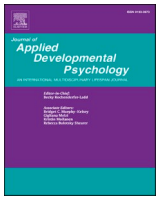
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Perceptions and experiences of science among diverse adolescent youth during COVID-19

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ABSTRACT

The present study adopted a funds of science identity framework, an asset-based, justice-oriented approach that centers the lived experiences of minoritized students in science, in order to explore high school students' perceptions and experiences of science and science engagement during the COVID-19 pandemic. In July of 2020, we conducted 11 virtual focus groups with 38 high school students across grades 9–12 (34 % Hispanic, 23 % Multiracial, 16 % Black) from two university-based summer research programs in the United States serving students underrepresented in higher education and STEM pathways. Our qualitative, thematic analysis underscores the importance of sociocultural and sociohistorical contexts in which science takes place, as well as individual differences in future time perspective and self-efficacy that shaped perceptions and experiences of science and science engagement during the pandemic. We conclude with directions for future research in science identity that incorporates the evolving social and historical circumstances that affect adolescent development.

The present study applies a funds of science identity framework to examine the perceptions and experiences of science and science engagement during COVID-19 among high school students from groups historically marginalized in science. The unprecedented sociohistorical context of the global COVID-19 pandemic disrupted and reshaped identity formation processes in significant ways for adolescent youth (Branje and Morris, 2021; Hussong et al., 2021). Questions such as "who am I" and "who do I want to become" are often negotiated in peer and school contexts within the affordances and constraints of historical circumstances (Branje, 2022), but these settings were dramatically altered due to the impacts of the pandemic. The pandemic also brought science and the role of scientists to the forefront across the globe in an unprecedented way, prompting conversations around who is (and is not) visible, represented, and successful in science, consequently shaping students' beliefs about science and aspirations to pursue science pathways. As such, our work is rooted in an understanding of educational equity that focuses on access to the opportunities and resources required to address each individual's needs (Cipriano & Strambler, 2024), including needs and goals related to science pursuit. The present study draws from various theoretical frameworks and employs an in-depth qualitative analysis to uncover new insights into adolescent science identity development by exploring the nature of students' perceptions and experiences of science and science engagement during COVID-19. This work underscores the importance of considering specific characteristics of the sociohistorical context in which development take place, rather than treating it simply as a variable operating in the background. Specifically, the study identifies future research directions and implications for intervention and instruction that accurately capture the ecological, situated, and dynamic nature of science identity in sociohistorical context.

Theoretical framework: funds of science identity

Our study is rooted in a relatively new theoretical framework called funds of science identity (FSI), an asset-based approach for studying the lived experiences of students in science (Wofford & Gutzwa, 2022). FSI

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0193-3973/© 2025 Elsevier Inc. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

derives from the anthropological concept known as funds of knowledge (FoK), which refers to the accumulation of knowledge and skills that are shared within cultural communities (such as households) and are exchanged with other members through familial networks based on trust (Esteban-Guitart & Moll, 2014). FoK has its roots in anthropology and education and was originally used to counter the deficit perspectives commonly used to study Latine students and their families. While FoK refers to the strategic and cultural resources present within the household (Velez-Ibanez & Greenberg, 1992), FSI refers to how individuals apply their funds of knowledge in their engagement within science learning contexts. The FSI framework encompasses three dimensions, each of which are represented in our study design and analysis: (1) Incorporating lived experiences in shaping science identity, (2) Addressing injustices through identity-affirming contexts, and (3) Accounting for STEM discipline-specific structures of power and context (Wofford & Gutzwa, 2022). The FSI framework acknowledges funds of knowledge as important and useful assets in the science classroom, countering deficit perspectives that focus on what minoritized students lack that prevent them from being scientists or achieving highly in science. As such, we join the growing movement within developmental science to shift away from comparative, deficit-based models and towards strengths-based, culturally relevant approaches that better help us understand science learning and engagement among young people from minoritized groups.

For individuals who possess marginalized identities, science identity formation can be particularly fraught with challenges, as individuals navigate entrenched lay beliefs about the nature of ability and success in science and who is represented and belongs in science. For example, research has highlighted the importance of examining science identity as it intersects with other identities—such as gender, ethnicity, and religion—within sociocultural and sociopolitical contexts (Avraamidou, 2020; Avraamidou & Schwartz, 2021). Other qualitative work also underscores contextual factors such as earlier science-related opportunities, family support, supplemental academic services, and recognition from others in the development of science identity among minoritized students (Rocha, Cabral, Chen, Rodriguez, & Yancy, 2023). Indeed, recent theorizing in this area reflects a shift away from individual-level explanations and towards a dynamic process that involves both individual- and multi-level contexts (Carlone, 2023). Yet, a gap in the empirical literature is to consider how science identity development unfolds not simply within broad sociocultural and sociopolitical contexts, but also how more acute, timebound sociohistorical events can also shape development. We seek to address this gap in the present study.

The role of time in shaping science identity

In addition to sociocultural and sociopolitical contexts, the sociohistorical context also matters. Parallel to the FSI framework, we were particularly interested in examining the role of the sociohistorical context (i.e., the COVID-19 pandemic) and people's perceptions of time and future in shaping students' perceptions and experiences of science and science engagement. Building on previous work using an ecological systems framework to examine COVID-19 impacts on adolescent development (Velez, Hahn, & Troyer, 2022), we specifically examine the role of the chronosystem. The bioecological model of human development posits that development results from interactive processes—through bidirectional person-context interactions—that occur at multiple levels (Bronfenbrenner & Morris, 2006; Skinner, Rickert, Vollet, & Kindermann, 2022). In this model, the *chronosystem* refers to the phenomenon that "developmental processes are likely to vary according to the specific historical events that are occurring as the developing individuals are at one age or another" (Tudge, Mokrova, Hatfield, & Karnnik, 2009, p. 201). The chronosystem is understudied but critically important to the theory because it encourages us to think about how particular sociohistorical conditions shape development. Although the present study examines how adolescent youth reflect on their perceptions and experiences of science and science engagement during the COVID-19 pandemic, we might be able to discern some themes that generalize to other significant historical events. For example, after the terrorist attacks of September 11, 2001, research showed how this event, which unfolded in specific locations in the United States, had far-reaching impacts that shaped adolescent youth in the United States and around the world (Hoven et al., 2005). Both events also sparked a shared, widespread fear and uncertainty that affected everyday individuals. However, what is particularly relevant about the COVID-19 pandemic was the universal experience of social disruption across all geographic regions, transcending political and cultural boundaries, as the virus transmitted and mutated worldwide.

The COVID-19 pandemic also elevated the importance of science in unprecedented ways (Delicado & Rowland, 2021). Scientists such as Dr. Tedros Ghebreyesus, director of the World Health Organization, and Dr. Anthony Fauci, director of the National Institute of Allergy and Infectious Diseases in the United States, were prominently featured in news media. Perhaps inspired by these figures as well as the renewed interest and appreciation for the role of science and medicine, applications to medical schools in the United States increased dramatically during the pandemic, which was dubbed the "Fauci effect" (Burke, 2021). The COVID-19 pandemic was a unique sociohistorical event—it occurred at a particular moment in historical time—that fundamentally shifted our understanding of concepts and ideas that many in the West had not previously grappled with, such as the role of collective action and the tension between individualistic and collectivistic understandings of the self and society. The pandemic also foregrounded mortality and death in ways that have not been encountered in recent memory. As such, the pandemic might have shaped individuals' beliefs and values about the world, including science, as well as altered opportunities and pathways that may have been normative prior to the pandemic (Burke, 2021; Fong, 2022). As such, as our research progressed, our study aims shifted to encompass the affordances and constraints that adolescent youth perceived in science during COVID-19, emphasizing the role of student engagement and how students reflect on their participation in scientific spaces in shaping science identity (Brickhouse et al., 2000; Burke, 2021).

The COVID-19 pandemic can be seen not only as a time-bounded event but also as an event that redefined our understanding of time as "pre-pandemic" and "post-pandemic." The pandemic also shifted individuals' perception and experience of time itself. Collective trauma from events such as the pandemic can shape individuals' perceptions of time and their future identities (Holman & Grisham, 2020). Empirical research from a national United States sample revealed that individuals experienced distortions in time perception during the COVID-19 pandemic, which were associated with negative mental health outcomes (Holman, Jones, Garfin, & Silver, 2022). These studies build on a long history of research on future time perspective that examines the various dimensions that characterize how people perceive time in relation to one's future goals, including one's perception of the immediacy of one's future (see Husman & Lens, 1999, for a review). Future time perspective shapes identity formation (Luyckx, Lens, Smits, & Goossens, 2010) and is an important aspect of adolescent development more broadly (Johnson, Blum, & Cheng, 2014). Adolescence is a critical time for science identity development, but research has largely neglected the role of the sociohistorical context and the perception of time in how youth navigate science identities. We propose that the COVID-19 pandemic—as a defining sociohistorical event that made science and scientists salient and shaped how people perceive themselves in relation to others as well as their own future goals—presents an important opportunity to examine how adolescent youth reflected on their own engagement in science during a time characterized by significant disruption and challenge globally. Moreover, because the COVID-19 pandemic occurred during a time of renewed attention to inequality and social justice around the world, another contribution of the present study was to systematically examine the nature of students' reflections of

science and their science engagement during unique sociohistorical circumstances.

Study aims

The present study sought to examine how high school students, during a unique and generationally-defining sociohistorical event—the COVID-19 pandemic—reflected on their perceptions and experiences of science and science engagement after watching videos of mentored science learning activities featuring students of similar ages and backgrounds. We expected that the pandemic would elevate the importance of science for youth in visible and concrete ways, but we did not know exactly how our participants would perceive its impact on their own views of science and science engagement. As such, our approach was more exploratory, with a focus on hypothesis generation rather than testing specific hypotheses. Our data analysis and interpretative work were designed to provide a blueprint for applied developmental scientists in designing future empirical work. Reflecting our desire to be more inclusive of the various ways that science identity can be conceptualized and operationalized, we applied a funds of science identity framework (alongside ecological systems theory) and adopted qualitative methods to elevate the voices of a gender and racially diverse sample of adolescent youth. Finally, we were particularly interested in examining how the COVID-19 pandemic context could expand our understanding of science identity, so we analyzed data collected during the height of the pandemic and developed questions to probe for students' pandemic experiences as they related to science and otherwise.

Materials and methods

Study development

The present study is drawn from a larger project that developed a self-directed online curriculum which includes a series of digital storytelling videos (Robin, 2008)—co-produced by the authors—that portray youth of color pursuing science academic and career pathways. The videos feature authentic depictions of mentored science learning activities between undergraduate mentors and high school mentees interacting together in both formal (e.g., natural science labs at a major research university) and informal settings (e.g., on-campus residence and dining halls). The videos were originally designed using principles of identity-based motivation theory (Oyserman, 2015), such as encountering positive and negative forces, overcoming roadblocks, and imagining future selves in science; these media depictions can be particularly powerful in shaping STEM identity among adolescent females (Steinke, 2017). These videos also reflect each of the three dimensions of the FSI framework: (1) the videos elevate and amplify students' actual lived experiences and identities in science, (2) the interactions featured in the videos occur in identity-affirming contexts both in and out of the lab, and (3) the mentors and mentees work in labs spanning different areas of science, highlighting discipline-specific experiences and insights. Although these videos were produced before the start of the COVID-19 pandemic, we saw this as a unique opportunity to use these videos to prompt reflections about students' perceptions and experiences of science and science engagement during a historical moment when science had become especially salient. Indeed, qualitative analyses of COVID-19 narratives have uncovered specific themes surrounding the social construction of the coronavirus and its impacts, indicating that storytelling can help individuals make and convey meaning especially during times of crisis (Mclaughlin, Pelletier, & Boespflug, 2022). As such, another contribution of the present study was to use these videos—as a sort of "funds of knowledge" possessed by mentors from groups underrepresented in STEM—to prompt deeper and more authentic reflection from adolescent youth regarding their own experiences in science. That said, our analyses were not designed nor intended to adopt a critical lens to specifically interrogate race and gender in the development of science identity. Rather, we took a more exploratory approach to see what types of identity-related reflections emerged unprompted based on our videos and within our diverse sample.

Participants

In July of 2020, we conducted 11 virtual focus groups with 38 high school students (50 % female, 40 % male, 5 % non-binary or gender nonconforming) from two university-based summer research programs in the Pacific Northwest region of the United States. These programs served students traditionally underrepresented in higher education and STEM pathways. Thirteen participants identified as Hispanic/Latine (34 %), nine as multiracial (24 %), eight as White (21 %), and six as Black/African American (16 %). Two students did not provide gender and race information. Participants were roughly evenly distributed across the four grade levels of high school (18 % 9th grade, 32 % 10th grade, 24 % 11th grade, 24 % 12th grade).

Procedure

The study was approved by the Institutional Review Board at the [name of university masked for peer review]. After obtaining parental consent and student assent, students were randomly assigned to focus groups that took place entirely online; due to scheduling idiosyncrasies and non-attendance, focus groups had anywhere from one to five students. Focus groups took approximately 90 min and were led by one trained member of the research team; each author conducted at least one focus group. Focus group recordings were professionally transcribed by a third-party transcription service; transcriptions were reviewed by the project team to ensure accuracy.

We used a focus group methodology for four reasons. First, we wanted the focus group to reflect the group learning experience for which we originally designed the videos. Second, we recruited the participants through a summer research camp; the focus group methodology allowed us to build on the classroom dynamic that students were already familiar with. Third, the focus group dynamic allowed for the exchange and building of ideas only possible in group exchanges. A group format can often encourage greater openness in participant responses through what is known as a "loosening effect" (Vaughn, Schumm, & Sinagub, 1996). Indeed, research has shown that focus groups are more likely to yield more personal disclosures and sensitive themes compared to interviews (Guest, Namey, Taylor, Eley, & McKenna, 2017). Further, because participants are not required to answer every question, responses that are made are more likely to be meaningful and genuine (Vaughn et al., 1996). Fourth, a group format allowed us to better identify common threads among students and if there was consensus or disagreement about what they had just watched in the videos.

Focus group protocol

The focus group protocol was developed collaboratively by the project investigators and graduate research assistants and was designed to elicit responses aligned with our broad research themes but also to generate viewer feedback on our video content. We wanted the protocol to capture students' experiences with science during the pandemic and their aspirations for pursuing science in the future, and the questions were worded in a way to give participants maximum freedom to respond in their own way. The focus group began with initial questions about participants' perceptions of and personal experiences with science and the pandemic (e.g., Where have you noticed science happening over the past several months?). Then, students watched two videos: (1) a four-minute video that introduced the video series as well as the undergraduate mentors and high school mentees that would appear in the rest of the videos (all participants watched this video), and (2) one of the

four main videos (ranging from two to eight minutes in length) randomly assigned to their group. Although the videos are designed to be viewed as part of a series within a curriculum, the videos can be viewed individually because each video captures a particular theme. (Links to the videos can be found at https://osf.io/8cwdy.) In the present study, the videos were used to prompt more authentic reflections around science and science engagement. Focus groups continued with questions that prompted participants to connect what they watched to their own experiences and perceptions of science, as well as questions that were specific to the second video they watched. The session ended with questions about participants' interest in science and their perceptions about the future. Example focus group questions are in Table 1. A full list of the focus group questions can be found in the Supplementary Material.

Positionality statement

Study design and qualitative data analysis are always influenced by the backgrounds and intersectional identities of the researchers. Therefore, each author reflected on their experiences and identities and how they might influence the research process. The research team encompassed a range of academic disciplines (developmental psychology, educational psychology, communication sciences, critical studies), racial and ethnic identities (Asian American, African American, White), socioeconomic classes (working class, middle class, upper-middle class), and career levels (graduate student, early and mid-career researchers). Reflecting the first author's academic training, the study's broad framing was influenced by developmental theory. The project team's disciplinary diversity ensured that this conceptual organization was also combined with research perspectives and approaches that were able to capture the nuance associated with science identity development in context. Using a process similar to the framework of researcher racial and cultural positionality proposed by Milner IV (2007), the team engaged in collaborative sensemaking that sought not to elevate a particular approach but to negotiate different research perspectives while honoring and elevating the students' voices, which were the primary focus of this study.

Coding and analysis

We employed a reflexive thematic analysis (Braun & Clarke, 2021) incorporating both deductive and inductive coding elements (Byrne, 2022). Because our study focused on science identity development and salient identity markers (such as gender and race/ethnicity), we initially sought to examine the focus group responses through these lenses. However, to preserve the authenticity of participant voices and capture divergent and unexpected perspectives, we also coded inductively to identify cross-cutting themes that we did not originally anticipate.

Various approaches are used to establish interrater reliability in qualitative research. Acknowledging that establishing and aiming to reach a particular reliability threshold can sometimes contradict the spirit of collecting and analyzing qualitative data, we adapted the approach outlined in Campbell, Quincy, Osserman, and Pederson (2013) for examining interrater consistency in coding. First, guided by theory and prior empirical research, the coding team generated a preliminary coding dictionary. Using this initial set of codes, coders individually examined the same focus group transcript selected for training and reliability purposes. After a group discussion to refine and expand our coding dictionary to incorporate emergent themes, coders recoded the transcript. This transcript was divided into four sections of roughly equal length and assigned to each of the four coders (the first four authors of this paper). Each coder identified and extracted meaningful units of text that were assigned a code or codes. Then, each coder saved the document with just the selected meaningful text units but without the codes. The lead coder then compiled all of the meaningful text units and distributed these to the coding team for double coding. As such, this allowed each coder to be the "expert coder" for a section of the transcript, and the codes from the coding team could be matched against the codes assigned by the expert coder.

Upon completion of the double coding, the lead coder compiled a spreadsheet detailing how each coder coded each text unit, highlighting any text units that had substantial disagreement. Overall, the coding team exhibited substantial agreement on how each text unit should be coded. Of the 50 distinct text units that were coded for reliability purposes, there was 100 % agreement on at least one code for 40 units, 75 % agreement (i.e., three out of four coders agreed) for 7 units, and 50 % agreement for 3 units. The coding team then engaged in a "negotiated agreement" process (Campbell et al., 2013) where we discussed discrepancies in the coding process; after reaching consensus on disputed text units, the four coders individually coded the rest of the transcripts.

Table 1
Example focus group questions.

Pandemic experience and science (all students)
Has science directly impacted your life or the lives of your family or friends? If so, how?
Has your experience in the pandemic changed the way you think about science? If so, how?
Video 1: Skills and attitudes to do science
What qualities make the students in the video good scientists?
Do you share any of these qualities?
Video 2: Look and feel of science
Do any memories come up for you about doing science in the past?
After you graduate from high school, what will you be doing that relates to science in some way?
Video 3: Positive and negative forces
What experiences, people, or opportunities helped the students in the video succeed in science?
What experiences, people, or opportunities have made it more challenging for the students in the video to succeed in science?
Video 4: Pathways to the future
What's a roadblock you think you will encounter in your life?
What's something you can do to overcome this roadblock?
Pursuit of STEM career pathway (all students)
Are you interested in pursuing a science pathway? Why or why not?
Does your future feel more uncertain now than before the pandemic began?

Table 2
Coding dictionary.

Code	Description	Number of text units
Pandemic-related	Any excerpt—identity or otherwise—that relates to the pandemic or the coronavirus	142
Interests (now-focused)	Interests that refer to the present time	126
Career / aspirations (later-focused)	Mention of aspirations or career plans that refer to a future time	89
Other identity	Other facets of identity that are not related to race/ethnicity, gender, age, and SES/class. Must address aspects related to a sense of self for the individual.	37
Age	Mention of age	24
Racism / discrimination	Language around experiences or observations of racism and discrimination	17
SES / Class	Mention of SES or class	16
Race / ethnicity	Mention of race or ethnicity—explicit or implicit OK	13
Gender	Mention of gender—explicit or implicit OK	11
Intersectionality / diversity	Non-specific reference to diversity (i.e., does not specifically identify which identity markers are included when referring to "diversity")	11

Table 2 presents the final list of codes, definitions, and frequency of text units. The most common codes were pandemic-related (29.2 % of text units), interests (25.9 %), and career/aspirations (18.3 %), reflecting the salience of sociohistorical context and time as prominent themes for our adolescent sample, as we will describe later.

Then, we coded the focus group data inductively to identify cross-cutting themes that were present across multiple students and multiple focus groups. We used the experience from our deductive coding work to guide this process. The lead author then led a collective sense-making process that incorporated each coder's interpretations of the data. This iterative process yielded a set of four themes that form the basis of our results.

Results

We identified four themes that reinforced some of our deductive coding work (e.g., pandemic impacts and the role of time) but also extended this work by characterizing with greater detail and nuance the perceptions and experiences of science and science engagement among adolescent youth during the COVID-19 pandemic. All names are pseudonyms to protect participant privacy.

Science identity development through peer, family, and community influences

Our focus group participants referred to their relationships with others, especially peers and parents, in their reflections about science in relation to the pandemic. Geri noted her relationship with family members in shaping her future plans in science:

> *"Yeah what maybe got me interested was the fact that my parents have always said that they would love to have someone, one of me or my sisters become a doctor so we don't have to pay so much just for a headache or something or just so we don't have to go to the doctor for every little thing because, and then it just adds up to more and more bills. That and my cousin is also, she also wants to study the same career as me so she's like, when I told her I wanted to go into medicine she was like, "Yes you should definitely go you should pursue it. It was the best thing for me ever." So I'm just inspired by those." (Geri, 11th grade, female, Hispanic/Latine).*

For other students, the changing family dynamics that resulted from the pandemic—or perhaps, preexisting dynamics that were amplified by the pandemic—were front of mind for some students. Avery, a 10th grade student identifying as non-binary and multiracial, explained:

> *"It's been difficult because not only do I have my sister, but also my brother who is turning 14 in 12 days, I think. And then I have my dad who has asthma and he's also OCD, it's hard because he's always wanting everything clean and we only have four chores a day and he thinks it's not enough, but it's too much in our opinion. And then a mom who's been starting her own business, that's a bit hard. And then we have two dogs too, it's been a lot of people in one house."*

Although participants were not able to interact with peers face-to-face as they normally would, it was clear that the influence of similar-aged peers was still important, even in virtual settings. Allison noted that seeing familiar faces in the videos strengthened her interest in pursuing science:

> *"I believe the most interesting part was seeing familiar faces. I didn't think that this video was going to be about our fellow classmates partaking in this video explaining how they feel about science. So seeing their faces made me feel more comfortable about doing the same thing that they did." (Allison, 11th grade, female, Hispanic/Latine).*

Other students mentioned other points of similarity. Samara, a 10th grade student identifying as both White and Middle Eastern, mentioned the gender inequities that exist in STEM and connected it to how the videos depicted young female students just like her. Avery also noted how similar the students were in age to them. Across the different videos, participants made explicit connections with the characteristics, experiences, and perspectives of diverse peers they watched in the videos.

Broadening the scope beyond peers and family members, other students reflected on the role of community—broadly defined—in shaping their perceptions about science. Nicole, a mixed-race female identifying as African American, remarked how the videos emphasized the importance of community, demonstrating how youth can leverage the funds of knowledge present in their local communities to inspire and propel their own academic and career pursuits:

> *"...knowing that there are people like you that want to do what you want to do and there's a community that can support you through that and help educate you, like how the college students helped the high schoolers. … maybe we can find better ways to communicate and then build a community of STEM people that really want to pursue it."*

Nicole also went on to reflect on how the pandemic laid bare structural inequalities in society:

> *"I think that certain communities don't get the same access to the healthcare and have all the services to really protect themselves which results in, like, the unequal distribution of the cases and how they're mainly in, like, lower income communities."*

Borrowing language from ecological systems theory, these responses demonstrate how relationships and interactions with the microsystems of family and peers and the macrosystem of community shaped how students reflected on science and their own interest and engagement in science.

The pandemic's impact on how students viewed science

As we described earlier, we expected that the pandemic would elevate the importance of science for youth in visible and concrete ways, but we did not know exactly how our participants would perceive its impact on their own views of science and science engagement. Our focus group data yielded valuable insights into this question in ways that connect to individuals' perception of and relationship with historical time. Joseph, a high school senior, recognized the historical significance of the pandemic:

> *"This is the first pandemic everyone has been through, besides the one that happened many, many years ago. If that was bad enough, then what's happening now is bad enough. This is kind of teaching us what we should do, and how we should prepare for the next one, just in case it happens." (Joseph, 12th grade, male, African American).*

Jade provided a different, more concrete perspective, emphasizing how science could directly affect everyday life experiences:

> *"Well, before COVID-19 I thought that science is more like scientific discoveries and all of that was more like a general universal thing… I didn't think it was never focused on small towns and really focus on a small amount of people but actually grow into a large amount of people. And I never thought I would actually see that in my lifetime." (Jade, 11th grade, female, Hispanic/Latine).*

Eddie, a high school senior, made a distinction between the current historical period and previous generations, reflecting on how individuals consumed news and engaged with information and with each other:

> *"I would say definitely how people are treating people nowadays just is a little bit different. If you go back and you look at the 50s or the 60s or whatever, where everybody was at least a little bit nicer to each other and things like that. I think nowadays we're a little bit more paranoid with some of the stuff going on and that's just how we are, I guess, as people. It was different back then because we didn't have all this stuff that we have*

today. There's all this news and things getting out that we didn't exactly have way back in the day when people were just kinder to each other. And whereas today you get a little tiny bit less of that, which I think is a big issue because I think we all need to be nice to each other, golden rule kind of thing." (Eddie, 12th grade, male, multiracial).

Eddie's comment reflects a theme that we originally proposed in framing our study—that historical events and circumstances can affect how individuals view the world around them, including their perceptions and experiences of science. Other students expressed confusion and frustration that family members, acquaintances, and public figures would sow fear, uncertainty, and doubt regarding the science underlying COVID-19, indicating that polarization and social media might have affected how individuals consume and disseminate information about science.

Allison, the student we encountered earlier who recognized the familiar faces from the videos, made the distinction between the pandemic's impact on her views about science versus scientists. She explained:

I don't think it's changed the way I think about science. I just think it's changed the way I think about scientists. The fact that we're still dealing with COVID, it makes me believe that there's a lot of things going on that scientists still haven't figured out about COVID-19. And this is why they're taking so long with the cure because every time I believe that they tried to make the cure, another … If you have pink eye, or a sore throat, or a fever, you can get COVID now. And they're coming up with new symptoms, so I believe they're trying to put a stop to it, but there's so many other symptoms coming up, that they can't.

Allison's reflection provides a clear example of how the pandemic allowed her to draw clearer connections between other common ailments and COVID and how that might complicate efforts to develop an effective cure, reflecting a more non-linear path of scientific discovery. Damian expressed a similar view in reflecting on the nature of scientific progress:

"The thing with this and science is like pros and cons. This is a firsthand basis during a pandemic in seeing how science plays a big role in it. This is our first time seeing the process it takes for scientists, and how long it takes to develop new ideas, and slowly move towards a progress of finding a cure. And we usually look at science and we're like, "What's the process? How does this work?" And now we get to see the scientists themselves work day and night. Day and night we see slowly that process in these coming months." (Damian, 11th grade, male, Hispanic/Latine).

Consistent with Dimension 1 of the FSI framework, both of these reflections demonstrate how individual lived experiences of the pandemic can shape how students think about science and science engagement.

One of the unexpected themes that emerged from our analysis was students' reflections on how their perspectives on life changed not just because of the pandemic, but also due to other historical events that were unfolding at the same time. Justin referenced the Deferred Action for Childhood Arrivals (DACA) program, which related to the policy of deportation of individuals who came to the United States as children, Samara mentioned gun violence and gun control, Brynn mentioned climate change, and six students referenced the Black Lives Matter movement. Consistent with research showing that adolescence is a time of increased prosocial development and behavior (Crone & Achterberg, 2022), students' reflections about science was inextricably linked to broader issues of social justice. Indeed, Dimension 2 of the FSI framework centers the importance of how students contend with injustices. Our results show that injustices do not need to be present only in scientific spaces in order for these to shape science identity; rather, broader societal injustices can affect how students think about and engage with science. Yanni encapsulated these sentiments in his reflection:

"I think science has helped me change my perspective on a lot of things over these past few months. Like, at the start of the year we all brushed off coronavirus as just kind of like a flu or something we shouldn't really care about, but over the past few months, my perspectives on a lot of things, like could be political, could be scientific, could be anything. My views on a lot of things have changed just because of science and the pandemics going on." (Yanni, 10th grade, male, White and Native).

In summary, students' perceptions and reflections of science appeared to be heavily influenced by the pandemic as well as students' own experiences of the pandemic. However, there was very little discussion around students' own actual science engagement, which could be due to the lack of meaningful science activities that occurred during the last few months of the academic year which immediately preceded the focus groups.

The thwarted pursuit of social and emotional goals

The pursuit of social and emotional goals with family members and similar-aged peers was front and center for many of our adolescent youth. Becca explained,

"What's really important to me, is keeping my family safe and myself safe, and just staying inside. That's what I've been doing this whole time, and just trying to not think about that much of the virus because when I think about it, I get emotional. So I try not to think about it as much as I should, but it always comes up. So yeah." (Becca, 10th grade, female, African American).

Participants also mentioned how the pandemic shaped how they think about themselves in relation to other people they care about. Angel shared:

"What I care about and during this pandemic is to keep my family safe, away from the virus and all that stuff and to have the right information, instead of those false rumors that are going around social media, and informing my family with the right information." (Angel, 11th grade, male, Hispanic/Latine).

Jasmine, one of the few ninth grade students in our sample, explained the tension behind pandemic restrictions and her need for social and emotional closeness:

"The issue that I care about is that basically, people can't really see each other if they want to see each other, but at the same time it's good that we can't see each other because then we get coronavirus. But, it's also sad that we can't see our friends and some of our families because my grandma wants to come over, but my parents are like, no you can't come because we get coronavirus maybe. Because I usually spend my summers with my grandparents, but I can't do that this summer." (Jasmine, 9th grade).

However, the complex dynamics brought on by increased time at home with family members, fewer opportunities to engage with friends in person, and evolving messaging regarding virus precautions, impeded students' ability to successfully pursue social goals with others successfully. Damian, an 11th grade male of Hispanic heritage, explained the difficulty associated with wanting to reach out socially in meaningful ways during the pandemic, but experiencing challenges: *"Mentally, knowing about all these things, and then knowing people personally can really have an effect on you. And since you're blockaded, there's not many people you can talk to. Physically, that really messes with your mind."* Samson, a 10th grade African American male, described with some frustration the one time he was allowed to interact with friends at school, *"The only time I was allowed to, it was at a basketball court and we were six feet apart right until the end."* This tension between peers and parents was exemplified by Avery in reflection about their struggles associated with being at home due to the pandemic:

"I've only seen one of my friends since this has happened and that was hard. That's probably been the hardest part- is normally I get all my

support from my friends and I usually talk about things in person because my parents read what's on my phone and I hate that. I can't say something because of that."

Research has shown that while adolescents understood the rationale behind COVID-19 public health guidelines, their desire to spend time with friends was justified as a way to protect their mental health (McGuire, Farooq, & Rutland, 2023). In our study, though students reported interacting with other students online, adherence to physical distancing guidelines may have been a barrier to pursuing more meaningful social goals with peers. As before, but perhaps not surprisingly, very little of students' reflections around their social and emotional goals revolved around their perception and experiences of science, as shown in the participant quotes. Rather, it appeared that science was largely seen as an achievement-related endeavor which was incompatible with students' desire to pursue social and emotional closeness, which was prioritized during the pandemic.

Students' mixed sense of personal agency about their futures in science

Participants' reflections about their future engagement in science were often uncertain and couched in abstract terms. It appeared that the videos helped prompt participants to think more about what a science-related future might look like for them, but these reflections were vague and not closely tied to specific aspects of the self. Grace, a female senior who identified as African American and Hispanic, said: *"I really liked seeing the high school students in the lab actually performing the experiments because it motivated me and maybe I can be there someday. That was cool."* That statement of possibility reflected what appeared to be a newfound sense of agency.

In contrast to Grace, however, most participants expressed considerable uncertainty regarding whether their futures would be related to science. Interestingly, although all of the videos depicted mentors and mentees working in specialized science laboratories, the specific science activities shown in the videos did not appear to be particularly salient to our participants. If participants did notice them, they did not find them meaningful enough to talk about them, as evidenced by the lack of specificity in their responses or discussing science topics that were unrelated to the themes highlighted in the videos. Samson said:

"I don't know yet what I'm going to get my degree in because I'm only in 10th grade so I'm trying to figure out by the end of the year. Maybe help endangered species, I don't know. Help the world stop using plastic."

Although Samson talked about specific examples of what they could do in a science-related career, it was not clear whether he had a personal interest in endangered species and plastics, or whether those were simply the two science-related issues that came to mind. It was also notable that this student wanted to figure out his college degree plans by the end of the year, even though he was only in the 10th grade. This quote highlights the uncertain sense of personal agency that Samson felt regarding his future.

Despite the lack of specificity in the participants' reflections about their futures, it was clear that students spent a lot of time thinking about their future selves; however, much of these reflections were negatively valenced and reflected a general anxiety and concern about the future. Carmen, a 10th grade Hispanic female student, shared: *"And I've just been worrying about school next fall. I mean, this fall, and how are we going to do everything. And it's pretty much it. Just the worrying of the future."* Jasmine also echoed these concerns: *"I don't know how long this pandemic will go on, if it will affect college, or how well I learn in school, or maybe what job I get of some sorts."* Reflecting the challenges associated with time perception during the pandemic, Jade remarked, *"I'm more concerned about how coronavirus is going to affect... Is it like a short-term effect or a long-term effect and what is it exactly going to be affected in the long term?"*

Other students had a very different time orientation that appeared to reflect a detachment from one's future. In response to a question asking participants to visualize their possible future self, Yanni explained how he did not prefer to think about his own future at all:

"I typically don't tend to look into the future for myself because I have had really a lot of past experiences that changed my perspective on my future self, so I kind of just tend to avoid thinking about it, and kind of just fully immerse myself in the present, to kind of understand it to my fullest ability, I guess."

In response to the focus group question, "How do you think the people that you watched in the video will be ready to help us deal with crises in the future?" Samson responded, *"I don't think anyone will because at the end of the day, they are just kids."* The response "they are just kids" is particularly interesting, as the students depicted in the videos were high school and college students, very similar in age to participants like Samson. Yet, the question posed was about how the people in the video could help address crises *in the future*, instead of in the present time. It appears Samson was unable, or unwilling, to imagine a future where these students would have the ability to make a difference. Whether this reflected a pessimism about the current state of the world, or the student's own pessimism about the future or doubts about his personal agency to affect it, was unclear. But Samson was not alone in his sentiment; Nancy also expressed doubt about her agency to make a difference:

"Definitely we're going to have more advances but at the same time I don't feel like we're going to be fully prepared for example we were not prepared for the coronavirus and maybe something is going to happen in the future."

However, in contrast to the uncertainty and negatively valenced responses presented above, some participants engaged in cognitive reappraisal to reframe these challenges as opportunities for growth. Up until now, we have discussed how the pandemic context likely reduced feelings of personal agency among adolescents. However, Avery, the same student we introduced at the beginning of the Results section, took a different, more optimistic perspective by reflecting metacognitively about time and the future. Rather than dwelling on lost time and opportunities, Avery saw a silver lining:

"I guess I feel like I've been more grounded since the pandemic has started and I've had more time to think a lot more time to think. Really, I've just been like, 'Yeah, this is what I want to do.'"

Avery was not alone in this sentiment; Lincoln, a 10th grade Hispanic student, also expressed an optimism that he would be able to contribute to a brighter future: *"I think for me it makes me excited, that me and people I know get to be a part of... The next generation get to be a part of like solving these problems next."* Though the pandemic was broadly understood as negative or challenging for adolescent development, it may have provided adolescents like Avery and Lincoln with unique opportunities to reflect on their identity and aspirations—related to science and more broadly—in ways that might not be as apparent or available during normal times.

Discussion and implications for research and practice

Science identity is rooted in dynamic sociocultural and sociohistorical context

In our focus groups, students reflected on their own experiences (reflecting their individual funds of science identity), as well as interpersonal dynamics and connections that shaped how they reflected on their personal identities during the pandemic. Our insights are not new; they are broadly consistent with research indicating the importance of interpersonal connections among teenagers, particularly youth of color, for promoting STEM learning outcomes (Gray, McElveen, Green, & Bryant, 2020). Perhaps it is not surprising that the videos, which

featured authentic interactions between undergraduate mentors and high school mentees engaged in science research, would prompt student reflections about relationships with friends, family members, and other individuals. However, students rarely made explicit references to their own personal racial or gender identities in their reflections, even though the videos prominently featured mentors and mentees of color and highlighted themes related to struggles in science due to race- and gender-based bias and discrimination. This could be because our focus group questions did not explicitly invite students to discuss their personal identities; nevertheless, students' responses clearly indicated that social justice issues, including issues related to race, were front and center in their reflections.

In addition, although we had a diverse participant sample, we were not able to drill down more deeply to examine within- and between-group variation in science engagement as a function of gender and racial identities. Research indicates that individuals vary in terms of how connected they feel to their racial group (e.g., Sellers, Smith, Shelton, & N., Rowley, S. A. J., & Chavous, T. M., 1998). Given the uneven racial disparities that exist in STEM fields, as well as individual differences in how people see themselves within a particular racial or ethnic identity group, we must be cautious in generalizing our results too broadly. Yet, other research has shown the benefit of intentional, culturally affirming approaches for promoting science identity development among Latinx students, particularly female Latinx students (Camacho et al., 2021; Vasquez-Salgado et al., 2023), indicating that mere exposure to diverse representations may not be sufficient for producing meaningful change in science identity development. Indeed, the intersection of multiple marginalized identities can have profound implications for how students experience science and success in science (Avraamidou, 2020). As such, future research could examine whether and how these findings might vary as a function of various dimensions of racial and ethnic identity (such as centrality and salience), as well as other identities that individuals possess, such as gender and socioeconomic class.

Also contrary to our expectations, many of the students' responses did not relate specifically to science even though the videos intended to prompt authentic reflections and our focus group questions both centered on science. Rather, as demonstrated in our example quotes from participants, students often touched on historical and political issues often unrelated to science. The year 2020 was marked by a renewed focus on racial injustice due to highly publicized instances of police brutality in the United States. As previously mentioned, students mentioned the Black Lives Matter movement in their focus group reflections in addition to DACA, gun control, and climate change, demonstrating how salient these other sociohistorical events and political issues were for youth, in addition to the ongoing pandemic. Therefore, our findings show that studies of science engagement and science identity are likely to be incomplete if they also do not take into account the other identities and values that young people possess (which are themselves changing during adolescence), as well as the unfolding of historical events that shape how individuals view themselves and the world around them. As such, as individuals' sociocultural and sociohistorical contexts evolve, microgenetic approaches that are better able to track changes over time in science engagement and science identity could build on more commonly used methods of simple pre-post change. Applying this blueprint to other areas of inquiry, researchers could consider assessing how individuals understand different developmental concepts and phenomena (instead of simply assessing change in variables), as these understandings themselves could change in subtle or dramatic ways across time. Dimension 3 of the FSI framework underscores the importance of attending to discipline-specific (e.g., biology vs. computer science) structures of context and power in shaping science identity. Our research was not able to directly examine discipline-specific structures, but our data show that power structures and histories of oppression more generally were front and center for adolescent youth, indicating that systems of privilege and power at multiple levels are important factors in shaping science identity.

Future time perspective and the pursuit of social and emotional goals during COVID-19

The pandemic context impended the pursuit of social goals, leading adolescents to grapple with their desire for social connection with peers in the face of virus restrictions and school closures. The tension between the pursuit of social goals and the numerous barriers preventing meaningful social interactions during the pandemic comes into clearer focus when examined through future time perspective and socioemotional selectivity theory (Carstensen, 1992). Socioemotional selectivity theory posits that the perception of an extended time horizon is related to adopting goals focused on achievement. People who have a longer time perspective tend to prioritize goals related to achievement, such as academic, career, and personal goals. However, people who have a shortened time perspective tend to prioritize social and emotional goals, such as fostering and maintaining relationships with other people (Carstensen, 1992). Shifting priorities from future-oriented to present-oriented may be a function, not of the end of life, but simply of an ending of a significant life phase or the immediacy of a life-changing event, such as graduation from college (Kurtz, 2008). Prior research on adults have also shown that the perception of time can become compressed during traumatic events (Fung & Carstensen, 2006).

Developmentally, adolescents and emerging adults are likely to have a more extended time horizon. But the shift away from future and achievement-oriented goals can occur when people are reminded of catastrophic events that make life seem shorter, such as the terrorist attacks of September 11, 2001, the 2003 SARS outbreak, or the 2004 Indian Ocean tsunami (Fung & Carstensen, 2006). A study of Swedish youth who experienced the 2004 tsunami in Thailand reported shifting their time perspective that resembled the goals of older people and they reported feeling as if their lives were coming to an end (Västfjäll, Peters, & Slovic, 2008). Based on this theory, we would expect that a sociohistorical event such as a pandemic that heightens the fragility of life would prompt individuals to shift from pursuing achievement goals to social goals. Although adolescence is characterized as a developmental period during which youth explore and try out possible future selves (Oyserman & Fryberg, 2006), we extended this work to show how the COVID-19 pandemic primed otherwise healthy young adults to think about the fragility of life, and affected students' ability to visualize and articulate their futures. Recent quantitative research on the effects of COVID-19 on future time perspective found that younger age was associated with greater vulnerability to the negative impacts associated with the pandemic (Fynes-Clinton & Addie, 2023). The students' voices in our study provide us with a richer understanding of how adolescents reflect on their experiences as learners and as potential future scientists during a time of sociohistorical crisis in isolation.

Our findings therefore point to the importance of attending to the constraints and affordances that are present in a particular environment or historical period when studying science engagement. Research in developmental science has often operationalized science identity and engagement as an individual difference variable, yet our findings show that the historical context of COVID-19, as well as personal experiences of the pandemic, can prompt students to consider their academic and career goals and pursuits from a different perspective. Indeed, recent research has demonstrated how the pandemic frayed strong social ties with peers (due to limited interactions online) and negatively impacted science identity formation for Latina college students (Contreras Aguirre, 2024). Because our focus groups were conducted a single point in time during the height of the pandemic, our data are retrospective in nature and therefore cannot speak to whether the pandemic and its effects caused a shift in student science identity and motivation.

One unaddressed question is whether the pandemic prompted a shift in whether individuals perceive STEM contexts as settings where they can fulfill communal or other-oriented goals. The goal congruity perspective posits that individuals are more likely to enter and persist in STEM fields if individuals value communal goals and individuals

perceive STEM fields as being places where communal goals can be pursued (Diekman, 2013). Historically, individuals have not perceived science as a context where individuals can successfully pursue other-oriented goals, which could also explain gender gaps in STEM (Diekman, Steinberg, Brown, Belanger, & Clark, 2016). However, it is possible that personal experiences of the pandemic, as well as media depictions of the pandemic and its effects, could have shifted societal beliefs regarding STEM as a place where communal goals can indeed be pursued and achieved successfully. Longitudinal data collection efforts, or experimental research that manipulates student exposure to different types of messages about science, could provide more insights that could shape how educators consider the impact of future sociohistorical events on student development.

Common phrases such "scientific advancement" or "finding a cure for cancer" relate to our understanding of science as inherently future-oriented, as an endeavor that seeks to make a difference for future generations. However, as previously mentioned, individuals can vary in terms of how people view the immediacy of one's future, which could shape one's desire to engage (and/or the quality of one's engagement) in science. A study of Italian youth during the earliest months of the pandemic showed wide variability in how adolescents perceived their short-term futures, with most responses being negatively valenced (Commodari & La Rosa, 2020). A separate study of Italian university students conducted further into the pandemic found that the pandemic impacted students future time perspective and that these changes were related to stress and depression (Parrello et al., 2024). A study of Dutch youth during the same period showed that the pandemic impacted how they saw their current and short-term futures but had little discernible impact on adolescents' thoughts about their longer-term futures, which could have been due to people's expectations that the pandemic would be short-lived (Henkens, Visser, Finkenauer, & Stevens, 2020). And consistent with our findings as well as similar research with older adults (Hytman, Hemming, Newman, & Newton, 2023), a recent scoping review revealed that the pandemic increased feelings of uncertainty and altered short-term and long-term academic and career plans among adolescent youth (Carey, Bailey, & Polanco, 2023). Therefore, our findings prompt applied developmental scientists to consider the role of time not simply in terms of individual change as a function of development, but also one's time perspective, when studying approaches for enhancing science identity and engagement.

The role of self-efficacy in adolescent science identity

Students generally expressed a mixed sense of personal agency about their futures in science as well as their futures more broadly during the pandemic, despite the messages in the videos intended to prompt such reflections. Research on future time perspective has often distinguished between short-term and long-term futures and how differences in one's perception of time and time horizons can impact behaviors and outcomes (e.g., Wakslak, Nussbaum, Liberman, & Trope, 2008). Evidence from the pandemic suggests that social distancing and quarantining at home may have impacted individuals' ability to perceive the passage of time more generally (Loose, Wittmann, & Vasquez-Echeverria, 2021). The emphasis on near-term goal setting and a lack of ideas for long-term plans that we observed from our participants could have been related to the disruption of the COVID-19 pandemic given the intense state of uncertainty it produced globally.

One empirical study found individuals' distant future self (at least one year into the future) was more likely to be more abstract compared to individuals' near future self (one week into the future; Wakslak et al., 2008). Our findings are generally consistent with this research: when the participants in our study were asked to reflect on what a future in science could look like for them, responses were generally vague, as shown in the example quotes earlier. Previous research has indicated that adolescents who report feeling more connected to their future selves tend to describe their futures with greater episodic richness (McCue, McCormack, McElnay, Alto, & Feeney, 2019); extending this logic, it may be that this abstractness could be attributed to participants' lack of connection to their imagined futures, or a lack of self-efficacy for pursuing desired goals.

Research has identified four sources that shape the development of self-efficacy; in addition to personal experiences of mastery, individuals can also have vicarious mastery experiences by observing someone else experience success or failure (Bandura, 1997). Yet, despite watching the video depictions of how other adolescents were successfully navigating science pathways, most participants struggled to articulate their future plans (related to science or otherwise) with much specificity. Because the pandemic context appeared to contradict the content featured in the videos (e.g., adolescent youth freely engaging in one-on-one and group science activities without masks), our participants might have been unable to vicariously relate to or connect with the individuals featured in the videos in a meaningful way. Additionally, opportunities to reflect on the videos they watched were limited to the focus group discussion, which may have cut short their personal interpretations and connections. Our findings have clear implications for applied work: the mere provision and viewing of videos—even if those videos feature other high school youth grappling with common issues in adolescence—may not be sufficient for prompting the type of deep reflection that can shape science engagement in meaningful ways. Rather, students might benefit from deeper personal reflection and hands-on facilitation that could encourage the type of perspective taking that appears to be important for shaping how students think about their futures in science—a process that might not occur naturally without intentional prompting from teachers and mentors. This type of process could take place within one or more of the distinct trajectories that connect the three dimensions of the FSI framework; each of these trajectories provides an opportunity for researchers and practitioners alike to foster identity-affirming spaces at multiple levels where science identity can be studied and cultivated (Wofford & Gutzwa, 2022).

Constraints on generality and future directions

In addition to some of the limitations already described previously, we wish to highlight several other constraints on generality and future directions that could build on this exploratory work. Participants were recruited from two university-sponsored programs in the United States that focused on expanding opportunities in higher education and research. As such, these participants might be a self-selected group of students who might have already possessed an interest in science or academics. But it is also possible that the virtual focus group setting might have expanded opportunities for research participation. Regardless, future research could examine our research questions in a broader sample of high school youth not participating in academic or research-related programs.

Our focus groups were not designed to yield generalizable data. Rather, our data collection and analysis were intended to provide deep insights about how students reflected on their science engagement during COVID-19 after watching videos designed to prompt authentic reflections. Because of our study design and exploratory aims, different focus groups watched different sets of videos, and some of the questions we asked were unique to a specific video. Although generalizability is rarely the goal of small sample qualitative research, future work could seek to standardize data collection by providing a standard set of prompts and questions that are experienced by all participants.

The COVID-19 pandemic is just one example of a sociohistorical event that has had far-reaching impacts among youth. To what extent would the themes we identified generalize to other sociohistorical events, such as the Great Recession, the Black Lives Matter movement, or the War in Ukraine? Just as ecological systems theory states that individuals and settings can vary in terms of their proximity to the individual, historical events also vary on several dimensions, such as whether its impacts are proximal or distal, whether it is limited to a

particular geographic region, the duration of a particular event, or whether the event threatens one's mortality. Retrospective studies examining this question would be important for better understanding the conditions under which science engagement and adolescent science identity development might be more or less affected, with potential implications for how we can intervene to promote positive youth development during times of unusual stress and adversity.

Conclusion

Acknowledging the continued need to redress inequities in science and contribute a more inclusive developmental science, a major contribution of the present study was to apply a funds of science identity framework to examine perceptions and experiences of science among students from groups marginalized and underrepresented in science (Avraamidou, 2020; Jackson & Suizzo, 2015; Rocha et al., 2023; Rosa, 2018). Our qualitative study points to specific directions for future hypothesis-driven research in science identity that acknowledge the sociocultural and sociohistorical contexts in which science takes place, individual differences in future time perspective and self-efficacy, and intersecting identities beyond race and gender that shape individuals' perceptions and experiences of science and science engagement in and out of school. Findings underscore the importance in addressing the unique societal challenges that arise out of emergency situations—such as global pandemics—for refining developmental theory and reimagining approaches for supporting science identity and science engagement among adolescent youth.

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Declaration of competing interest

The authors report that there are no competing interests to declare.

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Data availability

The authors do not have permission to share data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appdev.2025.101755.

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