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**From Imagined to In-Practice and Performed STEM Identities: Measuring the Impact of a Latina STEM Fellowship on the Educational Trajectories of Latina High School Students**

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**Abstract**

Science, technology, engineering, and mathematics (STEM) educational camps and fellowships that specifically target underrepresented populations in STEM fields, such as Latinas, have become more common place across the United States. In this article, we analyze multimodal ways of representing, opportunities, and role-models present at these camps, which together assemble an environment that uplifts participants with greater knowledge about possible STEM educational/career pathways and develops within participants an identity as future STEM professionals. We place identity and the power of imagination front and center in our study and through a multimodal systemic functional linguistics approach (Przymus et al., 2020), we analyze the experience of six Latina high school students and document all meaning-making textual interactions that moved these Latina STEM Fellowship (LSF) participants from imagined to in-practice and performed STEM identities. Results indicate that participants are deeply aware of the stereotype threat and identity contingencies that face Latinas in STEM careers, but that interacting with other high school Latina peers and with accomplished Latina scientists at the LSF worked to counteract these challenges and discourses of deficit.

**Keywords:** imagined identities; in-practice identities; Latina STEM Fellowship; multimodal systemic functional linguistics; performed identities

“As long as I’m doing the right thing that will help me get to my career goal,  
then like nothing would be able to bring me down”

(Latina Stem Fellowship Participant, Summer, 2018).

“What do you want to be when you grow up?” This question is posed to children in households around the world, and certainly was part of our lived experiences, growing up in the United States. Answers are influenced by role-models, both personally present in children’s lives and those from many diverse affinity outlets, such as musicians, athletes, and actors. Caraballo (2019) points to another important and influential indicator of identity development being socialization. Many youth “rely on discourses of race, class, and gender in which they have been socialized to construct narratives of identit(ies) in the cultural worlds experienced with/in academic contexts and beyond” (Caraballo, 2019, p. 1282).

Some populations of students, such as Latinas, are the recipients of discourses of deficit with/in academic contexts when it comes to certain content, such as higher level math and science courses (Jackson & Seiler, 2018). As children grow and move through schooling, however, membership and participation in social groups begins to have an increasing influence on individuals’ future goals and vision of self and can act to either reify or counteract such deficit discourses. As we will take up, below, imagining and experimenting with in-practice science, technology, engineering, and mathematics (STEM) identities can work to counteract stereotypes and deficit discourses about young Latinas and STEM. Youth fluidly move in and out of many diverse communities of practice (Wenger, 1998), both concrete and imagined (Kanno & Norton, 2003), and experiment with multiple imagined identities (Early & Norton, 2012), throughout their schooling years. Przymus’ (2016) work with culturally and linguistically diverse youth in educational communities of practice highlights that interactions and students’ identities, imagined and created, have tremendous influence on the educational possibilities and future career decisions of youth.

In this article, we utilize a multimodal systemic functional linguistics approach (Przymus et al., 2020) to analyze and raise the voices of six Latina high school students who participated in a Latina STEM Fellowship (LSF). Through relaying their voices, we learn that their experience with education is that their schools have not extended them agency over educational decisions and that they have not experienced relatedness with STEM content. They have also not had

teachers or many professional role-models that look like them and have had similar life experiences. All these factors have reified identity contingencies and stereotype threat around their (Latinas') place in STEM careers, knowledge about how to achieve STEM careers, and self-motivation to embark on STEM educational trajectories. They found all of this, however, through participating in the Latina STEM Fellowship (LSF), documented in this article.

By documenting these Latina high school participants' completed and stated desired actions for the future after participating in the Latina STEM Fellowship, we can begin to assess the effectiveness of such camps and fellowships that target underrepresented populations in STEM careers, on these students' imagined, in-practice, performed, and actualized STEM identities. With this study we specifically set out to uncover in what ways these kinds of fellowships have the potential to provide the learning experiences, community, and role-models needed to make an impact on Latinas' self-assessment, self-determination, and identity. Might opportunities like the LSF provide space for these youth to experiment, take risks, and create imagined identities as STEM professionals that might lead to actualized identities in the future? Highlighting concrete examples from the below documented LSF, might aluminate pathways for how Latinas who participate in these kinds of STEM fellowships and camps actually make different decisions that have the potential to lead them to choosing STEM educational degrees and careers. Documenting these participants' perspectives and actions can also inform successful implementation of similar camps and fellowships across the U.S.

### **Literature Review: Underrepresented STEM Identities**

Difference in appearance, language, historic expectations, and ideologies about who is successful in STEM related subjects can lead to deficit thinking (among teachers and students) and difference in instruction/learning. Licona (2013) describes how "immigrant children are relegated to the non-gifted and lower track classes where science is taught from an abstract and non-contextual and therefore less engaged basis" (p. 859). Manzo et al. (2011) also document the need for teacher professional development to address the lack of preparation needed to adequately teach science to immigrant and English learners (ELs), which they

contend, “contributes greatly to the continued failure of teachers to engage ELs in ways that make learning science relevant, meaningful, and challenging” (p. 42).<sup>1</sup>

Although all Latina and some second generation,<sup>2</sup> none of the participants in our study were immigrant newcomers to their U.S. schools, nor were ever labeled as English Learners. Yet, the persistent ideology of Latinx<sup>3</sup> students’ place in STEM, either top-down from teachers or bottom-up from their own positionalities, exists. Although work calling for the need for teacher professional development to address teaching immigrant and English learners exists (Manzo et al., 2011), this professional development needs to be expanded to raising the awareness that Latinx students are not homogenous, have varied identities (both imagined and in-practice), have diverse sociocultural backgrounds and experiences, and clearly are not all immigrants and English learners. Without this targeted professional development and purposeful educational interventions for students, Latinx students may continue to be subjected to inequitable STEM education expectations and opportunities.

In measuring the effectiveness of educational interventions on students’ school and career trajectories, we must consider the impact of these students’ diverse and intersectional cultural identity. “Cultural identity is intricately related to...social domains such as education, employment and how people want to live out their lives” (Obsiye & Cook, 2016, p. 1062). Even though cultural identity as a determined fact has been problematized (Hall, 1990), recent studies documenting the impact of STEM-based educational interventions have highlighted how participants both lean into and leverage their cultural identity for resilience, but also feel the weight of stereotypic and negative contingencies linked to their identities as Latinas in STEM fields of study (Gonzalez et al., 2020; Sparks et al., 2021).

Evidence of resilience, cultural-based-spaces of support, and the presence of Latina professor/scientist role models/mentors are common aspects in the literature that highlights Latinas who have found success in STEM education. Gonzalez et al. (2020) document the

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<sup>1</sup> The U.S. Department of Education’s current bureaucratic label “English learner” (EL) or “English language learner” (ELL) is given to: A [Limited English Proficient] student [...] who was not born in the United States or whose native language is a language other than English; or ... who comes from an environment where a language other than English has had a significant impact on his or her level of English language proficiency (Migration Policy Institute 2017).

<sup>2</sup> Individuals who are just one generation removed from immigration to the U.S.

<sup>3</sup> Gender inclusive term for Latinos

persistence of Latinas in STEM and the development of resilience that can come from Latina professor role models, who share cultural values and ethnicity and “family and strong support systems that reflected their Hispanic culture” (pp. 9-10; see also Ruiz, 2013; Sparks et al., 2021). Similarly, Sparks et al. (2021) describe the importance of spaces and programs that provide access to Latina STEM professional role models and mentors, where students are encouraged to draw on “their race/ethnicity and culture for resiliency” (p. 11). A final related example of identity work around successful Latinas in STEM comes from Martínez et al. (2019), who utilize the theoretical construct of contextual mitigating factors (CMFs) to understand how Latinas develop “critical consciousness in the form of resiliency” in STEM related contextualized spaces and social interactions in order to “develop the ability to succeed in STEM pipelines” (p. 1098). Learning from these and our current study is needed to address the continued underrepresentation of Latinas in STEM fields of study and careers.

According to the Pew Research Center (2017), the growth of employment in STEM has outpaced growth of overall employment, 79% and 34%, respectively, with some areas of STEM such as computer science increasing as much as 338%. Additionally, the post-graduate educational attainment of employed adults in STEM is significantly higher than non-STEM employees, 29% and 12%, respectively (Pew Research Center, 2017). Women, however, continue to represent a disproportionately lower percentage of employed scientists and engineers. In 2015, Hispanic (2%) and Black (2%) women constituted only 4% of all employed scientists and engineers (National Science Foundation, 2017). Marsh et al. (2019) point to a decade long “strong push from governments in postindustrial nations to increase the retention of students in science education and the representation of women in STEM education and careers” (p. 1631). The impact of these efforts, however, seems to be both slow and unproven.

We recognize the potential negative effect of writing about the underrepresentation of women of color in STEM. Although true, this narrative alone can act to strengthen the stereotype that Latinas are not good at STEM and in turn intensify the identity contingency that these students feel in the classroom. Steele (2011) reports that simply by bringing attention to women’s gender identity, prior to taking a math test, that the students underperformed when compared to no gender related priming (p. 93). He states that “social identities shape who we are, what we do, and how well we do it,” but that there are remedies to address the effects of stereotype threat and identity contingencies (2011, p. 62). Many of the solutions that Steele

puts forth for mitigating the ill effects of identity contingencies can be found in the structural components of the Latina STEM Fellowship (LSF) examined in our study. Steele posits that

By improving a group's critical mass in a setting, you can improve its members' trust, comfort, and performance in the setting...By allowing students, especially minority students, to affirm their most valued sense of self, you can improve their grades, even for a long time. By helping students develop a narrative about the setting that explains their frustrations while projecting positive engagement and success in the setting, you can greatly improve their sense of belonging and achievement (p. 216).

Researchers in STEM have begun to document the impact of raising young women's critical mass in STEM, via camps, such as Bindis' (2020) study on the Women in Science Experience (WISE) novel summer camp. Less common is research that addresses multiple intersections of marginalization, such as being young, female, and Latina and the effectiveness of such camps on disrupting these STEM positioned identities (Sparks et al., 2021).

The underrepresentation of Latinas in STEM cannot be disentangled with these students' identities and opportunities to develop the positive identities that they wish/dream for themselves. In the discussion that follows, we focus on the fluidity of identity (imagined and in-practice), and understand that "students construct multiple and overlapping identities as situated in and fostered by their school context" (Caraballo, 2019, p. 1284). As Caraballo focused on specific discourses associated with achievement, instead of generalizing the results of a minority population "to apply to most students from a particular ethnic or racial background" (2019, p. 1284), we, too, focus on the individual behaviors and perspectives of six Latina STEM fellowship students. We believe that we can learn from these participants to inform better instruction and STEM community development, but also recognize that these findings are specific to these students and their unique contexts and identities.

## **Theoretical Framework: Imagined and In-Practice Identities**

### **Imagined Identities**

Imagination and its impact on identity development, is a powerful educational resource to harness (Przymus, 2016). Wenger's (1998) parable of the two stonecutters wonderfully captures the essence of imagined identities. When asked about their work, one stonecutter replied, "I am cutting this stone in a perfectly square shape" and the other answered, "I am

building a cathedral” (p. 176). Applying this story to Latina high school students in a chemistry class, we might imagine one student answering, “I’m just completing a required lab assignment,” whereas the other responds, “I’m taking the first step in creating an antigen that will become a vaccine for coronavirus variants.” Clearly, just as the two stonecutters’ visions of their work differ, so does the imagination of the two Latina chemistry students. Przymus (2016), in researching how high school immigrant students are positioned negatively with discourses of deficit at schools, largely based on language proficiency, created a program for students to leverage their lived experiences and imagined identities to find acceptance and reposition themselves in a positive light at school. Przymus (2016) found that English language learners (ELLs) imagine themselves with diverse identities (soccer players, actors, dancers, artists, poets, etc.) and those who can experiment with these identities, within an existing community of practice with peers at school, are more engaged at school, have more diverse friend groups, and experience greater academic achievement:

A drive for affiliation in imagined communities can also provide students with a sense of direction, a raised level of commitment, and greater investment in their learning trajectories. As such educators have the opportunity to tap into students’ imagined identities and encourage ELLs to dream beyond their current status and imagine participation in school communities that align with their background knowledge and interests (Przymus, 2016, p. 267).

Latinas can experience much of the same identity positioning, both ascribed and avowed, when it comes to STEM related content classes where they do not see teachers who look like them, lack STEM role-models in their lives, or have never heard of nor studied famous Latinx scientists and mathematicians (Sparks et al., 2021). Furthermore, if their schools do not provide opportunities for STEM related communities of practice, tapping into STEM interests and nurturing Latina students’ imagined STEM identities may require in-practice, out-of-school STEM fellowship, that purposefully invites and supports young Latinas.

### **Identities-in-Practice**

Caraballo (2019) puts forth an identities-in-practice framework that highlights individuals’ agency as they negotiate identity construction within and across ascribed racial, ethnic, gender, etc. categories and group membership. According to Caraballo, “identities are forged from overlapping and intersecting subjectivities connected to social constructs such as



race and gender...and are shaped by the context in which they are constructed and negotiated” (2019, p. 1284). Ventura (2017) describes how “Latino youth and adult community allies constructed a space of belonging where youth shared their experiences and knowledge” and how this “constructed space differed greatly from the schools youth attended” (p. 23). Similar to the space constructed in Ventura’s study, the Latina STEM Fellowship (LSF) described within, brought youth together to interact with community allies, who were also Latinx STEM professionals, in a constructed space that differed from the participants’ schools. Herein, lies the potential for a LSF to counteract the negative discourses normalized within schools that do not purposefully address the needs of aspiring Latina STEM professionals. In supportive, created figured worlds (Holland et al., 1998), dedicated to providing these youth with Latina STEM role-models, concrete pathways to STEM careers, and imagined identities as STEM professionals, “discourses of achievement, defined as the normalized expectations of academic achievement, become more overt” (Caraballo, 2019, p. 1284). Within these kinds of spaces, camps, and communities, there is potential for Latinas to push back on discourses of deficit and to become STEM experts, co-creators of knowledge, and achievers.

We have taken the time and space to situate this study squarely within identification, as we believe the work of education is largely the work of identity (Wenger, 1998). In describing STEM identities, Mark (2018) states that STEM identities “intersect with and develop alongside existing gender, ethnic, racial, linguistic, socioeconomic, and other identities” (pp. 984-985). Rosa (2018) claims that “science was built with an image that reflects many of the traits linked with masculinities...as a result, it makes it easier for young men to identify with STEM than young women when we consider favorite subjects at school or career choices” (p. 1008). This means that to combat the persistent underrepresentation of women of color in STEM fields, purposeful educational interventions, such as the Latina STEM Fellowship (LSF), must be present.

In this article we consider the intersectionality of these students’ fluid identities (Sparks et al., 2019) and the power of imagination, yet couple this with the reality that these students battle persistent identity contingencies related to STEM content. We want to further the work on what schools and communities can do to leverage students’ imagined and fluid in-practice identities in order to address these STEM related contingencies. We look specifically at what impact STEM camps and fellowships, that specifically cater to students of color, can actually

have on these students' identity development and educational/life decisions. To focus our analysis on the effectiveness of the Latina STEM Fellowship, we utilized the following two research questions:

1. In what ways might participation in a Latina STEM Fellowship move youth from imagined to performed identities related to STEM careers?
2. In what ways have high school Latina STEM Fellowship participants taken steps toward these realized/actualized identities?

## **The Study**

### **Setting**

Within, we study a Latina STEM fellowship, just for high school girls, that provides opportunities for engagement with both culturally and linguistically similar peers and accomplished Latina STEM researchers, and addresses raising this group's critical mass, which has the potential to affirm participants' valued sense of self. The Latina STEM Fellowship (LSF) took place in the North Texas region of the American Southwest and was founded with the following mission statement: "To support young women interested in STEM through skill building, career exploration, education planning, and mentorship." Fellowship participation, across a two-week summer camp and continued monthly events/activities throughout the year, also provided ample opportunities for participants to develop a narrative about who they imagine themselves being and a concrete road map for the educational steps they need to take to achieve those identities. The LSF was conceptualized, implemented, taught, and directed by two Latina Biology professors with doctoral degrees. The idea of the fellowship was two-fold: 1) create a pipeline for secondary school Latinas through a college STEM program and to a STEM career and 2) create a support system for a group underrepresented in STEM fields.

The LSF was housed at a 2-year community college in the American Southwest beginning the summer of 2016. It began as a two-week summer camp for women ages 14-21 as required by the funding agency. Funding was provided through a public grant for the first two years. After its second year, the program supported 20 young women in grades eight through twelve. Funding after the second summer camp was provided through private grants. These grants allowed for year-round programming, which was a request by the young women in the program. During the fall and spring semesters, programs were held twice per month,

throughout the year. During both the summer camp and year-round program, learning opportunities allowed the students to: broaden their knowledge of STEM-related careers; gain real world perspective from accomplished female researchers (e.g. university biology professors, pediatricians, science education doctoral students, etc.); visit state-of-the-art research facilities; interact with STEM professionals; cultivate professional, peer, and near-peer mentor relationships; network with peers who are also interested in STEM fields; perform scientific techniques being utilized in STEM fields; navigate through the various stages of the college application process; improve writing skills for college applications and scholarships; explore undergraduate and graduate school opportunities; and visit universities with STEM programs. Several students had the opportunity to attend national conferences, including the National Diversity in STEM conference. Although not an intended outcome, several students had the opportunity to improve their presentation skills by participating as emcees for larger programs, which included community members outside of the LSF program. Two students had the opportunity to present at a national conference in California.

Parents were included in several programming activities including a bilingual leadership conference, hosted by a local organization, which provided information on: college preparation for both students and parents, financial aid, scholarships, leadership, culture-embracing, professional development, life skills, money management, and career guidance. Parents were also invited to community events hosted by the LSF such as, but not limited to, the *Women in STEM Symposium and Epigenetics* movie and discussion. The LSF programs specifically for parents included a *Financial Aid 101* session and a *What to Expect When You are Expecting...Your Daughter to Go to College* session which addressed the social and emotional aspects of the transition to college for parents.

## **Participants**

The research team, consisting of one College of Science and Engineering professor, two College of Education professors, and two doctoral students from three U.S. private and public universities, received IRB approval from Przymus' (Author 1) university. From a pool of 20 high school Latina participants of the 2018 LSF, the research team used convenience sampling to select the final set of students ( $N = 6$ ) for voluntary participation in the study, based on daily interaction and involvement at the two-week LSF summer camp and on camp counselor/facilitator recommendations. Table 1 details participants' names (all personal names

are pseudonyms), grade at time of the study, self-declared race, generation of college/university attendance within their families, ethnicity, bilingual ability, and career aspirations. All six participants were enrolled in different North Texas, public high schools, which ranged from one Latinx majority and economically disadvantaged school (Amada), to two middle-class, more racially-balanced schools (Natalia, Blanca), and three mostly White, upper-class high schools (Patricia, Etta, Estrella).

**Table 1**

*Study participants and personal characteristics*

<b>Students and Grade</b>	<b>Race and College Generation</b>	<b>Ethnicity (Self-Described)/ Bilingual Status</b>	<b>Career Aspiration</b>
Amada/10th	Other/2 <sup>nd</sup> Gen.	Mexican-American, Latina, and/or Hispanic/bilingual	Nurse Practitioner
Patricia/10th	White-having origin of Europe, Middle East, or North America/2 <sup>nd</sup> Gen.	Hispanic/not bilingual	Pediatrician
Blanca/10th	Mixed-Race/1 <sup>st</sup> Gen.	Hispanic/Latina/bilingual	Biologist
Estrella/11th	Mixed Race/2 <sup>nd</sup> Gen.	Hispanic/not bilingual	Aerospace engineer/astronomer
Natalia/10th	White-having origin of Europe, Middle East, or North America/2 <sup>nd</sup> Gen.	Hispanic/bilingual	Forensic Scientist
Etta/12th	American Indian or Alaska Native/2 <sup>nd</sup> Gen.	Latina/bilingual	Physical Therapist

*Note.* In Table 1, participants provided their grade level, self-declared race, generation of higher ed attendance, ethnicity, bilingual ability, and career aspirations that they identified during the semi-structured interviews.

## **Data Collection**

Three of the research team members (Sparks, Silveus, and Cartmill) conducted semi-structured interviews with the participants to measure the impact of the LSF on students' identity development and educational/career decisions. In order to create a naturalistic setting, the interviews were conducted at the two-week LSF summer camp site (Patton, 2014). Sample semi-structured interview questions included asking the participants to describe the extent of STEM-related opportunities/evolvment at their current high schools, their prior experience with Latina STEM teachers/role-models, their current and future educational/career aspirations, the people/activities/experiences that they most identified with and were influenced by during the two-week summer camp, and the importance of their gender/ethnicity/language. Participants were also given time to reflect upon their experiences with the LSF and what advice they would have for future campers/LSF participants. Due to the semi-structured nature of the interviews, all questions were asked across all participants, but at times the researchers allowed leeway for participants to go off script and share in greater depth about their families, past schooling experiences, and desires for the future.

## **Data Analysis**

During the year following the interviews, each research team member analyzed and first-level coded (Strauss & Corbin, 1998) interview transcripts individually and then met multiple times as a research team to compare, contrast, identify common themes among participants (Stake, 2006), and merge all members' data analysis into our reported results below. Coding was informed by the research questions regarding 1) in what ways might participation in a Latina STEM Fellowship move youth from imagined to performed identities related to STEM careers and 2) in what ways have high school Latina STEM Fellowship participants taken steps toward these realized/actualized identities? During cross-case analysis and multiple levels of coding, the following four common themes emerged across the participants' LSF experience:

1. Learning from women (mostly Latina) scientists provided participants with a concrete vision of an educational trajectory, coupled with a realistic and at times sobering understanding of challenges, consequences, hardships, etc. involved.

2. The LSF filled the gaps of knowledge/experiences left from the participants' high school opportunities (e.g. high schools lacked Latina teachers/STEM role-models, lacked STEM communities of practice, lacked accessible and relatable information about college and career preparation, such as cost, what courses to enroll in, where are good programs, and how to navigate the climate and culture of STEM programs where these Latinas will be a minority).
3. The LSF experience inspired and prompted participants to take concrete steps to start an educational/career path in STEM (e.g. registering for Advanced Placement (AP) physics in the fall, joining the University Interscholastic League (UIL) team for science and biology).
4. Participating with other Latina peers, professors, and scientists during the camp, who have similar cultural and linguistic experiences, raised participants' awareness to how they leverage their bilingualism as a resource.

In order to attempt to capture the imagined, in-practice, and performed identities of fellowship participants, we utilized a multimodal systemic functional linguistics (MSFL) approach (Przymus et al., 2020) that allowed us to document participants' choice of words, physical actions, stories of past interactions, desires for future action, perceptions of positionality, etc. and demonstrate how these semiotic resources align to create knowledge and develop identities. Where schools currently fail to recognize Latina students' imagined and possible STEM identities, MSFL has been specifically used in educational studies (see examples in following section) to teach educators to look beyond just the typical, in-practice, to the imagined and multimodal meaning-making moments of students' lives and experiences (which we link to the four themes above).

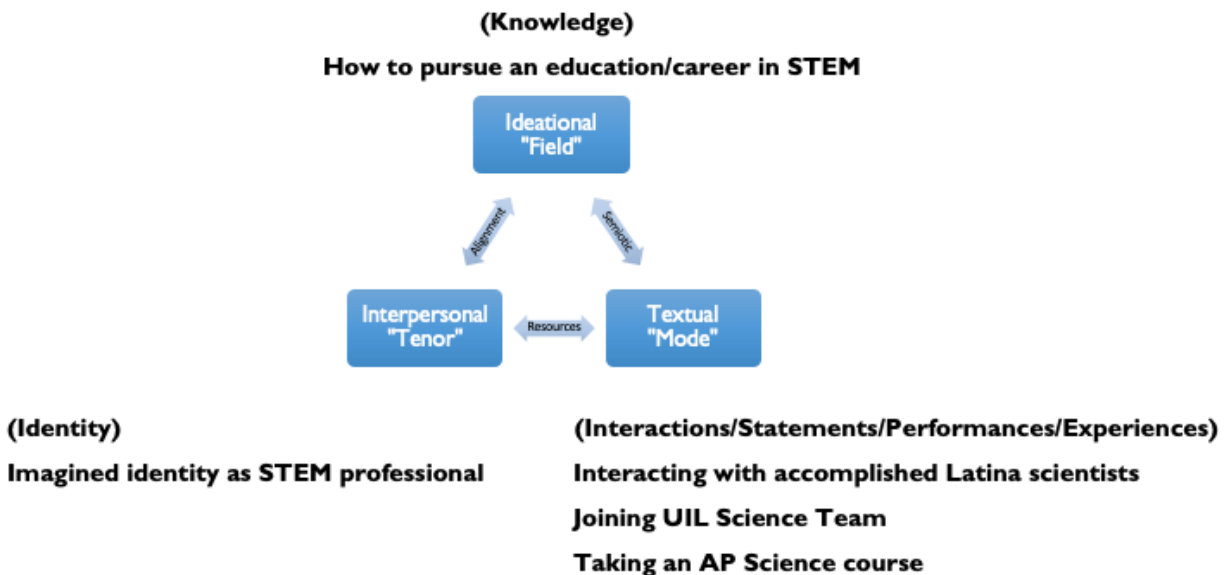
In order to paint a picture of the LSF's influence on these students, in the results below we provide a combined (all six participants) MSFL image that illustrates a sample of the multimodal alignment of these participants' collective semiotic resources. In the findings section, we link examples from this large combined MSFL image to the four themes and then narrow in on the experiences of one individual participant and provide a MSFL illustration of how she imagined, practiced, and performed her STEM identity.

### Demonstrating the Alignment of Semiotic Resources

There is a tradition in science of representing knowledge construction and learning through alignment of semiotic resources (Lemke, 2004) and some have utilized triadic models, similar to the multimodal systemic functional linguistics (MSFL) approach that we use here (Waldrip et al., 2010). With our analysis of the effectiveness of a Latina STEM Fellowship (LSF), we consider all semiotic elements (e.g., labs, field trips, guest speakers, etc.) to be meaning-making texts in social interactions. Other educational researchers have shared this recognition of multimodal texts as meaning-making elements (Kress, 2011: speech, writing, film; Martin, 2000: music, gestures, gaze, facial expressions; Fairclough, 2011: social events; Przymus et al., 2020: videogame play; Wilson, 2011: space, seating arrangements at school). Image 1 below shows our MSFL triad, demonstrating the alignment of semiotic resources.

#### Image 1

*Multimodal systemic functional linguistics alignment of semiotic resources (with examples)*



Although there is no real starting and ending point in using this model, for the purpose of explanation we start with the lower right-hand corner and the textual metafunction or the mode of interaction. We conducted a sentence level analysis of every sentence spoken by the participants during their individual interviews. Across these hundreds of sentences, we considered all that the participants said, experienced, performed (in relation to the LSF) as their mode of interaction in this STEM educational intervention. Linking this MSFL analysis to our theoretical framework, these modes of interaction are moments of in-practice-identity

development that both creates knowledge and possible imagined identities. Moving counterclockwise, these modes of interaction (textual metafunction) cause knowledge co-creation among participants/LSF facilitators, which we consider as part of the ideational metafunction or the field of knowledge. Finally, these modes of interaction, plus the co-created fields of knowledge, all influence participants' interpersonal metafunction/tenor or identity development. Again, making a connection to our theoretical framework, it is here in the interpersonal metafunction/tenor or identity development where we most concretely get insight into possibilities for self or imagined identities. These strengthened or newly formed imagined identities then influence, inform, and make possible, risk-taking and more moments/interactions/modes of in-practice-identity formation, starting the cycle all over again.

This MSFL approach provides a holistic understanding for meaning-making through multimodal textual interactions. Using the example above in Image 1, we can see how interacting with accomplished Latina scientists (e.g., university biology professor, pediatrician, engineer at Lockheed Martin, etc.) at the LSF, during a guest lecture, field trip, or lab experiment (textual), can lead to new knowledge regarding how one actually starts, perseveres through, and finishes a degree in STEM (ideational). These interactions (textual) and new knowledge (ideational) both influence new imagined identities (interpersonal) as future STEM professionals, which encourage new interactions (textual), such as joining a STEM UIL team or taking an AP science course—starting the cycle of aligning semiotic resources, all over again.

The usefulness of this kind of analysis is that it highlights the potential impact of the textual metafunction or mode of interaction. If educators (both school and program based) want to co-create new knowledge with their students and want to nurture positive STEM identities within their students, these educators can focus on the kinds or modes of interaction (textual metafunction) present and adapt these or introduce new ones that may produce the desired knowledge and identity development. Using systemic functional linguistics in this way differs from traditional work with systemic functional linguistics (Eggins, 2004), but we believe that this “multimodal representation of how diverse semiotic elements are aligned” (Przymus et al., 2020, p. 2) is effective for measuring the impact of the LSF; as it is a way to, as Pennycook (2017) writes, “analyse all that is happening in any one moment or place: *moment analysis*” (p. 270).



## Findings

Below, we share a large MSFL image that combines the alignment of example semiotic resources from all six participants. This 10,000-foot view of the participants' experiences related to the LSF gives an overview of the fellowship's impact on moving these participants from imagined STEM experts to in-practice, performing, and future STEM professionals. Each entry on the image begins with the first two letters of the participant's name, followed by the page number where the data point is found on their transcribed interview, and corresponding line on that page.

In order to visually link specific data in the image to corresponding themes of analysis, we have bolded entries/examples of theme 1: **impact of learning from and interacting with Latina scientists on vision of educational trajectory**; we have italicized entries/examples of theme 2: *LSF filling gaps of knowledge/experience left from lack of these provided by high schools*; we have capitalized entries/examples of theme 3: CONCRETE STEPS/ACTIONS TAKEN BY LSF PARTICIPANTS TOWARD EDUCATIONAL/CAREER PATHS IN STEM; and finally we have underlined entries/examples of theme 4: participation in the LSF has risen participants' awareness of how they can leverage their bilingualism as a resource. Direct participant quotes are treated as "modes of interacting" and thus are relayed in the mode (textual metafunction) corner of the image. Many of the multimodal interactions (textual) and their resulting knowledge (ideational) and identity (interpersonal) creation fall across multiple themes and are thus represented accordingly.

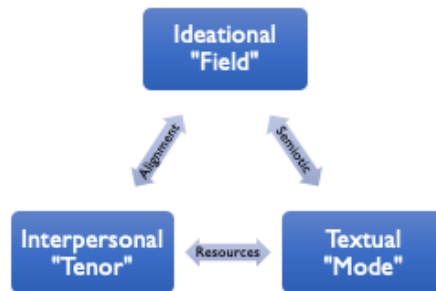
Looking at this extensive, but by no means exhaustive, list of social interactions and their meaning-making impact associated with the LSF, we can draw attention to some overlap across participants and contextualize these across the four themes.

## Image 2

### Participants' alignment of semiotic resources

(Knowledge)

Es, 3.6: Has gained new knowledge of how to pursue education & career in astronomy  
ES, 3.12: WILL HAVE ADVANCED SCIENCE COURSE DURING UPCOMING SEMESTER  
**Es, 5.5: Now has studied about and studied with distinguished Latina STEM professionals**  
**ES, 10.5: KNOWS THAT THERE ARE FEWER WOMEN ASTRONOMERS-THIS IS MOTIVATION**  
BL, 1.16: NOW HAS ACCESS TO EXTRACURRICULAR SCIENCE PROGRAMING  
BL, 6.1-5: Has bilingual ability and understands that bilingualism is a resource  
**BL, 9.6: INSPIRATION FROM GUEST SPEAKER, CONCRETE VISION/EXAMPLE OF LEADER**  
Na, 3.2: Concrete example of crime scene investigation (forensics) from LSF camp  
Na, 6.6-10: Shared bilingual skills with family members (dad, sisters) and believes this to be a resource  
**NA, 9.1-14: EXPANDED UNDERSTANDING OF OPPORTUNITIES, INCREASED KNOWLEDGE ABOUT ENGINEERING & BIOCHEMISTRY**  
Am, 6.4: Bilingualism as a resource to help others  
**Am, 7.9: New hope/vision/future trajectories**  
AM, 11.11-18: NEW AGENCY FOR ACHIEVING CAREER-RELATED GOALS  
PA, 3.1-5: HAS KNOWLEDGE OF THE MCAT, HAS NEW KNOWLEDGE OF RICE UNIVERSITY  
Et, 3.13: LSF's "university research project" gave her new knowledge; changed her educational trajectory  
Et, 9.12: Understands/realizes the advantages & strengths of being bilingual...that it got her a job at fitness center  
ET, 21.8: GAINED UNDERSTANDING OF COLLEGE CREDIT TRANSFER PROCESS  
Et, 22.10: Gained new vision of possible STEM related careers (e.g. engineering from Lockheed Martin field trip)



(Identity)

Es, 3.6: Critic of public school, future physicist/astronomer  
ES, 3.12: IMAGINED ADVANCED SCIENCE STUDENT  
**Es, 5.5: New imagined identity as STEM professional**  
**ES, 10.5: MOTIVATED TO BE TRAIL BLAZER FOR WOMEN IN ASTRONOMY**  
BL, 1.16: UIL SCIENCE MEMBER/EXPERT  
BL, 6.1-5: Skillful bilingual, able to talk to & help others  
**BL, 9.6: FUTURE LEADER**  
Na, 3.2: Imagined identity as crime scene investigator  
Na, 6.6-10: helpful bilingual (superhero).  
**NA, 9.1-9.14: IMAGINED IDENTITY AS PH.D./EXPERT, FUTURE LEADER, GRATEFUL**  
Am, 6.4: Proud bilingual  
**Am, 7.9: Hopeful, motivated, encouraged**  
AM, 11.11-18: CONFIDENT, RISK-TAKER  
PA, 3.1-5: IMAGINED IDENTITY - FUTURE MEDICAL STUDENT AT RICE  
Et, 3.13: Views self as college ready/deserving  
Et, 9.12: Proud bilingual, bilingual fitness center employee  
Et, 22.10: Imagined identity as engineer

(Interactions/Statements/Performances/Experiences)

Es, 3.6: "Don't really get exposure to specific careers in public schools. This program helps me like find specific careers. I'm interested in a lot of the math part of astronomy, like physics and stuff."  
ES, 3.12: SIGNED-UP FOR AP PHYSICS  
**Es, 5.5: No previous Latinx STEM role-models**  
**ES, 10.5: RESEARCHED WOMEN IN ASTRONOMY**  
BL, 1.16: JOINED UIL BIOLOGY TEAM  
BL, 6.1-5: States that bilingualism is an advantage for  
\*connecting to culture (roots)  
\*communicating with family  
\*communicating with/helping others  
**BL, 9.6: IN REFERRING TO A DISTINGUISHED LATINA SCIENTIST GUEST SPEAKER AT CAMP, "I WILL HELP OTHERS BY A BEING A LEADER LIKE HER."**  
Na, 3.2: Excited by LSF camp forensics activity  
Na, 6.6-10: Recognizes bilingualism as an advantage  
**NA, 9.1-14: "I DIDN'T THINK ABOUT GETTING A PH.D., PRIOR TO CAMP, BUT NOW I'M DEFINITELY LOOKING INTO IT"**  
Am, 6.4: "I use my bilingualism to stand up and help people out."  
**Am, 7.9: Encouraged by stories from women mentors at LSF camp**  
AM, 11.11-18: MAKES REQUEST TO VISIT HOSPITALS & CADAVAR LABS  
PA, 3.1-5: TALKED TO COUSIN ABOUT TAKING THE MCAT, RESEARCHED AND TOURED RICE UNIVERSITY  
Et, 3.13: Learned from "university research project" at camp  
Et, 9.12-10.5: "I'm bilingual. It's an advantage, of course...I am only teen hired at health fitness center."  
ET, 21.8: ASKED FOR COLLEGE CREDIT TRANSFER DETAILS FROM CAMP PERSONNEL  
Et, 22.10: Participated in year-round LSF activities (field trips, internship presentations, etc.)

**Theme 1. Learning from women (mostly Latina) scientists provided participants with a concrete vision of an educational trajectory, coupled with a realistic and at times sobering understanding of challenges, consequences, hardships, etc. involved.** Examples from this theme (all **bolded** above) can be found from most participants in the image. Even if not represented in the limited space of the large image above, all participants claimed to have gained inspiration, motivation, and a concrete vision of how to achieve an education and degree in STEM, as Latinas. This influence was at times both complex and nuanced, such as when Patricia acknowledged that learning about and learning from accomplished Latina scientists was encouraging, but also scary, as she and others learned about having to sometimes move away from family to attend school, and about the anxiety related to the cost of education. Patricia also learned from a Latina guest speaker about being in male dominated fields, “She said she had to grow a tough skin to deal with like everybody coming at her...which makes me nervous. I’m scared like what if I’m not gonna handle it enough.” The major takeaway, from this theme, however, seemed to be one of solidarity. Interacting with other Latina peers and with Latinas with Ph.Ds., gave these participants a sense of pride and strength as Latinas—something they did not get from their high school experience.

*Theme 2. The LSF filled the gaps of knowledge/experiences left from the participants’ high school opportunities/experiences/teachers/role-models, etc.* All six participants relayed examples from this theme and Image 2 provides specific examples from several participants (*italicized in the Image 2 above*). Most of these examples addressed learning about new STEM related content or career opportunities that they were not exposed to at their high schools. Etta reflected, “Sadly, our school doesn’t have any STEM clubs.” For Etta, the LSF was her first experience in such a community of practice, and where she learned practical things that she did not learn from her school, such as how to transfer college credits to another university. A lot of examples from this theme overlapped with the first theme of interacting with other Latinas, such as learning about how to navigate the climate and culture of future higher education STEM programs, where they are likely to be a minority. These lessons led some of the participants to take concrete steps toward starting an educational and career pathway in STEM.

**THEME 3. THE LSF EXPERIENCE INSPIRED AND PROMPTED PARTICIPANTS TO TAKE CONCRETE STEPS TO START AN EDUCATIONAL/CAREER PATH IN STEM.** Examples from this theme (**ALL CAPS IN IMAGE 2**) give us the most direct insight into how

this LSF moved participants from imagined to performed identities in STEM. Estrella took it upon her own initiative to research women in astronomy and then registered in Advanced Placement (AP) Physics for the following semester. Blanca joined the University Interscholastic League (UIL) biology team and projected an identity as a future LSF mentor, giving advice to future participants. Another participant, Patricia, took a tour of Rice university, has started helping out the sports trainers at her school, and has actually started preparing for the Medical College Admission Test (MCAT). Through these examples we get a better understanding of how interacting with other Latinas, in a fellowship that specifically lifts this population of students up, strengthens their imagined identities as future STEM professionals—a powerful experience that has begun to lead to concrete educational and life decisions toward these students' goals.

Theme 4. Participating with other Latina peers, professors, and scientists during the camp, who have similar cultural and linguistic experiences, raised participants' awareness to how they leverage their bilingualism as a resource. Theme 4 examples, although fewer in number in relation to the other themes, were strongly consistent across participants' perspectives. The consistent message that these students took away from their LSF experience is that their bilingualism is a resource. Keeping in line with current bilingual education research definitions of bilingualism as, “developing language proficiency in two (or more) languages” (Przymus et al., 2021, p. 40), we documented moments when participants shared meaningful, quotidian bilingualism. They shared experiences of stepping in, interpreting, and helping others with their Spanish/English bilingualism. Etta specifically shared that she believes it was her bilingual ability that helped her get her health fitness center job. Finally, participants included their bilingualism as a characteristic/skill that sets them apart, gives them a super(she)ro power, and a strength/resiliency that they will leverage upon entering STEM higher education programs and careers.

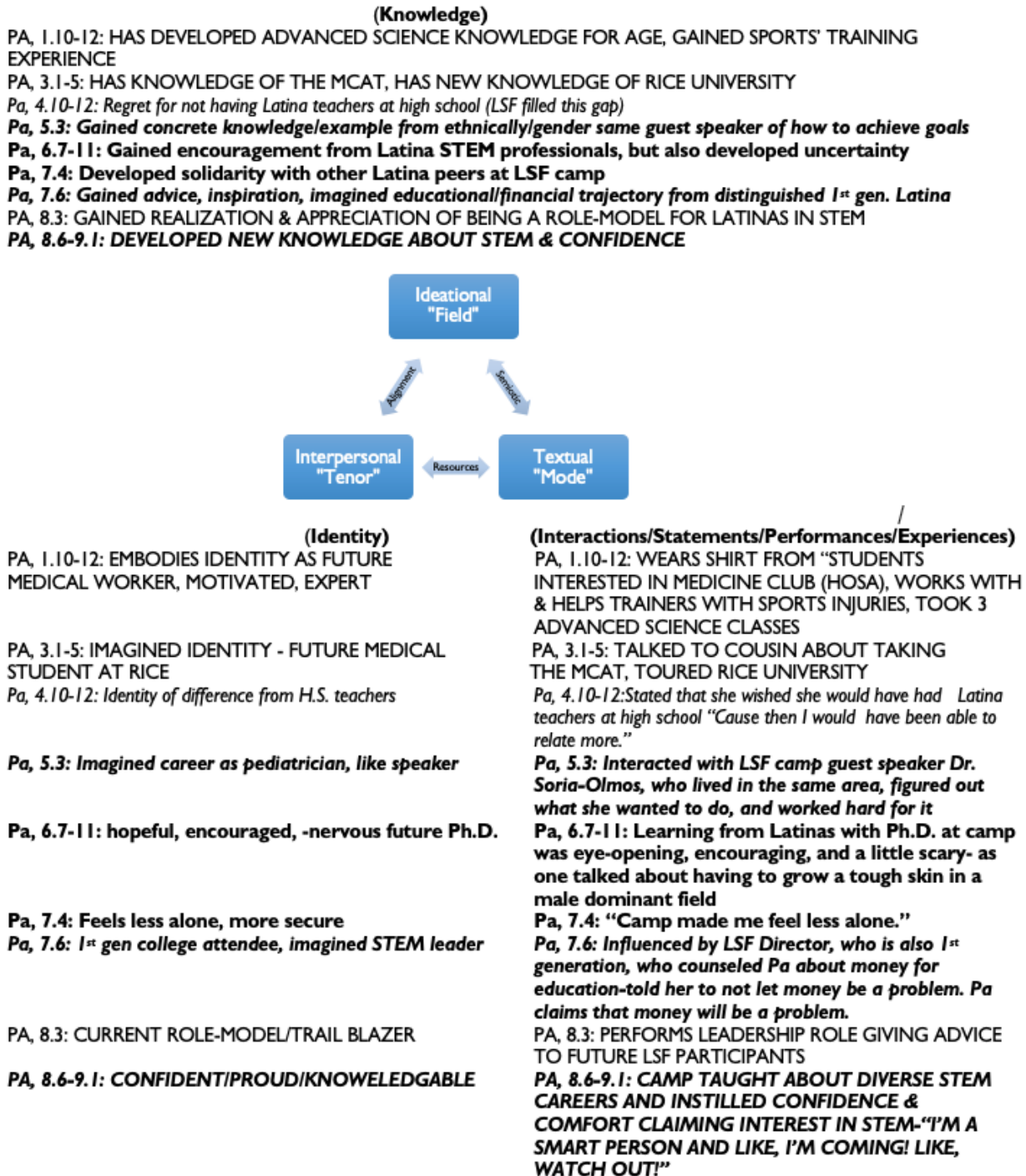
### **Bringing it all Together: A MSFL Case Study of Patricia**

Out of all of the LSF participants, Patricia really seemed to understand this opportunity and leveraged it as a spring board to an education and career in STEM. Below we share one more MSFL image to illustrate the specific impact of the LSF on the alignment of Patricia's semiotic resources and how this moved Patricia's imagined STEM identity to a performing STEM identity. As an example, we see that Patricia interacted at the LSF with guest speaker Dr.

Soria-Olmos (interaction), which gave her knowledge for how to achieve career-specific goals (knowledge), and resulted in her imagined career as a pediatrician (identity). This imagined identity will start the cycle again by prompting a new interaction.

### Image 3

#### Patricia's alignment of semiotic resources



We can clearly see that through Patricia's statements about and the interactions/experiences that she had within the LSF, she was able to co-construct new knowledge that led to a new, confident, STEM identity. The impact of the LSF on Patricia's imagined to performed identity can best be summed up with her own advice to future LSF participants (relayed in all caps here, as it is a concrete action as her performed identity):

DON'T LET IT SCARE YOU...IT'S HARD...AND IT'S GONNA FEEL LIKE YOU'RE LONELY SOMETIMES, BUT YOU GOTTA REALIZE THAT THERE'S OTHER WOMEN OUT THERE, THAT YOU ARE DOING THIS FOR THEM...I COULD LIKE MAKE A PATH FOR YOU AND BLAZE THAT TRAIL.

### **Voices of Moving from Imagined to Performed STEM Identities**

The above examination of identity work is temporally located at the time of these students' participation in the LSF. However, each participant provided insight into future actions, prompted by participation in the LSF, that they plan to take to continue to perform their STEM identities. Their voices (examples shared below) echo the themes of learning from Latina scientists to gain a realistic understanding of educational and career trajectories (Theme 1), seeking new experiences to fill the gaps of knowledge, left by their high school STEM experience (Theme 2), leveraging the LSF experiences for knowing about and finding new STEM-related experiences (Theme 3), and relying on their intersectional and overlapping identities, derived from their race, class, gender, ethnicity, and language (Theme 4).

Etta shared her appreciation for a guest Latina scientist from Colombia and how much she related to and learned from her. "I think I just related to her in a sense too. Like she came over here and she want to go big...she's already something, you know, up here and big and huge and she want to go beyond that...that's part of our culture." Combining the first, second, and third themes, Etta shared how the LSF director (a Latina biology professor) encouraged her to apply to university, try for internships, and gave her information that her high school had not. "Here you will learn, you know, many things that your counselors won't tell you in high school...It's time for us to stand out and go to school... Dr. Garcia (Author 3) gave me advice about admissions and it's just the small things you didn't know about that help you." Etta ended her interview stating that this coming year, she was going to act on internship opportunities, "Oh, this seems so cool, like...they were talking about um, internships with them and I was like, Wow. I didn't even know I had that opportunity."

Estrella offered that the LSF “was the first time I’ve actually started looking at colleges...I’m trying to figure out for myself how to get through this path because I personally don’t have someone to like look off of in my personal life.” Estrella, who shared that “my mom is full Latina, and my dad is just White,” really leaned on her gender identity in this Latina-centered STEM figured world, claiming, “If I get somewhere in life and I do accomplishments, I think I would be more recognized as um being like the first female to do something rather than the first Latina.” Finally, demonstrating a vision for moving from an imagined to a concrete/performed identity in a STEM field, Estrella stated “Being a Latina in a STEM field, I know there aren’t a lot of people doing it, but in my head I know I have this strength and the knowledge to get me there. So, with education I can find opportunities for myself. I’m gonna keep pushing myself to find something.”

### **Discussion & Implications**

In educational contexts where inclusive STEM schools (Saw, 2019), meant to address the needs of traditionally underrepresented students, do not exist, educators must be innovative and purposeful in creating identity-based opportunities for these students. In multimodally documenting and analyzing the LSF participants’ semiotic resources, the findings in our study build upon existing research on the impact of extra-curricular STEM programs on young girls’ achievement in school and decisions to choose STEM careers. The existence of other Latina peers interested in STEM at the fellowship provided participants with influential socializers and a new community of practice. Importantly, the STEM fellowship placed these participants in front of Latina STEM professionals, providing the teacher/role-model support that these youth lacked at their high schools. Marsh et al. (2019) claim that “Teacher support may not only be an important factor for students but also be a buffer against negative stereotypes” (p. 1635). They also report that “women who enrolled in STEM university courses reflected that previous learning experiences were critical to their decision to enter into STEM, alongside with role-models in the field and parental support” (2019, pp. 1635-1636). Caldwell et al. (2018) refer to these as pathway programs that seek to seal the leaks in the STEM educational pipeline. Although our analysis of the LSF does not address the lack of early – learner STEM pipeline programs for elementary school children identified by these researchers,

our findings do contribute to Caldwell et al.'s call for more research for understanding the needs of underrepresented groups' achieving success in STEM.

Fancsali (2002) summarizes the related literature on the needs of women in the STEM pipeline, demonstrating "that mentors, role models, and networks are important from the early grades and throughout a woman's career in the sciences" (p. 2). In highlighting the work of Campbell and Steinbrueck (1996) and Ferreira (2001), Fancsali outlines that "Programs for girls combining hands-on activities, role models, mentoring, internships, and career exploration have improved girls' self-confidence and interest in STEM courses and careers and helped reduce sexist attitudes about STEM" (p. 2). Other researchers have similarly, highlighted the need for facilitating opportunities for academic engagement with dedicated adults and other students, concerned about issues of class, race, and gender, through exploration of leadership and creativity (Sparks et al., 2021). Hansen et al. (1995) also point to the support that can arise from contexts of single-sex grouping.

The LSF, a single-sex, Latina-focused out-of-school program, provided for a rich research context to put the above attributes of supportive/successful STEM projects to the test. The LSF became the figured world, where these students' intersectional identities (at times gender, other times ethnicity, and/or language) could act as contextual mitigating factors to being positioned as others in STEM courses or the imagining of having STEM careers. The hands-on activities, Latina Ph.D. mentors, career and college exploration sessions, phenotypic and gender similar participants, etc. present in the LSF all confirm that these aspects of gender-equity focused STEM projects are important and needed. As evidence of the positive influence of the LSF, some of the former participants still keep in contact with LSF directors and instructors. Patricia, who's MSFL image is highlighted above is a current university student and as of the writing of this manuscript was helping at the 2021 LSF summer camp, as a near peer.

The most concrete way to measure the impact of the LSF is to look at what participants imagined for themselves during the camp and to cross-reference this with what they are actually doing now. Patricia is well on her way to achieving her goals and imagined identity in STEM. In fact, Patricia is currently involved with a COVID 19 study at her university and her mom, influenced by the *What to expect when you are expecting... Your Daughter to Go to College* session at the LSF, has started a Facebook group in Spanish for other moms of Latinas at Patricia's university.



## **Conclusion**

Research conducted on what marginalized and underrepresented students in science need to be successful, consistently points to the nurturing of students' positive identity with science (Jackson & Seiler, 2018). Jackson and Seiler point to the research claiming that "this identity work can be supported by the creation of spaces where students can draw on resources from a variety of aspects of their life rather than just the standard resources readily available in a traditional science classroom" (2017, p. 763). In this kind of supportive contextualized space, the intersectionality of identities of the Latina students were reclaimed to address multiple intersections of marginalization, outside of the LSF. This created a supportive figured world within the LSF that created the possibility to imagine and to start to take steps toward performed STEM identities, beyond the LSF.

In revisiting the research questions regarding how a LSF might move young Latinas from an imagined identity to a performed STEM identity and in what ways have the LSF participants taken concrete steps along this trajectory, we observed that within the LSF space, participants studied about and interacted with accomplished Latina scientists. We see how this both inspired the participants and provided them with exemplars that shared realistic educational trajectories to STEM careers. The participants noted that the LSF filled the gaps of STEM knowledge and experiences, not provided by their high schools and that many took advantage of these new found opportunities to take concrete steps to achieving their goals. Finally, these Latina high school students became aware of how they leverage their bilingualism as a resource; a super(she)ro power that allowed them to help others.

Clearly these young Latinas had imagined identities of being a STEM professional when answering the question of what they wanted to be when they grow up. Their voices above point to their gratefulness to have had the opportunity to develop those identities in-practice and to begin to perform them through the LSF. We wish for this same identity trajectory for other young Latinas, who are answering this ubiquitous childhood question with a STEM dream.

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