IDENTITY NEGOTIATION WITHIN PEER GROUPS DURING AN INFORMAL ENGINEERING EDUCATION PROGRAM: THE CENTRAL ROLE OF LEADERSHIP-ORIENTED YOUTH

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Abstract

As part of ongoing efforts to support a diverse and robust engineering workforce and ensure that children and adults from all communities have the engineering and design thinking skills to succeed in a science, technology, engineering, and mathematics (STEM)-rich world, identity has become a growing focus of research and education efforts. In order to advance our understanding of engineering-related identity negotiation within informal STEM education contexts, we conducted an in-depth, qualitative investigation of six adolescent girls participating in an afterschool engineering education program jointly run by two community-based organizations and a science center. Building on the Identity-Frame Model developed through our prior work, analysis of videotaped program sessions and secondary data from participants, program facilitators, and parents highlighted the important role that leadership-oriented youth played in shaping the identity negotiation of participants during the programs, both in the ways they recognized and positioned the situated identities of other youth and through their influence on the activity frames that defined the nature of the engineering activities. These findings extend prior classroom studies and suggest a new lens to help teachers and program facilitators support identity negotiation for youth in STEM education programs.

Identity Negotiation within Peer Groups during an Informal Engineering Education

Program: The Central Role of Leadership-Oriented Youth

As part of ongoing efforts to support a diverse and robust engineering workforce and

ensure that children and adults from all communities have the engineering and design thinking

skills to succeed in a science, technology, engineering, and mathematics (STEM)-rich world,

identity has become a growing focus of research and education efforts (Brotman & Moore, 2008;

NRC, 2009). Research suggests that identity, like interest, is a fundamental motivator of human

behavior (Falk, 2009, 2017, Gee, 2000, 2014; Stryker & Burke, 2000), shaping how and why

youth and adults choose to engage with STEM topics and activities inside and outside of school

(Archer et al., 2013; Calabrese Barton et al., 2012; Tan, Calabrese Barton, Kang, & O'Neill,

2013). Evidence of STEM-related identity development have been documented as early as

elementary school (Archer et al., 2010; Tai, Liu, Maltese, & Fan, 2006), although the precursors

of identity, such as normative expectations about gender roles relative to different activities and

careers, likely develop much earlier (Alexander, Johnson, & Leibham, 2015; Nelson, 2003;

Pattison, 2014; Thompson, 2006). Researchers have documented how these early identities

subsequently shape the ways youth come to see themselves relative to STEM topics and careers,

including engineering, and the learning experiences and opportunities they choose to pursue

(Calabrese Barton et al., 2012; Jones, Corin, Andre, Childers, & Stevens, 2017; McCreedy &

Dierking, 2013; Tai et al., 2006).

The identity research to date in the STEM education field has primarily focused on how

youth develop and negotiate productive identities relative to STEM topics and careers, and how

educators can support these processes (Brotman & Moore, 2008; Pattison et al., 2017). STEM-

related identities are shaped by culture and experience (Archer et al., 2010, 2012; Bricker & Bell,

2014; Brown, 2006; Sayman, 2013) and are continually negotiated and revised through ongoing interactions with family (Leaper, Farkas, & Brown, 2012; Tenenbaum & Leaper, 2003), with peers (Aschbacher, Li, & Roth, 2009; J. E. Stake & Nickens, 2005), in the classroom (Carlone, Haun-Frank, & Webb, 2011; Shanahan & Nieswandt, 2009), and during informal learning experiences (Polman & Miller, 2010; Tan et al., 2013). Research has particularly highlighted how girls and youth from traditionally underserved and under-resourced communities face significant barriers to developing strong associations with engineering and STEM. These youth must navigate cultural and gender stereotypes, normative expectations from peers and teachers, and tensions between their engagement with STEM and other facets of their identities, interests, and home cultures (Archer et al., 2012; Brown, 2006; Fies & Langman, 2011; Nasir & Saxe, 2003; Sayman, 2013). Research specifically on engineering-related identity development before college suggests that teacher professional development and hands-on experiences with engineering in the classroom can increase children's connections with engineering and engineering careers (Capobianco, Yu, & French, 2015; Dyehouse, Yoon, Lucietto, & Diefes-Dux, 2012), although there is still little known about what engineering identity looks like and how it develops at this age, especially for youth from traditionally underserved and under-resourced communities.

Much of the work that youth do to develop and negotiate their STEM identities happens in social contexts among groups of children and adults, both inside and outside the classroom. Peer group and collaborative learning approaches are becoming increasingly popular in formal classroom settings (Chan & Bauer, 2015; Eberlein et al., 2008; Storch, 2005) and have long been a hallmark of informal learning (Falk & Dierking, 2013; NRC, 2009). Although many educators and scholars have promoted the benefits of collaborative peer group learning (Johnson, Johnson,

& Smith, 2006; Mitchell, Ippolito, & Lewis, 2012; NRC, 2015), the social dynamics of these contexts can also make learning more complex. Research outside the field of STEM education indicates that disagreement, status, hierarchical role differentiation, competition, power and control, and management of expertise and knowledge are all common characteristics of peer group interactions that can have important implications for the involvement and roles of group members and their learning experiences (Cekaite & Björk-Willén, 2013; Christianakis, 2010; Jakonen & Morton, 2015; Jordan & McDaniel, 2014).

Given the importance and complexity of these experiences, researchers over the last several decades have increasingly focused on the ways that interactions with peers in collaborative learning contexts afford and constrain the identity negotiation of youth and, ultimately, long-term identity pathways (e.g., Gamez & Parker, 2017; Kane, 2015). However, almost all of this work to date has been conducted in classrooms, and there has been almost no research specific to engineering. In the present study, our goal was to extend the literature to understand how peer group interactions shape identity negotiation for adolescent girls participating in an informal engineering program. Aligned with prior research on peer group social dynamics, described below, our emergent findings highlighted the important role of what we have called "leadership-oriented youth" within peer groups—or youth who play stronger leadership roles relative to their peers during the interactions and are central to directing and guiding the focus and actions of the group. In the analysis reported here, we focused on how these leadership-oriented participants influenced the identity negotiation of their peers and the mechanisms through which the youth afforded and constrained identity negotiation within the collaborative peer groups.

Peer Group Interactions

Interactions with peer groups is a common feature of learning inside and outside the classroom for children and youth (Leman, 2015). These interactions involve complex, ever-evolving social dynamics characterized by ongoing decision-making and disagreement resolution; the contribution and recognition of ideas; and the negotiation of authority, roles, expertise, and group norms (Cekaite & Björk-Willén, 2013; Gamez & Parker, 2017; Heyd-Metzuyanim & Sfard, 2012; Jordan & McDaniel, 2014; Verma, Puvirajah, & Webb, 2015). A variety of factors have been shown to influence the social dynamics within peer groups, including friendship (Strough, Swenson, & Cheng, 2001; Takeuchi, 2016), social status (Ellis, Dumas, Mahdy, & Wolfe, 2012; Spataro, Pettit, Sauer, & Lount Jr, 2014), perceived expertise or achievement level (Ryu, 2015; Yun & Kim, 2015), child age (Leman, 2015), language ability and linguistic resources (Gamez & Parker, 2017; Takeuchi, 2016), and group norms (Hegedus, Carlone, & Carter, 2014; Yun & Kim, 2015). These interactions become particularly complex as children enter adolescence, when social dynamics and approaches to collaboration become more sophisticated (Leman, 2015).The dynamics can be especially pronounced when a teacher or adult program facilitator is not present to mediate peer disagreements (Cekaite & Björk-Willén, 2013; Jakonen & Morton, 2015; Sharma, 2013), although teachers can also heighten tensions within groups by unintentionally reinforcing hierarchies of power, status, and expertise (Christianakis, 2010).

Research on peer group interactions in the classroom has also highlighted the important role that peer leaders play in shaping the nature and outcomes of these interactions. Mercier and colleagues (2014) defined leadership within classroom peer groups as "attempts to move the group forward, either by addressing issues of organization of the group, such as turn

management, or addressing the intellectual aspects of the activity, such as idea management and development" (p. 401). Leadership, like other aspects of peer group learning, is constantly negotiated. Therefore, the authors argued, a group leader is a youth that whose bids for leadership, or "leadership moves," are acknowledged and taken up by the group. These leaders can have a strong influence on the participation and engagement of other peers within the group by regulating group discussions, creating or diminishing space for participation and involvement, and nurturing or complimenting others (Yun & Kim, 2015). Peers with more authority or status can also have a larger impact on the goals of an activity or how the activity is understood by the youth, which subsequently shapes expectations and norms for participation and discourse (Shim & Kim, 2018; Tan & Calabrese Barton, 2008).

Peer Groups and Identity Negotiation

Recently, several researchers have attempted to apply these understandings of peer group dynamics to the study of youth identity negotiation. It is broadly recognized that students and youth construct and negotiate their identities through ongoing interactions with peers and adults, and that peers and teachers play important roles in how they position or recognize the identities of others (Carlone & Johnson, 2007; Gamez & Parker, 2017; Kane, 2012, 2015; Tan & Calabrese Barton, 2008; Tan et al., 2013; Varelas, Martin, & Kane, 2012). Collaborative peer group activities provide a unique context for identity negotiation because of the complex social dynamics among peers and the lack of teacher facilitation (Gamez & Parker, 2017; Varelas, Tucker-Raymond, & Richards, 2015). In many studies, however, understanding the mechanisms of peer influences on identity negotiation has not been the primary focus or has been analyzed secondhand through narrated identity accounts (e.g., Kane, 2012; Ryu, 2015; Tan et al., 2013; Varelas et al., 2012, 2015). As Gamez and Parker (2017) noted, "science education research

focused on identity formation and the role it plays in explaining how and why students engage in science to varying degrees has placed less emphasis on understanding how student–student interactions within small groups shape students' potential science identities" (p. 3).

A few studies have looked at the mechanisms of peer influences on identity negotiation during classroom interactions. In his study of elementary school students in collaborative peer group learning contexts in a science classroom, Kane (2012) argued that peers and teachers provided recognition for youth identities by asking for help, wanting to work with particular students, answering questions, or encouraging input and active engagement. In the study, peers and teachers also undermined identity work by not recognizing competence, interrupting, criticizing ideas, engaging in conflict when students tried to help or work with materials, and highlighting issues with performance or grades. Other studies have also emphasized the importance of peer and adult recognition (Fields & Enyedy, 2013; Tan & Calabrese Barton, 2008), supporting and contesting ideas during group discussions (Kane, 2015), and learning spaces that offer flexible opportunities for youth take on new roles and be recognized for their expertise and contributions (Fields & Enyedy, 2013; Kane, 2015; Tan & Calabrese Barton, 2008). One study found that, similar to the peer group interaction literature, leaders within peer groups can play important roles by either supporting the identity work of other youth or undermining roles and identities (Tan & Calabrese Barton, 2008). Peer group interactions also shape the development of classroom norms over time, such as normative expectations about being a "good student" or expectations about gender roles, which in turn influence opportunities for identity negotiation (Bhana, 2005; Hegedus et al., 2014; Kane, 2012; Varelas et al., 2015).

Research Questions

Although researchers have made headway in understanding how peer group interactions influence youth identity negotiation and development, it is not clear how these findings extend to informal learning contexts. This is despite the broad claims that experiences such as museum visits or afterschool programs offer valuable opportunities for youth, and especially those from traditionally underserved and under-resourced communities, to develop their identities related to STEM (NRC, 2009, 2015). As noted, collaborative social learning is often an essential element of informal learning contexts. Therefore, it is critical that researchers and educators understand how the social dynamics in these settings afford or constrain identity negotiation for participants, and how these dynamics are similar to or different from those observed in classrooms.

The study described in this article was part of a multi-year effort to explore the engineering-related identity negotiation of adolescent youth participating in an informal engineering education program implemented in both museum and afterschool settings. Our previous work described the strategies that youth used to negotiate identities during the program, the types of situated identities that emerged or were contested, and the connection between identity negotiation and the ways that participants understood and engaged with the engineering activities and content—or what we have collectively referred to as *identity negotiation patterns* (Pattison et al., 2017). One emergent finding from the research was the role that leadership-oriented youth within peer groups appeared to play in affording and constraining the identity negotiation of other participants. Knowing that leadership is an important part of the social dynamics of peer group interactions, the current study focused on better understanding how these youth leaders influenced the engineering-related identity negotiation of their peers during collaborative learning activities. The study was guided by two research questions:

1) What are the engineering-related identity negotiation patterns of youth participants who appeared to play stronger leadership roles during the collaborative learning activities?

2) What implications do these identity negotiation patterns appear to have on how peer groups understand the engineering activities and the opportunities for other group members to negotiate their engineering-related identities?

By addressing these questions, we hoped to contribute to the literature in several ways. First, the study was intended to extend the existing literature on peer group interactions and identity negotiation by understanding how these dynamics function in an informal education program, with potential implications for the design of such programs to support identity development. Second, the study explored identity negotiation specifically related to engineering. Much of the work in this domain has adopted a more static perspective on identity (e.g., Capobianco et al., 2015; Dyehouse et al., 2012), and there is little data on how youth negotiate engineering-related identities inside or outside the classroom. Finally, our goal was to deepen the field's understanding of the specific mechanisms and social dynamics through which youth influence the identity negotiation of their peers, and especially the important role that group leaders play in this process.

Theoretical Framework

To understand the identity negotiation patterns of leadership-oriented youth and how they influence the identities of other participants, we used the Identity-Frame model (Figure 1), which emerged through our previous work with adolescent youth engaged in informal engineering education experiences (Pattison et al., 2017). The model is based on a *situated perspective of identity* (Falk, 2009; Gee, 2000; Norris, 2011; Penuel & Wertsch, 1995). In contrast to more static notions of identity as a relatively stable characteristic of an individual and his or her self-

perceptions, a situated perspective highlights how identities are context specific and actively

negotiated between an individual and others (Carlone & Johnson, 2007; De Fina, 2011; Gee,

2014; Penuel & Wertsch, 1995) using linguistic and discursive tools drawn from cultural models,

normative expectations, and identity prototypes within communities (Bakhtin, 2014; Gee, 2014;

Lave & Wenger, 1991; Norris & Jones, 2005; Wertsch, 1998). From this perspective, identity is

a "rhetorical process" (De Fina, 2011) through which individuals, consciously or not, perform

their identities and make claims to be seen as certain types of people relative to others and other

cultural models. These claims, or identity "bids" (Carlone & Johnson, 2007; Pattison et al.,

2017), can be recognized, supported, or rejected by others in an ongoing process of identity

negotiation specific to the situation and context. Aligned with a broader mediated discourse

perspective (Norris & Jones, 2005; Scollon, 1998; Wertsch, 1998), the model focuses on how the

negotiation of situated identities occurs within specific contexts that have associated goals,

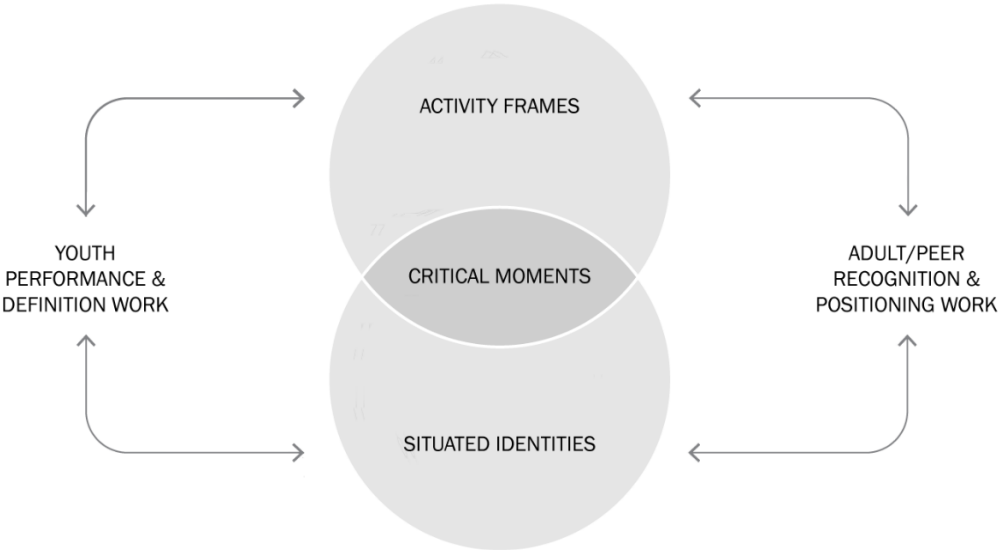expectations, and resources, all of which constrain and afford the identity negotiation process.

Figure 1. The Identity-Frame Model of youth situated identity negotiation

The Identity-Frame Model attempts to represent this process as we observed it for youth engaged in engineering activities in informal learning contexts, including afterschool programs and museum-based interactions. As shown on the left of Figure 1, the model posits that situated identity negotiation is an ongoing process of youth, consciously or not, performing and defining particular (or multiple) identities. On the right side of the diagram, these identities are, in turn, recognized, or not, by other peers and adults, who also actively position youth relative to certain identities, which may or may not align with those that the youth are trying to negotiate. As shown in the center of the diagram, this ongoing cycle of negotiation creates emergent, context-specific *situated identities* for participants that are made particularly salient during certain critical moments, such as disagreements between youth participants about activity goals and materials or instances when teachers or program staff facilitate interactions within peer groups. Building on the literature outlined above, within our work we define situated identity as the context-specific, emergent understandings, either implicit or explicit, of who a youth is during the interaction, including understandings about (a) the youth's knowledge and competence related to the engineering activity and (b) the youth's role within the group.

The model also highlights how this identity negotiation process is closely linked to the ongoing negotiation of what we refer to as *activity frames* (Goffman, 1986)—or the goals, expectations, and understandings that emerge as salient within a particular interaction and define how that situation is perceived by participants, including the potential roles and identities that are available to them in that moment (Greeno, 2009; Hand, Penuel, & Gutiérrez, 2012; Hegedus et al., 2014; Norris, 2011; Norris & Jones, 2005; Rowe, 2005; Scollon, 1998). In the education literature, these frames have been described as representing "what kind of activity" students think they are engaging in (Hutchison & Hammer, 2010). Also known as situation definitions

(Rowe, 2005), activity frames are a fundamental part of human social interactions, affording and constraining the roles that participants can adopt within a specific interaction, behaviors that are expected or sanctioned, and ways that actions and talk are interpreted. Although the concept of activity frames has rarely been linked to STEM identity research, the Identity-Frame Model highlights how youth actions simultaneously communicate expectations about both frames and identities and that the activity frames that are made salient in a specific situation constrain and afford the identities that youth can negotiate and how these identities are perceived by others (see also Vedder-Weiss, 2017). In our research, we define an activity frame as the context-specific, emergent understandings or expectations, either implicit or explicit, about the nature and goals of the interaction and the engineering activity. These activity frames are not static but instead, like situated identity, are actively negotiated and may or not be shared among participants within an interaction (Rowe, 2005).

Several studies have highlighted the dynamic negotiation of activity frames within the context of STEM classroom learning (Greeno, 2009; Hutchison & Hammer, 2010; Jimenez-Aleixandre, Rodriguez, & Duschl, 2000; Shim & Kim, 2018). For example, "productive" or "unproductive" framings about the nature of science inquiry and group discourse can have a powerful influence on student participation in peer group work (Shim & Kim, 2018). Students may frame a science activity as being about "making sense of the phenomenon" versus "playing the classroom game" (Hutchison & Hammer, 2010) or "doing science" versus "doing school" (Jimenez-Aleixandre et al., 2000), each of which has different implications for peer group dynamics and the types of discourse and participation that are expected and valued (Jimenez-Aleixandre et al., 2000).

In our prior work (Pattison et al., 2017), we identified characteristics of each aspect of the model that we argued were particularly salient in the context of informal engineering education activities. For example, youth frequently made identity claims (performance and definition work, see Figure 1), or were positioned by other peers and adults (recognition and positioning work), relative to their skills, knowledge, and competence working through the engineering activities and successfully completing engineering design challenges (situated identities). Some youth made strong bids to be seen as the best and most successful at the design challenges, while other participants negotiated identities as helpers and collaborators relative to their peers. In parallel, youth also negotiated activity frames related to the activities being seen as competitive or collaborative and failure as a negative or positive aspect of the engineering design process. Through their actions and talk, some youth communicated implicit expectations that the goal of the activities was to get the correct answer as quickly as possible, with failure being a negative outcome to be avoided or dismissed. In contrast, other youth appeared to see the activities as both collaborative and iterative, supporting and encouraging other participants and using failure moments as an opportunity to make improvements to their engineering designs. In our prior research we observed that these categories of situated identities and activity frames existed on various continuums, with youth often falling between each end of the extremes or moving between the two ends during different interactions.

In the present study, we applied this model to understand how three participants who often played leadership roles in the program influenced the identity negotiation of their peers during the collaborative activities. Because past research highlights both the importance of peer recognition and the negotiation of how activities are framed and understood for influencing youth situated identities, (Shim & Kim, 2018; Tan & Calabrese Barton, 2008), the Identity-

Frame model provided an excellent tool for understanding the influence of these leadership-oriented youth and their impact on the dynamic intersection between identity negotiation and activity frames within peer groups.

Methods

Given the exploratory and descriptive nature of the study and the focus on the complexities of situated identity negotiation, we adopted a qualitative approach to data collection and analyses (Charmaz, 2006; Creswell, 2013; Patton, 2015). This approach is characterized by studies that are generative from observation and use emergent, inductive strategies to analyze and interpret data and develop new models and hypotheses—especially when existing research is limited, the focus is on complex and interrelated phenomena, or participant perspectives are paramount (Morgan, 2014). The research team was embedded within the project throughout the process, enabling us to develop a deep understanding of the program context and continually learn from the perspectives of the broader project team, community partners, and participants.

Study participants were adolescent girls (ages 9-12) involved in the National Science Foundation-funded Designing Our World (DOW) project through afterschool, community-, and museum-based programs with two local youth development organizations. Through videotaping, naturalistic observation, interviews, and reflective activities with youth and staff members, researchers observed and recorded participant behaviors and perspectives across time and in a variety of contexts. As the DOW program and exhibit teams engaged in efforts to influence girls' interests, knowledge, and ultimately career choices by making engineering more enticing and relevant, we observed, recorded, and analyzed how these strategies connected with participant identity negotiation during collaborative learning interactions.

As in our previous work, we followed a culturally responsive approach for ensuring that research was sensitive and inclusive to the diversity of participant cultures, backgrounds, and

experiences (e.g., Allen et al., 2007; Frechtling, 2010; Gutierrez & Rogoff, 2003; Okazaki & Sue, 1995; Thomas & Parsons, 2017). Specific strategies included: reviewing research designs, protocols, and instruments with staff members from partner organizations; ensuring that youth and families were comfortable with the study before beginning data collection and providing opportunities to discuss and clarify study methods; employing members of the research team who could interpret verbal and non-verbal cues from participants; conducting data analysis that was linguistically and contextually informed; and disseminating findings broadly in ways that were relevant to local communities. Aligned with the audiences of our partner organizations, we focused particularly on culturally responsive practices relevant to Spanish-speaking and low-income participants. For example, the team included two bilingual/bicultural researchers (Hispanic/Latina) able to analyze and interpret video data in Spanish and English. Partnerships with the two local youth serving organizations participating in the study further solidified community collaboration and helped increased the relevance of study findings for local families and stakeholders (Kirkhart, 1995).

Study Context

The DOW project, led by the Oregon Museum of Science and Industry (OMSI), focused on reimagining engineering as an attractive activity for young female audiences by delivering engineering programing that framed the field as collaborative, altruistic, and personally relevant. The project specifically engaged communities where representation in the engineering workforce is scarce, including girls from Hispanic/Latino families and low-income backgrounds (NASEM, and Medicine, 2016; NSB, 2010, 2016). Program activities supported participants through a network of related experiences to motivate ongoing learning and interest development, including seven afterschool engineering education sessions delivered by OMSI staff in collaboration with

community partners, ongoing engagement with local engineer role models, one to two family engineering nights at OMSI during which participants and their families were invited to enjoy an evening of engineering activities, a field trip to OMSI for youth participants to interact with hands-on engineering exhibits, and professional learning sessions for parents and staff.

The program was implemented with participants from two local community-serving organizations: Girls Inc. and Adelante Mujeres. Girls Inc. is a national, nonprofit youth organization offering informal education programs that encourage girls to take risks and master physical, intellectual, and emotional challenges. According to program staff members, about 650 girls (ages 6-18) were served in Portland, OR, during 2013, 80% of whom identified as minorities or were living in poverty. Adelante Mujeres, located in Forest Grove, OR, is a Latino-serving community organization that provides holistic education and empowerment opportunities to low-income Hispanic/Latina women and their families to ensure full participation and active leadership in the community. The DOW programs were run with the girl-serving arm of the organization, called the Chicas Youth Development Program, which served approximately 350 girls in 2013.

The DOW programs included in this study ran between January and May 2016. The typical program session consisted of an introductory activity or ice breaker, an interview with an engineering role model, and a small-group engineering design challenge. Examples of the small-group collaborative activities highlighted in this manuscript include: (a) *Save the Day*, an activity in which participants are given a fictional character and then instructed to design an object to improve that character's life; (b) *Bioswales Pollution Solution*, in which participants use elements of green architecture to prevent run off and water pollution; (c) *Smooth Travels*, which challenges participants to use a pegboard to design a model of a safe route for a person in a

wheelchair to access a mountain viewpoint; (d) *Zip Line Rescue*, in which the goal is to create a system to safely carry an injured person down a zip line; and (e) *Surgical Solutions*, which engages participants in creating tools for specific types of surgeries (e.g., removing a marble from inside a long tube). All of the activities and session components were intended to illustrate the ways that engineering careers and activities can be altruistic, personally relevant, and social. The program sessions also focused on highlighting engineering as a collaborative process and failure as a positive aspect of the iterative design process.

Focal Youth Participants

Participants in the DOW sessions were selected in collaboration with partner organizations. For Girls Inc., the project was marketed as an afterschool program focused on engineering challenges, and partner staff members recruited girl participants who either had an interest in STEM from previous programs or were excited by the program description. For the Adelante Mujeres program, all participants were already enrolled in a year-long afterschool program that encouraged Latina girls to develop their leadership potential, adopt healthy lifestyles, build cultural identity, and achieve academic success with high school graduation and college enrollment. There were a total of 14 girl participants from Girls Inc. and 29 participants from the Adelante Mujeres, with ages ranging from 9 to 11. Participants reflected a diverse range of racial, ethnic, linguistic, and socioeconomic backgrounds, and the vast majority of participants in the Adelante Mujeres group spoke Spanish and English.

After the DOW programs were complete, the research team conducted an initial review of the video, observation, and secondary data to select a final set of focal youth participants for in-depth qualitative analysis. In order to maximize our ability to understand the micro-level processes of situated identity negotiation, we identified three focal youth from each community

program. Focusing on patterns of identity and role negotiation, we saw participants primarily take (a) leadership roles, (b) collaborative support roles, or (c) independent roles during the activities. In other words, some youth played a central role in directing and guiding the focus and actions of the group (leadership), some supported or followed the guidance and direction of other youth (collaborative support), and others primarily worked alone (independent). Although these categories were emergent in our analysis, they align with the conceptualization of youth leadership during peer group interactions from Mercier and colleagues (2014) described above. We hypothesized that these broader roles represented important aspects of situated identity negotiation, including how youth perform and are recognized as competent and skilled during the activities, and that these patterns might have implications for long-term engineering interest and identity development. Therefore, following a maximum variation purposive sampling approach (Marshall & Rossman, 2011), we chose three youth from each of the afterschool settings (Girls Inc. and Adelante Mujeres) that generally aligned with each of the three role negotiation patterns, based on our initial understanding of the data, and who were also well represented in the data set (e.g., they participated in the majority of program sessions and most of the reflective activities). The final group of participants (ages 9 or 10) were: Amparo, Reina, Cristina from Adelante Mujeres and Rosey, Leia, and Patsy from Girls Inc.[1]

Data Collection

Data collection over the six-month period included videotaping youth participating in the engineering activities, researcher observations and reflections, interviews with staff from partner organizations, interviews with parents, debriefs with program staff, and reflective activities with youth participants (e.g., group discussions and individual reflections as part of a "design notebook"). For videotaping and observations, two separate cameras, each with a wireless

microphone, were set up in unobtrusive locations to record two different groups during the engineering design activities. Only participants who had completed informed consent for the study were assigned to these groups. While the videotaping was occurring, a researcher remained close by and conducted observations by taking running notes, which were then used after each session to draft reflective research memos. Overall, we collected approximately 15 hours of video and observation data across 14 program sessions at both partner sites. In two cases, videotaping was not possible, so researchers collected detailed ethnographic notes on participant behavior. These were analyzed with the video, as described below.

A number of secondary data collection methods were also employed to complement the video data and provide for multiple perspectives on the interactions from youth, staff, researchers, and parents. For example, we worked with the program team to integrate a "design notebook" into some of the sessions, which prompted participants to write down their reflections on the program experience and their reactions to the different engineering activities. As part of our efforts to engage in culturally responsive research and support the interpretation of the primary video data, we also collaborated with the project team and partner staff members in several professional learning discussions about the program and preliminary research findings. In addition, we interviewed both staff and, when possible, parents of participants to learn more about the focal youth and their perspectives on the program. These interviews, as well as notes from team and partner discussions, were incorporated into secondary data analysis, as described below.

Data analysis

The analysis drew from techniques in grounded theory (Charmaz, 2006; Glaser & Strauss, 1967) and case study research (R. E. Stake, 2006), as well as general recommendations

for increasing the trustworthiness and transferability of qualitative study findings (Creswell, 2013; Marshall & Rossman, 2011; Patton, 2015). Because this study built on the detailed coding framework and protocol developed through our previous research, we used an abductive approach (Patton, 2015) rather than a purely inductive, emergent coding process, both applying the previously developed codes and revising and adding to those codes based on characteristics and patterns that emerged from the new data set. In general, we followed four phases of analysis: (a) updating the coding framework, (b) systematic focused coding, (c) youth profile development, and (d) interpretation. The research team included two bilingual and bicultural researchers (second and third authors) who were fluent in the primary languages of study participants (Spanish and English). All video coding and analysis were conducted using NVivo software.

In the first stage of the process, we iteratively reviewed and discussed the video and secondary data and made updates to the coding framework. The previous framework included micro codes for identity bids, adult and peer reactions to youth identity bids, positioning actions by peers and adults, and youth failure moments. An additional set of macro codes was designed to capture overall engagement, roles in the small and large group activities, and youth social orientations (see Pattison et al., 2017, for additional details). For this study, two significant changes were made to the coding framework. First, the identity bid code was broadened to include bids both related to youth's skills and knowledge relative to the activities as well as their roles relative to other youth in the group. This change reflected our growing awareness that the process of identity negotiation during the activities was integrally linked to how youth positioned themselves and were positioned by others within the emergent hierarchal structures of the group (e.g., leader, supporter, independent). Second, we added a specific code to identify moments

when youth, peers, or adult program facilitators communicated information about the activity

frames that were at play during the activities (e.g., framing the activity as collaborative versus

competitive). This addition helped to more explicitly examine the complex interplay between the

negotiation of activity frames and situated identities during the interactions.

After updating our coding framework, we applied the codes systematically to the video

data, using a grounded theory focused coding approach (Charmaz, 2006; Glaser & Strauss,

1967). Each video was coded separately for each focal youth. In other words, if two focal youth

were present in one videotaped interaction, the micro and macro codes were applied for each

youth separately, from the perspective of that youth. During the initial round of focused coding,

three members of the research team coded a subset of the same videos and reviewed the results

for discrepancies. All differences were discussed and resolved, and the code definitions were

subsequently updated and clarified. The second and third author then coded the remaining videos

independently. At least two videos from each focal youth were double coded to ensure ongoing

consistency between the coders. Each coder also had the option of flagging moments in the video

for review by another team member whenever there was a question about the coding. As before,

all questions and discrepancies were discussed until agreement was reached within the team and

appropriate changes were made.

Following the video coding, we developed narrative descriptions for each focal youth

based on findings from researcher observations and the close review of the video data. We also

used these narratives to synthesize perspectives from the secondary data collection methods (e.g.,

staff and parent interviews, youth reflective activities) into one source. These youth profiles

provided a way to bring together a general youth description, a summary of their involvement

and participation, patterns and routines of identity negotiation, relevant activity frames

communicated by each focal youth, and factors that influenced youth identity negotiation.

Drawing from a case study approach (R. E. Stake, 2006), the narratives allowed for a more

holistic exploration of the youth experiences and identity negotiation patterns, complementing

the details grounded theory coding. Primary authors for each one of the youth profiles developed

initial drafts of the narratives, which were then reviewed by a second team member. Researchers

discussed and resolved any points of disagreement and updated the profiles as needed.

This analysis process resulted in detailed coding summaries and a narrative-style profile

for each focal youth. These were reviewed and discussed extensively by the research team and

used to identify themes and patterns that emerged from the data and were relevant to our research

questions (Charmaz, 2006; Glaser & Strauss, 1967). Throughout the analysis and interpretation

process, we used a variety of strategies to check our assumptions and interpretations and support

the credibility and trustworthiness of study findings (Creswell, 2013; Marshall & Rossman,

2011; Patton, 2015), such as triangulating data across data sources and soliciting multiple

perspectives on emerging findings and interpretations.

Results

As we observed in our past work, the negotiation of situated identities and activity frames

was a defining characteristic of the informal engineering education programs presented at both

partner sites. Youth regularly made bids to be seen as skilled, competent, and knowledgeable

relative to the engineering activities and communicated their implicit or explicit expectations

about the nature of the topic and the experiences. We also observed youth negotiating their

situated identities related to the roles they played among their peers, including as leaders,

supporters, or more independent participants. Within these collaborative learning environments,

youth and adults reacted to the identity negotiation of others, sometimes recognizing and

supporting the identities and activity frames that youth communicated, and other times undermining these bids, either intentionally or not.

Although all youth participants engaged in these ongoing processes of identity negotiation, the data collected in the study highlighted the central and outsized influence of specific leadership-oriented youth within the groups. Within our sample of six focal youth, three participants repeatedly worked to position themselves and be recognized by others as leaders during the engineering activities, although each demonstrated a very different approach to leadership. We observed these three leadership-oriented focal youth influencing the identity negotiation and involvement of other youth in two primary ways: (1) shaping the activity frames that tended to dominate the interactions and set the tone for participants' approach to the engineering activities and (2) directly supporting or undermining the identity negotiation of peers, either through positioning or recognition work. In discussing the findings from the study, we begin with an overview of these two themes. We then provide detailed examples from three of the leaders in our sample, highlighting their approaches to the negotiation of identities and activity frames and the ways these approaches appeared to afford and constrain the identities and involvement of other participants. Although we focus the presentation of the results on the three leadership-oriented youth, the in-depth analysis of all six focal participants was critical for developing our emergent understandings of leadership within the group interactions and the ways that the youth-oriented leaders influenced the identity negotiation of their peers.

Shaping Dominant Activity Frames

During the program sessions at both partner sites, the leadership-oriented focal youth in our study consistently played a central role during the interactions, vocalizing expectations and assumptions about the activities, being hands-on with the activity materials, and managing or

facilitating the work and involvement of other youth and adult program facilitators. Through these central roles, we observed the youth shaping the activity frames that came to dominate the interactions. These activity frames, in turn, were associated with the nature of engineering engagement and learning within the collaborative peer groups and the identity negotiation of participants, including the other focal youth.

Two activity frames emerged in this study as particularly salient for influencing the identity negotiation and participation of other youth: (a) expectations about the activities as primarily individual and competitive or collaborative and supportive and (b) understandings of failure and iteration as positive aspects of engineering design or negative outcomes to be avoided. Through the program, staff facilitators worked to emphasize engineering as a collaborative process and failure and iteration as positive aspects of the design process. At times, we observed leadership-oriented youth supporting these activity frame through their own identity negotiation, such as by celebrating group success, sharing and distributing materials among participants, and encouraging ideas and contributions from group members. Similarly, some participants encouraged themselves and others to keep trying when a design did not work out or focused on slowly creating, testing, and improving their designs in stages, rather than quickly getting the "correct answer." In contrast, others leadership-oriented youth communicated expectations about the activities as competitive, primarily focused on individual success, and implied failure was a negative part of the experience to be avoided at all costs. This included celebrating individual rather than group success, collecting materials and keeping them from other participants, negatively critiquing the ideas and suggestions of other group members, becoming frustrated with the challenges, and criticizing peers whose designs did not work out immediately.

As exemplified in the experiences of the three focal youth in our study who did not frequently negotiate roles as leaders, how these two activity frames were negotiated during particular activities connected with how the engineering process was enacted. This, in turn, afforded and constrained the identity negotiation of other participants. As we have seen in past work, when an activity frame of engineering as collaborative becomes established through identity negotiation, this can afford opportunities for more meaningful involvement across participants and more successful and supported identity bids for youth as skilled, knowledgeable, and involved. In contrast, when an activity frame of engineering as competitive and focused on individual success comes to dominate, less assertive or more collaborative-oriented youth can become marginalized or choose to disengage from the experience. Similarly, expectations about failure as positive not only reinforce messages from program staff but also support more authentic engineering design processes, with cycles of planning, testing, and improvement, as well as idea sharing among youth. Activity frames associated with failure as negative can reinforce misconceptions about engineering and contribute to competitive conflict within groups, again marginalizing or constraining the identity negotiation of some participants.

Recognizing and Positioning Other Youth

We also observed the three leadership-oriented focal youth in our study shaping the involvement and identity negotiation of other participants more directly through the ways they positioned and recognized the identity negotiation of others. Because the youth leaders in these programs were dominant participants in the interactions, they played a strong role relative to other participants by being the primary recipients of and responders to the identity negotiation of their peers.

Some leaders in the program engaged primarily in recognition and positioning work that supported and affirmed the identity bids of other youth and afforded youth opportunities to create meaningful roles for themselves within the engineering activities. This not only included reacting positively to identity bids by other youth and actively positioning youth as skilled, competent, and involved during the activities, but also being flexible in their leadership roles and sometimes allowing other youth to take on more central positions within the group. In contrast, leadership-oriented youth also engaged in identity negotiation work that we observed undermining the identities of other participants or constraining how these participants could position themselves within the activity. Primary indicators of this type of identity negotiation were unsupportive reactions to the identity bids of others and positioning other youth negatively relative to their involvement in the activities or their identities as skilled and knowledgeable. Some youth were also less flexible in their approach to leadership, insisting on assuming and maintaining a leadership role within the group despite the roles of other participants. This approach not only precluded opportunities for other participants to play leadership roles but also could lead to group conflict and lower involvement or exclusion of some participants.

Examples of Three Focal Youth

Next we turn to specific examples from our study to illustrate the themes outlined above. Although the examples below highlight the three focal youth we identified as playing more leadership roles compared to other participants, we weave in the stories of all six focal youth, as well as other program participants, to illustrate how these leaders had a strong and central role in influencing the involvement and identity negotiation of their peers.

Example #1: Rosey (Girls Inc.)

Rosey was 10 years old and a fifth grader at the time of the study. She had participated in Girls Inc. previously and was part of their Girls Council, which represent Girls, Inc. at different events and focuses on cultivating leadership skills. Throughout the program, she was very involved with the activities and seemed to enjoy developing and testing ideas. In her design notebook, Rosey described herself as "quirky," "creative," "friendly," and "a leader." She also shared that she loved writing and math and was "really good at solving problems." Similarly, program staff members mentioned that Rosey was always very engaged with programs, asked a lot of questions, was a good problem solver, and enjoyed working together with others. She attended all seven program sessions and appeared to be consistently engaged and hands-on with the activities throughout.

Compared with other youth, Rosey showed particularly assertive patterns of identity negotiation, often focusing on positioning herself, either intentionally or not, as a competent, knowledgeable leader within her groups. She had had a total of 106 identity bids across three recorded and analyzed activities, with the majority of these bids (63%, n=67 of 106) related to communicating her knowledge about the activities, sharing her success, and providing suggestions to others. For example, in many of the activities, Rosey would approach the design challenge and immediately state that she had an idea (e.g., "Wait, wait, wait, I have an idea!" or "We can use the bucket, watch, watch"). She would also claim knowledge by telling other youth information about the challenge. Rosey was very vocal about highlighting and celebrating her success, using phrases like: "Look at how many washers I got out!" and "I did it, I did it!"

Much of this identity negotiation was associated with positioning herself as a group leader. Rosey seemed to want to work with others, as program leaders reported, but only as long as she was able to serve in a leadership capacity. Across sessions, she had a large number of

identity bids related to claiming a particular role (19%, n=20 of 106), usually leader in the activities, and a similar number of identity bids in which she communicated knowledge and claimed a role simultaneously (21%, n=22). Both of these were more evident in the *Smooth Travels* activity when she seemed able to gain control of the design right from the beginning of the activity. Examples of this included Rosey telling other youth where to put the sticks and tubes along the peg board and Rosey saying that they need to attach some tubes while asking others in the group to do it. She seemed to view other youth as helpers and would instruct them on what she wanted to do (e.g., "Tie that to the others" and "It needs to go slow as possible").

Shaping dominant activity frames. As a leader and assertive member of the group activities, we observed that Rosey had a strong influence on how activity frames were negotiated among participants. At odds with the stated goals of program staff, Rosey often communicated a framing of the activities as more individual and competitive, compared to collaborative and supportive, and a framing of failure as a negative part of the engineering process, rather than an important part of iteration and design. Rosey communicated an activity frame of engineering as individual and competitive by promoting her own ideas, avoiding sharing with other participants or groups (e.g., "don't copy us"), and making comparisons between her work and that of other participants, including which designs worked better or who had the more difficult engineering challenge. Rosey was also more focused on adults compared to other participants and would often call adults over to review or praise her work (e.g., "Do you want to see?"). She frequently made comments to other participants about the importance of adult approval (e.g., "How many did you get approved? We got two approved").

Table 1. *Rosey at the* Zip Line Rescue *activity.*

	Conversation	Behavior
1	*Participant 1*: It's working!	Watching her design slide down the zip line.
2	*Rosey*: No, it didn't go all the way. It has to go all the way.	Participant 1 walks away, looking frustrated.
3	*Participant 2*: Can I use that cup?	Asking for a plastic cup that Rosey is using for her design.
4	*Rosey*: No!	Moving the plastic cup away from participant 2, who sits back and looks frustrated.
5	*Rosey*: Let me see the person. Let me see, let me see, let me see!	Trying to take the "test" person from participant 3, who is still testing the design that participant 1 created.
6	*Participant 3*: No, it doesn't have to go all the way.	Arguing with Rosey.
7	*Rosey*: Yes it does.	
8	*Participant 3*: Does it have to go all the way?	Asking an adult program facilitator approaching the table.
9	*Adult*: What do you think? If this was a real zip line and it went to here and this was the land…	Indicating a stop point before the bottom of the zip line.
10	*Participant 3*: Yeah.	Smiling and agreeing with the educator that the cart has to go to the end of the zip line to safely deliver the person.
11	*Adult*: Hmm, it might be dangerous.	
12	*Rosey*: Ready?	Preparing to test her design again.
13	*Participant 2*: I don't want to be in this group anymore.	Sitting back and looking frustrated.
14	*Participant 3*: Hah, yours stopped!	Playfully waving her finger at Rosey's design, which stopped before the end of the zip line.

Note. Girls Inc. session #5, 2/10/16, 14:53–15:28.

Her expectations about the engineering activities as individual and competitive were

particularly apparent during the *Zip Line Rescue* activity (Table 1). Before the interaction shown

in Table 1, Rosey and three other participants had begun to play with the different design

materials at one of the activity stations. Rosey told the group she had an idea using the bucket

from the materials pile and insisted that others watch as she began assembling her design. One of

the participants (participant 3) continued looking through the materials, while the other two looked frustrated. As she worked, Rosey ignored participant 2, who insisted that "you have to make sure that everyone plans on doing it" and "everybody has to do it too." After a few minutes, participants 1 and 3 created a different design and tested it on the zip line.

At the beginning of Table 1, Rosey was quick to point out the failure of other group members as they tested their design (lines 1-2) and was highly possessive over the materials she was using (lines 3–4). In her identity negotiation, Rosey claimed knowledge about the rules and criteria of the design challenge (lines 6–7), which was subsequently confirmed by the adult (lines 9–11). Although participant 3 began the activity helping Rosey and working with participant 1, she ended up supporting the competitive activity frame that Rosey had initiated, mimicking the same rule policing that Rosey exhibited earlier (line 14). The experience was noticeably frustrating for participants 1 and 2, who tried to establish a more collaborative activity frame but ultimately ended up leaving the group. Although there were a few cases when Rosey was more successful at working collaboratively with other youth, such as during the surgery activity, even in these instances we observed her primarily focusing on her own success, rather than group efforts.

Rosey's actions and behaviors also indicated that she saw failure more as a negative, which was different from the activity frame communicated by the adult facilitators. When Rosey encountered failure, she often became visibly frustrated. For example, during the *Surgical Solutions* activity Rosey got upset multiple times because she couldn't attach a magnet to a popsicle stick, and in the *Zip Line Rescue* activity she often complained because her design would get stuck in the middle of the line. Several times she raised her hands up in frustration and said, "No!, that didn't work! It's frustrating me!" or "Dang it! That won't work." At other times,

Rosey would blame the materials or other youth in her group (e.g., "I'm telling them it has to go diagonal!").

Recognizing and positioning other youth. Although Rosey was praised by staff members for her teamwork and positioning by staff was either positive (67%, n=6 of 9) or unclear (33%, n=3 of 9) but never negative, her more aggressive and relatively inflexible approach to identity negotiation created a challenging environment for other youth participants. In her central role as a group leader, she was usually unsupportive of identity bids from other youth, especially when they conflicted with her leadership role, and often positioned other youth as less competent or skilled relative to the engineering challenges. As a result, there were many instances of interpersonal conflicts within the small groups involving Rosey. In fact, out of the three video recorded sessions, in two cases only one other youth remained working with Rosey by the end of the activity. Despite the support she received from adults, we observed that she had trouble negotiating recognition for her role as a leader compared to other youth. Peer reactions to her identity bids were more often unsupportive (12.3%, n=13 of 106) than supportive (7.5%, n=8 of 106) and all of the positioning moments from peers were either unsupportive (50%, 3 of 3) or unclear (50%, n=3 of 6), often involving youth questioning Rosey's suggestions, design, or approach to the activity.

Rosey's strong approach to negotiating her identity as a competent and knowledgeable leader relative to the engineering activities involved her frequently criticizing, directing, or taking over the work of other participants. For example, when she saw Leia trying to get a marble out of a tube with a magnet in the *Surgical Solutions* activity, she asked her if the marble was magnetic, emphasizing that if it wasn't the magnet would not work. In the same activity she told Leia multiple times to tilt a stick so she could get a toothpick out of a cup. When Leia

successfully got the toothpick out, Rosey then said, "wait let me see if I can do it" and took over

that station. In fact, she often took over stations or designs from others, either to confirm others'

results or tell them about improvements she thought they could make.

Table 2. *Rosey at the* Safe Travels *activity.*

	Conversation	Behavior
1	*Adult*: Do you guys want to test again and I can time it?	Walking over and addressing group.
2	*Several participants*: No!	
3	*Patsy*: No, because it fell out.	
4	*Adult*: Okay.	
5	*Rosey*: It doesn't go all the way down. I'm telling them it needs to be diagonal.	Addressing the adult as she walks away.
6	*Leia*: Yeah, that's what we're doing.	Adjusting the design, sounding frustrated. Group continues adjusting the design and trying out different materials.
7	*Rosey*: We need it diagonal so that…	Critiquing the design that Leia is working on and demonstrating the angle that the slope should be.
8	*Leia*: We know!	
9	*Rosey*: I know, I'm just…	Taking over the portion of the design that Leia is working on as Leia gathers more materials.
10	*Leia*: Rosey!	Reacting and looking frustrated as Rosey takes over control of the design.
11	*Rosey*: Will you let me try my idea!	Continuing to control the materials as Leia steps back, looking frustrated.

Note. Girls Inc. session #4, 2/10/16, 5:24-6:13.

These dynamics were particularly apparent during sessions when Rosey worked with one

of the other focal youth, Leia, such as during the *Safe Travels* activity. Before the excerpt shown

in Table 2, Rosey, Leia, Patsy, and one other participant had been working together at the

activity station for just over 20 minutes, experimenting with different ways of attaching materials

to the board and different ideas for slowing down the ball. At the outset, all members of the

group were engaged in trying out new ideas. Leia especially spent much of the first portion of the interaction contributing new ideas to the group, building pieces for the ramp, and testing out materials on the board. However, as the interaction progressed, Rosey became less and less flexible in her control, taking over the design and use of materials and relegating other participants to secondary roles, such as testing or attaching pieces to the board.

At line 1 in Table 2, the group had just tested their ramp system unsuccessfully. As the educator initiated a critical moment by checking in with the group (line 1), Rosey positioned herself as knowledgeable and having the correct solution, critiquing the work of the rest of the group and reacting negatively to Leia's contributions, who was trying to adjust the end of the ramp (lines 5–6). Rosey then demonstrated for Leia the way she "should" be designing the ramp (line 7), further positioning Leia as less knowledgeable and not capable of leading the group. Leia tried to assert her role within the group, using "we" in her response to Rosey's critiques (lines 6 and 8), but became increasingly frustrated until Rosey finally took control of her materials (lines 9–10), undermining the role that Leia had been playing. At this point, Leia moved back from the activity, watching from a distance and looking angry.

Example #2: Patsy (Girls Inc.)

Patsy was 10 years old and a fifth grader at the time of the study. She was a friendly girl who liked to joke and seemed to have a good sense of humor. In her design notebook, Patsy described herself as "smart," "helpful," and "creative," and she shared that she loved "to draw and come up with ideas quickly." Program staff members did not have previous experiences with Patsy, since this was her first time at Girls, Inc., but their impression after the program was that Patsy was very creative and independent and that she could express herself well. They also mentioned that she was able to collaborate with others because she enjoyed sharing her ideas,

was flexible, and avoided interpersonal conflict with other youth. Patsy attended all seven

sessions of the program and appeared highly engaged and hands-on with the activities

throughout.

Compared with other youth, we observed that Patsy showed more flexible patterns of

identity negotiation and adapted her approach to a variety of situations and social dynamics. She

was able to consistently position herself as competent and knowledgeable regardless of the role

she assumed (leader, supporter, or independent) and worked collaboratively with others in her

group without conflict. Across the four recorded and analyzed activity sessions, she had a total of

126 identity bids, with the majority of these bids (58%, n=74 of 126) related to communicating

her knowledge, competence, and success. For example, during *Surgical Solutions* she

communicated knowledge about the activity when she quickly identified areas for improvement

in her team's designs and explained that the washers in the patient's stomach needed to be closer

to the edge so she could get them out. Then she explained what she would do with some

materials to be able to get the washers closer to the edge.

Much of Patsy's identity negotiation positioned her as a resource and collaborator for

other youth in her group, regardless of her role as a supporter or leader. For example, during

activities when she was paired with youth that had assertive leadership styles, such as Rosey, she

assumed more of a supporter role but still performed activities related to leadership. This was

clear in the *Safe Travels* activity when she became the "tester" of the design and spent much of

the activity holding the ball that represented the wheelchair that they were trying to get down a

ramp. She also reminded the group of rules and requirements for the design, (e.g., "it has to start

from the top" or "it has to go slow") and actively tried to include other members of the group

who had been marginalized by other participants.

During activities in which she was not competing for the leadership role within the group, Patsy made sure all of the group members knew the rules of the activity and tried to lead in a diplomatic manner by asking others how they wanted to do things and offering possible suggestions. For example, she would ask others in the group, "How would you do that?" and quickly follow by saying, "maybe we can have this or this" as she signaled the materials. She would also pose questions (e.g., "Should we have something to hold this in place?") that implied what she thought needed to be done for the design to work.

Shaping dominant activity frames. Patsy had a strong impact on the activity frames but in a very different way than Rosey. As a flexible leader, she continuously reinforced and promoted the activity frames communicated by adult program facilitators of engineering as a collaborative process and failure and iteration as positive aspects of engineering design. She did this by repeating the messages highlighted by the adults, modeling the expectations with her own behaviors, and acting as a bridge or translator by revising the messages to be clearer or more relevant to other youth. We identified many instances of Patsy reinforcing the activity frame of engineering as a collaborative process, such as showing flexibility, especially when it came to group composition and working with different youth. While many of the participants voiced concern or disappointment when paired with others in small groups, Patsy did not seem to place a lot of importance on group composition. Regardless of the members of the group, she always shared her ideas, asked for input, and provided suggestions, usually with humor and a positive disposition. In fact, she seemed to rely on humor frequently as a tool to encourage collaboration and relieve tension caused by interpersonal conflict among other group members. Often Patsy encouraged and gave herself and others pep talks (e.g., "we have to work together" and "things can be possible if we try").

Patsy also promoted failure as a positive by iterating and continuing to work after she or the group encountered failure, including trying different solutions until the group managed to complete the design challenge. She consistently encouraged other youth to "test early and test often," as suggested by program staff. Furthermore, when she saw other youth struggling with failure she would encourage them to keep trying and celebrated when they succeeded. Her expectations of failure as a positive aspect of engineering design were particularly apparent during the *Zip Line Rescue* activity. Patsy worked with Leia and another participant on two different zip line designs. They tested one design a total of 11 times before they got a version that was able to travel all the way to the end of the zip line, with Patsy offering words of encouragement throughout (e.g., "So close" and "I'm kind of scared this is not secure, but that's ok"). After encountering success, the group celebrated but then faced a new challenge getting the zip line to the other end in the presence of wind (a fan blowing directly onto the line). Although the group failed another six times, Patsy again encouraged the team to work through the challenge and improve the design.

Recognizing and positioning other youth. In addition to modeling a collaborative and supportive activity frame, Patsy's flexible leadership style and her approach to positively positioning and recognizing the identity negotiation of other youth created a welcoming environment that promoted active involvement and positive relationships among participants. This was especially true during her interactions with Leia, who worked with her during three of the recorded activities. During *Safe Travels*, Leia was becoming marginalized by Rosey's leadership style (e.g., Table 1). At one point in the activity, Leia was working independently and trying to put some sticks together when Patsy made a joke to include her in the activity: "What you doing Leia, trying to start a fire?" This made Leia and the rest of the group laugh, and it was

an example of Patsy using humor as a tool to relieve tension within the group. At other times, she would playfully provide feedback, saying things like, "you can do that, but it will be very risky," thereby helping to guide group members without positioning them negatively relative to the activity. Patsy's support, encouragement, humor, and gentle style of leadership affirmed Leia's identity bids and afforded her opportunities to adopt meaningful roles.

A clear example of this approach occurred during the *Save the Day* activity. Before the interaction outlined in Table 3, Patsy and Leia had been working on designing a toy for a giant when Leia noticed that the giant, pictured in a card, was holding some knitting needles. She then got the idea to make knitting needles that could be incorporated with the doll that she had been working on with Patsy. When one of the adult program facilitators asked Leia a question (line 1), Patsy was quick to speak for Leia and position her as making a positive contribution to the design (lines 2-3)—which stands in stark contrast to other youth, such as Rosey, that used critical moments of adult facilitation to make bids for their own identities. In this case, Patsy did not respond negatively when Leia deviated from what they were doing to work on the knitting needles. She recognized and valued Leia's contributions (lines 3 and 9) by remarking how similar her design looked to the card (line 3) and by complimenting the sturdiness of the tool (line 8).

Table 3. *Patsy and Leia at the* Save the Day *Activity.*

	Conversation	Behavior
1	*Adult*: What are you making?	Talking to Leia
2	*Patsy*: She is making something. I think it's the knitting thing.	Looking at Leia and pointing to the materials in her hand.
3	*Patsy*: That looks actually really similar, except for these things.	Comparing Leia's design to the knitting needles in the card with the picture of the giant.
4		Leia makes a funny face and shakes her head, implying she doesn't want to add the yarn that was pictured on the card.
5	*Leia*: Here it is!	Putting the design in the middle of the table.
6	*Adult*: How do I use it?	Picking up the design.
7		Leia picks it up and decides to make multiple changes. A couple of minutes pass as she works on including a rubber band in the design. As Leia finishes, she puts the design in the middle of the table.
8	*Patsy*: This is really sturdy.	Grabbing the design and pretending it's a pair of scissors. Patsy then drops the design on the table from a certain height to see if it breaks.
9	*Leia*: No, don't do that.	Leia and Patsy laugh together.

Note. Girls Inc. session #2, 1/20/16, 22:05-24:06.

Example #3: Amparo (Adelante Mujeres)

Amparo was 10 years old and a fourth grader at the time of the study. Born of immigrant parents, this was her second year participating in Adelante Mujeres. Staff members described her as creative, confident, and independent and said that she took part in leadership programs at her school in addition to Adelante Mujeres. Her mom reported that she enjoyed being helpful and liked to spend time with her five siblings. According to her own reflections, Amparo had a close relationship with her mom, whom she admired greatly and tried to emulate. Amparo attended all seven program sessions and, like Rosey and Patsy, appeared highly engaged with the activities. Based on our observations, Amparo was popular among other youth in the program and many of

them wanted to be part of her group. In fact, in an opening session when adult program facilitators asked the girls to draw a person they felt was their role model, one of the girls drew Amparo and said that she admired her because she is "perfect, nice, intelligent" and "the best."

Compared to the other focal youth, we observed that Amparo had more success positioning herself as a competent, knowledgeable leader in the engineering activities. She seemed to have a strong desire to be a leader and actively assumed this role through most of the activities without much argument from other youth. Most of her identity bids (42%, n=66 of 107) communicated her knowledge, competence, or success, and she also had a fair number of identity bids positioning herself as a leader in the activities (22%, n=24 of 107). When approaching a design challenge, Amparo would often start by trying to divide the work among members of the group. After work had been assigned, she held other youth to high standards and would regularly offer critiques and suggestions. Overall, she appeared to be very interested and involved in the engineering activities and to take pride in successfully completing the design challenges.

Amparo's bids for leadership during the engineering activities were generally well received by both peers and adult program facilitators. When adults were present, their reactions to her identity bids were either positive (18%, n=9 of 51) or neutral (82%, n=42 of 51). Similarly, peer reactions to her identity bids were more often either positive (10%, n=11 of 107) or neutral (89%, n=95 of 107) and rarely negative (4%, 4 of 107). Amparo's actions positioned her as someone who could keep the group on task and could serve as a collaborative leader, and peers tended to have supportive reactions when Amparo proposed new design ideas. For example, in the *Save the Day* activity when the group found out they had to design something for a superhero, Amparo suggested they make a shield, an idea that was quickly supported by the

group. Similarly, adults often complimented Amparo's explanations of her designs. For example, in the *Zip Line Rescue* activity most of the adults said they liked her design and agreed with her ideas of making the design heavier or adding some cushion.

      Implications for engineering-related activity frames. Amparo's identity bids and the reactions of her peers played a prominent role in shaping the activity frames that emerged during the program sessions. Negotiating her identity as a leader, Amparo encouraged the sharing of ideas and working on the design as a team, and she communicated expectations surrounding success and failure as positive. Amparo's actions and behaviors indicated an activity frame of the engineering activities as collaborative and supportive instead of more individual and competitive, aligned with the expectations communicated by program facilitators. Examples of the way Amparo communicated these activity frames included a focus on being fair, dividing the work equally among the group members, and encouraging others in the group to maintain high standards for the work.

      Amparo' actions and behaviors also supported failure as a positive aspect of the engineering design process, although she strived to be successful in each design challenge. She paid attention to the facilitators' instructions for the engineering activities and would stop other participants from playing with the materials until the group was ready (e.g., "Leave it here, don't touch until we know what to do"). In the *Save the Day* activity, she had to share before she had a chance to complete her design, and as soon as group sharing was done she continued working on the challenge until she was able to show an adult a successful version. When Amparo encountered failure, she for the most part tried to motivate the group to continue trying, such as by saying, "Nothing happen, try again" in a joking matter when it didn't go well.

Table 4. *Amparo at the* Surgical Solutions *activity.*

	Conversation	Behavior
1	*Amparo*: That one is going to be really hard.	Approaching the activity station.
2	*Adult*: So, what are some ideas of how you would approach it?	
3	*Amparo*: *Mira! [Look!]* Toothpicks, we could go like this!	Sharing her idea with the group and beginning to work on the design. Other participants begin working on other challenges at the table.
4	*Adult*: Nice. So, what is that, what is that for?	
5	*Amparo*: It's like chopsticks to get the marble. Let's try this out. Okay, help me out here. Do we need more rubber bands?	Trying her design as the adult walks away. She is unsuccessful on her first attempt and passes on the tool to another youth at the table while she tries to improve her design by adding more rubber bands at the top.
6	*Participant 4*: This won't get it, we need something that will hold it tight.	Trying her design without success.
7	*Amparo*: Right? I was trying to tie rubber bands to this. This is the right size to get it.	Pointing to another design she had been working on that involved a clothes pin.
8	*Amparo*: We can suck it out.	Amparo grabs a straw. Participant gives her a disgusted look, grabs the clothes pin, and tries to tie the end open.
9	*Participant 4*: Oh! Gross! Would a real surgeon actually do that?	Looking at Amparo in disbelief.
10	*Amparo*: If they have to, yea! Let me try it.	Amparo uses suction with straw to try to remove the marble from tube.
11	*Amparo*: Yea, it's too heavy. Oh, it has other straws in it!	She is unsuccessful but continues to work, realizing the straw she had been using had other straws inside, impeding the airflow. She removes the straws and tries again without success.
12	*Adult*: I like that technique. I haven't seen anyone else do that.	Amparo and other youth abandon suction and try another design.

Note. Adelante Mujeres session #5, 4/21/16, 14:13–17:59.

An example of her support for an activity frame of failure and iteration as positive is

shown in Table 4. The group had been working for a few minutes on the *Surgical Solutions*

activity when one of the adult program facilitators approached the group. Although Amparo

initially recognized that the activity would be challenging (line 1), she immediately jumped in

with an idea for her group (line 3). Amparo and a second participant tried out a series of different approaches (lines 5, 8, 12), each time encountering a problem or challenge but staying positive and looking for different strategies. Even when her team member questioned one of her ideas (line 9), Amparo persisted, implicitly suggesting that even surgeons have to try strange approaches when things get difficult (line 10). At the end of the segment, the activity frame of failure as positive was subtly supported by the adult program facilitator, who congratulated the team on coming up with a unique idea through their iterative process (line 12).

Recognizing and positioning other youth. When taking on a leadership role, Amparo was mostly supportive of the youth in her group, asking others for suggestions and listening to their ideas. For example, Amparo would almost always encourage the youth in her group to continue to work on the activity, suggesting they try another design if they were not successful the first time. Sometimes she would divide the group into different roles or ask individuals in the group to participate, positioning them as important and valuable members of the engineering work.

Table 5. *Amparo and Reina at the* Bioswales Pollution Solution *activity.*

	Conversation	Behavior
1	*Amparo*: The plants can go all right there and right there and there. Yeah? Okay, let's just try it.	Talking to another group member pointing to the paper, indicating where she will make marks on it. She looks to the other group members and they nod.
2	*Amparo*: Okay, so *lo verde va ser las plantas. Una plantita aquí, y otra acá. O quieren ser todos? [Okay, so the green will be the plants. A little plant here and another here. Or do we want to do all of them?]*	Making marks on the paper where the group has agreed the plants should go.
3	*Reina*: *Todos, y luego acá también. [All of them, and then here too.]*	Agreeing with Amparo and grabbing another pencil while Amparo is coloring in the plants.
4	*Cristina*: *Las casas son éstas. [The houses are these ones.]*	Indicating the color of pencil to use for the houses. Amparo takes that color and starts coloring in the houses
5	*Amparo*: *Esta es una casa, para como cinco personas. [This is one house, for like five people.]*	Discussing what she is doing with the other participants. They nod.
6	*Participant 5*: How many people will fit in the house?	Asking Amparo about the design.
7	*Amparo*: I don't know, we have to test it. We have to see, we have to measure it out. The biggest you can go is five, so we can go the same on all of them.	Responding to the group.
8	*Participant 5*: We have more, we have more than anyone.	Talking to group. The group works on the design. Participant 5 leaves to go look at what other groups are doing.
9	*Reina*: *No, la casa no va así. [No, the house doesn't go like that..*	Amparo is drawing the house with the wrong color. Reina points out the mistake and Amparo grabs the right one, continuing to draw.
10	*Amparo*: *Sí? Les gusta hacer así? [Yea? Do you all like to do it like this?]*	Pausing and looking at other youth for agreement.
11	*Reina*: *Sí, aha, sí. [Yes, aha, yes.]*	
12	*Amparo*: Okay, so now we can make a box like this.	Drawing boxes to represent houses while group members point out where they should be.
13	*Reina*: *Y luego ponemos otra caja aquí. [And then we put another box here.]*	Amparo continues drawing houses where suggested.
14	*Amparo*: *Puede ir otra casa aquí. [Another house can go here.]*	Amparo continues drawing.

Note. Adelante Mujeres session #4, 3/31/16, 00:42–02:18.

The excerpt in Table 5 illustrates the ways Amparo positively positioned and recognized the identity negotiation of her peers during the *Bioswales Pollution Solution* activity. Before the excerpt, the group had been given a sheet of paper and a marker and was beginning to plan out their design. In lines 1-2, Amparo, who was holding the paper and marker, positioned Reina and Cristina as knowledgeable members of the team by checking in with them about the location of the different plants. When the two girls made several other suggestions to Amparo about the location of the plants and the color used to show the houses (lines 3-5), Amparo recognized their bids and quickly implemented their suggestions. In lines 9–11, Reina pointed out that Amparo was not using the right color to draw the houses. Amparo in turn recognized Reina as knowledgeable by admitting fault and immediately implementing her suggestion. Amparo also verbally checked in with other youth to make sure they were all included and in agreement with the design approach (line 10). Throughout the rest of the activity, Amparo supported the engineering identity negotiation of the youth in her group by actively seeking out their ideas and using them alongside her own (lines 10-14).

This positioning and recognition work afforded the identity negotiation and involvement of the other participants, even though Amparo retained her role as the primary leader in the group. This support appeared to be particularly important for Cristina, who was generally shy and often took a more passive role during the engineering activities. During her interactions with Amparo, she was able to contribute ideas to the group and remained actively engaged throughout the session.

Despite her generally supportive approach to leadership, however, Amparo also occasionally undermined the identities of other youth, especially when they were not contributing to her vision for the overall success of the group. An example of this can be seen in

the *Smooth Travels* activity as she was worked with Reina and others to create a ramp down the

pegboard (Table 6).

Table 6. *Amparo and Reina at the* Smooth Travels *activity.*

	Conversation	Behavior
1	*Reina: Es que… Es que si no funciona no es mi culpa. [It's that… It's not my fault if it doesn't work.]*	Throwing herself into a chair, looking at the ceiling, and rolling her eyes.
2	*Amparo: Reina, está bien, no dijimos que era tu culpa. [Reina, it's fine, we didn't say it was your fault.]*	Reina starts to grab sticks to put on the board.
3	*Amparo: Aquí, aquí donde puse esto, aquí. No, no, no se quitó. No, se estancó. [Here, here where I put this. No, no, no, it fell. No, it's stuck.]*	Giving directions to the group where to put sticks on the board. Some sticks fall and some are stuck on the board.
3	*Carmen: Es que [it's that] Reina is moving them.*	Accusing Reina of disturbing the board.
4	*Amparo: Reina, no la muevas. [Reina, don't move them.]*	
5	*Reina: Yo no estoy moviendo nada. Solamente me hechan a mí la culpa. De que hago esto, de que hago lo otro. [I am not moving anything. You only blame me. You are saying I do this and I do that.]*	Acting frustrating and appearing to be close to crying. The other participants don't look at Reina.
6	*Reina: ¡Esto no me gusta! [I don't like this.]*	Walking away.
7	*Zayra: Oh my God!*	
8	*Amparo: Está bien [It's ok],* let's just get another idea.	

Note. Adelante Mujeres session #2, 03/10/16, 16:28–17:10.

Amparo, Reina, and two other participants had been working together on a design to get

the ball to the bottom of the ramp safely and slowly. Reina suggested that they should create a

staircase using sticks (*"Podemos hacer una escalera, yo creo… Porque no hacen una escalera y

ya!" [We can make a staircase, I think… Why don't you make a staircase and done!]*). Amparo

and the two other participants, however, wanted to tie tubes to the board to create a steep ramp.

After the group was dismissive of her idea, Reina became frustrated (line 1). Amparo appeared

to try to placate Reina (line 2), but still continued to ignore her ideas and undermine her role in

the group (lines 3–4). When Reina finally decided to leave (line 6), Amparo did not try to stop

her or help reincorporate her into the activity. Later, when adults became involved in the

situation, Amparo demonstrated some awareness of how her actions may have influenced Reina,

exclaiming to an adult program facilitator, "Reina is kind of frustrated."

Discussion

The goal of his study was to extend our prior work on situated identity negotiation with

adolescent girls in an informal engineering education programs and explore how the identity

negotiation patterns of leadership-oriented youth in collaborative peer group interactions

afforded and constrained the situated identities of other participants. A growing body of literature

has highlighted how conflict, hierarchies, and power dynamics are common features of peer

group learning experiences, and that youth with more leadership, status, or authority in these

groups play an important role in shaping the social dynamics and learning opportunities. A small

body of research on situated identity has also emphasized the importance of peer interactions for

influencing identity negotiation, although almost of this work has been conducted in the

classroom. This study contributes to prior research by exploring how these identity negotiation

patterns extend to learning outside of school and within the specific content domain of

engineering.

Using the Identity-Frame Model of situated identity negotiation, we focused particularly

on three leadership-oriented program participants who regularly positioned themselves as leaders

within the peer group activities and appeared to have a central role in shaping the experiences for

other participants. Our qualitative analysis highlighted how these youth afforded and constrained

the engineering-related identity negotiation of their peers by: (a) influencing the activity frames that dominated during the interactions, including the relative emphasis on the engineering challenges as either competitive or collaborative and failure as a positive or negative aspect of the engineering process, and (b) recognizing and positioning other youth, either supporting their identity negotiation and involvement or limiting the ways they were able to be recognized as active and competent participants in the activities. Overall, some of the leadership-oriented youth appeared to adopt styles of identity negotiation that created space for and supported the identity negotiation of other youth, while others appeared to have a more negative impact on identity negotiation opportunities for other participants. Similarly, some of the youth modeled and reinforced messages and activity frames communicated by adult program facilitators, while other youth explicitly or implicitly undermined these messages.

Because our research was conducted within the context of an informal engineering education program, it helps address the relative lack of research on STEM identity negotiation and development outside of school. As noted, informal learning environments have long been championed as important opportunities for youth identity development (McCreedy & Dierking, 2013; NRC, 2009, 2015; Verma et al., 2015), and preliminary evidence suggests that these programs can offer youth flexible and supportive environments for reconciling multiple aspects of their identities and finding positive roles as STEM learners (Polman & Miller, 2010; Tan et al., 2013). However, the current study emphasizes that informal STEM education programs, like classroom contexts, can both afford and constrain the identity negotiation and development of youth depending on the structure and design of the program, the role of adult program facilitators, and social dynamics among participants. In this program, as in many other informal STEM education settings, participants had a high degree of freedom during peer collaborative

learning activities to structure the activities and participant roles. This type of agency can be highly motivating. However, as we saw, it can also benefit the identity negotiation of some youth over others, depending at least in part on the identity negotiation style of leadership-oriented youth within the groups. As other researchers have noted, "cooperative and collaborative approaches can also be problematic because they do not account for complicated peer worlds, which may involve unanticipated dynamics related to peer status, gender, and race" (Christianakis, 2010, p. 426).

Implications for Future Research

Although we believe we have made important headway in understanding how youth negotiate engineering-related situated identities during informal STEM learning programs, this study was still exploratory, with a focus on description and hypothesis generation. The research leaves many questions unanswered about how these findings might transfer to other participants and settings, content domains, and program contexts. Because this work was conducted in a specific free-choice context as part of two existing afterschool programs, it may be that the social dynamics we observed differ from other types of free-choice learning environments, such as family learning in museums. And as with all work on situated learning dynamics, there is also a continual need to understand not just what happens in particular moments, but how these identity negotiation patterns become routines that begin to shape the long-term identity pathways of youth (Carlone & Johnson, 2007; Kane, 2015).

Our findings do suggest that close attention to the identity negotiation dynamics in peer groups can help address the equity issues that motivated this study, including understanding how leadership-oriented youth create or diminish opportunities for all program participants to develop positive connections to engineering. We acknowledge, however, that although the DOW

program was focused on youth from traditionally underserved and under-resourced communities, and especially girls from low-income and Spanish-speaking backgrounds, our analysis did not directly address how these aspects of participants' identities interacted with the situated identity negotiation patterns we observed. Prior research has highlighted the importance of race, ethnicity, and language preference in shaping peer group interactions and identity negation with classroom contexts (e.g., Brown, 2006; Carlone, Johnson, & Scott, 2015; Varelas et al., 2015). We suspect that these dynamics are at play in informal STEM learning programs such as DOW, as well, and may shape the connections between leadership-oriented youth and identity negotiation within peer groups.

Similarly, there are likely a number of other program and contextual factors that influenced the identity negotiation and peer interaction dynamics we observed in this study and that can help to focus future research. For example, prior literature highlights the important role that classroom teachers can play in shaping the dynamics of peer group interactions (e.g., Christianakis, 2010; Sharma, 2013). In our study, we observed that adult educators played a strong role in launching the activities but then primarily allowed peer groups to guide their own engineering design process. In other programs with varying levels of adult involvement and approaches to facilitation, for both educators and engineering role models, we might see very different identity negotiation patterns. In addition, researchers should explore the influence of other program design elements, including time for group and individual work, explicit assignment of youth roles, the nature and framing of the engineering challenges, materials use, and length of program. Adult involvement and program design relate to youth choice and agency, which, as we have argued, likely both contribute to the appeal of informal STEM education experiences and the potential for unexpected identity negotiation patterns.

One intriguing aspect of this study was the potential difference in the education and youth development philosophies and messages of the two afterschool programs that participated in the DOW project, especially related to youth leadership and peer collaboration. Although both organizations emphasized youth empowerment, Adelante Mujeres program staff also reported placing more emphasis on relationships and group bonding. If it is true, as this study suggests, that leader-oriented youth play a critical role during peer learning experiences in shaping opportunities for the identity negotiation of other youth, then it may be critical for programs and organizations to reflect on their philosophies and approaches to supporting youth leadership (e.g., Mercier et al., 2014). Interestingly, both of the partner organizations also incorporated leadership trainings for specific youth, raising questions about how these trainings influenced the power dynamics that we observed in the interactions. Future research might explore how these types of program philosophies influence the activity frames that emerge during collaborative learning and, subsequently, the identity negotiation of youth.

The analyses reported in this article focused on two activity frame continuums that were prominent in the data (collaboration versus competition, failure as positive or negative), both of which represent important aspects of the engineering process and engineering education (Cunningham & Kelly, 2017; Katehi et al., 2009). However, the study also suggested additional activity frames to be investigated in future research. For example, youth appeared to negotiate activity frames related to the importance of following the rules and goals outlined by the adult program facilitators. This was highlighted by some youth continually emphasizing the rules and criteria outlined by program facilitators and policing the adherence to these rules by other youth. Some youth also implied different perspectives on copying and sharing ideas as either acceptable or unacceptable parts of the engineering design process, even though program facilitators

repeatedly emphasized that looking at ideas from other groups for inspiration is a great way to deal with failure or challenge. Future research should identify additional activity frames that influence identity negotiation during informal STEM education programs, as well as distinguish between frames that appear to be important across STEM topic domains and those that are unique to specific topics, such as engineering.

Finally, these findings suggest new challenges for researchers and evaluators attempting to assess the impact of informal STEM education programs. Although a program may be well designed to support identity development for individual participants, group social dynamics and the approaches to leadership taken by participants may ultimately have a strong influence on program outcomes. As with any program evaluation, researchers need to consider the variety of contextual factors that influence how the program works, for whom, and in what circumstances, including the impact of peer learning dynamics and specific configurations of youth participants. This is especially true in informal learning environments, where the relatively free-choice nature of the experiences make social context and individual agency central to shaping the learning process and outcomes (Falk & Dierking, 2013; NRC, 2009). Researchers should continue to explore the roles that social dynamics and individual identity negotiation patterns play as moderators and mediators influencing the connections between program design and participant outcomes.

Implications for Educational Practice

Although this line of research is not yet ready to support definitive claims about the processes and causal relationships associated with situated STEM-related identity negotiation for youth, or the long-term outcomes of these interactions, the work nonetheless has several potential implications for informal and formal educators. First and foremost, the study and the

Identity-Frame Model in general provide new perspectives for educators to understand their

work and their role relative to peer learning and identity negotiation. Past research in the

classroom emphasizes the important role that teachers play in helping to shape and support

productive peer group learning dynamics—and therefore support equitable opportunities for

positive STEM identity negotiation for all participants (Gamez & Parker, 2017; Kane, 2012;

Kane, & Varelas, 2016; Leman, 2015; Strough et al., 2001; Varelas et al., 2012, 2015). Beyond

thinking about what messages they are communicating to participants and how they are

facilitating engagement, educators should also be aware of the ways participants are influencing

the experiences and identity development opportunities for their peers. They should consider

who is playing a leadership role in the group, what activity frames those leaders are supporting,

and how they are positioning and recognizing other participants. As past research has shown,

these dynamics can also be influenced by the relationships among group participants, including

friendship status and perceived expertise (Strough et al., 2001; Yun & Kim, 2015). The current

study also motivates educators to reflect on their own understandings and practices related to

STEM identity and how the ways that they support and position particular youth, especially

leadership-oriented youth, can influence the experiences and identity negotiation opportunities of

other participants. As research on collaborative learning and peer interactions has shown,

teachers and educators can unintentionally support stereotypes and unproductive learning

dynamics when facilitating peer group interactions (Christianakis, 2010).

This type of reflection and deep understanding of the complex dynamics of collaborative

learning are challenging for even the most experienced program facilitators. We have seen in our

own work that educators benefit greatly when they partner with colleagues to observe and

discuss program sessions, providing multiple perspectives on interactions among participants and

between facilitators and youth. One outcome of the DOW project was a facilitator reflection tool,[2] developed collaboratively by research and program staff members and designed to help facilitators notice identity negotiation dynamics within their programs. The tool also encourages educators to explore strategies for guiding how activities are framed and the opportunities youth have to negotiate identities for themselves during the activities. Our hope is that it can be used in conjunction with other professional learning resources within the informal STEM education field, such as Reflecting on Practice,[3] REVEAL,[4] or team-based inquiry (Pattison, Cohn, & Kollmann, 2013), with the ultimate goal of developing adaptive facilitation approaches to respond to the unique needs of different programs and participant groups.

In considering the implications of this line of work, both educators and researchers should take care not to make unnecessary value judgments about different leadership styles, situated identities, or activity frames. There is still much we don't understand about how these context-specific social dynamics influence long-term identity pathways. From the perspective of engineering education, it seems clear that some leadership approaches and activity frames are more aligned with the practices of engineering and design (Cunningham & Kelly, 2017; NGSS Lead States, 2013), including the value of collaboration and iteration. However, youth, and especially those from traditionally underserved and under-resourced communities, often must juggle multiple identities and navigate a variety of social and cultural barriers as they develop their relationships with engineering and STEM. At times, these youth might be well served by adopting a more individual, competitive leadership approach or activity frame, especially when dealing with existing, normative understandings of a "good student" (Hegedus et al., 2014). Keeping these tensions in mind will help educators carefully consider how their approaches to

program design and facilitation align with their goals for youth, and what implicit assumptions and expectations underlie those goals.

Finally, this study and prior work on hierarchies and power dynamics within peer learning groups highlight a critical question for the informal STEM education field: How can informal education programs preserve the essential qualities of free-choice learning, including individual agency and motivation, while providing sufficient structure to support positive, equitable learning experiences and identity development opportunities for all participants? Support for individual agency and motivation, flexibility to individualize learning experiences, and collaborative and social learning opportunities are all frequently cited as critical characteristics explaining the power of informal learning (Falk & Dierking, 2013; National Research Council, 2009, 2015). These same characteristics, however, arguably create opportunities for the challenging dynamics that we observed in this study, including instances when individual participants undermined the involvement and identity development of others. By continuing to explore the complex dynamics of identity negotiation within collaborative learning groups, the field can begin to develop an understanding of how to strike this balance and ensure that informal STEM education programs create positive learning opportunities for all participants.

References

Alexander, J. M., Johnson, K. E., & Leibham, M. E. (2015). Emerging individual interests related to science in young children. In K. A. Renninger, M. Nieswandt, & S. Hidi (Eds.), *Interest in mathematics and science learning* (pp. 261–280). Washington, DC: American Educational Research Association.

Allen, S., Gutwill, J. P., Perry, D., Garibay, C., Ellenbogen, K., Heimlich, J., … Klein, C. (2007). Research in museums: Coping with complexity. In J. H. Falk, L. D. Dierking, & S. Foutz (Eds.), *In principle, in practice: Museums as learning institutions* (pp. 44–56). Lanham, MD: AltaMira.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2010). "Doing" science versus "being" a scientist: Examining 10/11-year-old schoolchildren's constructions of science through the lens of identity. *Science Education, 94*(4), 617–639.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2012). "Balancing acts'': Elementary school girls' negotiations of femininity, achievement, and science. *Science Education, 96*(6), 967–989.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2013). 'Not girly, not sexy, not glamorous': Primary school girls' and parents' constructions of science aspirations. *Pedagogy, Culture & Society, 21*(1), 171–194.

Aschbacher, P. R., Li, E., & Roth, E. J. (2009). Is science me? High school students' identities, participation and aspirations in science, engineering, and medicine. *Journal of Research in Science Teaching, 47*(5), 564–582.

Bakhtin, M. (2014). The problem of speech genres. In A. Jaworski & N. Coupland (Eds.), *The discourse reader* (3rd ed, pp. 121–132). New York, NY: Routledge.

Bhana, D. (2005). "I'm the best in maths. Boys rule, girls drool." Masculinities, mathematics and primary schooling. *Perspectives in Education, 23*(3), 1–10.

Bricker, L. A., & Bell, P. (2014). "What comes to mind when you think of science? The perfumery!": Documenting science-related cultural learning pathways across contexts and timescales. *Journal of Research in Science Teaching, 51*(3), 260–285.

Brotman, J. S., & Moore, F. M. (2008). Girls and science: A review of four themes in the science education literature. *Journal of Research in Science Teaching, 45*(9), 971–1002.

Brown, B. A. (2006). "It isn't no slang that can be said about this stuff": Language, identity, and appropriating science discourse. *Journal of Research in Science Teaching, 43*(1), 96–126.

Calabrese Barton, A., Kang, H., Tan, E., O'Neill, T. B., Bautista-Guerra, J., & Brecklin, C. (2012). Crafting a future in science: Tracing middle school girls' identity work over time and space. *American Educational Research Journal, 50*(1), 37–75.

Capobianco, B. M., Yu, J. H., & French, B. F. (2015). Effects of engineering design-based science on elementary school science students' engineering identity development across gender and grade. *Research in Science Education, 45*(2), 275–292.

Carlone, H. B., Haun-Frank, J., & Webb, A. (2011). Assessing equity beyond knowledge- and skills-based outcomes: A comparative ethnography of two fourth-grade reform-based science classrooms. *Journal of Research in Science Teaching, 48*(5), 459–485.

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching, 44*(8), 1187–1218.

Carlone, H. B., Johnson, A., & Scott, C. M. (2015). Agency amidst formidable structures: How girls perform gender in science class. *Journal of Research in Science Teaching, 52*(4), 474–488.

Cekaite, A., & Björk-Willén, P. (2013). Peer group interactions in multilingual educational settings: Co-constructing social order and norms for language use. *International Journal of Bilingualism, 17*(2), 174–188.

Chan, J. Y. K., & Bauer, C. F. (2015). Effect of peer-led team learning (PLTL) on student achievement, attitude, and self-concept in college general chemistry in randomized and quasi experimental designs. *Journal of Research in Science Teaching, 52*(3), 319–346.

Charmaz, K. (2006). *Constructing grounded theory*. Thousand Oaks, CA: Sage Publications.

Christianakis, M. (2010). "I don't need your help!" Peer status, race, and gender during peer writing interactions. *Journal of Literacy Research, 42*(4), 418–458.

Creswell, J. W. (2013). *Qualitative inquiry and research design: Choosing among five approaches* (3rd ed). Los Angeles, CA: Sage Publications.

Cunningham, C. M., & Kelly, G. J. (2017). Epistemic practices of engineering for education. *Science Education, 101*(3), 486–505.

De Fina, A. (2011). Discourse and identity. In T. A. van Dijk (Ed.), *Discourse studies: A multidisciplinary introduction* (2nd ed, pp. 263–283). Thousand Oaks, CA: Sage Publications.

Dyehouse, M., Yoon, S. Y., Lucietto, A., & Diefes-Dux, H. (2012). *The effects of an engineering teacher professional development program on elementary students' science/engineering*

content knowledge and engineering identity. Retrieved from http://www.researchgate.net/profile/So_Yoon_yoona_Yoon/publication/261760656_The_eff ects_of_an_engineering_teacher_professional_development_on_elementary_students_scienc eengineering_content_knowledge_and_engineering_identity/links/0f3175357231542a0b0000 00.pdf

Eberlein, T., Kampmeier, J., Minderhout, V., Moog, R. S., Platt, T., Varma-Nelson, P., & White, H. B. (2008). Pedagogies of engagement in science: A comparison of PBL, POGIL, and PLTL. *Biochemistry and Molecular Biology Education, 36*(4), 262–273.

Ellis, W. E., Dumas, T. M., Mahdy, J. C., & Wolfe, D. A. (2012). Observations of adolescent peer group interactions as a function of within- and between-group centrality status. *Journal of Research on Adolescence, 22*(2), 252–266.

Falk, J. H. (2009). *Identity and the museum visitor experience*. Walnut Creek, CA: Left Coast Press.

Falk, J. H. (2017). *Born to choose: Evolution, self, and well-being*. London: Routledge.

Falk, J. H., & Dierking, L. D. (2013). *The museum experience revisited*. Walnut Creek, CA: Left Coast Press.

Fields, D., & Enyedy, N. (2013). Picking up the mantle of "expert": Assigned roles, assertion of identity, and peer recognition within a programming class. *Mind, Culture, and Activity, 20*(2), 113–131.

Fies, C., & Langman, J. (2011). Bridging worlds: Measuring learners' discursive practice in a PartSim supported biology lesson. *International Journal of Science and Mathematics Education, 9*(6), 1415–1438.

Frechtling, J. (2010). *The 2010 user-friendly handbook for project evaluation*. Washington, D.C.: National Science Foundation. Retrieved from http://informalscience.org/documents/TheUserFriendlyGuide.pdf

Gamez, R., & Parker, C. A. (2017). Becoming science learners: A study of newcomers' identity work in elementary school science. *Science Education, 102*(2), 377-413.

Gee, J. P. (2000). Identity as an analytic lens for research in education. *Review of Research in Education, 25*(1), 99–125.

Gee, J. P. (2014). *An introduction to discourse analysis: Theory and method* (Fourth edition). New York, NY: Routledge.

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Chicago, IL: Aldine Pub. Co.

Goffman, E. (1986). *Frame analysis: An essay on the organization of experience*. Boston, MA: Northeastern University Press.

Greeno, J. G. (2009). A theory bite on contextualizing, framing, and positioning: A companion to Son and Goldstone. *Cognition and Instruction, 27*(3), 269–275.

Gutierrez, K. D., & Rogoff, B. (2003). Cultural ways of learning: Individual traits or repertoires of practice. *Educational Researcher, 32*(5), 19–25.

Hand, V., Penuel, W. R., & Gutiérrez, K. D. (2012). (Re)framing educational possibility: Attending to power and equity in shaping access to and within learning opportunities. *Human Development, 55*(5–6), 250–268.

Hegedus, T. A., Carlone, H. B., & Carter, A. D. (2014). *Shifts in the cultural production of "smartness" through engineering in elementary classrooms*. Presented at the 121st ASEE Annual Conference & Exposition, Indianapolis, IN. Retrieved from https://peer.asee.org/shifts-in-the-cultural-production-of-smartness-through-engineering-in-elementary-classrooms.pdf

Heyd-Metzuyanim, E., & Sfard, A. (2012). Identity struggles in the mathematics classroom: On learning mathematics as an interplay of mathematizing and identifying. *International Journal of Educational Research, 51–52*, 128–145.

Hutchison, P., & Hammer, D. (2010). Attending to student epistemological framing in a science classroom. *Science Education, 94*(3), 506–524.

Jakonen, T., & Morton, T. (2015). Epistemic search sequences in peer interaction in a content-based language classroom. *Applied Linguistics, 36*(1), 73–94.

Jimenez-Aleixandre, M. P., Rodriguez, A. B., & Duschl, R. A. (2000). "Doing the lesson" or" doing science": Argument in high school genetics. *Science Education, 84*(6), 757–792.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (2006). *Active learning: Cooperation in the college classroom* (3rd ed). Edina, MN: Interaction Book Co.

Jones, M. G., Corin, E. N., Andre, T., Childers, G. M., & Stevens, V. (2017). Factors contributing to lifelong science learning: Amateur astronomers and birders. *Journal of Research in Science Teaching, 54*(3), 412–433.

Jordan, M. E., & McDaniel, R. R. (2014). Managing uncertainty during collaborative problem solving in elementary school teams: The role of peer influence in robotics engineering activity. *Journal of the Learning Sciences, 23*(4), 490–536.

Kane, J. M. (2012). Young African American children constructing academic and disciplinary identities in an urban science classroom. *Science Education, 96*(3), 457–487.

Kane, J. M. (2015). The structure-agency dialectic in contested science spaces: "Do earthworms eat apples?" *Journal of Research in Science Teaching, 52*(4), 461–473.

Kane, J. M., & Varelas, M. (2016). Elementary school teachers constructing teacher-of-science identities: Two communities of practice coming together. In L. Avraamidou (Ed.), *Studying science teacher identity: Theoretical, methodological and empirical explorations* (pp. 177–196). Rotterdam, Netherlands: Sense Publishers.

Katehi, L., Pearson, G., Feder, M. A., Committee on K-12 Engineering Education, National Academy of Engineering, & National Research Council (Eds.). (2009). *Engineering in K-12 education: Understanding the status and improving the prospects*. Washington, DC: National Academies Press.

Kirkhart, K. E. (1995). 1994 conference theme: Evaluation and social justice seeking multicultural validity: A postcard from the road. *American Journal of Evaluation, 16*(1), 1–12.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. New York, NY: Cambridge University Press.

Leaper, C., Farkas, T., & Brown, C. S. (2012). Adolescent girls' experiences and gender-related beliefs in relation to their motivation in math/science and English. *Journal of Youth and Adolescence, 41*(3), 268–282.

Leman, P. J. (2015). How do groups work? Age differences in performance and the social outcomes of peer collaboration. *Cognitive Science, 39*(4), 804–820.

Marshall, C., & Rossman, G. B. (2011). *Designing qualitative research* (5th ed). Los Angeles, CA: Sage.

McCreedy, D., & Dierking, L. D. (2013). Cascading influences: Long-term impacts of informal STEM experiences for girls. Philidelphia, PA: The Franklin Institute Science Museum. Retrieved from https://www.fi.edu/sites/default/files/cascading-influences.pdf

Mercier, E. M., Higgins, S. E., & da Costa, L. (2014). Different leaders: Emergent organizational and intellectual leadership in children's collaborative learning groups. *International Journal of Computer-Supported Collaborative Learning, 9*(4), 397–432.

Mitchell, Y. D., Ippolito, J., & Lewis, S. E. (2012). Evaluating peer-led team learning across the two semester general chemistry sequence. *Chemistry Education Research and Practice, 13*(3), 378–383.

Morgan, D. L. (2014). *Integrating qualitative and quantitative methods: A pragmatic approach*. Thousand Oaks, CA: Sage Publications.

Nasir, N. S., & Saxe, G. B. (2003). Ethnic and academic identities: A cultural practice perspective on emerging tensions and their management in the lives of minority students. *Educational Researcher, 32*(5), 14–18.

National Academies of Sciences, Engineering, and Medicine. (2016). *Developing a national STEM workforce strategy: A workshop summary*. (J. Alper, Ed.). Washington, DC: National Academies Press.

National Research Council. (2009). *Learning science in informal environments: People, places, and pursuits*. Washington, DC: National Academies Press.

National Research Council. (2015*). Identifying and supporting productive STEM programs in out-of-school settings*. Washington, DC: The National Academies Press.

National Science Board. (2010). *Preparing the next generation of STEM innovators: Identifying and developing our nation's human capital* (No. NSB 10-33). Arlington, VA: National Science Foundation.

National Science Board. (2016). *Science and engineering indicators 2016* (No. NSB-2016-1). Arlington, VA: National Science Foundation.

Nelson, K. (2003). Narrative and self, myth and memory: Emergence of the cultural self. In R. Fivush & C. A. Haden (Eds.), *Autobiographical memory and the construction of a narrative self: Developmental and cultural perspectives* (pp. 3–28). Mahwah, NJ: Erlbaum.

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. Washington, DC: National Academies Press.

Norris, S. (2011). *Identity in (inter)action: Introducing multimodal interaction analysis*. Berlin, Germany: De Gruyter Mouton.

Norris, S., & Jones, R. H. (Eds.). (2005). *Discourse in action: Introducing mediated discourse analysis*. New York, NY: Routledge.

Okazaki, S., & Sue, S. (1995). Methodological issues in assessment research with ethnic minorities. *Psychological Assessment, 7*(3), 367–375.

Pattison, S. A. (2014). *Exploring the foundations of science interest development in early childhood* (Doctoral dissertation). Oregon State University, Corvallis, OR. Retrieved from http://hdl.handle.net/1957/54783

Pattison, S. A., Cohn, S., & Kollmann, E. (2013). *Team-based inquiry: A practical guide for using evaluation to improve informal education experiences*. Retrieved from http://www.nisenet.org/catalog/tools_guides/team-based_inquiry_guide

Pattison, S. A., Gontan, I., Ramos-Montanez, S., Shagott, T., Francisco, M., & Dierking, L. D. (2017). *The Identity-Frame Model: A framework to describe situated identity negotiation for adolescent girls participating in an informal engineering education program*. Manuscript in review.

Patton, M. Q. (2015). *Qualitative research & evaluation methods: Integrating theory and* practice (4th ed). Thousand Oaks, CA: SAGE Publications.

Penuel, W. R., & Wertsch, J. V. (1995). Vygotsky and identity formation: A sociocultural approach. *Educational Psychologist, 30*(2), 83–92.

Polman, J. L., & Miller, D. (2010). Changing stories: Trajectories of identification among african american youth in a science outreach apprenticeship. *American Educational Research Journal, 47*(4), 879–918.

Rowe, S. (2005). Using multiple situation definitions to create hybrid activity space. In S. Norris & R. H. Jones (Eds.), *Discourse in action: Introducing mediated discourse analysis* (pp. 123–134). New York, NY: Routledge.

Ryu, M. (2015). Positionings of racial, ethnic, and linguistic minority students in high school biology class: Implications for science education in diverse classrooms. *Journal of Research in Science Teaching, 52*(3), 347–370.

Sayman, D. M. (2013). Quinceañeras and quadratics: Experiences of Latinas in state-supported residential schools of science and math. *Journal of Latinos and Education, 12*(3), 215–230.

Scollon, R. (1998). *Mediated discourse as social interaction: A study of news discourse*. New York, NY: Longman.

Shanahan, M.-C., & Nieswandt, M. (2009). Creative activities and their influence on identification in science: Three case studies. *Journal of Elementary Science Education, 21*(3), 63–79.

Sharma, B. K. (2013). Enactment of teacher identity in resolving student disagreements in small group peer interactions. *Linguistics and Education, 24*(2), 247–259.

Shim, S.-Y., & Kim, H.-B. (2018). Framing negotiation: Dynamics of epistemological and positional framing in small groups during scientific modeling. *Science Education, 102*(1), 128–152.

Spataro, S. E., Pettit, N. C., Sauer, S. J., & Lount Jr, R. B. (2014). Interactions among same-status peers: Effects of behavioral style and status level. *Small Group Research, 45*(3), 314–336.

Stake, J. E., & Nickens, S. D. (2005). Adolescent girls' and boys' science peer relationships and perceptions of the possible self as scientist. *Sex Roles, 52*(1–2), 1–11.

Stake, R. E. (2006). *Multiple case study analysis*. New York: The Guilford Press.

Storch, N. (2005). Collaborative writing: Product, process, and students' reflections. *Journal of Second Language Writing, 14*(3), 153–173.

Strough, J., Swenson, L. M., & Cheng, S. (2001). Friendship, gender, and preadolescents' representations of peer collaboration. *Merrill-Palmer Quarterly, 47*(4), 475–499.

Stryker, S., & Burke, P. J. (2000). The past, present, and future of an identity theory. *Social Psychology Quarterly, 63*(4), 284–297.

Tai, R. H., Liu, C. Q., Maltese, A. V., & Fan, X. (2006). Career choice: Planning early for careers in science. *Science, 312*(5777), 1143–1144.

Takeuchi, M. A. (2016). Friendships and group work in linguistically diverse mathematics classrooms: Opportunities to learn for English language learners. *Journal of the Learning Sciences, 25*(3), 411–437.

Tan, E., & Calabrese Barton, A. (2008). From peripheral to central, the story of Melanie's metamorphosis in an urban middle school science class. *Science Education, 92*(4), 567–590.

Tan, E., Calabrese Barton, A., Kang, H., & O'Neill, T. (2013). Desiring a career in STEM-related fields: How middle school girls articulate and negotiate identities-in-practice in science. *Journal of Research in Science Teaching, 50*(10), 1143–1179.

Tenenbaum, H. R., & Leaper, C. (2003). Parent-child conversations about science: The socialization of gender inequities? *Developmental Psychology, 39*(1), 34–47.

Thomas, V. G., & Parsons, B. A. (2017). Culturally responsive evaluation meets systems-oriented evaluation. *American Journal of Evaluation, 38*(1), 7–28.

Thompson, R. (2006). The development of the person: Social understanding, relationships, conscience, self. In W. Damon & R. M. Lerner (Eds.), *Handbook of child psychology (6th Ed.), Vol. 3. Social, emotional, and personality development* (6th ed, pp. 24–98). Hoboken, N.J: John Wiley & Sons.

Varelas, M., Martin, D. B., & Kane, J. M. (2012). Content learning and identity construction: A framework to strengthen African American students' mathematics and science learning in urban elementary schools. *Human Development, 55*(5–6), 319–339.

Varelas, M., Tucker-Raymond, E., & Richards, K. (2015). A structure-agency perspective on young children's engagement in school science: Carlos's performance and narrative. *Journal of Research in Science Teaching, 52*(4), 516–529.

Vedder-Weiss, D. (2017). Serendipitous science engagement: A family self-ethnography. *Journal of Research in Science Teaching, 54*(3), 350–378.

Verma, G., Puvirajah, A., & Webb, H. (2015). Enacting acts of authentication in a robotics competition: An interpretivist study. *Journal of Research in Science Teaching, 52*(3), 268–295.

Wertsch, J. V. (1998). *Mind as action*. New York, NY: Oxford University Press.

Yun, S. M., & Kim, H.-B. (2015). Changes in students' participation and small group norms in scientific argumentation. *Research in Science Education, 45*(3), 465–484.

Acknowledgments

Notes

[1] All names reported in this article are pseudonyms.

[2] https://omsi.edu/educator-resources

[3] http://mare.lawrencehallofscience.org/partnerships/current/rop

[4] https://REVEAL.TERC.edu