like more relaxed and more fun. Which was nice.” When working with the girls, Emerson would facilitate productive science conversations and interactions, but also insert her own humor into discussions with the girls. While working on a science investigation with her small expert group she shared a joke/riddle a fellow science teacher had shared with her:

T: Ms. Ohler shared a joke with me. She said if heat is molecules moving faster does blowing on your food really make it colder?

Ss: Ha ha...

T: Do you get it?

Ss: Yeah...Ha, ha!

S: Yeah, so if you blowing on your food is making molecules move faster is it really cooling it?

Emerson was able to intermittently make this casual conversation with the girls as they did serious science business. After STARS was over, Nina described Emerson in the STARS afterschool space in comparison to her school science classroom as being happier.

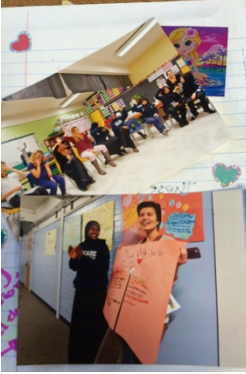



In STARS she was more fun...she was more happy or it seemed like she was...In school she was more strict. Because she knows in school you have to follow the rules and in STARS she didn't. So I think she was funner. (Nina, 8<sup>th</sup> grade)

Laughter became an intricate part of the productive, positive atmosphere that was integral for the girls to work together and take action together (Roth et al., 2011). Allowing for fun and laughter is akin to taking up and using students' everyday experiences and language, but extends these practices to incorporate everyday interactions such as using humor in the classroom as a way to enhance learning experiences and seriously make learning more enjoyable. The balance between construction of serious science knowledge and/or taking action and having fun with each other strengthened the group as a working group, bonding them together through "inside jokes" and finding humor through science.

Pictures and videos taken throughout STARS display laughter in small group work, when presenting information to the whole group, when informally socializing, and when working in expert pollution and solution groups (Table 1, pictures 1A-1D). The mix of laughter, fun, and seriousness created "intimacy, complicity, and solidarity" between the girls that enabled them to interact in a way that resembled interactions in less restrictive everyday activities, allowing them to work productively together (Roth et al., p. 454).

Table 1.

*Fun Times Throughout STARS Science Activities*

1A. Whole group voting with eyes closed and laughter when sharing out ideas	1B. Lead teacher laughing with Gloria before breaking up into pollution expert group	1C. Informal art and snack time: Girls working on sketchbooks	1D. Goofing around at the polluted lake
			

**Comfort in Sharing Ideas with Other Girls**

Like you're really shy and like you barely even do nothing (in science class) because there (are) guys around you, you know how girls are. And with girls you get along with them. Because they're girls and I'm a girl too. (Gloria, 8<sup>th</sup> grade STARS student)

Gloria's quote exemplifies shared reflections from many girls in STARS on why they felt more comfortable sharing ideas in the all-girls STARS space versus their in school science mixed-gender class. They expressed this sense of comfort in being with all girls and feeling free to share any and all ideas. Here is a collection of responses expressing this comfort:

Paulina: Because we are all girls...we understand each other.

Lan: We never laughed at each other for saying something.

Hannah: We feel good with each other. It's like we are family, you know.

Nina: After I would say something, you like actually asked me about it, like you cared what I said.

Donna: And I think people in STARS are like more willing to participate and stuff because they know that in class you're going to feel like, 'Oh, if I say this and people know I know the answer they're going to make fun of me,' and just like dumb stuff that shouldn't happen but it happens all the time. Because, I don't know. It's just really dumb. But like with STARS people can speak up and they know that, 'Oh yeah, I can say this and people won't think I'm stupid or anything if it's wrong.' Whereas like in class people are like, 'Oh, that's wrong. Blah blah blah.' And it just puts you down.

Being an all-female science space helped the girls shed their hesitation in sharing ideas with each other and created a safe, comfortable space where they knew their ideas were being heard and valued. In contrast with their school science classroom where they felt constrained from being "laughed at" by boys in their classroom. One girl, Lana, expressed her experience of sharing one idea in science class, being laughed at by boys, and then not wanting to speak up again.

It was through careful consideration and planning for intentional ways of sharing that fostered how the girls came to feel comfortable sharing and listening to all ideas. First, sharing ideas was nurtured through intentionally planned activities that attended to the orchestration of small group sharing and constructing ideas in combination with whole group sharing of ideas (Table 2). Ensuring that each girl had a voice in STARS and ample opportunity to share science and life stories, small groups were given their own expert topics to investigate and build an evidence-based model on and were referred to as "small expert groups." Ample time was provided for each small group to share hypotheses, revise hypotheses, draw and revise models based on new evidence, and also intentional and multiple opportunities for practice on what and how ideas would be shared with the entire group of girls (Table 2, picture 2B). In other words, building and sharing ideas in small groups was extremely scaffolded and prepared the girls to

feel comfortable sharing ideas with the larger group. In their small groups they would also consider what questions they had for other groups who were studying other pieces of the overall community issue. As Paulina expressed in her post-STARs interview, “we like wanted to know what other people’s ideas were about.” They were prepared to show that they valued what the other girls had to share and were also eager to share their part of why Lake Evergreen was so polluted.

Well I was in one team, because there were three different—well we were a team as a whole but there were three different teams... as a team we would get to interact with each other, do fun experiments with other people, get to know them better... it’s different than a class because in a class we would get a piece of appear and assignment and it would have to be done. But in STARs we would be able to interact with people, talk, have fun, eat. And we would just have a lot more fun. (Paulina, 8<sup>th</sup> grade)

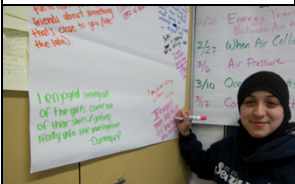



Second, breaking into small expert groups not only scaffolded the process of sharing ideas, but also aided the girls in being science experts of one part of the overall science explanation. There was no need for every girl to know the complete, rather complex story of why Lake Evergreen was so polluted and why it was so hard to clean it up, but rather for every girl to be part of the overall scientific explanation and be able to clearly explain their piece to the entire STARs group and the community. It was in whole group discussions that the girls knew to rely upon each other to ask questions and collaborate to synthesize ideas. Synthesizing was possible because they had practiced and were primed to ask questions of other groups based on what they felt they did not know as a small group (Table 2, picture 2C & 2D). Expert groups were periodically mixed together with other groups to allow for whole group hypothesis sharing and

progression of solution hypotheses. As Gloria stated, “If someone needed my help with something, then I could help them in the small expert group or in the whole group. Real easily.”

The comfortable bond that formed through sharing ideas meant that the girls could share any idea and know they would be listened to, not be laughed at, and could trust that others needed their ideas so they could make progress on science ideas together.

Table 2.

*All Ideas Heard, Shared, and Used Together to Make Progression on Science Ideas*

2A. Individual ideas heard and shared in multiple ways and in settings	2B. Expert pollution groups constructing science explanatory models	2C. Whole group explorations, observations, evidence gathering, and hypotheses sharing about Lake Evergreen	2D. Sharing and synthesizing pieces of science explanation together
			

### **Making New Friends and Belonging**

Like we're all—we're different but we get along with each other very well. We don't really care about our background, we just get along with each other. I don't think—well to me it doesn't matter whatever they are. If I get along with them okay, it's fine. (Selena, 8<sup>th</sup> grade)

It's like kind of amazing because it's people that you didn't know at first and then you're just coming all together and working with them and having this opportunity to get to know them better. (Sonya, 8<sup>th</sup> grade)

The girls in STARS were a small yet powerful group because they felt a sense of belonging to each other. This bond between them was novel as ethnic and cultural boundaries that kept them “apart” during the school day no longer existed and they were brought together through friendship and acceptance of the uniqueness of each person in the group. Planning for the girls to become friends was not possible, but planning a space where everyone felt like they belonged could be attended to in the planning process. To foster the sense of belonging meant that meeting time had to capitalize on informal social time together.

Before each meeting, the girls would meet in the cafeteria and then walk together to the STARS meeting room (Table 3, picture 3A). When they entered the meeting room they were always full of laughter and lots of stories to tell. To capture this social time and transition to working on science ideas, part of STARS meetings were planned for art, snacks, and free talk so the girls could get to know each other and each other’s interests. Informal socializing occurred as hoots of laughter, horseplay, and sharing of personal items such as art sketchbooks, music, and stories from in and out of school were shared with each other and with teachers took place in this unstructured time. It was in this period of time that the girls mixed up with each other and rather than any cliques forming, the groups formed a deep bond with and across each other.

Okay, so you know how like every school is divided into the popular clique and the nerdy clique? And well I noticed some of the popular girls who I was previously afraid of in STARS and I was like, ‘I didn’t know they would come to this. This is kind of scary,’ because they intimidate me because they can do a lot with their popular status. And so but I’ve gotten to be more friends with them. Like I don’t want to say names but-  
(Hannah, 8<sup>th</sup> grade)


Friendships were formed while doing science, sharing ideas, and supporting each other for who they were (Table 3, pictures 3B & 3C). Forming new friends was about learning about each other and admiring differences that were present in the science space. Over half of our girls were Muslim and many of our Latina girls were able to ask questions around why they wore a scarf. Muslim girls were able to listen and ask about how to say certain words in Spanish. As exemplified by Hannah’s reflection on why STARS was fun she reflected upon how all girls were able to talk and ask each other questions about their lives.

I think STARS was cool because there were frequently conversations about Arabic. Or about Somali. Or about Spanish. And like even Lily was able to participate in those conversations, you know? It would be like ask questions about—like, ‘When do you wear the hijab, why do you wear it?’ (Hannah, 8<sup>th</sup> grade)

The sharing of whom the girls were as individuals with each other and the friendships that resulted became a natural part of STARS and was easily visible in all interactions. This bond of belonging to and with each other was leveraged as they worked together as a group to make changes in their community (Table 3, picture 3D). In the next section, I describe how pride was a feeling that many of the girls cherished for themselves and as a collective group.

Table 3.

*Sense of Belonging.* Belonging to each other as individuals, as whole group, and as part of larger community.

3A. Belonging together	3B. Belonging to friends, old and new	3C. Belonging to a group with similar interests	3D. Belonging to a community
			

### **Proud to Use Science to Take Action in Community**

All girls in their post-STARs interview expressed feeling proud of learning rigorous science, using their knowledge to take action in the community, and most of all being able to communicate these ideas to a variety of audiences. Girls expressed feeling proud because they could have new conversations with their moms, dads, stepdads, sisters, and brothers about what they were doing in STARs. Many of these conversations would take place on the way home from STARs, while preparing dinner, while washing dishes at home, or over the weekend while visiting family. For example, Gloria shared how after each meeting her mom would ask her about what they did in STARs, a new type of conversation that Gloria felt proud about.

I shared with my mom. Like every time I would get out of school and she would pick me up like, ‘Oh, I learned this and I learned that about why the lake is so dirty,’ I was very excited to tell her what I learned because I want her to feel very proud of me. So I would talk with my mom and she was like, ‘Oh, I’m very proud of you and what did you learn?’ and then she’s like, ‘Explain this to me and like explain that.’ (Gloria, 8<sup>th</sup> grade)

Siskia, an eighth grader, frequently described how being in STARs enabled her to talk and “actually have conversations” with her stepdad about science. He was a “science guy” and because of what she was doing in STARs she was able to “talk at his level and stuff.” She would follow her stepdad around their house as he worked on house projects, telling him everything about the science behind the polluted lake and what she was doing. When he asked her to wash the dishes she would shout through the house about what she did in STARs, not sure if anyone was listening.

The pride in the science work was evident as parents would pick their girls up from the club and/or send letters thanking us for having the program. One mother told Emerson, “Thank

you so much for making this happen. This is amazing, it's been great for her. She has fun. She gets social time in a way that we approve of and it's still academic and like it looks good on a resume, she enjoys it.”

The girls decided to take action in their community by producing a documentary film about their experience in STARS and designing a fun and educational nature walk for the community. The nature walk consisted of four signs, each designed with a different message to help the community learn how they could help clean up Lake Evergreen: 1) Lake Evergreen in the past and present conditions, 2) Information for animal lovers, 3) A comic for people of all ages, and 4) The need for installation of a bioswale, a constructed wetland (see Appendix E). The signs and film represented a variety of ways that the girls felt they needed to share ideas with the community. They wanted to talk across generations and even impact generations to come.

At the film showing, the theater was filled with friends, family, community scientists, neighbors, school administration and teachers, and university faculty. Before the film, the theater lobby was filled with introductions of family members, laughter, and casual talk as the community ate food and viewed the signs that were on display. The STARS girls were excited to introduce their families to the lead teachers and have them see the film they had worked on. After the film, girls expressed how proud their families were after seeing the film.

Renee: I felt really nice because I felt like I accomplished something and my mom was proud of it. My parents were proud of it.

Tara: I feel proud of myself when my mom and dad watched that video. I feel proud when I was holding my notebook writing what we did on the...on the experience when we do the plants and things.

Anna: I was proud of it because it was like the first thing—I've never made a film before about...I don't think I've ever made a film before. So it was cool and different.

Cathy: They plugged it into the TV and they all sat to watch it and they all said that they were proud of me because I was helping the community and they said it was really cool.

Barbara: I don't know, it just made me feel proud of myself. Like I just joined a club and then I made a difference.

Vera: I felt better, like more proud, because they (her parents) actually wanted to come and see what I've been doing for the past, how long?





Brittany: I'm proud of that I get to learn more about science and then I'm actually proud of that I get to meet new people.

The feeling of pride, being proud of yourself and having others be proud of you, was another form of bonding that occurred in the group (Table 4, pictures 4A-4D). It was not through the actions of one person in the group, rather it was the collective group that was proud of what they were learning and doing that made a difference in their community. As JenAnn shared after STARS about how working together makes an impact for the present and also the future.

It sounds cheesy but amazing because this influenced all these people. So that for me was like, 'Well, if in the future I want to do something similar then all I have to do is try.' Because I've experienced something like this before... Like try for change. Try to communicate with different people, to get them to understand different things. Try to change the environment for the better. It's just you've got to try. And even if you have busy schedules if you're committed to something then you should go. Because it will make an impact on other people. (Jenann, 7<sup>th</sup> grade)

Table 4.

*Feeling Proud about Accomplishments*

4A. Sharing of expert solution group walking tour sign in the place where community will read it	4B. Documentary film about using science to take action in community	4C. Professional and fun poses for film night	4D. Communication to people of all ages on what actions are needed
		 <p>I liked being part of STARS a lot</p>	

The sharing of the work that the girls did in STARS was a powerful, meaningful experience for the girls. Showing the film in the district theater, having food for families and community members to share, getting on stage to talk about the work they had done in STARS was a unique event that they was unusual for them to experience, as expressed by Jenann when she stated, “We don’t usually get stuff like this, like in our neighborhood.” Learning rigorous science and using it to be part of a living change was an empowering and definitely a pride-filled event.

**(Re)Igniting a New Conversation**

This article does not present “new news” about the presence and meaning behind everyday human interactions in productive science, but rather it is an attempt to (re)ignite conversations about the joy of doing and being part of productive science learning. Hoping to spark a new conversation with other educators about the intentional inclusion of everyday social interactions and emotions in the classroom, I list lessons learned from STARS that can be used by practitioners across disciplines and learning spaces.

**Purposeful structures for sharing ideas.** Feeling safe and comfortable in sharing any and all ideas should be a basic human right in any learning space. Intentional planning of participation structures and conversations that address the voices of students that are usually muffled or muted across learning settings will help foster the sharing of and hearing of all voices. It also enables new ideas to rise to the surface and help make progression on existing hypotheses. Holding students to a high content rigor standard along with being flexible in terms of responsiveness to ideas expressed by multiple members takes organization of allowing all voices to be heard, openness to going a different direction than planned, and a keen listener to quieter voices.

**Invest time in relationship formation.** Albeit that establishing classroom norms is a common practice across some classrooms, more time needs to be planned to allow for relationship formation in a learning space. Akin to circle time or morning meeting in primary elementary classrooms, this relationship formation needs to be attended to across all grade levels. Norms for allowing others to feel like they can do serious work and not have to monitor extreme social behavior are necessary to respect all participants' rights to the time in the science space.

**Plan for fun and laughter.** Scientists work extremely hard, but also play hard too. Let's let students and teachers do that too. Having fun at the appropriate times is important, as is incorporation of laughter with learning. There is nothing better than a good laugh and sharing inside, science-based jokes.

**Celebrating others and us.** Intentional celebration of individual, group, and/or community accomplishments has a domino effect that trickles into other learning and everyday spaces. Allowing students to celebrate how they are proud and how others are proud of them fosters the sense that an individual or small group of students working together can make

changes that make an impact on their own and extended communities. We need students to leave learning settings feeling this way if we want to see just changes occur in society.

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## Appendix A

## Student Interview #1

- 1) Tell me about a time when you stood up for yourself, a friend, or a family member. For example, when a friend was having a hard time with another person or someone was picking on one of your siblings or someone was making you feel like you needed to stand up for yourself. Describe when you took a stand, what it was for, and what you did to take a stand against this person or a group of people.
- 2) Tell me about a time when you stood up for one of your ideas. These ideas could be big or small, in or out of school, in family and/or with friends. For example, think about when you stand up against something your parents or friends are saying. Another example could be when you disagreed and took a stand against an idea a person at school said. Describe what idea you stood up against and what you did to stand up against it.
- 3) What are some important science-related issues or ideas that are shared in your families? For example, ideas such as eating healthy food, turning off lights to save energy, exercising, not polluting the environment, genetically modified organisms, vaccines, medicines, or other science-related issues in newspapers, magazines, or something you see on TV.
  - a. Who in your family takes a stand on these issues? (Mom, sister, brother, dad, grandparents...) When do you and your family talk about these science-related issues?
- 4) Describe a time in science that you really enjoyed learning about science? Think about a time in science that it felt like time went fast, that you were really interested in what you were doing, and enjoyed working with those around you.

Group activity: Thinking about what we have talked about here, what does it mean to take a stand? Have the group you interviewed design a poster that represents what it means to take a stand. We will share these with the whole group.

## Appendix B

### Student STARS Interview #2

I am going to ask you about your participation as a STAR-volunteering to come to this space every week (STARS meeting and film production day).

1. Why did you join STARS?
2. Tell me about your participation in STARS.
  - How would you describe your role in STARS? Did your role change over the course of STARS?
3. Tell me about your participation in science classroom.
  - You said this about STARS-tell me what that is like in science classroom.
4. If you could take something from STARS and put it in your school science class, what would it be and why?
5. Could you, would you, or will you use science to take a stand for something you believe in again? If so, what? If not, why not?
6. What does your role in STARS say about you as a scientist? An Activist? Something else?
7. What do you think others would say about your interactions in STARS and how you used science to take action in your community?
8. What are you most proud of in terms of your time in STARS?
9. What relationships and/or new friendships did you develop in STARS?
  - Did you ever have a hard time interacting with any STAR? If so, why and what happened?
  - Did any new relationships carry over into your science or other classrooms?
10. Tell me about a time that you enjoyed working with another STAR on your science explanation or sign.

#### Expert and Sign Groups

1. What did you know about Lake Evergreen before STARS?
2. What did your family know about Lake Evergreen? How did they learn about it?
  - a. Did you and your family ever go to Lake Evergreen before STARS? Have you visited since STARS? In the future?
3. What was your expert group?
  - a. What role did you have in the group?
  - b. What role did others have in that group?
  - c. What did you learn? How did you learn it?
4. How did you help share your expert group explanation?
  - a. How did your piece of the explanation connect with the other expert group explanations?

#### STARS Film

1. What was your favorite part of the film and why?
  - What was your favorite part of film night and why?
2. What do you think the film says about using science to take a stand?

3. Did you have friends or family members come to the film? If so, what did they say about the film? How did this make you feel?
4. Have you talked about the film since film night? If so, what have you talked about?
5. Do you think it is important to communicate your science ideas to others?

#### You

1. Who did you tell about STARS and what did you say?
  - a. What were you doing when you talked to them about STARS? (cooking dinner, riding home, other)
  - b. Can you give me an example of a conversation you had with that person (those people)?
  - c. How did that conversation make you feel about your work in STARS?
2. What are some other things that you would like me to know about you? About you in STARS? In science? In science class at school?
3. How will you carry what you have learned in STARS forward or with you?
4. We have been focusing on how to use science to make a change in your community, but how has science changed your personal life?
5. Tell me about you-
  - a. Friends in STARS
  - b. Your story.
  - c. Role of language
6. Individual question for each girl: Think back to a significant story, event, interaction, statement, conversation that this STAR had in STARS. Ask them about it.

#### STARS next year

1. Do you think we should have STARS next year? If so, why/why not?
2. Should STARS only be for girls? Why/why not?
3. What did being in STARS mean to you?

## Appendix C

## STARS Lead Teacher Final Interview Questions

1. Participation
  - a. What did you see as your role in this group and how is this the same/different as your role in the classroom?
  - b. Tell me about your role changed over STARS.
  - c. Tell me a story about your favorite experience in STARS. Why was it your favorite?
  - d. You participated in STARS in a variety of ways both in and out of our regular meetings. Tell me about an experience out of our regular meeting that was meaningful to you and why it was meaningful?
  - e. What are you most proud of in terms of your time in STARS?
2. Building Science explanations
  - a. Tell me about how your group constructed their expert explanation about nutrients, cyanobacteria, or floating islands. What roles did the girls take on?
  - b. Who made unique and/or significant contributions? Why do you think these were unique or significant?
  - c. What about in your sign-making group? Who took on what role?
3. Your classroom
  - a. Has your work in STARS influenced the way you think about the use of scientific explanations that are constructed in your science class.
  - b. If you could take something from STARS and put it in your school science classes, what would it be and why?
  - c. Tell me about a time when your work in STARS changed the way you did something in your science class.
  - d. Tell me about a time when you saw one of our STARS do something differently in your science classroom that you thought stemmed from their participation in STARS
  - e. How would you compare the explanation that was constructed in STARS to the explanations that are constructed in your classroom?
  - f. Tell me what you think about being a teacher in an informal setting. What did you get out of being in these two different spaces?
4. Communicating science ideas to community
  - a. What was your favorite part of the film and/or film night and why?
  - b. What do you think the film says about using science to take a stand?
  - c. What do you think the film meant to the girls?
  - d. Is communication of their science ideas in a variety of ways-for example film, signs-important?
  - e. Will you think or have you thought of communication of science ideas to a larger audience more in your classroom?
5. STARS Stories
  - a. Reflecting on this year, what pieces of STARS should be carried forward?
  - b. What changes should be made for next year?

- c. What do you think about girls in science? What relationships did you develop in STARS?
  - d. Did any interactions with the STARS surprise you?
  - e. Has leading STARS changed your relationship with any of your students? Who and how?
  - f. Tell me about the girls in STARS. Could you share a story about each of them?
  - g. Did STARS come up in conversation with other teachers? If so, what did you say?
  - h. Throughout STARS there were some tensions that existed between some STARS members. How do you think these tensions affected some of the girls interactions in STARS?
  - i. What role did emotion have in STARS? How is this the same or different from your science class?
6. You
- a. What are some other things that you would like me to know about you? About you in STARS?

## Appendix D

## Pictures of Scientific Explanatory Models

Pollution explanation	Pollution explanation group scientific explanatory models
<p><b>Nutrient expert group explanation</b></p> <p>There is more dissolved nitrogen and phosphorus in Lake Evergreen. Most of it enters the lake dissolved into rainwater that is washing over surfaces surrounding the lake. Because the lake is the lowest point in the watershed, most of this rain runoff in the area ends up in Lake Evergreen, dissolved as nitrate (<math>\text{NO}_3^-</math>) and phosphate (<math>\text{PO}_4^{3-}</math>) ions. Two main sources of these ions in Lake Evergreen are inorganic fertilizers and animal waste. The inorganic fertilizers incorporate nitrate and phosphate as easily water-soluble acids <math>\text{HNO}_3</math> and <math>\text{H}_3\text{PO}_4</math>. When they dissolve in the water, they become accessible to plant/algae absorption because they can “follow” water as it flows into the cells of these organisms (see <a href="#">filtration explanation</a>).</p> <p>Organisms need to absorb some phosphorus and nitrogen as dissolved ions in order to maintain important life-sustaining processes. For example, phosphate is a crucial atomic ingredient for DNA replication (sugar phosphate backbone). Nitrogen is found in nucleic acids (also crucial for DNA replication). Both phosphorus and nitrogen are also crucial atomic pieces of the structure of ATP, a nucleic acid-and-phosphate based molecule that can be used to supply the cell with the energy it needs to pump sugar in and out of the cell, to break that sugar down, and to build more cells. When the organisms absorb these nutrients, they become a part of the plant or algae cells. They can be consumed by a predator and broken down for that predator’s use. They can also become a part of the soil when the organism dies and is broken down by a decomposer. In this way, the nutrients can be “returned” to the dissolved state, where another organism can reabsorb them. This is called nutrient cycling. The individual atoms are never destroyed or created; they are simply broken apart and put back together in ways that are usable to different organisms. Natural sources of phosphorus include rock and mineral deposits that are eroded into water-soluble minerals.</p> <p>In Lake Evergreen, the runoff that is concentrated with nitrate and phosphate is causing an excess of these nutrients in the lake. This is causing an abnormal spike in cyanobacteria growth (see <a href="#">cyanobacteria explanation</a>). Larger-than-normal populations of cyanobacteria can overwhelm an aquatic ecosystem because the excess nutrients become “trapped” in the body of water. When the cyanobacteria die, they sink to the bottom of the lake and are decomposed by other bacteria. Because there are so many cyanobacteria in the lake, the decomposers begin to work overtime, rapidly depleting the oxygen levels in the lake. This severely limits the ability of many other organisms to grow (because it is an anaerobic environment). Aquatic plants have trouble growing not because of the low oxygen (they are looking for <math>\text{CO}_2</math>, remember) but because the cyanobacteria coats the surface of the lake, blocking sunlight from reaching the plants. Without sunlight, they have no ability to produce sugars for energy. As the phosphorus and nitrogen are released from the dead cyanobacteria back into the lake, the only thing living there are the cyanobacteria. Therefore, they are the only organisms that will absorb those nutrients, trapping them in a cycle that never leaves the lake.</p> <p>The floating islands help break this cycle because the plants are able to absorb the nutrients from the lake, but have access to the sunlight above the coated surface. When the plants die, they can be removed from the lake so that their decomposition does not recycle the nutrients back into the lake.</p>	<p><b>Nutrient group scientific explanatory model</b></p> 
<p><b>Cyanobacteria group explanation</b></p> <p>Why are cyanobacteria outcompeting all organisms in Lake Evergreen? Cyanobacteria, often called blue-green algae, these photosynthetic prokaryotes are thought to have converted the early reducing atmosphere into an oxidizing one (evolution of aerobic metabolism and eukaryotic photosynthesis), because they were (one) of the first oxygen-producing organisms on Earth. They occupy a wide range of habitats and can be found in extreme niches such as hot springs, salt works, and hypersaline bays.</p> <p>The availability of macronutrients, such as phosphorus, controls the growth of cyanobacteria. When there are disturbances in a watershed, such as the Lake Evergreen Watershed, one result may be unnaturally high levels of phosphorus (see P explanation), forming a nutrient-rich body of water. With a near unlimited source of phosphorus, cyanobacteria reproduce rapidly. They do not have a higher demand for P, but cyanobacteria are efficient at phosphorus storage.</p> <p>Aquatic cyanobacteria are known for their rapid-growth. High concentrations of cyanobacteria are known as blooms; these blooms can be toxic. In the right conditions, such as in the summer at Lake Evergreen, successive blooms can occur for up to several months.</p>	<p><b>Cyanobacteria group scientific explanatory model</b></p> 

The blooms can float to the surface and block sunlight from reaching organisms below the surface, therefore severely impacting or completely hindering aquatic plant growth.

Cyanobacteria outcompete all other organisms in Lake Evergreen, meaning that it uses the nutrients and resources available for life in Lake Evergreen. Dead cyanobacteria contribute to the nutrient overload problem by dying and decaying in the body of water, adding more nutrients to the water system (see P explanation). Fish used to live in Lake Evergreen, along with other plant life, but now cyanobacteria are the only present life. Migrant bird populations visit Lake Evergreen yearly. Humans, pets, and wildlife visit and have interactions with Lake Evergreen and its surroundings.

Cyanobacteria can produce several toxins, with two toxins, Microcystin and Anatoxin A, being of particular concern. Toxins are released as the cyanobacteria cells age and die, releasing their cellular contents. Microcystin produces Microcystin, toxins that affect liver, the most commonly found cyanobacterial toxin in water and are the toxins most responsible for human and animal poisonings. Microcystin blooms are a worldwide problem-China, Brazil, Australia, USA, and Europe. Once ingested it travels to liver, via bile acid transport system and binds covalently to protein phosphatases thus disrupting cellular control processes (destroy liver cell structure, increase weight of liver, heart attack and death).

Anatoxin A, another prevalent toxin in Lake Evergreen (see toxic data from County), is a potent neurotoxin (toxin that affects the nervous system) which can cause lethargy, muscle aches, confusion, memory impairment, and when taken in at high levels, death.

Solutions exist to try to decrease or minimize cyanobacterial blooms. In Lake Evergreen, Alum treatments have been performed, and currently four floating islands (see [floating island explanation](#)) have been installed (July 2013) to help filter excess nutrients from the water. Solutions that include reducing external nutrient inputs need to be implemented in order to make bodies of water, such as Lake Evergreen, a safe place for future generations of all species.

Global issue-clean drinking water: The major exposure of these toxins to humans is through drinking water, with minor exposures occurring through recreation in polluted bodies of water (through mouth and skin). To date the most lethal outbreak of exposure to cyanobacterial toxins in drinking water occurred in 1988. A bloom in a dam resulted in more than 2000 cases of illnesses, with 88 deaths over a 42-day period.

If there are toxic cyanobacteria in Lake Evergreen, why do we need to speak out for populations of organisms that can't speak up for themselves? What should we say for them?

### Water filtration group explanation

The islands in Lake Evergreen are constructed to be about "250 square feet in size, built of a durable polycarbonate, and anchored in place," according to a press release. "The islands are perforated with dozens of holes that are planted with a variety of native wetland species. The plants' roots will reach into lake as they grow, where they will take up excess nutrients. In addition, a bio-film of microscopic organisms that forms along the bottom of the floating islands and the plant roots will also take up nutrients from the water. (Themountainherald.com, 2013)

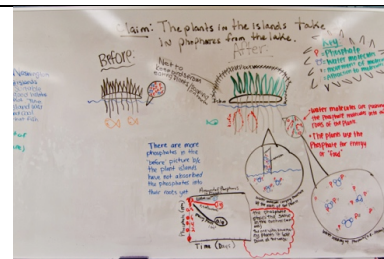
The plants have roots that grow into the lake which take up water in their roots along with dissolved nutrients. The reason why plants can take up the water with the nutrients is because of the polar properties of water.

Water is a polar molecule, which has one slightly negative oxygen and 2 slightly positive charged hydrogen's. This property allows ions and nutrients like phosphates to dissolve in the water. Positive ions are attracted to the oxygen side of the water molecule and the negative ions are attracted to the positive side of the water molecule. Every ion is surrounded by water molecules, creating a "hydration shell" made with water molecules centered around the ions.

Water is cohesive and adhesive. This means that it sticks to itself and other surfaces. For example, the slightly positive hydrogen's are attracted to the slightly negative oxygen's of neighboring water molecules. As the water comes into contact with the roots of a plant the water sticks to the roots and itself. This creates a "capillary action" effect where the water from the soil or Lake sticks to the walls of the roots and because the water sticks to itself, it causes the water to rise through the roots of the plant. The plant for cell processes then uses this water. The dissolved nutrients like phosphates are then taken up the roots with the water by capillary action. The phosphates have 3 slightly negative oxygen atoms that are attracted to the slightly positive hydrogen's in the water molecule and therefore dissolve in the water.

### Whole group model

An unnatural problem with a natural solution. Synthesized whole group model that the students used evidence and explanations from individual models to construct.



Water filtration group scientific explanatory model



Appendix E

Nature Walk Signs and Descriptions

Nature Walk Sign	Description
	<p>Sign 1: Introduction to Lake Evergreen, brief history, brief overview of tour</p>
	<p>Sign 2: For animal lovers-discuss the effects of the excess nutrients both on internal and external organisms</p>
	<p>Sign 3: "For kids of all ages" (to appeal to multiple audiences of walkers, Frisbee players, and school kids walking home or to school, weekend visitors): Information on Lake Evergreen that is accessible by kids of all ages, even elementary school kids</p>
	<p>Sign 4: Site of a future constructed wetland that could help clean up the water that enters Lake Evergreen</p>

## VITA

Sara Hagenah

**EDUCATION**

2010-2015 Doctor of Philosophy, College of Education, Curriculum & Instruction, Science Education, University of Washington, Seattle, Washington

Dissertation:

*Using Science to Take a Stand: Action-Oriented Learning in an Afterschool Science Club*

Committee Members: Jessica Thompson (Chair), Mark Windschitl, Morva McDonald, Alison Wylie

1999-2001 Master of Education, Secondary Science Education, The State University of New York: University at Buffalo, Buffalo, New York  
Including doctoral level coursework in biology and research in immunology

Thesis: *Discussion of Controversial Issues in the Science Classroom*

1995-1999 Bachelor of Science, Biology, The State University of New York: The College at Brockport, Brockport, New York  
Honors: Alpha Chi Honor Society, *magna cum laude*

Research: *Rattus lordosis* seasonal behavior

**CERTIFICATIONS**

2005-present National Board Certification: Early Adolescence Science

2002-present State of Washington Professional Education Certificate, 4-12 Science

2001-2006 State of New York Teaching Certificate, 7-12 Biology and Chemistry

**PROFESSIONAL EXPERIENCE**

2015-present Assistant Professor, College of Education, Boise State University

2010-2015 Research Assistant, College of Education, University of Washington

2009-2015 Core Faculty, School of Education, Antioch University Seattle

- 2007-2009 District Science Curriculum Developer, Bellevue School District, Bellevue, WA
- 2003-2007 Science Teacher, Odle Middle School, Bellevue, WA  
Taught 6<sup>th</sup>-8<sup>th</sup> Grade Integrated Science
- 2002-2009 Adjunct Faculty, School of Education, Antioch University Seattle
- 2002-2003 Science Teacher, Renton High School, Renton, WA  
Taught High School Biology and Integrated Science
- 2001-2002 Science Teacher, Odyssey High School, Rochester, NY  
Taught High School Biology, International Baccalaureate Curriculum Developer
- 2000-2001 Teaching Assistant, Sweet Home High School, Amherst, NY
- 1997-1999 Teaching Assistant, The State University of New York: The College at Brockport, Brockport, New York  
Organic Chemistry, Anatomy and Physiology

## PUBLICATIONS

### *Refereed journals*

Thompson, J., Hagenah, S., Kang, H., Stroupe, D., Windschitl, M., & Colley, C. (2015). Rigor and responsiveness in classroom activity. *Teachers College Record*.

### *Under review*

Thompson, J., Hagenah, S., Lohwasser, K. & Laxton, K. Problems without ceilings: Mentoring communities' engagement around ambitious and equitable teaching and learning. (Under review, *Journal of Teacher Education*).

### *In preparation*

Hagenah, S. Engaging students in opportunities for sense making: Novice teachers' attempts to contextualize science phenomena in students' lives. (In preparation for *Science Education*).

Thompson, J., Barchenger, C., & Hagenah, S. The coevolution of tools and practice. (In preparation for *Science Education*).

Thompson, J., Hagenah, S., & Colley, C. Focusing and funneling. (In preparation for *Science Teacher*).

## PRESENTATIONS

### *National presentations and conferences*

(\*refereed papers, \*\*invited)

- \*Hagenah, S. & Thompson, J. Action-oriented science teaching. (2015, April). In D. Stroupe and H. T. Zimmerman (Chairs), *Young people shaping science in and out of classrooms: Implications for teaching and learning*. Structured poster session conducted at the annual meeting of the American Educational Research Association, Chicago, IL.
- \*Hagenah, S. & Thompson, J. Science stories and life stories. (2015, April). In L. Bricker (Chair), *The impact of multimodal composing on youth transformative disciplinary identity work across settings*. Structured poster session conducted at the annual meeting of the American Educational Research Association, Chicago, IL.
- \*Thompson, J. & Hagenah, S. Responsiveness and rigor from a social practice perspective. (2015, April). In M. Braaten (Chair), *Responsiveness in science teaching*. Symposium conducted at the annual meeting of the National Association for Research in Science Teaching, Chicago, IL.
- \*Thompson, J., Barchenger, C., & Hagenah, S. (2015, April). Divergent paths: The coevolution of tools and practice in job-embedded professional development. In E. van Es and H. Kang (Chairs), *Design principles for a pedagogy of teacher education*. Structured poster session conducted at the annual meeting of the American Educational Research Association, Chicago, IL.
- \*\*Luehmann, A. & Hagenah, S. (2014, September 5). STARS: Students tackling authentic and relevant science. What does “authentic and relevant” science for youth really mean? [Webinar]. In *National Girls Collaborative Project Webinar Series*. Can be retrieved from <http://www.ngcproject.org/stars-students-tackling-authentic-relevant-science>.
- \*Hagenah, S. & Thompson, J. (2014, April). Engaging students in opportunities for sense making: Thirty-eight novice teachers’ attempts to contextualize science phenomena in students’ lives. In J. Cartier (Chair), *Rigorous and responsive learning by design: Transforming classrooms and practice-based teacher education*. Symposium conducted at the annual meeting of the National Association for Research in Science Teaching, Pittsburgh, PA.
- \*Thompson, J. & Hagenah, S. (2014, April). Changing contextual discourses to support the improvement of science teaching. In *Trajectories of teacher change: Activating and influencing teacher resources for enacting instruction around scientific practices*. Symposium conducted at the annual meeting of the National Association for Research in Science Teaching, Pittsburgh, PA.

- \*Thompson, J., Hagenah, S. Kang, H., Stroupe, D., & Windschitl, M. (2014, April). Rigor and responsiveness in classroom activity. In S. Moorthy and C. J. Harris (Chairs), *Productive talk and participation in disciplinary practices: Perspectives from science and mathematics education*. Learning Sciences symposium conducted at the annual meeting of the American Educational Research Association, Philadelphia, PA.
- \*Hagenah, S. & Thompson, J. (2013, April). Opportunities for sense making: Three novice teachers' attempts to contextualize science with students' lives. In K. Zeichner (Chair), *Equity-in-practice in STEM teaching*. Symposium conducted at the annual meeting of the American Educational Research Association, San Francisco, CA.
- \*Thompson, J. & Hagenah, S. (2012, April). Problems with ceilings and problems without: How mentoring communities frame and solve problems around ambitious and equitable teaching and learning. In *Tools and routines for preparing STEM teachers*. Structured poster session conducted at the annual conference of the American Educational Research Association, Vancouver, BC.
- \*Hagenah, S. (2012, March). How novice teachers use students' lived experiences as science stories. Special interactive poster symposium for Sandra K. Abell Scholars at the annual meeting of the National Association for Research in Science Teaching, Indianapolis, IN.
- \*Thompson, J. & Hagenah, S. (2011, April). Developing ambitious and equitable practices. In *Raising performance expectations for novice teachers: The promise of pedagogical tools and core practices*. Symposium conducted at the annual meeting of the National Association for Research in Science Teaching, Orlando, FL.

## RESEARCH EXPERIENCE

- 2013-2015     Lead Researcher and Project Manager  
*Science STARS (Students Tackling Authentic and Relevant Science)—Nurturing Urban Girls' Identities Through Inquiry*  
 Informal Science Education, National Science Foundation  
 Cross-site Principal Investigators: Jessica Thompson, April Luehmann (University of Rochester), & Angela Calabrese Barton (University of Michigan)
- Responsible for design and implementation of formal out-of-school science program for girls in high needs middle school.
  - Responsible for design and implementation of qualitative methods study to collect data on social justice science learning, action-oriented ambitious teaching practices, and identity trajectories of science students and teachers.
  - Responsible for developing theoretical basis for understanding how a community of middle school students and teachers learn and participate under social justice ambitious science education principles and practices.
  - Responsible for full Human Subjects approval process and National Science Foundation annual report.

- Collaboration with professional videographer to design and produce professional documentary film: <https://vimeo.com/92776664>.
- Collaboration with multiple community members involved in research project: local scientists, newspapers, local TV stations, park department, elementary, middle, and high school science teachers, school district administration, after school program coordinators.
- Weekly cross-nation collaboration with principal investigators on data collection, data analysis, and conference proposals.
- Collaboration with National Girls Collaboration Project (NGCP) on disseminating findings in a nation-wide webinar.

2012-2013

Lead Research Assistant

*Developing networked improvement communities for high quality mathematics and science teaching*

Washington STEM Grant

Principal Investigators: Jessica Thompson &amp; Elham Kazemi

Website: [http://tools4teachingscience.org/networked\\_improvement/](http://tools4teachingscience.org/networked_improvement/)

- Responsible for the refinement of qualitative research methods to collect data in a multi-case, multi-site study examining teacher development and student learning.
- Responsible for developing models of collaborative coaching practices and tools used to bridge professional development learning to classroom practices.
- Responsible for data collection and analysis based on teacher development and student learning across multiple middle and high schools.
- Planned and conducted job-embedded professional development days, Studio Days, for middle and high school teachers.
- Organized, planned, and conducted Next Generation Science Standards and Ambitious and Equitable Science Teaching Practices Summer Institute for thirty-five middle and high school teachers from three school districts.
- Collaborator with WA STEM to train and use Iris Connect Lesson Observation Platform with science teachers.
- Designed and disseminated Ambitious Science Teaching Professional Development videos.

2010-2012

Lead Research Assistant

*Buffering against regression: Supporting co-learning between teacher candidates and cooperating teachers*

Knowles Science Teaching Fellowship

Principal Investigator: Jessica Thompson

Website: <http://sites.education.washington.edu/mentorsci/>

- Responsible for refinement of qualitative research methods to collect data in multi-case, multi-site study examining co-learning between teacher candidate and cooperating teachers.

- Responsible for generation of theories of co-learning and practice emerging from data collected in study.
- Development of Ambitious and Equitable Science Teaching Mentoring tools.
- Planned and conducted Ambitious and Equitable Science Teaching Practices Summer Institute with middle and high school science cooperating teachers and teachers on special assignment from nine local school districts.
- Created and maintain Advancing Equitable Ambitious Science Teaching Practices social media website, presently used by 242 science teachers globally.

2010-2012      Research Assistant  
*Tool systems to support progress towards expert-like teaching by early career science educators*  
 National Science Foundation DRK-12 Grant  
 Principal Investigators: Jessica Thompson & Mark Windschitl  
 Website: <http://tools4teachingscience.org/>

- Responsible for refinement of qualitative methods used to collect data in a multi-case, multi-site, multi-researcher longitudinal study.
- Responsible for data collection of ambitious teaching practices.
- Responsible for synthesis and analysis of data from 222 high and middle school science lessons.
- Collaborated with quantitative data analyzer to produce mixed methods findings.

## UNIVERSITY TEACHING EXPERIENCE

*Graduate-level courses (All taught at Antioch University Seattle on quarterly basis)*

EDUC510	Strategies of Instruction and Assessment	2013-2015
EDUC615-618	Integrated Master's Project I, II, & III	2013-2015
EDUC608-609	Research Project I & II	2011-2013
ENV610	Integrated Environmental Science	2010-2011
EDUC610	Inquiry Proposal	2009-2011
EDUC620	Inquiry Development	2009-2011
EDUC650	Inquiry Report	2009-2011
EDU516	Content Area Studies: Secondary Science	2004
EDUC552	K-8 Science Methods	2002-2015

## PROFESSIONAL SERVICE

*Campus/University*

2014-2015      Member, Antioch University Seattle (AUS) Faculty Review Committee

- 2014           Presenter, Teacher Education Evidence Summit, University of Washington
- 2011-2012    Organizer and writer of AUS Washington State Teacher Education Reaccreditation Report
- 2011-2015    Chair of AUS Graduate K-8 Teacher Education Program
- 2011           Presenter, Teacher Education Evidence Summit, University of Washington
- 2010-2012    Designer of AUS K-8 Teacher Education Program redesign
- 2010-2011    AUS Global and Sustainability Task Force
- 2009-2015    AUS Institutional Review Board
- 2009-2015    AUS Scholarship Committee
- 2009-2015    Advisor of AUS Master of Arts in Teaching Graduate Students (15-30/year)
- 2009           AUS Planning and Budget Committee

*Regional*

- 2012           Professional development for Seattle Public Schools' science teachers
- 2010-2015    Member, Partnership for Science Educator Enhancement and Development (SEED)
- 2010-2013    Professional development for Highline, Edmonds, Renton, Seattle, Issaquah, Bellevue, Bethel, Federal Way and Kent school district science teachers and teachers on special assignment.

**AFFILIATIONS & MEMBERSHIPS**

- 2014-present   International Society of the Learning Sciences (ISLS)
- 2011-present   American Educational Research Association (AERA)
- 2010-present   National Association for Research in Science Teaching (NARST)
- 2009-present   Disabilities, Opportunities, Internetworking, and Technology (DO IT)
- 2008-present   Teachers of Teachers of Science (TOTOS)

**AWARDS, HONORS, & GRANTS**

- 2011 Sandra K. Abell Fellow  
Selected to attend weeklong training program for doctoral students in science education. Organized by the National Association for Research in Science Teaching.
- 2006 Bellevue School Foundation, \$800
- 2005 Teacher of the Year, Odle Middle School PTSA
- 2005 Nominated for Amgen Award for Science Teaching Excellence
- 2005 Bellevue School Foundation, \$800
- 2002 Renton High School, Science Club, \$200