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Changing Lanes: Relational Dispositions That Fuel Community Science Learning

Tamara Clegg
Kenna Hernly
University of Maryland, College Park
June Ahn
University of California, Irvine
Jason Yip
University of Washington
Elizabeth Bonsignore
Daniel Pauw
University of Maryland, College Park
Caroline Pitt
University of Washington

Supporting youths' STEM dispositions takes an entire community of adults, yet we must understand the dispositions that adults bring to such community

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Tamara Clegg is an associate professor in the College of Information Studies at the University of Maryland whose research focuses on the learning sciences, human-computer interaction, STEM learning and critical data literacy.

Kenna Hernly is a PhD candidate in the Department of Technology and Learning, Policy and Leadership at the University of Maryland whose research focuses on learning and technology in the arts and museums.

June Ahn is a professor of Learning Sciences and Research-Practice Partnerships at the UC Irvine (UCI) School of Education who conducts research at the intersection of participatory design, technology, education, and community partnerships.

Jason C. Yip is an associate professor of digital youth at the Information School at the University of Washington whose research focuses on learning sciences, human-computer interaction and science education.

Elizabeth Bonsignore is a research scientist and director of the Kidsteam participatory design lab in the College of Information Studies at the University of Maryland. Her research focuses on user experience and interaction, learning sciences, participatory design, and participatory learning.

Daniel Pauw is a PhD candidate in the College of Information Studies whose research focuses on science education, citizen science, games in education, and social media.

Caroline Pitt is a PhD candidate in the Information School at the University of Washington whose research integrates informal learning, social science, and media production to explore multimedia data through qualitative analysis.

efforts, ways they influence youths' learning and are shaped by the community. In this paper, we examine a sociotechnical system called Science Everywhere, which invited the broader community to interact with science learning experiences youths shared across home, school, and community settings. Integrating frameworks for disposition and asset-based community development, we present a case study of four focal adults within Science Everywhere embedded in one neighborhood. We make the case for a relational perspective of disposition development that leverages community members' science and relational assets to foster dynamic, community-specific learning opportunities for youths, particularly those from resource-constrained communities.

Keywords: case studies, technology and learning, in-depth interviewing, parents and families, qualitative research, science education, urban education

Dispositions toward learning characterize how one thinks about a discipline and the ways a person sees that topic relating to their own values (Gresalfi, 2009; Gresalfi & Cobb, 2006; Katz, 1993). For example, when an individual has a disposition toward science learning, they may readily look for and see opportunities to apply science in new contexts, value science as integral to understanding the world, and see the field as relevant to their daily lives (Clegg & Kolodner, 2014). They may later develop preferences and skills to apply their knowledge flexibly in new situations (Clegg & Kolodner, 2014; Gresalfi & Cobb, 2006; Katz, 1993). Disposition development in science promotes learners' connections between the field and themselves (i.e., their interests and lives) in ways that lead to sustained engagement through learners' own initiation (Clegg & Kolodner, 2014; Gresalfi & Cobb, 2006). Ultimately, fostering learners' scientific dispositions facilitates a cycle of science practice and learning.

The development of dispositions toward science is not only the sole responsibility of learners; it also relies on how others in one's life signal what is valued in the field. Formal science learning often signals particular skills to enact, or ways of thinking about the world, that may misalign with non-Western ways of knowing (Bang et al., 2016) and actively erase or disregard the rich scientific thinking that young people enact in their everyday lives. The dispositions of those who guide and support learners are vital to examine so that we might create more inclusive systems that recognize a wider range of scientific practices.

Research has shown that the dispositions of parents and teachers shape the types of learning experiences they support for youths (e.g., Tour, 2019; West et al., 2020; Yu et al., 2020). This observation resonates with the experiences of our research team. In a personal example, when the first author's mother started working at an institution of higher education, she began to see the types of STEM experiences undergraduates brought to college.

Author 1's mother was inspired to expose her children and their friends to novel professional paths to STEM by engaging them in fun, informal STEM activities. She enrolled her children and their friends in programs where they toured biochemical and phlebotomy labs at the local hospital, competed in regional bridge-building contests, and took field trips across the southeastern United States to STEM labs at historically Black colleges and universities.

Similarly, adults are gatekeepers to the *forms of engagement* that are supported in a child's life. Papert (1980) describes the rich experiences he had exploring bicycle gears at home as a child. Although Papert's caregivers likely encouraged such engagement, other parents might view such explorations as out of order or unproductive (Logler et al., 2020). Youths may not be permitted to participate, depending on adults' dispositions toward what they view as appropriate in a field (e.g., science). *Adults can potentially amplify or detract from learning*, depending on their particular science dispositions. Prior work in science learning has shown that parents, teachers, and community members can play influential roles in promoting a child's science practices related to their interests, hobbies, values, and daily lives (Bell et al., 2000; Clegg & Kolodner, 2014). Conversely, adults may not have time or see benefit in helping youths explore such contexts, and youths may feel limited to pursue science learning only in formal contexts or have less social support in doing science in their everyday activities (Clegg & Kolodner, 2014).

Research on STEM learning has shown that to support youths' STEM dispositions, an entire community of adults in a child's life plays substantial roles—parents, teachers, volunteers, mentors, and informal educators (Barron et al., 2009; Barron et al., 2014; Bell et al., 2013; Martin et al., 2017). Communities can work together to provide a range of learning opportunities for youths in neighborhood contexts. We must therefore understand how to leverage the wisdom of local communities, mobilize resources that are available in every community, and coordinate in ways that support young people's science learning across their life contexts (Banks et al., 2007). As our team grappled with this question, we built from research on Asset-Based Community Development (ABCD), which has long documented the importance of community members working together, recognizing the assets that are richly present even in resource-constrained communities, and increasing their capacity in ways that are meaningful to and driven by the community (Kretzmann & McKnight, 1996; Mathie & Cunningham, 2003).

In this paper, we examine a sociotechnical system called Science Everywhere (SE), designed to promote community-based, community-driven learning. SE is a community program comprising a range of adults and youths from one neighborhood. The sociotechnical system integrates a social media app that children codesigned to share the science they notice as they move about their everyday lives. We also integrated large, tangible, digital displays of their posts that were placed across local settings (e.g., neighborhood church, afterschool center, and the local middle school). The large displays invited the broader community to interact with the science learning the youths shared across settings (Ahn et al., 2018). Critically, our approach to designing this sociotechnical system included working with different community partners to integrate existing learning programs (e.g., afterschool clubs), institutions (e.g., neighborhood church and middle school), and adults (e.g., pastors, parents, and informal educators) with the technology tools that we developed.

This designed setting serves as our context to study how communities can learn science together. As we codesigned, implemented, and studied SE over 5 years, the profound shifts in the neighborhood adults' dispositions toward science struck us as one of the major developments that occurred over time. Understanding how to establish environments that promote this disposition development—supporting the adults and parents, along with the children—became a key focus of inquiry for our research team. Documenting and analyzing the features of SE through an ABCD perspective helps us link affordances of learning environments with the supports and dispositional development of the adults. Within this context, we explore the following research questions:

- RQ1: What science dispositions do adult community members bring to community-based science learning, and how are they influenced by experiences within a neighborhood sociotechnical system focused on STEM learning in everyday life?
- RQ2: What is the role of relationships in supporting adult disposition shifts?
- RQ3: How can sociotechnical systems support adults' science disposition shifts?

We present a case study of the SE sociotechnical system integrated in one neighborhood. Our analysis highlights the experiences and perspective shifts of four focal adult participants in SE with a range of program roles (i.e., parents, a community volunteer, and an outreach director). These cases broaden the scope of disposition research, illuminating a *relational* perspective of disposition that leverages the science and relational assets community members bring to foster dynamic, community-specific learning opportunities for youths.

Background

We build on two bodies of research. First, we draw on disposition research to clarify the focus of our analysis and how we theorize about adult disposition development. Second, ABCD research informs our understanding of the hyperlocal context in which our project is situated.

Defining and Characterizing Adult Science Dispositions

To understand adult disposition development in the SE program, we define *disposition* as the values of, ideas about, and ways of participating in a particular discipline that come frequently, consciously, and voluntarily (Clegg & Kolodner, 2014; Gresalfi & Cobb, 2006; Katz, 1993). This definition focuses on two aspects of disciplinary engagement. First, we consider the underlying mechanisms that influence behavior, such as values, perspectives, and ideas that shape one's interactions and indicate learners' science engagement (Gresalfi & Cobb, 2006). Second, we look at characteristics of a learner's behavior itself to understand someone's disposition development, specifically considering the frequency and initiation of their learning behaviors as well as the context(s) in which they are exhibiting the behavior (Bereiter, 1995; Clegg & Kolodner, 2014; Katz, 1993). Behavioral shifts, such as frequently engaging in scientific practices and initiating these practices in new situations and across contexts, are indicative of scientific disposition development—actions Clegg and Kolodner (2014) call *scientizing*. When someone scientizes, they begin to find new applications of science in their everyday lives and apply them, leveraging science to achieve personally meaningful goals (Clegg & Kolodner, 2014).

Science dispositions include, but are not limited to, values for and tendencies toward asking questions, designing experiments and investigations, collecting and analyzing data, making evidence-based claims, and applying scientific phenomena to new situations (Chinn & Malhotra, 2002; National Research Council, 2011; Osborne et al., 2003). Many studies focus on procedural and conceptual understanding of scientific phenomena as core elements of scientific disposition (Gresalfi, 2009), but these facets reflect only one component. Clegg and Kolodner (2014) highlight a more comprehensive and holistic set of factors in their consideration of four building blocks of disposition that need to be inherent in learners' experiences for effective science disposition development. *Procedural and conceptual understanding* involves helping learners develop scientific skills and conceptual understanding and apply their skills and understandings when relevant. Second, *interest-based experiences* are needed for learners to develop curiosity about science and a desire to investigate science-related concepts in their everyday lives. Third, learners need *social interactions* with others who are interested and engaged in science and scientific inquiry. Finally, learners need opportunities to connect science to their own *personal values*—to their cultures and identities. Clegg and Kolodner (2014) found that as learners had experiences across these building blocks of disposition development, they were more active and engaged in science practices across contexts. As their participation shifted, their values shifted—learners' perspectives of science became more closely connected to their identities, indicating scientific disposition development. Although these studies guide our understanding of dispositions in science, they are focused on youths' disposition development.

Less is known about how adult dispositions are influenced as they facilitate and engage in science learning with youths. One area where researchers are exploring adults' disposition development is in Teacher Education (e.g., Altan et al., 2019; Usher, 2019). However, this work is focused on teacher education programs wherein adults seek to develop or shift their careers. It is less clear how these disposition frameworks could apply to informal educators—community members, parents, or afterschool coordinators who also play important roles in youths' learning, but who may not have the time, interest, or resources to take extensive coursework. We focus our work on informal adult educators in a child's life, within a hyperlocal neighborhood context, to understand shifts and developments in adult STEM learning dispositions and how these dispositions shape adults' interactions with youths.

From Parent and Community Member Engagement to Adult Dispositions in Science

Parents are involved in a myriad of disciplinary domains with their children, from technology use and computational thinking to science learning (e.g., Luce et al., 2017; Tour, 2019; Yu et al., 2020). The parent engagement literature focuses on the roles and tasks parents take on with their children, such as formal learning experiences (e.g., Barton et al., 2004; Carreón et al., 2005), informal learning through everyday family activity (e.g., Luce et al., 2017), and learning across formal and informal contexts with and for their children (e.g., Barron et al., 2009; Takeuchi et al., 2019). Barron (2006) highlights the importance not only of parents but of other community members (e.g., informal educators and community group leaders) in supporting children's STEM learning experiences and underscores the need for more studies on the dispositions of the many adults in a child's life (not only parents), ways these dispositions shift as these adults have everyday experiences with learners across contexts, and ways these adult dispositions influence children's learning.

Insights into influencing factors of adult engagement in youths' learning also point to the need to pay attention to the perspectives of diverse parents, especially those from nondominant (e.g., minoritized, resource-constrained) communities. Tour's (2019) study of highly educated migrant workers in Australia reveals how they experienced socioeconomic status "downgrades" from lucrative, white-collar jobs in their native countries when they moved to Australia. To ensure that their children's economic opportunities grew in their new country, these migrant workers emphasized economic advancement and their children's performance in school, often viewing informal experiences and innovative pedagogies as a lower priority. However, money is not always the biggest differentiator in parents' pursuit of extracurricular experiences for their children (e.g., sports, scouting). For instance, Takeuchi et al. (2019) find that some parents were not aware of out-of-school learning programs, and different parents may value formal versus informal learning programs differently. Lastly, parents' perceptions of their own skills and backgrounds can shape their perspectives on learning jointly with their children (Yu et al., 2020). Our work extends efforts to unpack the views of adults from diverse backgrounds, targeting those who work with youths in minoritized communities situated in neighborhoods deemed resource-constrained through the placement of Title I schools.

ABCD

To move beyond formal, school contexts and into the local community of a child's life, we must understand how a community's structure may support learning across people, organizations, and resources. We draw on ABCD (Kretzmann & McKnight, 1996; Mathie & Cunningham, 2003) as a framework for studying learning at the community level. ABCD is a philosophy and a method for facilitating community-led development by focusing on a community's assets, as opposed to its needs or deficits. ABCD has been used as a framework for understanding communities traditionally seen through deficit lenses—that is, low socioeconomic, minoritized communities, as well as developing nations and communities plagued with chronic illnesses—to instead recognize and design for the assets that different communities bring (e.g., Harrison et al., 2019; Johnson Butterfield et al., 2016; Misener & Schulenkorf, 2016). The ABCD model fits particularly well with our asset-based focus and our emphasis on formal and informal social networks within the community.

Key to ABCD approaches is leveraging resources, relationships, and activities for community development (Kretzmann & McKnight, 1996; Mathie & Cunningham, 2003). The framework emphasizes mapping assets, or *resources*, from within the community (e.g., individual skills, passions, and personal resources) to needs that these resources can address. ABCD positions *every* community member as having individual assets that are beneficial to the community, even when their assets are not typically viewed as such (Kretzmann & McKnight, 1996; Mathie & Cunningham, 2003). Social capital derived from community relationships promotes and expands individual assets and is important for establishing trust, engagement, and broader community participation (Harrison et al., 2019). Outside organizations may provide additional activities and resources, but the core focus is on building from, and integrating with, the internal assets of local community development (Kretzmann & McKnight, 1996; Mathie & Cunningham, 2003). This sequencing actively resists traditional service-client mindsets that lead to a community's dependence on external organizations and that can cause community members to see themselves through deficit lenses. ABCD instead facilitates partnerships with external entities that serve to enhance—not lead or overtake—efforts the community is already engaged in (Kretzmann & McKnight, 1996; Mathie & Cunningham, 2003).

Numerous papers have been published on ABCD projects across multiple disciplines, including medicine, health and wellness, social work, and education (e.g., Forrester et al., 2020; Harrison et al., 2019; Johnson Butterfield et al., 2016; Misener & Schulenkorf, 2016). Although these projects shed light on how the components of ABCD promote community development, they do not explore the various groups of people who make up these community efforts or their relationships to the ABCD projects. It is necessary to understand the perspectives and experiences of these individuals (Johnson Butterfield et al., 2016). In our work, we have sought to understand the constellation of adults involved in SE, their experiences through their involvement, how their own dispositions shifted as they engaged with SE efforts, and how those shifts, in turn, influenced their participation in further project efforts and goals.

Scientific disposition development was initially framed in terms of classroom (Gresalfi, 2009) and professional (Chinn & Malhotra, 2002) contexts. Inherently, these frameworks espouse values commonly held by dominant perspectives of science, which can put disposition frameworks at odds with ABCD because such frameworks can prioritize dominant ways of engaging in science that are in tension with nondominant values and cultures and can discount or underacknowledge the disparate effects of discrimination some students experience in formal science contexts (Aikenhead, 2007; Bevan et al., 2020). Such prioritization can then cause communities' ways of being to be seen through a deficit lens if they do not align with dominant perspectives (Bang & Marin, 2015). However, we draw on the scientizing disposition framework (Clegg & Kolodner, 2014) because the framework's building blocks of disposition carefully consider and prioritize learners' interests, personal values, and ways of being to uncover and welcome nondominant means of engaging in science. Aligning with ABCD, the framework views such engagement as a science learning asset.

Taking an asset-based approach, our analysis focuses hyperlocally on the families in a neighborhood that form a support system of relationships and resources. We use the term *hyperlocal* to describe communities that are bound geographically and by the social ties between the people who live there, with resources unique to that place. In contrast with the notion of an entire city, state, or region, the hyperlocal setting invokes a sense of intimacy not present when scaling out to whole cities, counties, or districts. In contrast to the traditional approach in education of "scaling up," our analytical approach advocates for leveraging tight connections between a small group of people to support learning. Following from this lens, we study the experiences of adult participants in the neighborhood in which the SE sociotechnical system was implemented in the mid-Atlantic United States, including researchers/program staff, the church outreach director, church volunteers, teacher partners, and parents of SE youths.

The SE Sociotechnical System

As researchers in the learning sciences and human-computer interaction, we design and study technical systems, but we recognize the critical role of social systems in driving experiences with technology, use of such systems, and, ultimately, the overarching impact (or lack thereof) of such systems (Fischer & Herrmann, 2011). We carefully understand and infrastructure (Penuel, 2019) technical systems within existing social systems, norms, routines, and dynamic interactions, engaging the target communities in the design process and then carefully studying ways the resulting sociotechnical system develops and affects participants.

The project started with the research team focused on developing an understanding of the community's goals. Our team began from the existing work the community was already doing—running academic enrichment, out-of-school programs and establishing relationships with the surrounding neighborhood through community service. A researcher on the SE team was serving as a volunteer in Grace Covenant Church's (pseudonym) Homework Club educational outreach program. Grace Covenant Church, a nondenominational church with about 200 members, is a multicultural church led by two African American pastors with a majority of Black congregants (~50%) but also including White (~30%), Latinx (~10%), and Asian (~<5%) congregants.

The outreach director and church leaders at Grace Covenant Church had been looking for ways to offer more programming targeted specifically toward middle-school youths. Therefore, the project began as a community effort centralized at the church, leveraging the church's extensive relationships with the community to establish a partnership with the local middle school (Carnegie Middle School, pseudonym) that most children in the neighborhood attended. We established SE as a new afterschool and summer program at the church, with participants recruited from Carnegie Middle School and from Grace Community Church's other outreach programs. Over time, parents and youths petitioned for their younger children/siblings to participate, and youths continued to participate after they entered high school, resulting in a wide range of participants (ages 6–17 years old) throughout the study.

Within the church, we established a weekly afterschool program that included dinner and science activities for youths and, on some weeks, their families. Learning activities focused on a particular topic that related science to everyday life (e.g., investigating chemistry through making and perfecting dishes and exploring and addressing water quality in the local stream behind the church). Figure 2 shows a timeline of community science activities in SE. A range of adults in the community played integral roles in the SE sociotechnical system. Parents were involved through family science-night activities, where they participated in life-relevant science investigations with their children. They also took on "chaperone" roles during youths-only sessions, helping with program logistics. Similarly, SE researchers organized all program activities alongside our community partner, Grace Covenant Church, led by Pastor Taylor, the church's assistant pastor and director of community outreach.

Pastor Taylor led recruitment efforts and was instrumental in sustaining the community (e.g., convening parents during SE activities with youths and interacting with youths and parents in other community contexts).

SE researchers served as facilitators and designers of the sessions, but community volunteers from Grace Covenant Church helped facilitate, often working with small groups of learners to carry out their projects. We also partnered with teachers at Carnegie Middle School to codesign the SE technology and eventually use it in their classrooms (Mills, Bonsignore, Clegg, Yip et al., 2019). Teachers and students at the school were invited to engage with the science learning experiences by participating in the afterschool program at the church, inviting their students to participate, and linking us with other afterschool activities that were going on at the school.

SE Mobile App and Community Displays

The SE sociotechnical system includes a mobile app, and large community displays that were situated at multiple sites across the neighborhood. Grounded in ABCD, the SE design goal was to help learners recognize and build upon science learning assets already in the community by capturing and sharing science phenomena they noticed as they moved across home, school, and community contexts. Extending the ABCD practice of integrating community assets, resources, and activities, we codesigned all SE technology components with parents and children in the afterschool program (Ahn et al., 2018; Anonymous, 2014, 2018, 2019; Mills et al., 2019; Yip et al., 2016). The codesign process in 2011–2014 resulted in a web-based application (see Figure 1) that allows users to make posts with pictures, screenshots, or texts. Users can comment on each other's posts by selecting from a series of prompts that scaffold science dispositions (e.g.: "I am fascinated by…" and "I'm wondering about…"). They can also give "fist bumps" or "likes" to one another's posts. To ensure users' privacy and safety, app use was restricted to youth and adult participants in the SE program, youths at Carnegie Middle School, and members of Grace Covenant Church. Youths, their parents, science teachers, and SE facilitators were given SE accounts so that they could create and comment on one another's posts during the SE program. They were encouraged to create posts in the contexts of their everyday lives as they had experiences, questions, or thoughts that they related to science.

From 2014–2016, the SE research team developed large community displays to be situated at multiple sites in the community through a codesign process with children, parents, teachers, and community members. The public displays allowed children and adults in the community to scroll through posts made through the app and give *curious*, *insightful*, *collaborative*, and *investigator* badges to recognize the everyday science that was shared by youths (see Figure 1). Large displays were situated in the hallway of Grace Covenant Church and in the library at Carnegie Middle School so that the

Figure 1. **A: The SE mobile app enabled participants in the community to capture and share science experiences across contexts with pictures, polls, and text shown on a newsfeed. B & C: Tangible, interactive displays enabled multiple users to view and give badges to learners' SE posts at one time.**

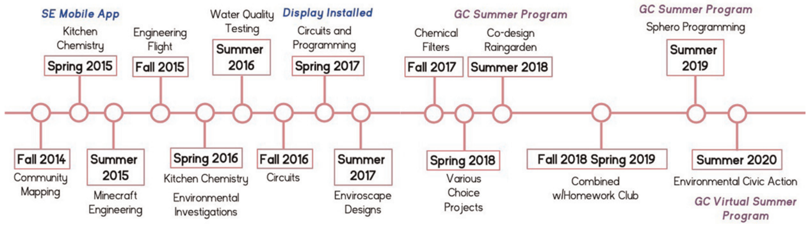

Figure 2. **The learning sequences each semester in the SE afterschool program, with markers for when the SE mobile app and community display were implemented.**

broader church and school communities could interact with participants' posts. Figure 2 shows a sequential timeline of the SE sociotechnical system, including SE learning experiences and SE technology development.

Methods

This case study is situated within a broader design-based research methodology that organized the overall SE project (Barab & Squire, 2004). In the following analysis, we study disposition development through the design, implementation, integration, and iteration of the SE sociotechnical system. We also present a case study within the boundary of one neighborhood instantiation of the SE sociotechnical system.

Data Collection

We collected a range of qualitative data (i.e., interviews, focus groups, field notes, video observations, and artifacts) from a variety of participants and stakeholders, from those central to SE's community of learners (e.g., children, facilitators, our Grace Covenant Church community partner, parents, and teachers) to those more peripheral (e.g., community volunteers and church members). We have reported on much of these data in other work (Ahn et al., 2018; Mills, Bonsignore, Clegg, Ahn, et al., 2018, 2019; Mills, Bonsignore, Clegg, Yip, et al., 2019; Yip et al., 2016), having primarily focused on youths' learning dispositions, funds of knowledge within the SE sociotechnical system, and their bridging experiences across community contexts.

For the current study, the research team began to observe a key theme over several years, as adults in the SE project shared their evolving reflections about science and science learning, which shifted substantially since they began participating. In 2018, we began conducting focus groups with adults in SE, specifically aimed at understanding *their* perspectives of science and the ways their perspectives and approaches to STEM learning had been influenced by the SE sociotechnical system (i.e., their science dispositions). We recruited parents to participate in focus groups while their children were in SE sessions. Four mothers (two Black/African and two Hispanic) participated; their children comprised 11 youths (out of ~30–40 who participated each week). The parents who participated in interviews also represented our most consistent program participants in SE's family events. Similarly, we invited all volunteers (three total: one Asian female and two White males) who were members of Grace Covenant Church and had participated in at least one SE session to participate in an interview or focus group. Additionally, all researchers and community partners (eight total: two White females, one Asian American female, one Asian/Caucasian female, one Black female, one Black male, one Hispanic male, and one White male) on the project team participated in focus groups. We interviewed a total of 18 participants. Focus-group questions covered participants' motivation to participate in SE, participants' perspectives of science (e.g., their definitions of science and relevance of science to their daily lives), and their experiences in SE.

Data Analysis

Our data analysis process involved multiple coding rounds and iterative incorporation of additional data points. In an initial structural coding round (Saldaña, 2015), we coded the 2018 focus groups and interviews to understand participants' disposition shifts and how these shifts affected the SE sociotechnical system. Specifically, for each adult participant, we coded for (a) their motivation to participate, (b) experiences they had in SE, (c) shifts in perspectives of science and science learning, and (d) the implications of those shifts on youths' learning. We inductively coded (Corbin & Strauss, 2008) the structural codes for each participant to understand broader views of their shifts and experiences in SE. This initial analysis revealed two distinctive categories that characterized most (but not all) participants in our focus groups. First, we identified a group of participants, whom we call *communitizing participants*, who were motivated to participate in and contribute to the SE sociotechnical system through their relationships in the community. These participants often expressed more distanced dispositions of science (e.g., science not being central to their goals) but foregrounded the community and relationship-based aspects of their participation in interviews. Second, we found that other participants, whom we call *traditional scientists*, were motivated by formal science learning and expressed tensions between their expectations of STEM engagement and the informal nature of learning in SE. Although all participants did not fit clearly in each category, most did—three in the communitizing category and six in the traditional scientist category.

We then selected two focal participants from each category, who had participated for the longest periods of time and from whom we had the richest data sets, for a deeper analysis. These criteria allowed us to sample the richest

Table 1

Role and Interview/Focus-Group Dates for Each Focal Participant in the Case Study

	Focal participant pseudonym	Role	Race & ethnicity	Interview 1 date	Interview 2 date	Interview 3 date	Interview 4 date
Communitizing participants	Pastor Taylor	Staff	Black	2/9/2016	8/9/2017	3/27/2018 (FG)	
	Imani	Parent	Black/African	5/14/2015	8/10/2015	2/8/2016	4/12/2018 (FG)
Traditional scientist participants	Norman	Volunteer	White	1/12/16	4/11/18 (FG)		
	Gloria	Parent	Black/African	5/21/15	8/12/2015	7/11/2016	4/12/2018 (FG)

Note. FG = focus group.

data sets so that we could more deeply understand the influences of focal adults' engagement in the sociotechnical system on their disposition shifts. We also selected participants to study a range of community roles (e.g., parents, community volunteers, and informal educators) to better understand adults' engagement and perspectives across the sociotechnical system. We gathered the interviews we had conducted with each participant over the course of the project that were focused on understanding their experiences (and, when relevant, their family's experiences) in SE. Table 1 shows each focal participant, their role, and the dates of their interviews/focus groups.

We coded these additional data according to our existing structural categories (Saldaña, 2015). Next, we conducted inductive coding (Corbin & Strauss, 2008) within each structural code to identify emergent themes for each focal participant. Specifically, within the excerpts for each structural code, we identified emergent themes that revealed their specific motivations, experiences in SE, shifts in perspectives, and the implications of those shifts. We then grouped related themes into higher-level themes, keeping track of the time stamp for the quotes/themes. Dispositions map the interrelations between the underlying mechanisms (i.e., values and perspectives) that influence action and the actions themselves (i.e., patterns and initiation) (Clegg & Kolodner, 2014; Gresalfi, 2009). Hence, the next phase of our analysis focused on mapping the shifts in perspectives, values, and corresponding actions of participants. To illustrate this mapping for each participant, we put themes together into a sequential trajectory that highlighted motivations, SE experiences, shifts in perspectives, and impacts on youths' learning for each focal participant (Tables 2 and 3 in the findings illustrate these trajectories for two focal participants, with example themes/codes that illustrate initial dispositions, shifts in SE, disposition shifts, and implications of shifts).

We triangulated findings with participants' posts in the SE social media app, incorporating their post data when relevant to themes in their trajectories. Each participant's posts (or their children's posts) were analyzed to identify posts that related to themes developed during analysis of their focus-group/interview data. For example, a theme for one participant was recognizing that she and her boys could do science in their daily lives. We included her son's SE posts sharing pictures of their family cooking at home as examples of science they were doing in everyday life. In an axial coding round (Scott & Medaugh, 2017), we identified common themes among participant types (i.e., communitizers and traditional scientists). Lastly, we looked across the two participant types to identify key similarities and differences in their disposition shifts and the influences on community-based learning for youths.

Findings

Our findings are organized by the two broad categories of participants—(a) communitizing and (b) traditional science participants. In each category, to map participants' disposition shifts (RQ1), we describe participants' actions and experiences, and we map those experiences to their shifts in perspectives (Clegg & Kolodner, 2014; Gresalfi, 2009). We then relate these participants' shifts back to their influence on ABCD, mapping to ways their disposition shifts influenced and were influenced by the SE sociotechnical system (RQ3). In the discussion, we then look across the analysis to develop a framework for understanding the role of relationships in supporting disposition shifts (RQ2).

Communitizing Participants: Pastor Taylor and Imani

The two focal participants in this category, Pastor Taylor and Ms. Imani, had strong networks within the community, which deeply motivated their participation in the SE program. Initially, they expressed more distanced dispositions toward traditional notions of science, and neither expressed science as particularly aligned with their focus on parenting or community work. However, as they began to see everyday connections to science, they initiated new connections with their own children (Ms. Imani) and used these everyday connections to science to garner participation in and excitement for new science opportunities in the community (Pastor Taylor). In their SE experiences, they saw how science could strengthen their relationships with children in the community. As they developed dispositions of science that were more related to their everyday lives, they increased their engagement in science. Over time, these engagements helped them see how science could enhance their communitizing roles.

Pastor Taylor: Communitizing Science

Our observations of Pastor Taylor's strong community focus, which he emphasized throughout interviews, suggest that he exhibited what we call a "communitizing" disposition—a strong value for promoting relationships and interactions and bringing the community together in empowering ways. Pastor Taylor had been an avid, well-known, and respected member of the local community for years at the start of SE. He had served as the outreach director at Grace Covenant Church for 15 years, and many local parents and youths knew him well from the programs he led and from his consistent presence in the community. His strong disposition toward community work motivated his partnership with the SE program. He saw the partnership as an opportunity to *communitize*, or enhance, the church's service to the community and build on relationships previously established with the local university and informal educators. Pastor Taylor's communitizing disposition helped SE identify new partners and find novel ways to involve youths and adults in the SE sociotechnical system. Additionally, his expertise with the community was instrumental in garnering support and addressing challenges with engagement.

Science Is Distant: "[Science Is] Not My Lane". Although Pastor Taylor had close relationships with community members, his interviews suggest that he had a distant perspective of science. In the spring of 2016, he reported that his confidence in his ability to do science was limited, although he was not very concerned because he did not see science as an integral part of his job, his role in our partnership, or his needed skill set more generally. This perspective, which distances science from everyday matters, resulting in limited confidence in science, mirrors commonly held views of science, particularly among minoritized learners (Atwater, 1996; Bang & Marin, 2015; Lee, 2003) and suggests that he initially had a distanced disposition toward science:

> *The greatest challenge would probably be my own lack of confidence in those areas of science. . . . I mean, I understand that's not my lane, so it's like I don't care, to be honest. . . . I don't excel at what this program does, I excel in the community part. That's what I bring.* [02-09-2016 interview]

At the time of this interview, Pastor Taylor believed that his role in the SE research project had come to a standstill because we were no longer recruiting new participants and thus were not drawing on his extensive connections to the community. However, his role was integral to our ABCD-focused efforts to connect families' everyday experiences to science. He often served as a small-group facilitator for science-learning experiences with the children and interacted with parents. Still, Pastor Taylor reported that he often preferred to be paired with another facilitator who had a professional science background when asked to facilitate a learning activity.

Recognizing New Opportunities to Communitize Science. Over time, our analysis suggests that Pastor Taylor began to contrast his original perspectives of science with what he observed in SE (and beyond), facilitating a disposition shift toward seeing science as more connected to his everyday life. He acknowledged that he had not made many SE app posts, as he believed that he did not have anything to contribute. However, in the same interview, he proposed ways he *could* begin to make posts and engage in science:

> *I'm not bent in that direction, that I don't have anything real to contribute [to the SE app]. Now, I did take this nice photo, though. When we had to shovel some snow, [my son] and I were finished, and there was this nice sunset, and, like, I wished I could have posted it, and I probably still can.* [02-09-2016 interview]

Although he saw relevant experiences he could capture, Pastor Taylor was not sure about how to relate those experiences back to science in a post. As researchers probed about why he did not post, Pastor Taylor replied, "But I don't know what I would say. This is a beautiful sunset?" One researcher suggested an example question he could have asked (e.g., "Why does the sky change colors when we have a sunset?"). Although the researcher's response bypassed Pastor Taylor's original question in a way that could be seen as suggesting that his question was not scientific enough, her suggestion indicated ways that asking questions about his observations in everyday life could be scientific. Pastor Taylor then began to think about how he had indeed begun to raise his own questions as he was outside observing the weather that day:

> *But that thought did cross my mind because of Science Everywhere. That's like, wow, look at this, you know? So, I wonder like, . . . how long will it take for this snow to melt? Like that's a science question. . . . So, I will try to scientize.* [02-09-2016 interview]

Here, Pastor Taylor decided that he would try to scientize, as he realized that there were more accessible ways to post life experiences and raise scientific questions than he had originally realized.

The SE sociotechnical system also played a role in scaffolding Pastor Taylor's scientizing efforts. Further illustrating his communitizing disposition, in 2016, Pastor Taylor expanded the role he envisioned that the SE app and display (which he helped codesign with the research team) could play in bringing the community together. He envisioned the system helping church members who were not involved with the community programs to become aware of activities in the church. He also thought that the display could facilitate community member involvement through their interaction with youths' shared posts and that it could connect the church community to other opportunities in science and technology in the local area.

In 2017, after the display had been situated in the church for several months, Pastor Taylor began to see the ways science was connected to his communitizing disposition. He was excited not only that posts were being shared from the SE program but also that the display was being used to showcase science in other community programs. He observed more people interacting with the posts on the display and noted that the increased public interaction coupled with more expansive community photos motivated him to post more to the SE system himself.

Seeing the Value of Scientizing for His Own Personal Goals: Deepening Community Work. Pastor Taylor still did not think of science as integrally related to his life: He was quick to point out in his 2017 interview that he did not have time to think about science ("I'm sorry, Science Everywhere. I'm probably not going to be interested in science. It has to be something very specific, like part of my goals"). However, in the next sentence, he began to reference environmental projects youths had begun at the church. That spring and summer of 2017, youths had investigated the water quality of the stream behind the church and found that the water quality needed improvement. They suggested stormwater management practices and installations (e.g., rain gardens) that the church could implement to improve water quality. In his 2017 interview, Pastor Taylor related the youths' environmental findings and suggestions to his role as a church pastor:

> *I've been at SE, and because the students told me that we need to do a better job of, like, getting water off of our property, when I see this, I'm like, okay, so how can we get something like this to happen with our water drainage?* [08-09-2017 interview]

This quote reveals Pastor Taylor's interest in the environmental projects that SE youths had carried out, especially as they began to advise him about stormwater issues around the church. His interest suggests a burgeoning disposition toward science, as science became more intertwined with his goals as a pastor (here, maintaining the church grounds): "Meaning, like, if we were to be able to start the rain garden or whatever, like it has to be something very . . . that makes me, like, you know, attracted to [science]" (08-09-17 interview).

In early 2018 interviews, Pastor Taylor's reflections further illustrate ways in which his disposition toward science had shifted. He reported that SE had inspired him to think more about science, a direct contrast with how he had originally viewed science:

> *Science has been one of my least favorite subjects from way back when I was in middle school and high school. However, being part of the SE project has made me think about science. Which is a feat already. Because for me, if I don't like something, I'm not thinking about it, but having been given access to how students think through the app, and also being aware of some of the projects that we've undertaken and seeing them, it's also made me begin to think in scientific ways.* [3-27-18 focus group]

Pastor Taylor's scientific communitizing has continued well beyond data collected in this analysis. One SE researcher connected Pastor Taylor with an environmental stewardship program. Together, the stewardship organization, the church, and the researcher worked to design and implement a rain garden at the church. Although SE youths codesigned the rain-garden layout with landscape architects at the stewardship organization, Pastor Taylor facilitated meetings with church members to review plans and to recruit help with planting. He leveraged connections with the neighboring high school to recruit high school volunteers for the planting.

Imani: Scientizing Parenting

Imani was an active SE volunteer and mother of three children: Isaac (17 years old), Dontae (14 years old), and Barack (8 years old). Imani and her children participated in SE from its beginning (spanning 5 years in the project), with her two older children participating in the church's youth programs years before SE began. She had developed a good rapport with Pastor Taylor and the church, which initially motivated her family's participation in SE.

Initially, she expressed a distanced disposition toward science, echoing commonly held emphasis on formal science contexts (Lee, 2003), stating that science was relegated to chemistry labs:

> *I have to admit before even I came close to SE, the notion of science for me was almost particularly related to chemistry, you know? What you do, you're in the lab. You do experiments in the lab. . . . So, that was science, you know?* [4-12-2018 focus group]

Recognizing Opportunities to Scientize: From the Lab to Everyday Life. As Imani began to observe community experiments and investigations in SE, she contrasted her original views of science with her SE experiences. She began to see that lab scientists were not the only ones who engaged in science; she and her children also asked questions and conducted investigations in their daily lives. This helped her transition from seeing science as mysterious to encountering the processes and materials of science closeup. Her 2018 reflections suggest that her science disposition was shifting, as she observed many ways in which her children engaged in science through everyday activities:

> *The fact of introducing our children to the element of SE, it opened for them that mysticism which you could be having around science and to bring it to everyday life experience closer to us, that they can even experiment themselves and bring up a conclusion on what is happening in daily life.* [4-12-2018 focus group]

This recognition of science in everyday life was evident in their family's posts on the SE app (Figure 3): They leveraged everyday activities to engage in science, which enacted her strengthening science disposition. After Kitchen Chemistry activities wherein SE learners investigated how leaveners work in bread, we encouraged them to think about how leaveners work at home. Dontae made posts as their family made waffles (see Figure 3) and as they made more traditional African dishes (e.g., "Akara" African doughnuts—see Figure 3). Later, he posted new home cooking experiences where the boys themselves were doing the cooking.

Incorporating Scientizing Into Parenting. Imani's sons shared SE posts of cooking experiments they did at home and environmental observations they made in their community (Figure 3). Likewise, she began to see these everyday contexts as places where she could engage in the wondering, reasoning, and exploring of science with her children. Additionally, she reported that she began to see her children leveraging experimentation in daily life. Her own reckoning of these practices reshaped the way her family viewed them, as she described a situation in which her youngest son was about to be disciplined by her husband for breaking a pair of eyeglasses until she stepped in

Figure 3. **A–E (left to right): Imani's SE posts with her children. The family's posts showcase some of the ways their family was seeing science in the community (B) and doing science at home, as her sons helped her cook (A, C, & D).**

and recognized her son's actions as experimentation and iteration (skills that were the focus of many SE sessions):

> *The one thing that the baby did one time that his dad was mad [about] and [I] said uh-uh, [he's] in SE. So, he has two glasses, but he wanted the frame on one. He take it apart, try to fix and get them in, and he did not do it right. Then, his dad was [mad]. . . . I said, "Leave him alone. He's experimenting. He did not break anything that belongs to you." . . . I said, "Next time, you'll get it right." . . . His dad was so upset. I said, "Leave him alone. He's in Science Everywhere."* [4-12-18 focus group]

Mapping Communitizers' Disposition

Pastor Taylor and Imani clearly demonstrated what Pastor Taylor termed a "communitizing" disposition throughout the program. Pastor Taylor sought new ways to connect with and empower the community and then took on those opportunities, while Imani's disposition in relation to SE primarily

Table 2

Pastor Taylor's Disposition Shifts as an Example of a Communitizing Science Participant

Initial dispositions	Shifts in science everywhere	Disposition shifts	Implications of shifts
Science Is Distant: I am a communitizer. Science is not connected to my goals, skills, or interests.	*Recognizing Opportunities to Scientize:* I observed a lower bar of entry to science—connecting to everyday life. *Seeing the Value of Scientizing for Personal Goals:* Maybe science *could* be related to my goals as a community organizer and grounds steward.	I am a communitizer, AND science connects to my goals, life, and interests. Science is not as intimidating as I thought.	• Initiated rain garden installation and design at Grace Covenant Church • Brought community organizations together for the rain-garden program • Incorporated science and other academic learning programs in Grace Covenant Church's summer program offerings

focused on parenting; she wanted to help her children have educational experiences in their close-knit community. Their perception of science was somewhat orthogonal to what they perceived as formal scientific values, perspectives, and sets of expertise, as exemplified by Pastor Taylor's sentiments that science was not his strength and Imani's view of science as something only done in labs.

Relationships motivated communitizers' science disposition shifts in that they were first motivated to participate in SE by relationships in the community. As they interacted with youths, researchers, and SE facilitators, Pastor Taylor and Imani began to observe more accessible paths to science (e.g., sharing everyday questions and observations and everyday family activities like cooking). New paths to science engagement arose for communitizers as they spent time with kids in the program and observed ways science could help them with their community goals (i.e., strengthening relationships in the community). Although Pastor Taylor never called himself a scientist in our interviews, our analysis suggests that his communitizing disposition became more scientific as he leveraged science to forge new community outreach activities and interactions, incorporating science learning into new leadership initiatives and using his community connections to promote science-based projects (Table 2). Similarly, Imani's reframing and realigning of science with her role as a parent also began to influence her parenting: She now saw potentially mischievous behavior as valued scientific exploration.

Role of the SE Sociotechnical System

The SE sociotechnical system helped communitizers develop a less distanced perspective of science by broadening the entry point to science engagement. Prompts in SE activities encouraged participants to share everyday activities (e.g., cooking and outdoor experiences) as scientific, and the SE app and display gave communitizers a platform to express science in the context of their everyday community concerns in their own words. Furthermore, communitizers recognized new opportunities to communitize science as the SE sociotechnical system validated their interests, expertise, and ways of engaging in science. Publishing their posts to the app and display provided recognition of their ideas and experiences as scientific, which they shared with the community. Conversations with facilitators and community members helped participants broaden their considerations of what could be counted as science to include their own questions, observations, experiences, and insights brought about by their roles and responsibilities as pastors and parents. They then saw the value of science for their own personal goals as the SE sociotechnical system facilitated connections between their interests in the community and science. The SE display situated science as an endeavor the community came together around and connected to communitizers' goals and roles. The public displays showcased other types of everyday connections, sparking their ideas for new community-driven science projects.

Traditional Scientists: Norman and Gloria

The two focal participants in the traditional scientist category had differing relations to the SE sessions and experiences than did the communitizing participants. The traditional scientist focal participants were motivated to enhance science-learning experiences for youths, but their science dispositions were limited in that they were focused on formal, procedural, and conceptual aspects of science. Although these participants valued community involvement and connections and had close relationships with youths, their formal, procedural approaches sometimes detracted from their relationships and rapport with them. However, as these participants engaged in science in everyday life contexts with youths, their science dispositions broadened. They discerned value in leveraging youths' informal interests and play to support stronger relationships, which, in turn, could help them establish and extend connections with them.

Norman: Foregrounding the Fun

Norman's initial science disposition was deeply rooted in formal modes of engagement, and he emphasized procedural and conceptual understanding in science with youths. He volunteered in SE from the program's inception (2014) through 2017, while he was a PhD student in aerospace engineering.

Norman had previously served as a mentor in the church's Homework Club program. Comparing his volunteering at the Homework Club, Norman saw SE as an opportunity for youths to experience science beyond school and to see science as fun. Indeed, Norman sought out opportunities to leverage his own engineering background and interest to help youths in the community with their academics.

Formal Expectations of Science Conflict With the SE Learning Environment. Norman's traditional science disposition was first challenged in SE when he focused solely on formal approaches to scientific concepts and procedures. Through these challenges, he reflected on changes needed in his own approach to STEM and how he supported the SE youths' efforts to scientize. Norman reflected that he went into SE sessions focused on procedural and conceptual understanding, but he quickly realized that his approach was not very successful with elementary-age learners. He observed the challenge of helping children (ages 7–9 years old) understand intermediate circuitry concepts in one set of SE activities, realizing that he should simplify his goals to first support their enjoyment and engagement:

> *They had a really hard time getting to the level of understanding where they could start thinking about, how could I put something together in a unique way? And so, for that, it was really challenging, and it sort of just became, like, how can I get them to have fun playing with circuits and not break things without worrying too much about learning outcomes or their larger goals that way?* [4-11-18 volunteer focus group]

Norman attributed some of his challenges to his early expectations that he should focus on procedural and conceptual understanding and more formal learning outcomes.

After observing that playful social experiences could lead to learning, Norman's science disposition shifted from *solely* emphasizing formal, procedural/conceptual aspects of science to integrating—and often leading with—personal, playful aspects of science. Norman reflected:

> *So, the first couple of times, we were actually trying to get them to learn the things, right? And after a while, I guess I sort of realized that that wasn't going to get anywhere, and so it was just like, okay, let's have fun, work on sharing these components, right, and make sure that we're treating the equipment nicely.* [4-11-18 volunteer focus group]

However, as the youths encountered circuit connection issues, he saw opportunities to support science learning through questioning and troubleshooting: "But then also kind of consistently, when they're running into trouble, make them think through, okay, why are we running into trouble?" [4-11-18 volunteer focus group]. Norman reflected that he shifted his expectations beyond formal STEM learning outcomes: "And so, I think the fact that I came in with really high expectations of like, okay, we're going to learn about resistance and power and stuff like that hampered my ability to connect with them early on" [4-11-18 volunteer focus group].

Observing Youths Buy In to Science. Norman's traditional science disposition continued to broaden as he observed youths "buy in to science." In 2016, Norman reflected that he had seen changes in the youths, reporting that some of the younger boys had "bought in more to actually doing the projects." Initially, Norman noted that the boys were not engaged and seemed to be participating mostly due to parental pressure. However, over time, he saw them engage more, reflecting:

> *I think had we thrown that at them earlier on in the process, they might have still enjoyed building and flying the paper airplanes, but they wouldn't have engaged as much in doing comparisons and learning about what's going on.* [1-12-2016 interview]

Although Norman perceived that the young boys were not "fully" engaged, he was surprised at the complex types of aerodynamic design comparisons they were making.

The 2016 interview from which the quote was excerpted came after the youths had finished a series of activities focused on flight mechanics. This series was initiated because of Norman's research in aerospace engineering, which he shared with the youths in SE. SE facilitators then developed a series of sessions focused on understanding flight mechanics through designing and testing paper airplanes. The first SE app posts Norman made are shown in Figure 4. He facilitated a station in which youths tested their paper airplane designs, during which he took photos and created posts of them with their designs. The text in his posts includes the youths' reflections on their test results. Triangulating these posts with his reflections on the youths "buy[ing] in to science" suggests that while creating these posts, Norman began to recognize the science concepts the youths were exploring, even in the busy, social, messy context of flying paper airplanes.

Shifting Expectations and Approaches to Engaging Youths. As Norman's disposition toward science expanded beyond formal conceptual, procedural approaches to more social and playful perspectives, he began to consider playful, hands-on options for engaging youths with his own research. First, he thought that activities should focus on objects that youths could engage with. Norman thought that a 3-D-printed model wind tunnel through which youths could control different aerodynamic forces would support active engagement and scientific inquiry, because they could test their paper airplanes in the model, and the model could provide more reliable methods for measuring the distances the airplanes traveled.

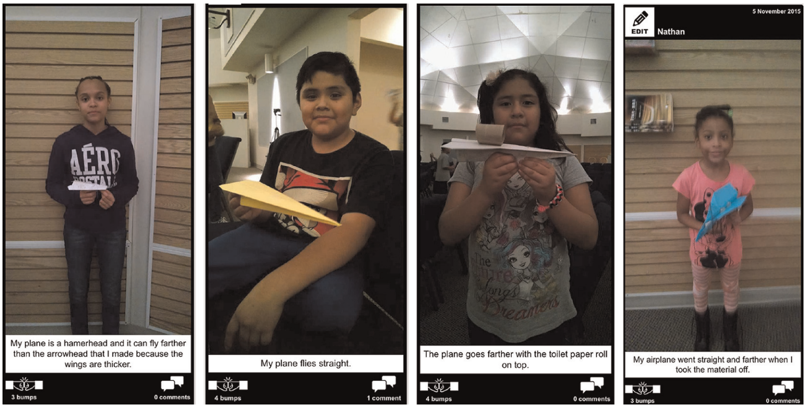

Figure 4. **Norman helped youths create posts during an SE session in which they designed, created, and tested paper airplanes.**

As Norman had these insights, he demonstrated how his dispositional shifts extended beyond his own research interests as he helped generate ideas for new SE activities. His broader disposition toward science magnified the importance of using the SE program to build learners' personal science interests that they could then enhance through related activities at home:

> *The problem is, it's got to be something that they're interested in doing at home. I think that's part of, like, during the time that they're with us, I think a lot of that has to be building interest in what the problem is.* [4-11-18 interview]

Additionally, Norman reflected on the importance of building relationships with youths in the community to help them buy in to the science engagement he was trying to promote:

> *I mean, part of it for me is just being able to connect with and sort of build additional repertoire with some of these kids, because . . . I'd see a bunch of them on Mondays at Homework Club and then again on Thursdays when we were doing SE. So, I think that helps, being able to be in two environments with them that are a little bit different. That helps me understand them a little better, . . . just see[ing] them interact with two different groups of people.* [1-12-2016 interview]

Gloria: Appreciating the "Little Stuff" of Science

Although Gloria was not a scientist by profession, she was adamant about engaging her twin daughters, Donna Joy and Atecia, in STEM enrichment activities. Her daughters participated in SE from 2014–2018 (Grades 6–10). Throughout their participation, they were actively engaged in several other academic programs and summer camps. Shortly after they joined SE, Gloria discovered the church's Homework Club and quickly enrolled her twins. Gloria's data suggest that she was keenly focused on the formal aspects of science engagement in the first two years of their SE participation. She wanted her daughters to learn that "You don't succeed in life only doing the fun stuff" [8-12-2015], a lesson she had been taught as a child growing up in Africa.

In multiple quotes from her 2015 interviews, Gloria's formal science disposition was evident, particularly in the ways in which it came into tension with the social and playful aspects of youths' experiences in SE. Although she appreciated that the program was "bringing [science] to life" [5-21-2015] for youths, she also believed that "you need to be more serious about [science]" [5-21-2015]. Her interview data in May and August of 2015 suggest that she did not think that we were being critical enough about youths' science engagement: "If someone just says things and [does] things and it is praised, then what is the science element there?" [5-21-2015].

Gloria also believed that some youths only attended the program for the social community, technology gifts, and food. In these interviews, she mentioned multiple times that she detected a disconnect between youths' SE science activities and their in-school science activities. She wanted us to make stronger connections between the two contexts: "So, maybe, what about getting those that are having science at school and seek[ing] out how what they are doing there is related to what they are doing here [in SE]? And bring[ing] that together." She believed that youths' activities in SE should more directly improve their school activities: "And if they are fortunate enough to like this activity for SE here, they have to reflect in the work in science at school" [8-12-2015]. Although Gloria may have been advocating for needed connections between school and SE, her reflections suggest that she was juxtaposing science learning with social experiences, as if the two were mutually exclusive—that is, those who were there for the fun were not there to learn.

Like Norman, Gloria's formal disposition toward science posed challenges with respect to engaging in science-related activities in SE, and she also faced challenges engaging her daughters in science. When the program explored science and engineering through the Minecraft gaming platform, we asked the youths to teach their parents about Minecraft. Gloria said that her daughters tried to teach her how to fly in Minecraft, but "Games [we]re not [her] strong point." Her interviews suggest that she was not able to, or that she chose not to, engage when the kids tried to talk to her about it. These reflections and others in which she faced challenges when activities lacked formal procedural structures or outcomes suggest that Gloria had trouble initially with less structured activities, perhaps because of her more formal disposition toward science.

Gloria also reported challenges she faced engaging her daughters in science, particularly on the SE mobile app, outside the program. In May and August 2015, Gloria reported that the girls would do activities at home and while on vacation that related to science; they would even connect these activities to SE in their conversations, telling their extended family about SE and how what they were seeing connected to our activities. Although she would try to encourage the girls to post these experiences to the SE app, Gloria reported multiple times that they never created posts about these conversations. At one point, she suggested that it may have been because we asked the youths to post about specific SE topics, and the girls did not see their daily life experiences as relevant to what we were doing at the time. In contrast to her initial preference for increased structure, Gloria suggested that we *reduce* the app's scaffolding and structure to allow for the different types of science experiences the girls might be having outside school. These data suggest that Gloria noticed that less structure could promote meaningful, informal learning as she watched her girls make explicit connections across formal science and everyday activities. Gloria's realizations were seeds to broaden her more traditional, procedural disposition toward science to include more open-ended informal experiences.

Observing Youths Buy In to Science. Reflecting on her challenges engaging in Minecraft with her daughters in 2015 interviews, Gloria realized, "Maybe this is the link I need with my kids. Maybe if I understand [their interest in MineCraft] better, maybe they will feel better connected to me." In this conversation, Gloria recognized that with more patience, she could learn things that did not interest her (here, games). She observed that taking the time to learn more from her daughters' interests might help her connect better to them. In contrast to Imani's realization that science could help her better connect with her sons, Gloria realized that her daughters' interests could help her better connect with them. Whereas earlier in 2015, Gloria had talked about the social aspects of SE as detractors from science learning, her 2018 reflections suggest that she was beginning to see how the girls' social experiences were also benefiting their learning. She recognized that her daughters had found a social community that they valued in SE, which made them more excited to attend and more invested in the activities:

> *One of the things I discovered, for example, is that when they have friends, and with their friends they have something to see, then it could be anywhere. If it [has] to do with [their friend] Dara, if it will be with [their friend] Gabriella . . . they'll go, and they are interested.* [4-12-18 parent focus group]

She also recognized that friend-initiated activities affected her girls differently than did parent-initiated activities: "So, it has to be something the children, like, initiate, and then they go. If the parents think, okay, you know there is this one, they'll be, like, reluctant. 'What is, what is she making me do now?'" [4-12-2018 parent focus group]. Gloria observed that SE afforded her daughters a set of scientifically engaged friends who motivated them to engage more as well.

In our final focus groups, Gloria realized that her concern that science in SE was disconnected from school had been resolved—not by any changes we had made to the program but through her own reflection: "So, I think [SE] has tried to bridge [school and SE] to bring them together. It kind of, to be conscious of doing something . . . to do a lot of stuff, but you don't know [whether] it's science or not." This quote suggests that Gloria was beginning to see how helping youths make everyday connections to science (i.e., facilitating their interest) could help them engage in school science. Although Gloria did not explicitly link specific activities in SE that created these bridges, she emphasized that she valued the presentations youths made at an annual research symposium hosted by the researchers' university lab. Each year, youths designed a poster with the SE facilitators about the science they had explored that year and presented their work in a poster session with graduate student researchers. Gloria was inspired that youths met with and presented their work alongside university researchers and practitioners. The symposium presentations that youths crafted were one of the more formal aspects of science that she noticed and appreciated as a result of their (informal, playful) participation in SE. Perhaps this was a place where the formal and informal bridges came together for Gloria as she attended each year.

By 2018, Gloria began to express science a little differently herself, connecting it more personally to her own daily life, values, and culture—further evidence of a broadened disposition of science. In 2018 focus groups, Gloria said that SE brought to her attention the "little stuff" of science, referring to the everyday applications and investigations that we conducted in SE. She linked SE's environmental projects to her African background, relaying her appreciation that the girls were learning about water quality because it is a significant issue in Africa (she observed that U.S. citizens did not typically question water quality). She reflected that her participation in SE's environmental projects helped her see that science did not have to be "big" things (which appeared to be in reference to more formal aspects of science); rather, the "little" things of science were interesting and important, too.

Shifting Expectations and Approaches to Engaging Youths. As Gloria made these shifts in SE, she observed that her family had found a "home" in the community at Grace Covenant Church: "That's exactly what this [church] has been for us, you know, like a home, . . . and the kids are socializing, meeting some more new friends, and actually creating that bonding" [4-12-18]. This quote suggests that Gloria not only observed these relationships but also grew to value them, as her disposition became more relational. Second, her daughters were cooking more at home with their nuclear and extended family (e.g., cousins), which she attributed to their participation in SE's Kitchen Chemistry investigations: "After that, they've been cooking. . . . Believe it or not, with their cousin when they come, then they take the time to cook." This report also suggests Gloria's perceived value of everyday science as a valid contribution to science.

Mapping Traditional Scientists' Disposition

Traditional scientist participants were first motivated to engage by formal science goals, as they began with more traditional, formally oriented dispositions toward science. Norman's science disposition and facilitation of youths' learning focused narrowly on the procedural and conceptual understanding building blocks of disposition. Similarly, Gloria was originally motivated by a desire to support her daughters' academic engagement with science, which she viewed as a strictly academic pursuit necessary to their success in school and, possibly, life.

With this formal disposition toward science, traditional scientist participants initially faced challenges engaging in science in the SE program. Gloria struggled with the informal nature of the SE program, frequently requesting linkages to school science curricula. Norman faced challenges engaging learners through his approach, which was narrowly focused on procedural and conceptual understanding. Norman learned that if he first promoted youths' interest in science through play and exploration of science materials in SE, they would eventually engage in formal practices normally associated with science (even if different from the way he expected). Gloria also faced challenges engaging in science with her daughters outside formal contexts. She began to recognize that science not only was connected to formal contexts, such as the classroom or professional disciplines, but also could be connected to her own everyday life, interests, and culture. Her reflections suggest that her disposition broadened as she observed how personally relevant issues could link science more closely with her everyday life—from water-quality issues in her home country to cooking at home with her daughters.

As they participated in SE, the traditional scientists encountered the importance of relationships for promoting youths' buy-in to science. Gloria's disposition also broadened as she saw the role that her daughters' friendships at SE played in promoting their interest in science, and she began to approach her daughters' science education by engaging with them in their interests. Norman also recognized the importance of relationships in the boys' playful interactions with each other and their need for strong relationships and continued interactions with him as a facilitator of science learning. Observing this buy-in, our findings suggest that Norman and Gloria began to value the role of relationships and social experiences for promoting the learning goals they had for youths (Table 3). By the end of the program,

Table 3
Gloria's Disposition Shifts as an Example of a Traditional Science Participant

Initial dispositions	Shifts in science everywhere	Disposition shifts	Implications of shifts
Formal orientations to experiences activities (e.g., wanted SE experiences to have structure, connections to school, and to be serious and performance-based)	*Formal expectations of science conflict with SE learning environment*	The "little things of science are interesting" and important, too	*Shifting expectations and approaches to engaging kids*: More cooking experiences at home Connections to water issues in home community
Social experiences as a detractor from learning	*Observing youths' buy-in to science*	Value for social/informal experiences in science	Developed strong sense of relationship with others in the program/ community

they were leveraging and building relationships to promote new science learning opportunities for them (Table 3).

Role of the SE Sociotechnical System

The hectic and less structured environment of SE was initially off-putting for the traditional scientists. However, the SE sociotechnical system's tools (e.g., the SE app) and experiences (e.g., the annual research symposium) for documenting and showcasing scientific insights, results, observations, and questions—even in playful social experiences—helped validate for traditional scientists that these experiences were, indeed, valuable for science. Furthermore, observing youths' buy-in through playful experiences in SE helped traditional scientists see the value of relationships and playful experiences for motivating youths' science learning. Additionally, the infrastructure of SE activities was dynamic and guided by community members, enabling the topics of SE to be particularly relevant to Norman's and Gloria's expertise and interests. As their expectations and approaches to engaging youths in science shifted, they were able to leverage the dynamic flow of SE activities to find new ways to engage youths through the adults' own interests, hobbies, and expertise.

Discussion

Through this analysis, we put forward a model for relational science dispositions. Our analysis reveals two distinct dispositional frames participants brought to bear in their support of science engagement in the community: their dispositions with respect to relationships in the community and their dispositions with respect to science practices. For example, communitizing

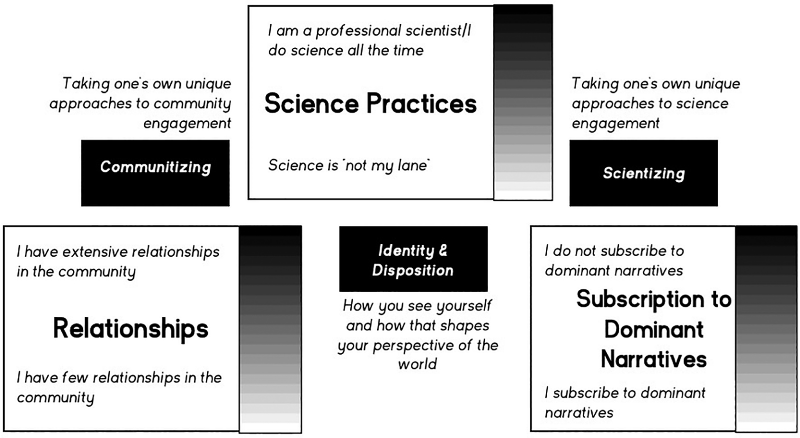

Figure 5. **Each of the three aspects of adults' disposition identified in our analysis is shown here. Each box shows the range of dispositions an individual might hold within that aspect of disposition. Communitizing and scientizing are represented as external enactments of dispositions, and identity and disposition are represented as broader frames an individual might hold that influence their science engagement.**

participants acknowledged their strong relational bonds in the community but did not necessarily view their day-to-day life practices as scientific. Traditional scientists, on the other hand, did tend to view their and their children's engagement as scientific but may have had fewer strong relational bonds in their community.

Further, another dispositional frame of note in our analysis is participants' subscription to dominant or nondominant narratives of academic engagement (particularly science learning). Traditional scientists especially expected science from participants to be situated and framed in terms of dominant narratives of school or formal science learning that conflicted with the playful, messy, social environment of SE activities. Communitizers likely also initially subscribed to these dominant models of science learning, likely influencing their distanced dispositions of science. Each adult carried with them a distinct dispositional frame in each of these areas into the SE community. Alongside each of these frames is the enactment of these dispositions—scientizing as the enactment of a disposition oriented toward science practices and communitizing as the enactment of a disposition toward community engagement. *Scientizing* and *communitizing* as terms represent an individual taking their own unique approaches to science and/or community engagement, respectively (see Figure 5).

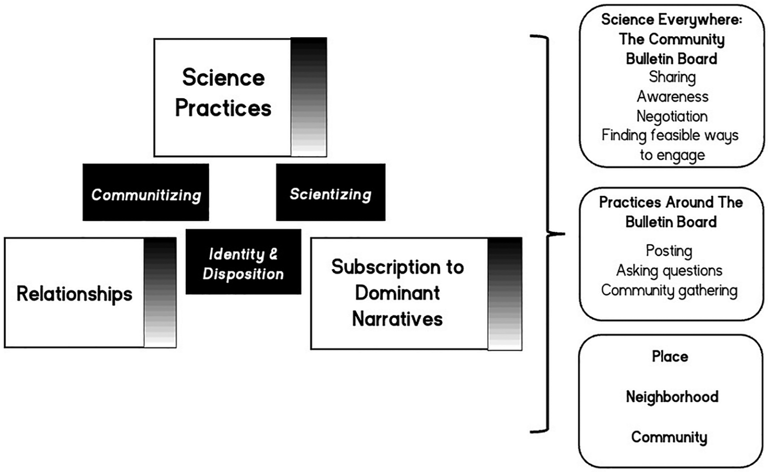

Figure 6. **This figure represents adults' dispositions and identities alongside the SE sociotechnical system. Each round box displays an aspect and/or role of the sociotechnical system in the community.**

The SE sociotechnical system (see Figure 6) included the SE app; large displays, which served as the village bulletin board; and the emergent community practices around the village bulletin board (e.g., sharing experiences/posting, asking questions about posts, and community gatherings around the posts). The sociotechnical system helped facilitate shifts in the three dispositional frames and in overlaps between them. Specifically, the sociotechnical system promoted entry points for the range of community members by promoting awareness and sharing of a broad range of experiences, supporting negotiation of practices among community members with different perspectives, and helping members find feasible ways to engage/contribute in the science learning experiences of the community.

The SE sociotechnical system served to broaden the entry point to science, encouraging traditional scientists to recognize playful, social experiences as scientific and communitizers to recognize their assets as contributing to science. Hence, the communitizing and scientizing aspects of Figure 6 became more closely aligned (as indicated in Figure 7), facilitating increases in individuals' science practices or relationships in the community (as indicated in the scales for each box on Figure 5). Lastly, the sociotechnical system helped participants find new connections between their interests and expertise with science in ways that helped the communitizers see the relevance of science for their goals and the traditional scientists identify new approaches

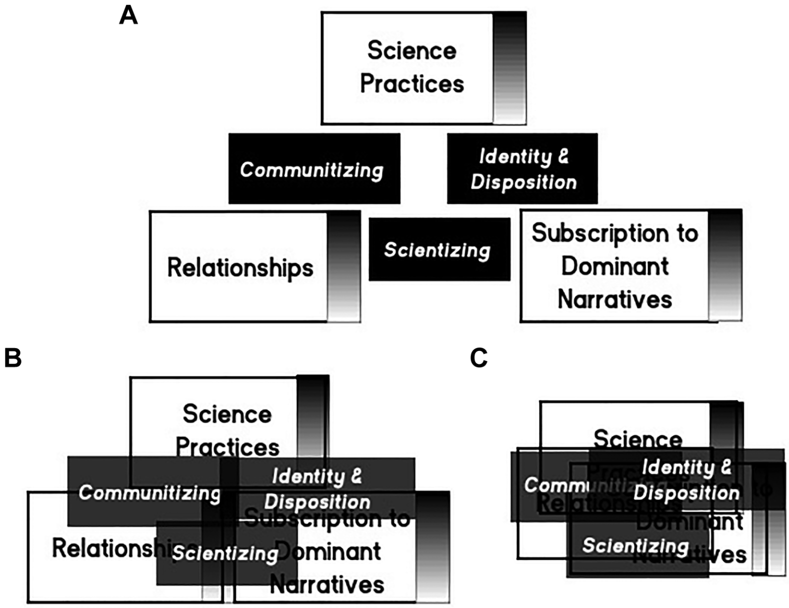

Figure 7. **As participants engaged with one another in the SE sociotechnical system, their individual dispositional frames began to shift with respect to science practices, relationships, and subscription dominant narratives (as represented in the gray-scale rectangles on the right of the three individual dispositional frames). Additionally, these aspects of their dispositions became more intertwined, leading to broadened definitions of STEM. Parts B and C illustrate how the dispositional aspects and participants' enactments of them (i.e., communitizing, scientizing, identity, and dispositions) became more intertwined as the boxes begin to overlap more and more.**

for facilitating science engagement with youths, supporting shifts in community members' identities and dispositions more broadly.

Broadening the entry points to science and finding these new connections supported participants' building blocks of disposition (Clegg & Kolodner, 2014). These experiences supported their interests and personal meaning by helping them find experiences that were relevant and meaningful to them. Their social interactions were supported as they engaged in science as a community and observed ways the community could come together around science. Their procedural and conceptual understandings were supported as they found feasible ways to connect their interests to science practices and to support one another in doing so (e.g., Pastor Taylor working with Norman during SE sessions to build upon his science content understanding, while Norman was also able to build upon Pastor Taylor's rapport with youths). Furthermore, Clegg and Kolodner (2014) point to the importance of the building blocks becoming intertwined for scientific disposition development. These experiences helped participants identify their own connections between these building blocks (e.g., how science interests could be personally relevant to them and how procedural and conceptual science practices, such as asking questions and engaging in scientific investigations, could facilitate meaningful social interactions in the community) so that they did become more intertwined for participants.

As the hyperlocal context and sociotechnical system brought community members together in SE, community members and their shared experiences began to influence one another. SE activities and practices helped communitizers subscribe to their own unique perspectives of science—seeing the science in everyday activities related to their community goals, indicated in Figure 7 by shifts in the individual relationship, science practice, and subscription to dominant narrative disposition boxes. Likewise, traditional scientists began to see the importance of relationships with and among youths in the community for supporting STEM learning, especially as they observed the impact of communitizers and communitizing experiences on youths' motivation and engagement in science. Observing these impacts then helped facilitate shifts in both groups' subscription to dominant narratives of science, as they began to see social, playful ways science could be done that contradicted their prior ideas of what science engagement looked like. We posit that these aspects of disposition became more intertwined and aligned for participants over time, as indicated in Figure 7 by the boxes becoming more and more overlapping. As our community partners developed in their dispositions toward science, the community took on and owned new science-based projects, such as the environmental investigations that youths conducted for the community water project. We call the overarching impact—the integrated set of dispositions, identity, and engagement depicted in the far right of Figure 7—*relational dispositions* because of the key role of relationships in influencing engagement and disposition shifts within our analysis.

This approach builds on prior research on community-based learning (e.g., Youth Participatory Action Research; Anyon et al., 2018), youths' agency (e.g., Barton & Tan, 2010), and Indigenous science (Bang & Marin, 2015). Along with these approaches, we advocate for learning experiences that position community characteristics, interactions, cultures, and histories as assets to be drawn upon for science learning. Our approach puts forward the need to empower adults to see their cultures, interests, hobbies, relationships with youths, and community concerns as assets that can support science learning in their local neighborhoods. Our findings point to ways adults can begin to support the community's science learning as they identify ways to connect their interests, hobbies, and community concerns to science.

As we integrate ABCD and disposition frameworks to support sustained science-based, community initiatives, our findings advocate for a definition of science that encompasses a wider range of learners' interests and culture. Our project sheds light on how one might conceptualize a dialogic approach, where science learning is co-constructed and negotiated with a given, hyperlocal community (Bevan et al., 2020), especially communities that have been traditionally marginalized in science education. We posit that as adults' dispositional frames become more intertwined, we will begin to see more expanded perspectives of science learning and engagement. In our case, this meant science becoming more playful, social, and relevant to everyday community concerns. The resulting ABCD projects and experiences then become models to inspire (but not prescribe) new experiences in a wider range of communities and to expand the perspectives of science engagement of traditional science community members.

Our participants' initial orientations to science in our study are well documented and justified in science education literature (e.g., Aikenhead, 2007; Brickhouse, 2007; Brickhouse et al., 2000; Feinstein & Meshoulam, 2014; Osborne, 2007). Communitizers' disconnect from science and perspectives of science being disconnected from their lives arise because dominant narratives of STEM learning emphasize Euro-centric connections to STEM concepts, ways of interacting, and abstract knowledge over everyday relevance (Aikenhead, 2007). Furthermore, these dominant narratives overlook and further propagate systemic discrimination minoritized learners have traditionally faced in science classrooms (Aikenhead, 2007; Bang & Marin, 2015; Bevan et al., 2020). Similarly, traditional scientists' initial orientations toward formal school ways of being are also well documented and explained in the literature (e.g., Lyons, 2006). In fact, this body of work calls into question Norman's initial expectations and responses to learner engagement in SE—questioning youths' ability to grasp scientific concepts and juxtaposing fun (i.e., playful and social) experiences with high learning expectations in a way that could be viewed as mutually exclusive (even if unintentional).

However, in this study, we highlight how adults can build and evolve their dispositions toward science through their own experiences. We also contribute an understanding of ways that adults' disposition shifts can facilitate a virtuous cycle[1] of community-based science learning for youths. We specifically present a model of a dialogic process in a hyperlocal community. For example, in our study, science was expanded to bring the community together to install a rain garden, shift parenting perspectives so children could tinker with household items, facilitate science problem-solving through playful exploration, and bridge youths' interests and friend groups so youths could forge personal connections to science.

Limitations

This work has several limitations. First, our study focuses on the hyperlocal context of one community, thus limiting its sample size and scalability. Although our sample size is within the norm of qualitative interview studies (Caine, 2016), we cannot generalize our study's findings to a large number or range of communities without further examination. Instead, we illuminate key principles and approaches in detail that should be studied in other contexts. Second, we do not report on parents with minimal interactions in the sociotechnical system, although their limited interactions were likely due to barriers often faced by parents in resource-constrained, minoritized communities (e.g., language, work demands, and transportation). More work is needed to develop alternative means of engagement that address these challenges, and more studies are needed to understand the dispositions and perspectives of these adults. Additionally, the scope of our study was focused on the perspectives and experiences of community adults and ways their perspectives influenced the range of experiences available to youths, which is only one aspect of a community's sociotechnical system for everyday science inquiry. More expansive sociotechnical work is needed to understand how these shifts influence youths' dispositions.

Conclusion

In the model we put forward for relational science disposition, we point to (a) ways individual aspects of participants' dispositions shifted (i.e., ways their relational dispositions, science practice dispositions, and subscriptions to dominant/nondominant narratives of science shifted) and (b) ways these aspects of their dispositions became more intertwined with one another. In our closing thoughts, we advocate for the need for both types of dispositional shifts to most effectively support hyperlocal science learning, especially for nondominant, minoritized, and resource-constrained communities. Although our analysis points to three specific dispositional aspects, as the range of life-relevant STEM experiences is expanded and as these types of studies are carried out in different types of hyperlocal contexts, we envision that additional influential aspects of adult disposition will be identified and added to this set.

These findings lead us to a vision for the future of community scientizing. If adults in a community develop dispositionally in the ways put forward in our discussion, then communities may begin to effectively support the type of cross-context learning and movement where youths' science learning experiences are diverse but supported in each setting (Cabrera et al., 2018). For example, imagine a scenario where a youth's scientizing is supported in one setting, but when they move to another context, an adult there has a very different idea of what science learning is (e.g., a traditional scientist or a parent who does not see science as related to everyday life). The youth's ideas and experiences will likely not be validated and definitely would not be built upon. But in our vision, as a learner experiences personal, scientizing experiences from setting to setting, they will encounter adults who recognize, support, encourage, and build upon those experiences. It therefore becomes important not to solely look at the types of support that mentors or other adults provide but also to consider their dispositions and how these dispositions develop and influence scientizing within the community. Our vision for this work is that adult disposition shifts will become the fuel for continued ABCD participation in communities that extends beyond any one grant, community member, or organization.

Note

[1] *Virtuous cycle* is a term of art that refers to a chain of events that reinforce themselves through a feedback loop, with outcomes deemed as positive. The primary virtuous value held in our use of the term is positive engagement with science broadly construed.

References

Ahn, J., Clegg, T., Yip, J., Bonsignore, E., Pauw, D., Cabrera, L., Hernly, K., Pitt, C., Mills, K., Salazar, A., Griffing, D., Rick, J., & Marr, R. (2018). Science everywhere: Designing public, tangible displays to connect youth learning across settings. *Proceedings of SIGCHI Human Factors in Computing Systems (CHI 2018), 2018-April*, 1–12. https://doi.org/10.1145/3173574.3173852

Aikenhead, G. S. (2007). Expanding the research agenda for scientific literacy. *Promoting Scientific Literacy: Science Education Research in Transaction*, *64*.

Altan, S., Lane, J. F., & Dottin, E. (2019). Using habits of mind, intelligent behaviors, and educational theories to create a conceptual framework for developing effective teaching dispositions. *Journal of Teacher Education*, *70*(2), 169–183.

Anyon, Y., Bender, K., Kennedy, H., & Dechants, J. (2018). A systematic review of youth participatory action research (YPAR) in the United States: Methodologies, youth outcomes, and future directions. *Health Education and Behavior*, *45*(6), 865–878.

Atwater, M. M. (1996). Social constructivism: Infusion into the multicultural science education research agenda. *Journal of Research in Science Teaching*, *33*(8), 821–837. https://doi.org/10.1002/(SICI)1098-2736(199610)33:8<821::AID-TEA1>3.0.CO;2-Y

Bang, M., Faber, L., Gurneau, J., Marin, A., & Soto, C. (2016). Community-based design research: Learning across generations and strategic transformations of institutional relations toward axiological innovations. *Mind, Culture, and Activity*, *23*(1), 28–41.

Bang, M., & Marin, A. (2015). Nature-culture constructs in science learning: Human/non-human agency and intentionality. *Journal of Research in Science Teaching*, *52*(4), 530–544.

Banks, J., Au, K., Ball, A. F., Bell, P., Gordon, E., Gutierrez, K., Brice-Heath, S., Lee, C. D., Mahiri, J., Nasir, N., Valdes, G., & Zhou, M. (2007). *Learning in and out of school in diverse environments: Life-long, life-wide, life-deep.* The LIFE Center

(University of Washington, Stanford University and SRI) & the Center for Multicultural Education, University of Washington.

Barab, S., & Squire, K. (2004). Design-based research: Putting a stake in the ground. *The Journal of the Learning Sciences, 13*(1), 1–14.

Barron, B. (2006). Interest and self-sustained learning as catalysts of development: A learning ecology perspective. *Human Development*, *49*(4), 193–224.

Barron, B., Gomez, K., Pinkard, N., & Martin, C. K. (2014). *The digital youth network: Cultivating digital media citizenship in urban communities*. MIT Press.

Barron, B., Martin, C. K., Takeuchi, L., & Fithian, R. (2009). *Parents as learning partners in the development of technological fluency*.

Barton, A. C., Drake, C., Perez, J. G., St. Louis, K., & George, M. (2004). Ecologies of parental engagement in urban education. *Educational Researcher*, *33*(4), 3–12.

Barton, A. C., & Tan, E. (2010). We be burnin'! Agency, identity, and science learning. *Journal of the Learning Sciences*, *19*(2), 187–229.

Bell, P., Bricker, L., Reeve, S., Zimmerman, H.T., Tzou, C. (2013). Discovering and supporting successful learning pathways of youth in and out of school: Accounting for the development of everyday expertise across settings. In B. Bevan, P. Bell, R. Stevens, A. Razfar (eds) *LOST opportunities. Explorations of educational purpose* (Vol. 23). Springer. https://doi.org/10.1007/978-94-007-4304-5_9

Bereiter, C. (1995). A dispositional view of transfer. In: A. Mckeugh, J. L. Lupard & A. Marini (eds) *Teaching for transfer: Fostering generalization in learning* (pp. 21–34). LEA.

Bevan, B., Calabrese Barton, A., & Garibay, C. (2020). Broadening perspectives on broadening participation: Professional learning tools for more expansive and equitable science communication. *Frontiers in Communication*, *5*, 52.

Brickhouse, N. W. (2007) *Scientific Literates: What do they do? Who are they?* Proceedings of the Linnaeus Tercentenary 2007 Symposium Promoting Scientific Literacy: Science Education Research in Transaction May 28–29, 2007, Uppsala, Sweden.

Brickhouse, N. W., Lowery, P., & Schultz, K. (2000). What kind of a girl does science? The construction of school science identities. *Journal of Research in Science Teaching*, *37*(5), 441–458.

Cabrera, L., Ahn, J., Yip, J., Clegg, T., Hernly, K., Bonsignore, E., Pitt, C., & Pauw, D. (2018). Exploring practices on the move: Facilitating learning across a neighborhood. In J. Kay & R. Luckin (Eds.), *Rethinking learning in the digital age: Making the learning sciences count. Proceedings of the 17th International Conference of the Learning Sciences (ICLS '18).* International Society of the Learning Sciences.

Caine, K. (2016). Local standards for sample size at CHI. *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, 981–992. https://doi.org/10.1145/2858036.2858498

Carreón, G. P., Drake, C., & Barton, A. C. (2005). The importance of presence: Immigrant parents' school engagement experiences. *American Educational Research Journal*, *42*(3), 465–498.

Chinn, C. A., & Malhotra, B. A. (2002). Epistemologically authentic inquiry in schools: A theoretical framework for evaluating inquiry tasks. *Science Education*, *86*(2), 175–218.

Clegg, T., & Kolodner, J. (2014). Scientizing and cooking: Helping middle-school learners develop scientific dispositions. *Science Education*, *98*(1), 36–63.

Corbin, J., & Strauss, A. (2008). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Sage.

Feinstein, N. W., & Meshoulam, D. (2014). Science for what public? Addressing equity in American science museums and science centers. *Journal of Research in Science Teaching*, *51*(3), 368–394.

Fischer, G., & Herrmann, T. (2011). Socio-technical systems: A meta-design perspective. *International Journal of Sociotechnology and Knowledge Development (IJSKD)*, *3*(1), 1–33.

Forrester, G., Kurth, J., Vincent, P., & Oliver, M. (2020). Schools as community assets: An exploration of the merits of an asset-based community development (ABCD) approach. *Educational Review*, *72*(4), 443–458.

Gresalfi, M. S. (2009). Taking up opportunities to learn: Constructing dispositions in mathematics classrooms. *Journal of the Learning Sciences*, *18*(3), 327–369.

Gresalfi, M. S., & Cobb, P. (2006). Cultivating students' discipline-specific dispositions as a critical goal for pedagogy and equity. *Pedagogies*, *1*(1), 49–57.

Harrison, R., Blickem, C., Lamb, J., Kirk, S., & Vassilev, I. (2019). Asset-based community development: Narratives, practice, and conditions of possibility—a qualitative study with community practitioners. *SAGE Open*, *9*(1), 2158244018823081.

Johnson Butterfield, A. K., Yeneabat, M., & Moxley, D. P. (2016). "Now I know my ABCDs": Asset-based community development with school children in Ethiopia. *Children and Schools*, *38*(4), 199–208.

Katz, L. G. (1993). *Dispositions as educational goals*. ERIC EDO-PS-93-10. http://www.ceep.crc.uiuc.edu/eecearchive/digests/1993/katzdi93.html

Kretzmann, J., & McKnight, J. P. (1996). Assets-based community development. *National Civic Review*, *85*(4), 23–29.

Lee, O. (2003). Equity for culturally and linguistically diverse students in science education: Recommendations for a research agenda. *Teachers College Record*, *105*(3), 465–489.

Logler, N., Pitt, C., Gao, X., Hishikawa, A. M., Yip, J., & Friedman, B. (2020). *I feel like this is a bad thing: Investigating disassembly in action for novices* [Conference session]. Proceedings of the 2020 chi conference on human factors in computing Systems (pp. 1–14).

Luce, M. R., Goldman, S., & Vea, T. (2017). Designing for family science explorations anytime, anywhere. *Science Education*, *101*(2), 251–277.

Lyons, T. (2006). The puzzle of falling enrolments in physics and chemistry courses: Putting some pieces together. *Research in Science Education*, *36*(3), 285–311.

Martin, C. K., Pinkard, N., Erete, S., & Sandherr, J. (2017). Connections at the family level: Supporting parents and caring adults to engage youth in learning about computers and technology. In Y. Rankin & J. Thomas (Eds.), *Moving students of color from consumers to producers of technology* (pp. 220–244). IGI Global. https://doi.org/10.4018/978-1-5225-2005-4.ch011

Mathie, A., & Cunningham, G. (2003). From clients to citizens: Asset-based community development as a strategy for community-driven development. *Development in Practice*, *13*(5), 474–486.

Mills, K., Bonsignore, E., Clegg, T., Ahn, J., Yip, J., Pauw, D., Cabrera, L., Hernley, K., & Pitt, C. (2019). Connecting children's scientific funds of knowledge shared on social media to science concepts. *International Journal of Child-Computer Interaction*, *21*, 54–64. https://doi.org/10.1016/j.ijcci.2019.04.003

Mills, K., Bonsignore, E., Clegg, T., Ahn, J., Yip, J., Pauw, D., Cabrera, L., Hernley, K., & Pitt, C. (2018). Designing to illuminate children's scientific funds of knowledge through social media sharing. *IDC 2018—Proceedings of the 2018 ACM Conference on Interaction Design and Children*, 266–277. https://doi.org/10.1145/3202185.3202737

Mills, K., Bonsignore, E., Clegg, T., Yip, J., Ahn, J., Pauw, D., & Pitt, C. (2019). Social media in the science classroom: Bridging funds of knowledge to scientific concepts. In C. Hmelo-Silver, M. Baker, & G. Gweon (Eds.), *A wide lens: Combining embodied, enactive, extended, and embedded learning in collaborative settings: Proceedings of the 13th International Conference on Computer Supported Collaborative Learning (CSCL '19)* pp. 705–712. International Society of the Learning Sciences.

Misener, L., & Schulenkorf, N. (2016). Rethinking the social value of sport events through an asset-based community development (ABCD) perspective. *Journal of Sport Management*, *30*(3), 329–340.

National Research Council. (2011). *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press.

Osborne, J. (2007). Engaging young people with science: Thoughts about future direction of science education. Promoting Scientific Literacy: Science Education Research in Transaction, 105–112.

Osborne, J., Collins, S., Ratcliffe, M., Millar, R., & Duschl, R. (2003). What "ideas-about-science" should be taught in school science? A Delphi study of the expert community. *Journal of Research in Science Teaching*, *40*(7), 692–720.

Papert, S. A. (1980). *Mindstorms: Children, computers, and powerful ideas*. Basic Books.

Penuel, W. R. (2019). Infrastructuring as a practice of design-based research for supporting and studying equitable implementation and sustainability of innovations. *Journal of the Learning Sciences*, *28*(4–5), 659–677.

Saldaña, J. (2015). *The coding manual for qualitative researchers*. Sage.

Scott, C., & Medaugh, M. (2017). Axial Coding. In J. Matthes, C. S. Davis, & R. F. Potter (Eds.), *The international encyclopedia of communication research methods* (pp. 1–2). John Wiley & Sons, Inc.

Takeuchi, L., Vaala, S., & Ahn, J. (2019). *Learning across boundaries: How parents and teachers are bridging children's interests*. The Joan Ganz Cooney Center at Sesame Workshop.

Tour, E. (2019). Supporting primary school children's learning in digital spaces at home: Migrant parents' perspectives and practices. *Children and Society*, *33*(6), 587–601.

Usher, A. S. (2019). Modeling resilient and adaptable work-integrated learning practice: The importance of learning dispositions in initial teacher education. *International Journal of Work-Integrated Learning*, *20*(2), 113–126.

West, C., Baker, A., Ehrich, J. F., Woodcock, S., Bokosmaty, S., Howard, S. J., & Eady, M. J. (2020). Teacher disposition scale (TDS): Construction and psychometric validation. *Journal of Further and Higher Education*, *44*(2), 185–200.

Yip, J., Clegg, T., Ahn, J., Uchidiuno, J., Bonsignore, E., Beck, A., Pauw, D., & Mills, K. (2016). The evolution of roles and social bonds during child-parent co-design. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*.

Yu, J., Bai, C., & Roque, R. (2020). Considering parents in coding kit design: Understanding parents' perspectives and roles. *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, 1–14.