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Breaking Stereotypes: How Undergraduates' Life Experiences of Scientists Shape their Scopes of Possibility

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ABSTRACT

Building on decades of scholarship critiquing scientist representation in classrooms and textbooks, the present study characterizes the lifetime experiences of undergraduate students regarding their perceptions of scientists and science identity. Informed by the theoretical framework of Cultural Learning Pathways (CLP), we conducted 31 semistructured interviews with undergraduates who completed six Scientist Spotlights (scientistspotlights.org), which are inclusive curricular supplements that feature counterstereotypical scientists. Despite decades of progress in curricular representation, our results revealed almost all students (94%, *n* = 29) recounted exposure to predominantly (if not exclusively) stereotypical scientists across social institutions (e.g., media, K12, universities, healthcare environments) throughout their lifetime, which *limited* their Scopes of Possibility to pursue science. All students (100%, *n* = 31) reported that Scientist Spotlights *enhanced* Scopes of Possibility for themselves and others from marginalized backgrounds to pursue science. Last, almost all students (97%, *n* = 30) shared characteristics they hoped to see when *imagining* Scopes of Possibility, emphasizing the need for a concerted effort to increase representation of counterstereotypical scientists across science curriculum and social institutions more broadly.

INTRODUCTION

We are socialized to associate certain images and characteristics with scientists, which may or may not align with how we see ourselves. A science teacher describes the journey of the *HMS Beagle*, extracting life from the South American coast to bring back to England for classification. Another Hollywood sequel shows a character holding test tubes and speaking scientific jargon in front of a computer screen. Children draw old White men in lab coats with disheveled hair and glasses. These stereotypes can have lasting negative ramifications on whether one views themself as a "science person" if these images differ from one's social identities (ethnicity, gender, sexual orientation, etc.), ultimately curtailing the pursuit of becoming a scientist. Scholars and practitioners working to increase the representation of students from marginalized backgrounds in science, technology, engineering, and mathematics (STEM) have spent decades studying the mismatch between self-image and the prototype of scientists to improve student persistence and success in STEM fields (Mead and Metraux, 1957; Chambers, 1983; Cheryan *et al.*, 2009, 2013; Steinke *et al.* 2009; McPherson *et al.*, 2018; Ferguson and Lezotte, 2020). However, our capacity to address the attrition rates among talented and capable STEM students from underserved student cohorts remains a persistent challenge due to inequitable science classroom experiences and difficulty in cultivating a science identity and sense of belonging in STEM (Seymour & Hunter, 2019).

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An intervention in STEM that has gained traction for nearly a decade to address some of these issues are Scientist Spotlight assignments (www.scientistspotlights.com), which teach course content through the stories of counterstereotypical scientists, including disabled, low-income or working-class backgrounds, people excluded due to race or ethnicity, and LGBTQIA+ scientists. Students engage in these assignments by reading a summary about the scientist next to the scientist's photo, exploring links related to the scientist's biography and research, then responding to reflection questions about the material covered, including, *"What do these resources tell you about the types of people that do science?"* Designed from education research by a community college professor (Schinske *et al.*, 2015; Schinske *et al.*, 2016), Scientist Spotlight assignments have corresponded to significant shifts in a variety of measures related to science identity. First, how college students described the types of people that do science significantly shifted from stereotypical language (White, male, elite) to more counterstereotypical language ("all types of people") following the Scientist Spotlights intervention. Second, students who received the Scientist Spotlight assignments had earned, on average, a course grade level higher than a comparison group who learned about the scientists but did not engage in written reflection (Schinske *et al.*, 2016). Last, Schinske and colleagues measured undergraduate students' relatability to scientists as a proxy for examining students' science identity. A similar study used the Performance/Competence Interest and Recognition (PCIR) instrument (Godwin, 2016) to directly measure shifts in aspects of science identity based on Scientist Spotlight interventions in secondary schools (Ovid *et al.*, 2023). Both studies found that these assignments enhanced aspects of students' science identity and relatability to science, attesting to the power of these assignments in shaping students' ideas of who does science.

Based on the above findings, there is growing interest to challenge long-standing scientist stereotypes by teaching about counterstereotypical scientists with characteristic(s) that differ from the stereotype (Ovid *et al.*, 2024). But while exposure to counterstereotypical scientists seems to shift students' perceptions of scientist stereotypes and science identity (Schinske *et al.*, 2016; Jarreau *et al.*, 2019; Gürkan and Echazarreta-Soler, 2023; Ovid *et al.*, 2023), there is a gap in systematically characterizing if and how undergraduate science students have experienced such exposure across social contexts and over the course of their lifetime (e.g., homelife, media, K12 schools, universities, healthcare settings). Further, if students do recall learning about counterstereotypical scientists before and during college years, do students perceive these experiences as shaping their views on who can/not become a scientist? How does this shift when exposed to counterstereotypical scientists through assignments like Scientist Spotlights?

To characterize undergraduate students' lifetime exposure to stereotypical and counterstereotypical scientists, and how this exposure may have shaped their science identity, we conducted an interview study that centers the voices of college students to assess social, cultural, and material experiences across different learning contexts over time. In the next section, we address the construct of science identity in relation to the internal and external factors that shape it.

The Internal and External Factors of Science Identity

Science identity is the extent to which someone identifies themselves as a scientist or as someone deeply involved in science. Identity plays a role in shaping students' immediate engagement with science and their perception of science as personally relevant (e.g., Basu and Calabrese Barton, 2007; Schreiner and Sjoberg, 2007; Calabrese Barton and Tan, 2010). Simpson and Bouhafa (2020) performed a systematic literature review and characterized internal factors (our perception of ourselves) and external factors (institutions and societal norms) that positively or negatively shape science identity). Internal and external factors are intertwined, and together, can enhance or impede science identity. Internal factors include phenomena such as how science identity can be affected by self-doubt (Ibourk *et al.*, 2022), imposter syndrome (Chakraverty, 2024), and self-efficacy (Flowers III and Banda, 2016). Social institutions—such as society, schools, doctors' offices, university settings, and other environmental settings—are influential external factors of science identity (Taconis and Kessels, 2009; Archer *et al.*, 2010; Aschbacher *et al.*, 2010; Bøe *et al.*, 2011; Le *et al.*, 2019). Other external factors that shape science identity can include "influential others" such as family, friends, peers, and teachers (Vincent-Ruz and Shunn, 2018). Such actors may "enact consciously or unconsciously oppressive behaviors," which discourage students from marginalized groups from pursuing science. Discouragement from an influential other could then lead a student to internalize that they are not a science person (Vincent-Ruz and Shunn, 2018). Our ideas about the types of people that do science—and whether students aspire or avoid becoming a scientist—can also be largely influenced by external factors such as scientist stereotypes (Schinske *et al.*, 2016) that shape students' internal mediation of whether they belong in science.

Scientist Stereotypes - Preventable or Inevitable?

"Draw a scientist." Thousands of students over decades have received this prompt, and the unchanging pattern reveals students drawing the stereotype—an elderly White man working inside a lab (Chambers, 1983; Ferguson and Lezotte, 2020). The commonly cited sources that reinforce these scientist stereotypes include but are not limited to textbooks and media (Suldovsky *et al.*, 2019, Wood *et al.*, 2020; Chacón-Díaz, 2022; Corsbie-Massay and Wheatly, 2022), but these are just a sliver of the countless ways students could be exposed to scientists. One may wonder whether students actually encounter more counterstereotypical scientists than what such studies would suggest. Do university students today still perceive these stereotypes as dominating their social experiences before and during college? To explore these inquiries, this study was informed by the theoretical framework Cultural Learning Pathways.

Shaping Science Identity and Confronting Scientist Stereotypes Through Cultural Learning Pathways (CLP)

Our environment, culture, access to resources and power, and experiences across contexts and time shape how we view ourselves and others. Heavily influenced by Ole Dreier's Theory of Persons (Bell *et al.*, 2012), the theory of CLP is based on critical psychology and analyzes the way in which individuals

are limited or supported in their engagements and identity development within the various contexts they find themselves across time (Dreier, 2009; Bell *et al.*, 2012). Through longitudinal ethnographic case-studies and with a specific focus on K12 settings, scholars have used CLP to answer a range of questions related to students' engagement with science. For example, CLP assessed the impacts of transdisciplinary STEM programs on individual learning and identity shifts across time (Rhinehart and Bell, 2023) as well as the value of informal cultural knowledge for increasing STEM participation for students from underserved backgrounds (Haden *et al.*, 2023). To our knowledge, CLP has not yet been applied for interpreting STEM undergraduate students' perceptions of science and scientists given their identities, backgrounds, and lifetime experiences. Thus, CLP offers a holistic approach to understanding how experiences over time and across contexts shape students' perceptions of what is possible for themselves and others in relation to science.

Below, we outline overarching aspects of the CLP framework that underpin the design of the present study: Social Institutions and Society and Scopes of Possibility. These two constructs can be used to construct meaning through qualitative inquiry and support the interpretation of how Social Institutions and Society shape students' Scopes of Possibility for themselves and others across time and contexts in relation to identity, science, and scientists. We further examine this interconnection below.

Social Institutions and Society. Social institutions, societal norms, and values influence how individuals move through social environments and settings as they engage in everyday activities (Bell *et al.*, 2012). Social institutions are formal places such as schools and other community locations (churches, hospitals, etc.). They also include informal settings like home life, online platforms, and media content such as the news. Depending on cultural values and social norms, learners must constantly adjust their skills, interests, and sense of identity to suit the varied environments they encounter. Thus, these settings and the people therein influence and potentially limit how an individual behaves and develops their identity. In the original CLP framework, such institutions, norms, and values are triangulated as manifestations of Places, Positions, and Actions:

> "**Places** are also unique in that group, organizational, and institutional activities often shape very specific social expectations for participation and learning. In this way, the institutional constraints of places [Dreier, 2009] have the power to invite or prohibit opportunities for action [Lefebvre, 1991], and therefore the power to **position** actors within places as having certain rights and duties. Schools often focus learning experiences on shared educational goals for all students. Parents often try to cultivate particular forms of social engagement for their children. Informal educational institutions have structural constraints that shape patterns of social **activity** within those locations." (Bell *et al.*, 2012, p. 276) [bold added for emphasis]

Given every single event has layers of Places, Positions, and Actions, our interview questions probed for these aspects of lived experiences related to students' exposure to scientists (see *Materials and Methods*). We encapsulate these ideas through the term "Social Institutions and Society" as aspects that can mediate students' exposure (or lack thereof) to scientists.

Scopes of Possibility. Another component of CLP is Scopes of Possibility defined as what individuals perceive is possible for themselves and others (Bell *et al.*, 2012). For the purposes of our study, Scopes of Possibility are related to the "kinds of persons" they view themselves and others to be.[1] Individuals must navigate and negotiate multiple identities associated with their life experiences within social contexts. These identities may intersect or conflict, posing challenges to the learning process. For example, if a student from a marginalized background feels they do not belong in science, which is (re)produced by the types of messaging in society, school settings, or home life, their perception of being a "science person" may be diminished. This is particularly salient for fields in STEM, where specific materials are often used in designated places that hold political and social significance (e.g., images and stories in science textbooks, posters of White environmental scientists on the wall of a classroom, photos on a university that tokenize a Black student scientist as falsely representing the university's inclusive and diverse student population). These places where STEM activities occur are not neutral—they are imbued with cultural, historical, and social meanings (Rodman, 1992).

Research Questions

Informed by the CLP framework, we investigated students' perceptions of Social Institutions and Society, focusing on STEM environments and interactions throughout the lifetime of undergraduate students. To characterize events that students perceived as reinforcing or diminishing their identities and learning, and how inclusive curricula (i.e., Scientist Spotlights) could impact Scopes of Possibility, we investigated the following research questions (RQs):

RQ1: In what ways do undergraduate students' life experiences with science impact their perceptions of themselves and others as scientists?
RQ2: How do inclusive curricula influence undergraduate students' Scopes of Possibility?

MATERIALS AND METHODS

Given the central theme of identity in the scope of the present study, below we share considerations to our positionalities and how this informed the study design, interview protocol, and qualitative methodologies.

Authors' Positionalities

As a collective of individuals from diverse backgrounds, we stand at the intersection of various social identities, each contributing unique perspectives and experiences to our shared understanding of this project. Our author group comprises

[1]We make the distinction between Scopes of Possibility and Possible Selves literature (Markus and Nurius, 1986) in that the former includes not only how students view what is possible for themselves, but also others.

individuals from marginalized communities, including but not limited to People of Color, LGBTQIA+ members, persons with learning disabilities, immigrants, first-generation college-going, and those from low-income backgrounds, as well as dominant identities such as educated, continuing generation, and White people. We recognize the inherent power dynamics embedded within these identities and acknowledge the privileges and disadvantages they afford us in different contexts. Through our collective experiences of navigating societal structures of oppression and discrimination, all aspects of this project have been informed by the authors' lived experiences.

Internal Review Board Approval

This project was approved by University of California, Davis's Internal Review Board under exempt status (Protocol #1825759-2).

Interviews

Participant Population. Participants were recruited from two physiology courses at a research university on the west coast of the United States. Course 1 was for majors, and Course 2 was for non-majors. Each course received six Scientist Spotlights as graded assignments, used to teach course content. To explore participants' experiences of Scientist Spotlight assignments more deeply, students who completed the assignments could sign up to participate in a Zoom interview about their perceptions of scientists. For the first course, 52 out of 159 students (32.7%) expressed interest in being interviewed. For the second course, 35 out of 143 (24.5%) expressed interest in being interviewed. The self-reported demographics of the students in these two courses are summarized in Supplemental Material A.

Of the 302 recruitment survey respondents, 87 participants expressed interest in participating in an interview (29% response rate). From students' self-identified personal characteristics, we selected interview participants through stratified sampling to ensure our interview study included students from backgrounds underrepresented in science (LGBTQIA+, first-generation college going, and race or ethnicity). We used stratified sampling of participants to strive for parity of demographics with students in both courses (see Supplemental Material B). A total of 31 students participated in our interview study, all of whom disclosed at least one aspect of identity that is counterstereotypical in science, including gender, sexuality, race, ethnicity, and/or first-generation college-going. Over half (52%, $n = 16$) were first-generation college-going students. Over a third (39%, $n = 12$) identified as LGBTQIA+ individuals. The gender composition of our participant population included 3 Gender Non-Conforming individuals, 5 Cis-Men, and 23 Cis-Women. Nearly half (52%, $n = 16$) of participants identified as Hispanic/Latinx/Chicanx, including mixed race. A.R.A.-P. assigned pseudonyms to reflect the cultural background of each participant based on the name they provided. Table 1 summarizes the pseudonyms and key characteristics of our interview participants.

Sampling Technique and Recruitment. To achieve a group of interview participants who held varied identities and backgrounds, we employed a stratified sampling technique based on three factors: sexuality, first-generation status, and race/ethnicity. We chose to stratify by these factors to establish comparable representation across demographic groups and experience (see Supplemental Material B). From this pool of individuals, A.R.A.-P. emailed these selected participants to schedule Zoom interviews through an online scheduling system. Interviews were scheduled for 1 h, and students were incentivized to participate for a $25 Amazon gift card. Not all potential interviewees responded, so email invites for interviews were sent on a rolling basis until the desired number of students were selected from each class. Those who signed up for interviews were first assigned unique identifiers on a separate spreadsheet to maintain anonymity, followed by pseudonyms. Interviews took place at the end of each course and were recorded on Zoom. At the end of each interview, participants were sent an e-gift card for their participation.

Interview Protocol Development. To address the RQs, the authors created an interview protocol that was aligned with the CLP framework. Example interview questions included, "*In what ways have your perceptions of the types of people who do science shifted over the course of your life?*" (RQ1), *"Before this class, what ways have you seen scientists that you identify with represented in science?* (RQ2), and *"In what ways has that shifted since taking this class?"* (see Supplemental Material C for Interview Questions). To establish validity of interview questions, A.R.A.-P. piloted these questions on six students unaffiliated with this study and had little to no relationship with herself. All three authors listened to the pilot interviews to check for consistency and clarity in how the questions were being interpreted. We revised our interview protocol questions based on these observations.

A.R.A.P. followed a semistructured format in which she asked a list of identical questions to all participants while allowing a dialogue between herself and interviewees. A notable feature of these interviews was A.R.A.-P.'s positionality statement at the beginning of the interview—she shared her background including her student-standing and identities (first-generation college-going status, LGBTQIA+, Latina). We believe this greatly enriched our data by enhancing participants' willingness to share about their intersecting identities, backgrounds, and vulnerabilities. As A.R.A.-P. was also an undergraduate peer to the participants, this allowed a shared affinity between the researcher and interviewees (Manohar *et al.*, 2019).

Qualitative Data Analysis. A.R.A.-P., D.O., and B.T. engaged in both deductive and inductive content analysis (Saldaña and Omasta, 2016). The tenets of CLP guided the deductive analysis, and any reflections that were unrelated to the CLP framework were inductively categorized under new codes. In the first cycle of coding, A.R.A.-P. chose ~20% of the 31 interviews that had the greatest difference in perspectives to enhance the diversity of insights. We independently read and annotated ideas that aligned with the CLP framework. We then reconvened to compare our insights and findings that led to a list of preliminary codes, referred to as initial coding (Saldaña and Omasta, 2016). We used a structural coding approach (Saldaña and Omasta, 2016) to categorize and organize the data into chunks with similar codes. We assigned main themes

TABLE 1. Pseudonyms, in alphabetical order, and self-reported demographics of students who participated in interviews ($n = 31$)

Pseudo-nym	Sex/gender	Sexual orientation	Race/ethnicity	First-generation college going
Alexa	Cis-Female/Cis-Woman	Heterosexual/Straight	White	No
Amira	Cis-Female/Cis-Woman	Heterosexual/Straight	Hispanic/Latino/a/x/Chicano/a/x	Yes
Amy	Cis-Female/Cis-Woman,Gender Queer/Gender non-conforming	Pansexual, Asexual	Asian	No
Andrew	Cis-male/Cis-Man	Heterosexual/Straight	Asian	No
Bond	Questioning	Gay or Lesbian	Hispanic/Latino/a/x/Chicano/a/x	No
Cristina	Cis-Female/Cis-Woman	Bisexual	Filipino/Pacific Islander	No
Esha	Cis-Female/Cis-Woman	Heterosexual/Straight	Asian	No
Estrella	Cis-Female/Cis-Woman	Heterosexual/Straight	Hispanic/Latino/a/x/Chicano/a/x	Yes
Fawn	Cis-Female/Cis-Woman	Heterosexual/Straight	Asian, White	Yes
Gracia	Cis-Female/Cis-Woman	Pansexual	Hispanic/Latino/a/x/Chicano/a/x	Yes
Greg	Cis-male/Cis-Man	Heterosexual/Straight	White	No
Hector	Cis-male/Cis-Man	Bisexual	Hispanic/Latino/a/x/Chicano/a/x	Yes
Huda	Cis-Female/Cis-Woman	Heterosexual/Straight	Middle Eastern	No
Jaslene	Cis-Female/Cis-Woman	Bisexual	White	Yes
Jenifer	Cis-Female/Cis-Woman	Heterosexual/Straight	Hispanic/Latino/a/x/Chicano/a/x	Yes
Joanne	Cis-Female/Cis-Woman	Heterosexual/Straight	Asian	Yes
Jocelyn	Cis-Female/Cis-Woman	Bisexual	Hispanic/Latino/a/x/Chicano/a/x, White	No
Linda	Cis-Female/Cis-Woman	Queer	Hispanic/Latino/a/x/Chicano/a/x	Yes
Malini	Cis-Female/Cis-Woman	Heterosexual/Straight	Filipino/Pacific Islander	No
Marisol	Cis-Female/Cis-Woman	Heterosexual/Straight	Hispanic/Latino/a/x/Chicano/a/x	No
Paloma	Cis-Female/Cis-Woman	Heterosexual/Straight	Hispanic/Latino/a/x/Chicano/a/x	Yes
Raspreet	Cis-Female/Cis-Woman	Heterosexual/Straight	Asian	Yes
Reina	Cis-Female/Cis-Woman	Heterosexual/Straight	Hispanic/Latino/a/x/Chicano/a/x	Yes
Ren	Cis-male/Cis-Man	Bisexual	Asian	No
Roque	Cis-male/Cis-Man	Heterosexual/Straight	Asian	No
Sabrina	Cis-Female/Cis-Woman	Bisexual	Black or African American, Hispanic/Latino/a/x/Chicano/a/x	No
Sadie	Cis-Female/Cis-Woman	Heterosexual/Straight	White	Yes
Sara	Cis-Female/Cis-Woman	Heterosexual/Straight	Hispanic/Latino/a/x/Chicano/a/x	Yes
Teresa	Cis-Female/Cis-Woman	Gay or Lesbian	Hispanic/Latino/a/x/Chicano/a/x	Yes
Valentina	Cis-Female/Cis-Woman	Heterosexual/Straight	Hispanic/Latino/a/x/Chicano/a/x	No
Violeta	Cis-Female/Cis-Woman	Heterosexual/Straight	Hispanic/Latino/a/x/Chicano/a/x	Yes

to these coded segments to capture our participants' perceptions of science and scientists across their lifespan. The entries formed a "codebook" or coding guide, encompassing initial themes and their respective codes derived from the initial interview transcripts.

During our second cycle of coding, we used the initial codebook to categorize another 20% of interviews chosen at random. We followed the same procedure as described above by extensively discussing coding variations and made adjustments by adding, revising, and rearranging codes. During this process, we consolidated codes with low representation (found in one or two interviews) into similar ones or removed them from the codebook when they were unrelated to the interview topic. After five cycles of coding, data saturation was reached where no new codes or themes were arising from our data. As an example of how we created themes from codes, the salient theme of "Limited Scopes of Possibility to become a science person" was characterized by interview participants who described negative external influences that shaped their view of themselves or others becoming a scientist such as social institutions and society (codes: K12, college, media, macroaggressions). Those who expressed negative internal factors (code: imposter syndrome) were also placed under the theme Limited Scopes of Possibility, illustrating how both external and internal factors limited what students' saw possible for themselves and others in relation to becoming a scientist. These iterative steps led to a finalized codebook with overarching themes (see Figure 1 and Tables 2–5 for a summary of themes and related codes).

The interview transcripts and the final codebook were then uploaded into MAXQDA 2020, a qualitative analytic software. D.O. and A.R.A.-P. then went through another 20% of uncoded interviews to achieve interrater reliability of greater than 80%. Following this, D.O. and A.R.A.-P. each independently recoded all transcripts (half coded by D.O., other half coded by A.R.A.-P.) according to the finalized codebook.

RESULTS

In this segment, we highlight the findings derived from 31 interviews conducted with undergraduate students to explore their viewpoints of science, scientists, and the Scientist Spotlight assignments. Notably, participants from the stratified

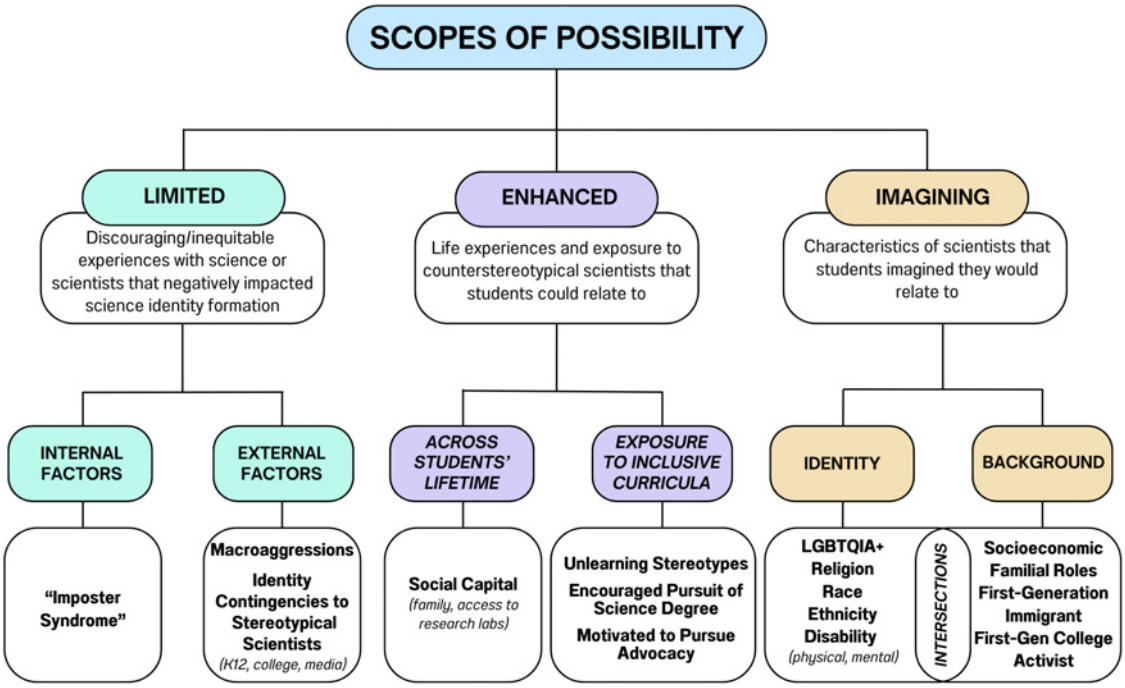

FIGURE 1. Final Codebook for Scopes of Possibility: Limited, Enhanced, and Imagining. Under Limited Scopes, categories include internal (imposter syndrome) and external factors (macroaggressions and identity contingencies to stereotypical scientists) that shape students' science identity. Under Enhanced, there are experiences before Scientist Spotlights (social capital through family and access to research experiences) and after receiving Scientist Spotlights (such as unlearning stereotypes, encouragement to pursue science degree, and motivation to pursue advocacy). Under Imagining, there are aspects of identity and background that students imagined would be relatable in an ideal scientist.

subpopulations (i.e., majors and non-majors) did not differ in the types of experiences they shared; hence, results from these subpopulations were consolidated. The primary themes that we constructed are based on tenets of the CLP framework, revealing that Social Institutions and Society largely shape three aspects of students' Scopes of Possibility: 1) limited, 2) enhanced, and 3) imagining Scopes of Possibility in which we describe below in relation to our RQs (Figure 1). In response to RQ1, we found that undergraduate students' life experiences with science shape perceptions of themselves and others by either limiting or enhancing their Scopes of Possibility, which we explore in detail in each respective subsection below. To address RQ2, we identified Scientist Spotlights as a recurring example of inclusive curriculum perceived as enhancing students' Scopes of Possibility. Further, we found that students could also imagine a scientist to whom they could relate which they had not yet encountered throughout their life, which we term Imagining Scopes of Possibility (see Figure 1 for outline of themes and related categories).

Limited Scopes of Possibility

To address RQ1, we invited students to share about their life experiences with science that shaped perceptions of themselves and others in science through the interview question, "*In what ways have your perceptions of the types of people who do science shifted over the course of your life?*" Of the 31 students who participated in our interview study, each with at least one aspect of identity that is counterstereotypical in science, almost all students in our sample (94%, $n = 29$) described discouraging or inequitable experiences with science or scientists throughout their lifetime that impacted their science identity formation (i.e., limited their Scopes of Possibility to become a scientist). We conceptualized these encounters as identity contingencies described by the CLP framework as, "specific identities held by an individual that might be in conflict or may relate to challenges that complicate the learning process." (Bell *et al.*, 2012, p. 275). Students expressed these experiences within Social Institutions and Society in which two salient distinctions emerged: internal affective factors and external deterrents that impact science identity formation (Table 2). The following section outlines evidence for each of these categories.

Almost a third of students identified internal affective factors (30%, $n = 9$), such as imposter syndrome, as dissuading them from pursuing science based on their social identities and backgrounds. Imposter syndrome is a person's intellectual self-doubt and fear of failure, marked by the concern that others have an inflated perception of their talents or abilities (Clance and Imes, 1978). Students, such as Violeta and Hector, shared their internal dialogue as examples of how they perceived their self-doubt, and how feelings of imposter syndrome stemmed from discrepancies between their own identities and the identities of those around them in STEM courses:

> "Before reading these Scientist Spotlights, I felt like maybe I had imposter syndrome. Maybe I don't fit in, maybe I have to be white to be a scientist. I think being a first generation, it's really hard because I am the first in my family

TABLE 2. Limited Scopes of Possibility—Example quotes from undergraduate students describing how imposter syndrome (internal factors) social institutions and society (external factors) shape science identity

Theme	Salient categories	Example quotes
Internal Affective Factors	**Imposter Syndrome –** *Describes how incongruence between aspects of identity and perceptions of scientists lead to imposter syndrome.* *n=9 (30%)*	Yeah, I have Imposter Syndrome and I think it is because I'm not white, I'm Hispanic. Even just talking to my friends in general, both white males and females, I start to second guess my information that I look back at it, even though it's correct. That's why when I'm studying for a test, I don't necessarily believe everything people tell me 'cause I'm just like, *"Yeah, sure. Yeah, sure it is."* 'Cause then I'll get it wrong on a test when I knew it all along. So I just kind of like... It got to a point, actually, recently that I don't even trust myself and what I know. So I'm just thinking like maybe I just don't know my information as well as I do. Yeah. But the only thing is I don't trust myself. –Valentina
		Before [taking this class] I was really intimidated to even major in science. I was like, "*I don't know, I'm a woman and Latina, I'm a first-gen student. I don't even think I'm adequate to even major in that.*" I didn't have any exposure to anyone I could even relate to. So definitely my view was really closed I would say, and more insecure. –Reina
		I always kind of had doubts. Like I said I was the only queer one in my lab. And like I knew that I would be able to be in the science field, but I always figured it would be a big struggle kind of like swimming against the current. –Bond
External Deterrents – Social Institutions and Society	**Macroaggressive Experiences** *Describes the macroaggressions experienced by Students of Color.* *n=14 (45%)*	When I go to the doctors, they start spilling a bunch of stuff to you about all these conditions that you don't know about. They were raised in a better way with more resources, but I just think seeing people who look like me or who came from a similar household or background in any type of way would be so much better. –Fawn
		Well, I think I have had this experience, where I was in a discussion and my group was working on a task and you're supposed to interact with other group members in the classroom and they were all White and weren't welcoming and they make you feel dumb. You could just tell, they're judging you. And it's really sad because it's like, you don't know me. Like you don't know me. And it's just sad. –Violeta
	Stereotypical Science Exposure *Describes experiencing stereotypical exposure to science and scientists or discouragement to become a scientist based on their identities* in…	I just knew like the traditional scientists, like Albert Einstein, just the ones that we grew up learning in high school. So I didn't expect it to be a thing that I can actually relate to 'cause, I don't like to say this, but the typical scientists that I learned growing up were mostly male and Caucasian, older male. –Reina
		I didn't envision myself as a scientist because of what I was exposed to as a kid, probably like a white man in a little lab coat. That's literally all I saw a scientist as. Because as a child, that's mostly what teachers pushed on you. It was like, "*Oh, this white man did all this, and he found this in science.*" –Raspreet
	…K12 Schools *n=29 (94%)*	
	…Media *n=8 (26%)*	For me, I think I know that there's a lot more marginalized people who are doing science and who I've never heard about before. I think that's probably due to the media just never acknowledges them. I don't think they've been represented that much. You see them... I've seen them sometimes in the media. Yeah, of course, say Twitter or something and briefly in some text but never too deep. Not like... I can't point at it and be like, "*Oh my God, I relate to them or they look like me.*" Super irritating. –Marisol
		When I read papers and see other forms of media, like even on television or other stuff, most of the researchers that we see generically are like White men in their 40s. –Alexa
	…College *n=7 (23%)*	I feel like most of the professors that I had were White and I mean, some of them were male, so I guess I identify with that, but not my Hispanic heritage or sexuality. I haven't seen much of that representation. –Hector think mostly in my college career so far, I've learned basically that typical white male scientist like George Mendel or just any of those people that you know about. Yeah, I rarely learn about a woman scientist, a female scientist. I can't even think of one right now. That just makes me angry because I am a woman in STEM. –Huda

to go to college. Everything has led to me being here, so that validates why I'm here, but seeing your surroundings in my STEM classes. I look around, and I see predominantly White. I was like, *'Oh my God. I'm like one of the only Latinas in this class.'* I'm scared to talk to someone, and they then make me feel dumb, which is so sad. Not having a safe space." - Violeta

"Every STEM course that I took, I was like, *'Oh my God.'* I always felt like I wasn't smart enough or didn't grow up with the same resources that somebody else is. So it's like, *'Oh, they're ahead.'* And I still encounter that, not even just in science, but in daily life, like speaking English, in knowing different words and saying stuff differently. I face a lot of imposter syndrome in science." - Hector

Likewise, Alexa reflected on how the requirement to work during college and having a developmental disability gave her self-doubt to succeed in science:

"When I came to college, because I'm interacting with older scientists who have already gone through undergrad, graduate school, worked as a professor, this is like their third job as a professor, they've already gotten all these awards, I felt less than, like, *'Oh my goodness, they've done so many things,'* and even some of my peers in these upper division programs have already done so much. But here I need to work as well, so how am I gonna get to that point? Also 'cause I have a developmental disorder. It's hard to talk or relate to these really well-off scientists, 'cause it's like, *'Oh shoot, I wonder if this is ever going to be a hindrance.'*" - Alexa

Along with the internal affective factors of imposter syndrome, almost half of students also described macroaggressions occurring in society or educational spaces (45%, $n = 14$). Interestingly, all students who explained these instances were Students of Color. Some students, like Raspreet and Poloma, reflected on macroaggressions from "influential others" (Vincent-Ruz and Shunn, 2018)—peers, teachers, advisors, family—that presented challenges or negatively impacted their ability to see themselves as a science person:

"Because I grew up in Long Beach and there are not very good areas, in elementary school, instead of [teachers] sharing with us that we could do something with our lives, like be a scientist or doctor, they did this really triggering thing. They brought in lawyers and detectives, and they would basically tell us what's right, what's wrong. Like *'This is an illegal thing to do, you will go to jail.'* They really didn't take the time to tell us, *'Oh, you can be a scientist, you don't have to stay here in poverty. You can go out, these universities exist.'* No, they were telling us not to do illegal things. It's so triggering even now." - Paloma

"There was really no exposure to scientists with different backgrounds, I feel like in the back of my mind there was always that myth that only white rich men can do science. I was getting [these messages] from peers in community college not wanting to work with me, and an advisor who advised me to drop out and start a family. So, the discouragement was coming from many avenues." - Sara

Students also provided examples of instructors tokenizing scientists from marginalized backgrounds rather than focusing on the importance of their scholarly contributions which is a type of macroaggression:

"In white academic spaces, I think it focused on [counter-stereotypical scientists] identities rather than their work. When they talk about diversity and stuff like that, they really drive the fact that these scientists are not like the other scientists or the other people that you've learned about before, which is awesome. But then they say, *'This person was a BIPOC person. This person was queer. This person was this, this person was that.'* As opposed to focusing on their wonderful work." - Jenifer

Other Students of Color specifically discussed their frustration with macroaggressions that were committed from their community or society based on their race:

Being a person of color, I think you just have a certain microaggressions and expectations placed on you just by existing in a predominantly white community, and so I was just kind of expected to be very good at certain subjects like math and science and if I did do well, it was like, "Oh well, it's probably you just have a natural gift because you're Asian." I'm like "Obviously not, it's because I study a lot." So yeah, I think it was just those things. They affect you, and so they hold you to a certain standard that you try to keep up when it's not necessarily sustainable. –Fawn

[There are] a lot of biases that come from the medical field, because I am again a woman, and I'm also an overweight. And the medical field pisses me off, because sometimes we get stereotyped into these categories when you're overweight or like when you're a minority and a woman. You get categorized into all of these stereotypes. It's just annoying 'cause medical doctors especially tend to say, "Oh, you're overweight. So obviously you're eating this and that." When in reality that's not what I'm eating. –Jenifer

Others identified external deterrents that limited their Scopes of Possibility to be a scientist based on an inability to relate to science and scientists in K12 schools (94%, $n = 29$), the media (26%, $n = 8$), and college (23%, $n = 7$). Sometimes these reflections included identity contingencies (Bell *et al.*, 2012), or misalignment between their social identities and those of stereotypical scientists. Interestingly, Grecia shared how the exclusively white male scientists she learned about in K12 prevented her from even considering the possibilities of doing science, which offers a poignant example of limiting students' Scopes of Possibility:

"In high school, my teachers mentioned all these scientists, mathematicians but never in-depth about their lives, and they were all white males. I wasn't taught about representation, and I, myself, didn't take my time to do research on underrepresentation because I thought science was just something I was not gonna do because I am not a white man." - Grecia

Almost a third of students provided examples of stereotypical scientist exposure throughout their lifetime from media

sources, which reinforced Limited Scopes of Possibility for themselves and others that do not align with such stereotypes:

> "Well, I think of Big Bang Theory, like Sheldon and TV shows and all that stuff. His character is the epitome of the stereotype of what people think scientists are. Kind of more introverted, kind of socially awkward. Growing up, they implanted that in our heads through the media. And that can really affect peoples' identities, push them away if they don't look like that." - Sadie

> "When we read newspapers and we see other forms of media, even on television, most of the researchers that we see generically are like White men in their 40s. My culture is never represented." - Alexa

A similar number of students described how they were discouraged to enter science in college specifically based on their identities, such as Sabrina reflected on abandoning her social identities in college STEM classrooms:

> "I think that a lot of times in science, specifically, in science and math, I feel like I have to leave my identity at the door, I can't really bring any personal identifying factors with me to the table. I feel like you should definitely bring your whole self to the discussion 'cause that's what causes you to ask good science questions. It's your perspective and it's your experience that is influencing what you're interested in. But there have been times where I have to abandon parts of myself just to fit in with the crowd there and be involved in the discussion at all. Like the fact that I can't talk about race in science classes. I'm encouraged to leave that out of discussions. So, that is so upsetting and discouraging." - Sabrina

One student, Esha, described barriers to entering science in college based on cultural and familial expectations:

> "My barriers [to entering science] were mental health related. Can I go into this considering it's so hard to balance cultural expectations, but also academic expectations, and so that was kinda something I had to deal with. I would classify that barrier as ethnicity related sort of. It was just the familial expectations and stuff that I had to balance and overcome." - Esha

From the interplay of internal factors, such as imposter syndrome, to external factors, like macroaggressions in society and educational spaces, to institutions that focus exclusively on a certain type of scientist, we can better understand how the tenets of the CLP framework, Social Institutions and Society, can limit undergraduate students' Scopes of Possibility and potentially hamper the development of their science identity. In the next section, we highlight examples that enhanced students' Scopes of Possibility.

Enhanced Scopes of Possibility

Counter to limited Scopes of Possibility, there were also life experiences with science and exposure to counterstereotypical scientists that *enhanced* students' Scopes of Possibility for themselves and others. These life experiences included, but were not limited to, Scientist Spotlights. To characterize this and whether/how students conceptualized inclusive curricular assignments like Scientist Spotlights as a meaningful experience, we distinguished students' reflections both *across students' lifetime* (Table 3)—addressing RQ1—and *with exposure to inclusive curriculum*—answering RQ2 (Table 4).

Enhanced Scopes of Possibility Across Students' Lifetime. A third of students referenced scientists they encountered through social capital such as family and access to research labs (n = 8, 26%, Table 3). We describe social capital as "social obligations ('connections'), which is convertible, in certain conditions, into economic capital" (Bourdieu, 1986, p. 16). Students described how social capital, such as their family, friends, upbringing, or being a part of a research lab positively influenced how they perceived themselves as scientists:

> "I knew I could be a scientist because of my family. My aunt was a psychiatrist, so I was kind of like of course I can do it if she did it sort of a thing. But I also think about growing up in [city redacted], obviously being a college town, every other person I met at volunteer activities or community parties or my friend's parents, they're kind of into science in some way. And so since they were a diverse group, I never really felt like it was solely a predominantly white or predominantly male field." - Esha

Even if the principal investigator of the research lab was not mentioned, students noticed if the people working in the lab were diverse and reflected on the impact of this observation on their science identity:

> "After joining one of the undergraduate research labs, I found out, '*Whoa, there's so many faces here, and it's really diverse here, and everyone has a unique identity.*' This class and that lab showed me to the light and actually encouraged me to pursue research and science." –Roque

> Students also recounted the sum of these experiences which enhanced their Scopes of Possibility *before* the Scientist Spotlights Intervention, including the influence of family members and meeting scientists from a similar background:

> "When I started researching actually at [University] Health, I met a physician Dr. [redacted], who was South Asian like me…She was kind of on the same path that I really wanted to follow. And so it was really cool seeing her and talking to her, and I guess we had similar cultures. She was a really cool physician." - Esha

> "But I think who really broke down those barriers [to entering science] was my parents encouraging me to pursue science…And I think after that, and after meeting other people who were of similar background to me, within the science field as researchers or as professors that really, I guess, calmed my nerves and encouraged me that, yes, that I can pursue this path and this path isn't just restricted to White people." - Roque

One may notice that the examples students shared about exposure to counterstereotypical scientists before the Scientist

TABLE 3. Enhanced Scopes of Possibility, Before Scientist Spotlights—Example quotes from undergraduate students describing exposure to counterstereotypical scientists before the Scientist Spotlights Intervention

Subcategory % (*n*)	Example quotes
Social Capital 26% (8) *Describing the ways in which one-on-one research labs, science programs, friends, and/or family enhanced their scopes of possibility to do science prior to experiencing Scientist Spotlights.*	But like in the lab that I'm working in, at [university redacted], there's actually a lot of queer people who are working in that lab. There's a lot of like gay and trans flags, like just little ones at people's desks. And I was like, "*Hey, like there's queer people in science*," and it made me really happy. –Bond The majority of these programs [that I participated in] were Hispanic like me, and so that's very nice to see. Like they're being headed by Hispanic people there. We're interacting with these Hispanic scientists who do all of this kinds of research, and so I feel like I was very lucky to be able to kind of relate on this, at least this one aspect, to a lot of scientists either in my field or not in my field, going on to do great things, who maybe are first generation, or their parents were first generation so they were technically second generation. And so, I was able to relate to them on that aspect. –Alexa Especially coming to college…the people around me are just like me. Honestly, I met so many people from the Bay Area who went to this high school, and we're out here struggling on classes, and we're just talking about things that we like and we have very similar interests. I have friends who do science and my major. It's like, 'Oh, I'm a normal person. You're a normal person. And we're both going into science, and you do science, I'm gonna do science.' So it's cool, we're all the same. –Sadie

Spotlights Intervention entailed social capital outside of their K12 educational experiences; however, this leaves students' exposure to counterstereotypical scientists to chance and contingent on access to resources.

Enhanced Scopes of Possibility with Exposure to Inclusive Curricula. For RQ2, we considered how students described Scientist Spotlight assignments specifically in relation to their Scopes of Possibility, posing the question: "*When you think about the Scientist Spotlights assignments, what comes to mind?* These responses were coded as *after* the intervention and are summarized in Table 4. Importantly, while less than half of participants shared experiences of Enhanced Scopes of Possibility before the Scientist Spotlights Intervention, all students ($n = 31$, 100%) provided evidence for Enhanced Scopes of Possibility because of their exposure to Scientist Spotlights (Table 4). The nature of this Enhanced Scopes of Possibility *after* the Scientist Spotlights Intervention included participants' description of how certain aspects of the featured scientists' personal and professional identities aligned with their own:

> Interviewer: "In what ways have your perceptions of the types of people who do science shifted since taking this class?"

TABLE 4. Enhanced Scopes of Possibility, After Scientist Spotlights—Example quotes from undergraduate students describing impacts of the Scientist Spotlights Intervention

Subcategory $N = 31$	Example quote
Unlearning Stereotypes *n = 31 (100%)*	I mean, [my perspective] dramatically changed because it's like when [the instructor] gave us the scientists spotlight assignments, I didn't know any of them at all, it was just new people to me…All of them were completely different, like they all came from different upbringings, different backgrounds, and they contributed a lot to their fields, but they also…used their own experience to help contribute to it. –Marisol
Identity Affinity *n = 30 (96.8%)*	I've heard about it a lot. South Asian groups have... Prone to different risks and I've seen it in my life too, with family members. And then when I saw that in one of the Scientist Spotlight, I always like, "*Wait, I know a little bit about this,*" *and I've seen it on TikTok a lot too, about that.*"–Raspreet
Encouraged Pursuit of Science Degree *n = 29 (93.5%)*	At this point, if I choose to change my major, I would probably choose a science because of this experience. It gave me confidence that I could be really good at science. –Grecia
Motivated to Pursue Advocacy *n = 10 (32.3%)*	We really need representation because like people could be affected from this. If you're recommending them, like something about the heart disease that only like works for like a different like region of people from like a different country or a different area. It's like, that's not accurate. That's not the best healthcare you could give this to this person. So that really resonated with me. I was like, yeah, it's so important. We need that like focusing on different regions of people like subgroups and everything and like representation, because that's how healthcare can be more inclusive and better for that individual. –Sadie

> Fernanda: "We had a lot of [Scientist Spotlight] stories about people who weren't White, which helped me relate more. Usually, when I read stories about scientists, they're White scientists…There are a lot of women scientists and people who didn't come from what you would think is a science background. A lot of them came from low-income families, which helped me relate because a lot of times I hear stories about people whose parents are chemists and they've had this legacy and the resources, but people who don't come from those resources finding their way to science and making their own space for themselves helped me relate to them…"

In addition to finding affinity with personal characteristics and identities of featured scientists, almost all students (n = 30, 97%) described how Scientist Spotlights aided in *unlearning* fixed notions of scientist stereotypes and broadened their perspectives:

> "I think that my perceptions of people who've done science definitely changed, and I always thought that people who do science, they know that they're gonna do science, that's just their calling and they know it, but we actually had a lot of examples of people who sort of stumbled into science, stumbled into their specific areas of interest or specific passions. So I think just the idea that to be a scientist, like you have to have a path that you're gonna follow, I think that that was definitely something that got proven wrong." - Sabrina

The majority of students (n = 29, 94%) described how Scientist Spotlights encouraged or reinforced their own pursuit of a science degree:

> "At this point, if I choose to change my major, I would probably choose science because of this experience. It gave me confidence that I could be really good at science." - Grecia

Beyond the ways students shared that Scientist Spotlights shaped internal factors that enhanced their Scopes of Possibility, participants also described the potential for Scientist Spotlights to motivate students who are "on their last straw" with science or college:

> "By having Scientist Spotlights and bringing diversity of scientists into someone's knowledge or awareness – that these scientists exist – I think it's beneficial to everyone to learn about their different backgrounds, their different identities, so that they feel comfortable, they feel welcomed, or they feel like they belong there. It's just a validation as well, like, 'Oh, this scientist has X, Y, and Z,' or, 'This scientist came from X, or likes Y, and I can relate to them,' and that might be a motivating factor [for science students]. Maybe they were on their last straw, and they're like, 'I don't know if I should be here,' Maybe that can be the validation that they need to keep moving forward in their education." - Violeta

Whether participants described Scientist Spotlights as supporting their own pursuit in science or others' persistence in science, for both cases, it demonstrates an Enhanced Scope of Possibility. Unexpectedly, about a third of participants (32%, n = 10) also felt motivated to pursue advocacy based on their reported experiences with Scientist Spotlights. Students described shifts from Limited to Enhanced Scopes of Possibility for themselves and others with the desire "to give back" to their culture and community:

> "I'm a [University] student. I feel like if you look around, you may meet a lot of people who are white here and you rarely see any Hispanics or minorities here. And when you do see them, you can see that they're losing their connections to their roots. Personally, when I came here to [University] – I feel like I'm starting to lose my Spanish just because I can't really speak to so many people around me in Spanish. So I feel like learning about the scientists and showing that they're appreciated in the culture, and they're appreciated for how they look and where they come from, that can really help students be like, 'Okay, this is not something I should be ashamed about. This is something that I should acknowledge, and I should push through and use it to my advantage to contribute to my culture and to my community to give back.'" - Jenifer

Last, less than 10% (n = 3) of participants claimed that they did not intend to pursue science beforehand and that they did not change their mind after the intervention. Nonetheless, these participants did perceive science as a more accessible pursuit after the Scientist Spotlights intervention:

> "I like science. I think it's important, but it's not a field I wanna pursue. I don't really wanna do research, but I would definitely say, seeing different types of people do science is giving me more insight and showed me that if it is something that I wanted to do, it's something that I'm interested in, I would definitely feel represented and like it's something that I could pursue if I chose to." - Jocelyn

Altogether, students exhibit Enhanced Scopes of Possibility (a construct of the CLP framework, Figure 1) based on their experience in the Scientist Spotlight Intervention. In the next section, we consider the theme of Imagining Scopes of Possibility.

Imagining Scopes of Possibility

To expand on RQ2 and explore how inclusive curricula featuring counterstereotypical scientists could more strongly align with salient aspects of each participant's background and identity, we inquired about students' nuanced imaginings of scientists by asking, *"If you could design the perfect scientist that represented who you are, what characteristics would you choose?"* Almost all students in our sample (97%, n = 30) could describe what they desired to see in an ideal scientist, someone with whom they could fully relate, which we categorized as students Imagining Scopes of Possibility (Figure 1). When responding to our prompt, students shared intersecting identities, ranging from representation of scientists who come from low-income backgrounds, familial roles, LGBTQIA+ status, first-generation college-going and immigrant scientists, women Scientists of Color, ethnic and cultural representation to struggles with mental health, activists, and faith-based scientists (Table 5). Given the variety of personal characteristics students shared, we did not quantify

TABLE 5. Imagining Scopes of Possibility—Example quotes from undergraduate students about aspects of identity and background they imagined would be personally relatable in a scientist

Imagining scopes of possibility (n = 30, 97%) Identity, background, and/or intersections	Responses to prompt: *"If you could design the perfect scientist that represented who you are, what characteristics would you choose?"* Example quotes
Low-income; Experiencing discouragement from influential others	Maybe like people who were like at certain disadvantages maybe like had a **poor upbringing**...or if **they had doubts because people don't believe in them**, or they'd been told like, "*Oh no, you shouldn't pursue this as a career because it's like X, Y, and Z*"–Marisol
Ethnic backgrounds; Experiencing mental health struggles	I think **more ethnicities** represented and **mental health** things. Mental health is something that I struggled with before. And so that I also really resonate with. I think it's like not spoken about enough. I think it's gotten better over time, but I think we can definitely talk about it more. –Joanne
Woman of color	I think that definitely I feel like I gravitate towards **women of color scientists**, just because I feel like there's a lot of issues with women of color and healthcare, and I feel like I'm really interested in how new perspectives can help change what people are looking for, if that makes sense, because I feel like there's a lot of instances where Black and Brown women are being under-diagnosed and there are misconceptions about, I don't even know the simplest things about who experiences pain differently and stuff like that, and I feel like with women of color scientists, I feel like they might be able to look for more things that maybe not... Might be present in the mind of White men issues that they might see that need exploring that it might not even cross these people's minds, so I feel like that definitely makes me gravitate towards scientists more. –Sabrina
Ethnicities and culture; LGBTQ+	I think, well, first off, probably someone who's like **Latinx or Chicano** just 'cause I feel like they know more about like the struggles that happen in like the Latino communities and everything and like people who don't live in as places with as good of like resources. So that would definitely be something. And then, I don't know, like probably also finding somebody who's like on the **LGBTQ spectrum.** I mean those would be two things that I feel like are something that I personally relate to or identify with. –Hector
Faith-based	Maybe like if they're a **Muslim** too or if they have **strong faith**, but I think that's just something I don't generally talk about with other people, but I guess it would be interesting to meet someone and also know that like they also, feel strongly about their faith. –Esha
Familial Role, Cultural Heritage	So I'm the eldest. So being the **older brother**, and watching after their younger ones, so that's typically very relatable when someone talks about and has that kind of elderly demeanor towards other people and just looking out for them. That definitely, and having a **strong sense of culture** with them. I notice I often identify with those people 'cause I have a really strong sense of culture from my mom's heritage, and I'm really proud of it. And I've noticed that I tend to relate with other people who have a very strong cultural heritage as well. –Roque
Academic Background; Struggled in school	I think the first one would probably be like somebody who didn't necessarily understand science when learning it, because I think I'm an intelligent person, however, science and math just have never came easy. Math could be pretty straightforward, so math did come easy at some points, but then at other points it's just like, I just couldn't really grasp some things in science. I'm like, "*Okay, how did this person come to that conclusion about this tiny little cell that you can't even see with the naked eye?"* 'Cause I'm... Right off the bat, I'm more of a realistic person like, " *Oh, if I can't see it, it's not there*," kind of, so maybe **somebody who couldn't really grasp concepts at first and had to work on understanding what they were learning**, I think that's maybe a trait that I would probably relate to. –Fawn
Immigrants, First-Generation College-Going, and Familial Roles	**Immigrants** – I can relate to growing up with like immigrant parents. Yeah, stuff like that. I don't know. It's just, it, when it resonates, it resonates, when it doesn't, it doesn't, it's like a feeling. Because you just like, feel like you just kind of have like an inkling of how they were raised and stuff. Just knowing how strict a lot of immigrant parents are kind of, and like how pushy they are of you to do a good career. And it's like, the weight of like, oh, they moved like to a different country for me. It's like, I have to do good. I have to succeed. I have to do this, it's kind of like, and my parents never went to college. **I'm the first person ever to go to my college**, go to college in America, like ever. So it's like, a lot of pressure, it's very like, "*Oh, go to college, go to college, do this. Like do STEM like do STEM and all that stuff*." I'm glad I have an interest in it, but it's like very, like, it's hard, it's like you have to live up to standards, **especially being a first born**. –Sadie

(*Continued*)

TABLE 5. Continued

Imagining scopes of possibility ($n = 30$, 97%) Identity, background, and/or intersections	Responses to prompt: *"If you could design the perfect scientist that represented who you are, what characteristics would you choose?"* Example quotes
Gender Identity	I would say definitely **gender identity** and also the knowledge, I guess. Or the understanding that they have their own struggles. And they have also issues with questioning themselves and their own identity–Amy
Activists	I don't know how to phrase it, I guess it's just like knowing that these researchers have also the same kind of internal struggles. And I guess becoming aware of it because they talk about it and **they go and join organizations and form activists**, kind of do activist stuff. That kind of is like "*Oh yes, I can relate to this person.*" –Amy

intersecting identities mentioned but provide a range of examples below. Consider Roque's reflection related to heritage and culture:

> "I'm the eldest. So being the older brother, and watching after the younger ones, that's typically very relatable when someone talks about and has that kind of elderly demeanor towards their people and just looking out for them. And having a strong sense of culture with them. I notice I often identify with those people 'cause I have a really strong sense of culture from my mom's heritage, and I'm really proud of it. And I've noticed that I tend to relate with other people who have a very strong cultural heritage as well." -Roque

Other participants expressed the desire to see immigrant and first-generation college representation, and described the immense pressure students experience from their parents who immigrated to America, such as Sadie:

> "[I'd want to see] immigrants I can relate to, like immigrant parents. Because you just feel like you have an inkling of how they were raised and stuff. Just knowing how strict a lot of immigrant parents are, and like how pushy they are of you to do a good career. The weight of like, '*Oh, they moved to a different country for me.*' It's like, I have to do good. I have to succeed. I have to do this, and my parents never went to college. I'm the first person ever to go to my college in America, like… ever. So it's like, a lot of pressure, it's very like, *'Oh, go to college, go to college, do this. Do STEM and all that stuff.*' I'm glad I have an interest in it, but it's very hard. You have to live up to standards, especially being a first born… I'd want to see more scientists like that." -Sadie

Some students described a desire to see scientists who struggled with mental health. This was particularly important for Students of Color who also suffered from mental disorders:

> "I think more ethnicities represented and mental health things. Mental health is something that I struggled with before. And so I really resonate with that. I think it's like not spoken about enough, especially in my culture. I think it's gotten better over time, but I think we can definitely talk about it more." -Joanne

Others spoke about the need to see scientists with religious faith as those topics are often excised from science spaces:

> "Maybe if they're a Muslim, too, or if they have strong faith. That's just something I don't generally talk about with other people in science classes, but I guess it would be interesting to [read about] someone and also know that like they also, feel strongly about their faith and they've made it in science." –Esha

Several students described a desire to see a scientist who struggled in school and still succeeded as a scientist, such as Fawn:

> "I think the first thing would probably be somebody who didn't necessarily understand science when learning it, because science and math have never been easy for me. I'm like, '*Okay, how did this person come to that conclusion about this tiny little cell that you can't even see with the naked eye?*' So, maybe somebody who couldn't really grasp concepts at first and had to work on understanding what they were learning, that's a trait I would relate to." -Fawn

Another characteristic that students were interested in seeing in a scientist were those who openly talked about their personal struggles and used these experiences to advocate and act for social change:

> "I guess it's just like knowing that these researchers have internal struggles. And I guess becoming aware of it because they talk about it and they go and join organizations and form activism, do activist stuff. That kind of is like '*Oh yes, I can relate to this person.*'" -Amy

Many students expressed more than two intersecting identities that they would like to see represented:

> "I think, well, first off, probably someone who's like Latinx or Chicano just 'cause I feel like they know more about the struggles that happen in the Latino communities and everything and people who don't live in places with as good of resources. So that would definitely be something. And then, probably also finding somebody who's like on the LGBTQ spectrum. I mean those two would be something that I personally relate to or identify with. So, I think that would make them feel more relatable." -Hector

Students' reflections on their ideal scientist with whom they can relate emphasizes aspects of identity that are salient to students. Notably, many of these characteristics are not readily captured from visual cues (e.g., photos) or by a demographic checklist. Rather, students described biographical details they would hope to learn more about that would make scientists relatable to them.

DISCUSSION

To balance the prevalence of dominant and underrepresented identities within the scientific enterprise, identifying undergraduate students' lifelong exposure to stereotypical and counterstereotypical scientists and ways they cultivate (or do not cultivate) a science identity may be important levers for characterizing why underserved students persist or leave STEM. Through this interview study, we provide a novel application of the CLP framework to elucidate how students' science identities are influenced by exposure to stereotypical and counterstereotypical scientists across institutions and over time. We adapted CLP's original conception of "Scopes of Possibility" and characterized three distinct categories informed by our data: *Limited, Enhanced, and Imagining Scopes of Possibility*. In the subsequent sections, we describe our findings in relation to our RQs and existing literature, as well as explore the implications of our main findings for both teaching and scholarly work.

Social Institutions, Society, and Lack of Social Capital can Limit Students' Scopes of Possibility

Based on the CLP framework, the construct Social Institutions and Society was the largest contributor to students' Limited Scopes of Possibility. The social institutions that students described as externally hindering their science identity across their lifetime included media, healthcare settings, their communities, and K12 schools and colleges with educational settings as among the most damaging social institutions in this study. While some students experienced seemingly unintentional messaging that they did not belong in science like lack of representation or being the only minority in their science classes, others reflected on classroom trauma. Recall Paloma sharing a triggering experience in one of her K12 classrooms:

> "Because I grew up in Long Beach and there are not very good areas, in elementary school, instead of [teachers] sharing with us that we could do something with our lives, like be a scientist or doctor, they did this really triggering thing. They brought in lawyers and detectives, and they would basically tell us what's right, what's wrong. Like *'This is an illegal thing to do, you will go to jail.'* They really didn't take the time to tell us, *'Oh, you can be a scientist, you don't have to stay here in poverty. You can go out, these universities exist.'* No, they were telling us not to do illegal things. It's so triggering even now." - Paloma

Such experiences are associated with discourse on curricular violence, which involves instructors making choices, sometimes unintentionally, in lesson planning and learning experiences that psychologically harm students, either intellectually or emotionally (Resnik, 2022). These educational interactions can worsen historical or institutional trauma, particularly for underserved student populations. Overt messaging that profiles students in the classroom are egregious examples that a dearth of counterstereotypical science representation is not the sole issue nor the singular solution. A much more pervasive challenge is related to systemic and institutional racism and bias within social institutions like education. This is further evidenced in our data when students reflected on their feelings of "imposter syndrome" in science. The current understanding of impostor syndrome is deeply flawed as it predominantly emphasizes the psychological aspects of what McGee and colleagues (2022) label "imposterism," often neglecting the role of interactions and societal structures that contribute to its persistence. Tulshyan and Burey (2021) in a Harvard Business Review argue racist institutions and structures should be where the blame is directed when People of Color experience this phenomenon:

> *In truth, we don't belong because we were never supposed to belong. Our presence in most of these spaces is a result of decades of grassroots activism and begrudgingly developed legislation. Academic institutions and corporations are still mired in the cultural inertia of the "good ol' boys" clubs and white supremacy. Biased practices across institutions routinely stymie the ability of individuals from underrepresented groups to truly thrive. The answer to overcoming imposter syndrome is not to fix individuals but to create an environment that fosters a variety of leadership styles and in which diverse racial, ethnic, and gender identities are seen as just as professional as the current model[…]"*

Given this, our job is not to fix students to feel like less of an "imposter," but instead, radically change educational spaces to design and implement curricula that liberates students from oppressive systems across their lifetime which will inevitably enhance their Scopes of Possibility.

Macroaggressive messaging from influential others (teachers, healthcare providers, advisors, peers) was also a source of invalidation that students' from underserved backgrounds perceived as limiting their science identity. Examples included racial macroaggressions from instructors that tokenized Scientists of Color (participant Jenifer), healthcare providers with a lack of racial concordance (participant Fawn), and even an advisor who suggested that one student skip college altogether to start a family (participant Sara). Similarly, Miles and colleagues (2020) found that Black students in engineering doctoral programs consistently lacked a sense of belonging based on racial microaggressions. Another study revealed Students of Color in undergraduate science settings experienced racial microaggressions from advisors, peers, and instructors at alarming rates (Lee *et al.*, 2020). These offenses are not isolated events in higher education. Our findings build on these studies revealing that microaggressions, which we label as macroaggressions given their ubiquity and magnitude of impact, consistently resurface across the lifetime of students from underserved backgrounds. When students reflect on having to "leave their identity at the door" and avoid talking about race in science classrooms (participant Sabrina) and feeling unsafe in educational spaces (participant Violeta), bigger issues are at play. These findings urge us to consider underlying ideologies that seem to enable macroaggressions—namely, the racist and inequitable structures that perpetuate white supremacy in science and education.

Even for the small portion of students who felt they were or could be a scientist, they never reflected on their educational experiences in the classroom as aiding in the development of their science identity. Instead, it was largely influenced by social capital such as exposure to family science role models (influential others) and access to research labs. Familial

support, regardless of the educational level of family members, is a key influence for Women of Color in STEM majors (Yap *et al.*, 2024). Thus, it was unsurprising that our findings revealed students without family science role models are often left with a mismatch between influential others within their culture at home and their perceptions of influential others of social institutions within science. This lack of familial science social capital may have impacts on how underserved students navigate college. For example, these students may be less aware of how to seek research opportunities as they are less likely to have family members who can provide guidance on how to navigate science in education and careers (Gándara *et al.*, 2003; Cooper *et al.*, 2021). As studies have shown how science research opportunities positively impact students' science identity and motivation (Starr *et al.*, 2020), a lack of research exposure may have the opposite effect. Additionally, students from lower socioeconomic backgrounds may need to work during non-school hours and cannot afford to spend time on research. Future scholarship may consider how Enhanced Scopes of Possibility, as observed in the present study, shape students' longitudinal decisions to persist or even switch into STEM majors, especially for populations where STEM and college dropout rates are particularly high.

Adding to the milieu of barriers to becoming a scientist, students also consistently reported identity contingencies, or misalignment, between their social identities and stereotypical scientists' identities. Students described a general sense of underrepresentation of scientists that looked like them, were neurodivergent, struggled with disabilities, came from similar backgrounds, or shared similar belief systems. This was largely influenced by their consistent exposure to stereotypical scientists in K12 and, to a lesser extent, college, shaping their idea of who does (and does not do) science. This supports literature dating back to 1975, in which Mead and Metraux (1957) observed high school students describing scientists predominantly as a man in a white lab coat conducting dangerous experiments. Chambers (1983) built on this idea by creating the Draw a Scientist Test (DAST) in which K-5 students drew male scientists with similar stereotypical characteristics (Mead and Metraux, 1957). Ferguson and Lezotte (2020) performed a meta-analysis from 2003 to 2018 in which researchers tasked students to draw a scientist using a modified Draw-a-Scientist Checklist (DAST-C) to quantify identities and characteristics of students perceptions of scientists. Researchers confirmed that student drawings of White, middle-aged to elderly men in lab coats have persisted across time in K12 environments. Our findings complement this literature by revealing that stereotypical exposure to scientists may not only deter science identity formation, but students in college continue to remember these lifelong exposures as pivotal in their view of who has the (innate) ability to become a scientist based on social identities. To change this for future generations, a reimagining and intentional reframing of both K12 and higher education messaging about who does science is desperately needed.

Students also described stereotypical exposure to scientists arising from the media. This supports research that provides evidence of portrayals of scientists across websites and classroom decorations/visual icons that diminished the interest of women and individuals from diverse racial backgrounds in STEM disciplines (Cheryan *et al.*, 2009, 2013; Steinke *et al.*, 2009). Across several studies conducted by Cheryan and colleagues (2009, 2013), researchers found that undergraduate women students were more interested in computer science when media articles and classroom decorations highlighted nonstereotypical computer scientists (Women of Color, etc.). Moreover, masculine environments in computer science decreased women's sense of belonging in science. Although educators may not be able to change media that students engage with outside of the classroom, assignments that portray counterstereotypical scientists through curated content in the classroom may increase students' science identity and relatedness to science (Schinske *et al.*, 2016).

Our study reveals how imposter syndrome is a symptom of white supremacy in social institutions and society, likely perpetuated by macroaggressions in science spaces that may contribute to identity contingencies. Repeated exposure to stereotypical scientists within academic spaces and media, as well as having a lack of social capital, further inhibits students from underserved backgrounds from developing a science identity and limits their Scope of Possibility for themselves and others to become a scientist. CLP offers a framework for reflective opportunities on the social construction of stereotypes as a first step to unlearning them. Thus, we anticipate that future studies could use CLP to assess other types of students' experiences, beyond exposure to scientists, that shape their perceptions of identity-related topics.

Exposure to Counterstereotypical Scientists has the Potential to *Enhance Scopes of Possibility* that Students Perceive for Themselves and Others in Science

There is no panacea to addressing racist ideology that persists in science education, but students in this study overwhelmingly reported an Enhanced Scopes of Possibility after completing Scientist Spotlight assignments. Interestingly, less than half of participants noted any meaningful exposure to scientists that enhanced their Scopes of Possibility to pursue science *before* completing Scientist Spotlights assignments. Despite this relatively low proportion of students, all students described how—*after* the course—the Scientist Spotlight assignments enhanced students' Scopes of Possibility. An *Enhanced* Scope of Possibility is when an individual undergoes a process of unlearning, thus, reconceptualizing an aspect of their identity to no longer be limiting and perhaps even to be an asset. The process of unlearning for a person is highly individualized, but the outcome is similar: what was once perceived negatively is no longer viewed negatively to the same degree or at all. Students described how the featured scientists had aspects of shared identities or backgrounds that aligned with their own, ameliorating identity contingencies. Nearly all students elaborated on how Scientist Spotlights encouraged or affirmed their own pursuit of science. Previous studies investigating various outcomes of Scientist Spotlights found an increase in students' relatability to scientists overall (Schinske *et al.*, 2016; Aranda *et al.*, 2021). Our study adds to the existing literature by providing a qualitative inquiry into the nature of this shift in "relatability" to elucidate how inclusive curricula, like Scientist Spotlights, is meaningful for students, especially those from backgrounds that have been marginalized in STEM.

Even for featured scientists with backgrounds that were different from their own, students described how these assignments challenged their ideas about the types of people that do science. This indicates that students had Enhanced Scopes of Possibility for others from marginalized backgrounds pursuing science as well. Students imagined how Scientist Spotlights assignments could encourage their peers to remain in STEM if they were having doubts or reaffirm their desire to pursue a science major/career. This finding suggests that students believe that their peers who are experiencing Limited Scopes of Possibility (see previous section) could complete an assignment like Scientist Spotlights and re/enhance their Scopes of Possibility to persist. Our work also builds on previous scholarship suggesting that students from backgrounds that are well-represented in STEM have the potential to unlearn biases through repeated exposure to counterstereotypes (FitzGerald *et al.*, 2019). Many wellsprings of evidence have suggested that students from majority groups in STEM also shift in their relatability to scientists following exposure to counterstereotypical scientists, and this has been observed in biology courses across a department (Aranda *et al.*, 2021) coursework consisting of counterstereotypical scientists biographies (Schinske *et al.*, 2016; Brandt *et al.*, 2020; Yonas *et al.*, 2020; Metzger *et al.*, 2023; Costello *et al.*, 2024) and/or in class discussions on Scientist Spotlights (Ovid *et al.*, 2023). Thus, future research on assignments like Scientist Spotlights should continue to consider not only how students from similar backgrounds relate to scientists, but also how students from different backgrounds can gain cross-cultural humility for a wider range of lived experiences.

Last, nearly a third of students expressed how Scientist Spotlights motivated them to consider advocacy to make a meaningful difference for people like them. This idea connects with our conception of Enhanced Scopes of Possibility as it shows students are inspired to pursue science, as well as these possibilities for others from their background. This finding applies the CLP framework beyond the individual and invites us to consider how collective CLPs influence one another. Future scholarship can consider students' proclivity to expand Scopes of Possibility for others through STEM-related opportunities that bridge civic engagement, service-learning, and other forms of critical action.

Tensions Between Limited and Enhanced Scopes of Possibility Through Influential Others

We focused our level of analysis for the present study on whether a salient memory of an experience was limiting or enhancing Scopes of Possibility. Such memories included a range of influential others: family, media, teachers, healthcare providers, and peers. Some influential others were associated with either limiting or enhancing Scopes of Possibility, but for some students, it was not so dichotomous. For example, Esha described how family *enhanced* her Scope of Possibility:

> "I knew I could be a scientist because of my family. My aunt was a psychiatrist, so I was kind of like of course I can do it if she did it sort of a thing. But I also think about growing up in [city redacted], obviously being a college town, every other person I met at volunteer activities or community parties or my friend's parents, they're kind of into science in some way. And so since they were a diverse group, I never really felt like it was solely a predominantly white or predominantly male field."

However, Esha also alluded to experiences of how familial expectations *limited* her Scopes of Possibility:

> "My barriers (to entering science) were mental health related. Can I go into this considering it's so hard to balance cultural expectations, but also academic expectations? So, that was something I had to deal with. I would classify that barrier as ethnicity related sort of. It was just the familial expectations and stuff that I had to balance and overcome."

This tension between family as both enhancing (i.e., social capital from her psychiatrist aunt) and limiting (i.e., familial expectations) Esha's Scope of Possibility adds complexity. We highlight this distinction to show how influential others may not unilaterally drive Scopes of Possibility in a singular direction for all students. Rather, students may perceive and share the sum of their experiences with influential others as nuanced and conflicting. Yosso (2005) discusses familial capital as an oft unrecognized asset of Students of Color in her model of community cultural wealth. While family is cited as a driving factor for Women of Color in their pursuits of advanced degrees in STEM (Yap *et al.*, 2024), there is also scholarship considering the weight of family achievement guilt for low-income, first-generation college-going students (Covarrubias *et al.*, 2021). Our data illustrate how sources of influence can have multiple representatives (e.g., relatives, friends, peers) and may come with extended and repeated exposure (e.g., from birth and over the course of a lifetime). Thus, these potential contradictions in how sources of influence can both limit and enhance Scopes of Possibility warrant additional qualitative inquiry.

Underserved Students Describe how Scientists with Shared Identities and Backgrounds can Affect their *Imagined Scopes of Possibility*

In addition to Limited and Enhanced Scopes of Possibility, students reflected on characteristics that they desired to see represented in the scientists they learn about, which we categorized as Imagining Scopes of Possibility. Despite the numerous advantages associated with introducing counterstereotypical scientists in education, certain studies argue against the effectiveness of diverse role models, suggesting that racial/ethnic and gender representation has minimal impact on student academic achievement (Ehrenberg *et al.*, 1995; Koch and Zahedi, 2018). While our study did not address academic achievement, the students we interviewed shared that they felt encouraged to persist when they learned about humble scientists who disclose their academic or intellectual struggles in science, scientists from low-income backgrounds, those who identify as a LGBTQIA+ member, first-generation scientists, immigrant scientists who studied issues of cultural representation, scientists with mental disorders, activist scientists, and faith-based scientists. The collective list of intersecting identities that students shared was important for them in imagining their ideal scientist and illustrates how personal characteristics and stories of

similar upbringings need more attention beyond what was represented in assignments in this study. For instructors who consider counterstereotypical representations in the classroom and curriculum, we posit that the more varied scientist identities and experiences that students encounter throughout their lifetime, the greater the expansion of what is possible for themselves and others entering science fields. Our findings on the representation of counterstereotypical scientists in inclusive curriculum align with scholarship on the impact of the representation of instructors themselves on students' perceptions of the classroom learning environment. For example, if/how science instructors reveal their concealable stigmatized identities suggests a positive impact on students from marginalized backgrounds (Busch *et al.*, 2022; Busch *et al.*, 2024a; Busch *et al.*, 2024b). When students can envision themselves as scientists—through representation in their curriculum and instructors—our study suggests that this will enhance students' Scopes of Possibility and has the potential to shape their choice to enter (or persist in) science majors and become scientists themselves. The findings of the present study have interesting connections with recent scholarship in neuroscience. Specifically, the hippocampus—a brain region associated with memory—is also associated with imagining the future. Informed by fMRI scans of people who are remembering the past and/or thinking about the future, neuroscientists have formulated the constructive episodic simulation hypothesis, which explains "the key role played by episodic memory in supporting simulations of future experiences" (Schacter *et al.*, 2017). Certain regions of the hippocampus are activated when remembering actual events of the past and also when imagining the future (Schacter and Addis, 2020). Given the ideas supported by CLP—our Scopes of Possibility can be limited or enhanced through our exposure to social institutions and society—one may wonder how students remembering their past events and then imagining their ideal scientist could challenge their future predictions of scientists. Future scholarship could explore connections between neuroscience and also futures thinking in science education (Lloyd and Wallace, 2004) as a means to challenge the long-standing scientist stereotypes that continue to dominate student experiences and memories, creating opportunities for critical hope and imagination for the future of science that this generation will inherit and create (Grain and Land, 2017).

Implications, Future Directions, and Limitations

This study underscores how undergraduate students perceive experiences across their lifetime as limiting or enhancing their perceptions of themselves and others as the types of people that do science. The potential benefits of featuring scientists who hold many other types of identities (e.g., faith, academic struggle, disabled) could further support efforts to increase retention and persistence in STEM, particularly for students from underserved backgrounds (Seymour and Hunter, 2019). With all the benefits counterstereotypical scientist exposure may bring, we encourage readers to consider if this alone can shift the tide of inequity in science and education. Although a valiant first step, there is much more work to be accomplished in developing science spaces that acknowledge historical harms, provide avenues for advocacy and action, celebrate the multitude of identities students hold through justice-oriented curricula, and ultimately change white supremacist policies. Although education policy reform may feel daunting as a way to eradicate white supremacy in education, teachers and instructors can take actionable steps right now within their classrooms, like developing socially just assignments that marry sociopolitical and culturally relevant considerations with science (Ladson-Billings, 1995), addressing racist and sexist assessment practices (e.g., standardized exams, high stakes assessments; Ballen *et al.*, 2017; Randall *et al.*, 2023), and decreasing the "tyranny of content" by diving deeper into real-world socioscientific issues (Tripp *et al.*, 2024). Benefits for teachers and college instructors may include improved relationships with students (King Miller, 2015) and a sense of accomplishment in working toward changing the inequitable nature of science. Our findings offer a framework for future research and practice to apply Cultural Learning Pathways to study aspects of identity, shape new curricular interventions, and challenge longstanding and limiting stereotypes in science and beyond.

Limitations of the present study lay the groundwork for future research in this area. Such limitations include representativeness and sampling bias as well as potential cognitive biases that shaped participant responses. All students were required to complete the survey as a part of their coursework, but they were not required to have their responses included in the study or to participate in the interview. Although we were limited to students who consented to participate in the interview and thus were self-selected, we used the stratified sampling technique by demographics to generate a participant pool that was close to parity with the overall student population of the courses. As the vast majority of our participants were cis-female/women, future work should consider additional sexes and gender experiences. Additionally, recruitment from a range of institution types could aid in assessing whether undergraduate students across contexts and disciplines find the same lack of representation throughout their lifetime and whether counterstereotypical scientist exposure shapes how they view themselves in science.

Regarding cognitive biases that come with self-report (e.g., primacy/recency, demand characteristics, and memory distortion), we found evidence that not all participants are affected equally by the same bias. For example, we can account for the potential impact of primacy/recency bias as some participants shared experiences from early childhood. Because the intention of the present study was to solicit the most salient memories related to students' previous exposure to scientists, future work could use a systematic biographical method, such as Pinar's *currere* method (2019), which takes a year-by-year approach to comprehensively cover schooling experiences. Meanwhile, demand characteristics can show up in any research where participants strive to be the ideal contributor. Given that this can vary by individual participant characteristics as well as their views of the study and/or the researcher (Nichols and Maner, 2008), one could speculate that the interviewer sharing her positionality at the start of this study could have mitigated the impact of this social desirability bias. Last, memory distortion (Roediger III, 1996) is yet another cognitive bias to consider for studies of this design. CLP was originally designed to evaluate experiences through direct observation in formal and informal educational settings, and

ethnography is an approach used in qualitative education research that can address issues of both recency effect and memory distortion. We anticipate that the present *ex post facto* research design can inform ethnographic scholarship in this area to consider students' experiences with science beyond spaces explicitly designed for formal and informal science learning, such as their consumption of social media and engagement in healthcare settings.

The present study offers insights into how undergraduates in a particular place and time recount their previous exposure to scientists and science culture. These students were primed to consider the representation of scientists through the implementation of an evidence-based inclusive curricular supplement, Scientist Spotlight assignments. Future work may consider the perspectives of students who do not receive this intervention as a point of comparison; however, special consideration should be given to the context from which counterfactual evidence emerges (Lemons *et al.*, 2014). One would hope that the representation of scientists from counterstereotypical backgrounds becomes the new normal, such that a comparison group of students without such exposure becomes impossible or obsolete. We would also encourage future studies that use this framework to use member checking as a practice that ensures the researchers' interpretation of the findings align with participants' intentions. In light of these considerations, future investigations are warranted.

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