# Understanding STEM from Students' Perspectives: Exploring Students' Lived Communities and the Learning Communities They Wish to Create

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## ABSTRACT

*Community engagement in STEM learning and teaching largely focuses on citizen science projects, serving the needs and goals of the largely white and male-dominated STEM fields with only cursory attention to the lived experiences and narratives of the learners who engage in these experiences (Mahmoudi et al., 2022; Rautio et al., 2022). This article explores how researchers can work with students to uncover how they experience learning environments and pathways for change according to their community memberships, aspirations, and goals. Participants in this research are high school biology students in a diverse mid-suburban city. To understand their perspectives, students participated in activity structures grounded in anthropological methods, including ethnographic interviews (Emerson et al., 1995; Spradley, 1979), illustrations (Haney et al., 2004), and pile sorts (Boster, 1994; Ryan & Bernard, 2003). Moving between consensus and individuals, this research demonstrates how students' critical and meaningful experiences and aspirations can be understood and heard.*

## INTRODUCTION

Those representing marginalized identities and communities—particularly race, ethnicity, home language, and dis/ability—are underrepresented in all STEM areas and often unable to leverage the opportunities, tools, and practices that a rigorous and well-rounded STEM education affords. This is true even in community-engaged STEM learning and teaching research, which largely focuses on citizen science projects. While citizen science projects have the potential to provide "authentic STEM experiences" (Lewenstein, 2022), they typically serve the needs and goals of the largely white and largely male-dominated STEM fields (Mahmoudi et al., 2022; Rautio et al., 2022) with only cursory attention to the lived experiences and narratives of the learners who engage in these experiences. Citizen science initiatives also occasionally serve as public relations strategies that intentionally discount the experiences and goals of the communities they should be serving (Blacker et al., 2021).

The fact that pathways through STEM education are described as a "pipeline" and the failure of diverse students to "successfully" gain entry into STEM careers is described as a "leaky pipe" is concerning. The STEM pipeline is not neutral, even though the metaphor makes it appear this way. The STEM "pipeline" contains numerous systemic and structural barriers for marginalized and underrepresented individuals and communities with limited entry points, pathways through, and exit points, resulting in more of a maze or labyrinth than a pipeline. The concept of epistemological, cultural, and linguistic barriers is primarily overlooked within STEM education and the STEM "pipeline" specifically (Cannady et al., 2014), as are the deep wells of cultural, social, cognitive, navigational, linguistic, aspirational, and resistant capital and wealth of marginalized and underrepresented communities (Yosso, 2005).

These omissions perpetuate and sustain the largely racial, social, and gendered monoculture of STEM learning and community engagement. Because science is integrally intertwined with society, science disciplines require a scientifically informed public, not just cohorts of diverse, well-prepared, and well-trained scientists. Rather than operating at cross-purposes, these goals are mutually compatible and can support each other. This can only be accomplished by listening to and understanding the experiences and perspectives of diverse communities and the students who represent them.

The classroom is a site where different communities intersect through the interaction of its members (Seiler & Elmesky, 2007). As human agents with diverse cultural, linguistic, racial, class, and experiential backgrounds, students and teachers are all representatives of intersectional identities (Crenshaw, 2017; Hernández-Saca et al., 2018; Tan & Calabrese Barton, 2018). Carrying these intersectional community memberships with them, historical and cultural factors are not "checked at the door" when entering the classroom (Holland & Lave, 2001). This influx of meanings around STEM learning is further influenced by various structural factors, such as racism and white supremacy, classism, ableism, politics, and notions of global competitiveness (Fensham, 2009; Fraser-Abder et al., 2006; Tan & Calabrese Barton, 2018).

This research seeks to understand how students understand STEM learning activities within sociohistorical ecological contexts (Bronfenbrenner, 1986; Stern et al., 2021), allowing us to understand more fully the experiences, goals, and cultural capital and wealth (Yosso, 2005) that students bring through their whole selves. This approach understands that this means not only providing "authentic scientific experiences" (narrowly defined as the epistemological and practical work of scientists in their field) but also understanding the science that students do outside the classroom in the worlds which occupy much of their time and thought (Polman & Miller, 2010; Tan & Barton, 2016; Tan & Calabrese Barton, 2018) and bring those worlds together in STEM learning. These experiences, which value and connect the sociohistorical contexts of the learner would science, would be authentic—and not alienating—for students. This research seeks to understand what these experiences could look like from the student's perspectives.

## CONTEXTS AND RESEARCH METHODS

### *Cotstead High School and the C-Block Biology Class*

I worked with a "middle-track" high school biology classroom comprised of students with prior achievement, home languages and cultures, and socioeconomic class. The district is located in Cotstead1, an inner suburb of a large New England city. Cotstead hosts a large number of technology and biotechnology companies in expansive office parks along a stretch of an interstate highway. However, residents of the city are greatly diverse, with a large number of immigrant and blue-collar families compared to its more affluent neighboring towns and cities. A school of about 1,400 students, approximately 12% of students at Cotstead High are Black/African-American, 25% Latinx, 5% Asian, and 0.4% Native American, while the remaining students are white.

Ms. Stoneham is a second-career veteran teacher who previously worked as a histologist in a hospital in the larger New England city. This previous career is significant as it provided Ms. Stoneham with lived experiences in a non-teaching STEM career. Her C-block biology class (see Table 1) represented a range of economic backgrounds, and about half the class spoke Spanish at home (with families largely originally from Guatemala and Puerto Rico). Some students spoke Brazilian Portuguese and Armenian at home. As a "middle-track" science class, there was an emphasis on study skills for academic success as well as the content of biology. However, tracking students at the subject level masked some of the diversity of achievement and the expectations they held for themselves. Most students held college attendance as an important goal, and several were in honors-level classes at the highest achievement levels in other subject areas.

## DATA COLLECTION AND ANALYSIS

I used four different data collection and analysis practices: pile sorts, participant illustrations, ethnographic observations, and ethnographic interviews. The protocols for this study can be found at https://osf.io/y4vzp/.

Pile sort activities provide visualizations of the relationships between different aspects of STEM. Students were asked to place different stories or vignettes describing people doing science-related activities into any number of related piles (Boster, 1994). I then interviewed each student individually and asked them why they placed each vignette into the particular piles. An aggregate proximity matrix was calculated, and a non-metric multidimensional scaling (MDS) analysis was conducted on two dimensions (Ryan & Bernard, 2003) using RStudio (Gebeyaw, 2017; RStudio Team, 2022).

**Table 1**
*Research Participants and Disclosed Identities*

| Pseudonym | Disclosed Race/Ethnicity | Disclosed Gender | Disclosed Language Spoken at Home |
|---|---|---|---|
| Ms. Stoneham | White | Female | English |
| Amanda | White | Female | English |
| Beryl | White | Female | English |
| Debra | Latinx | Female | Portuguese |
| Dylan | White | Male | English |
| Eduardo | Latinx | Male | Spanish |
| Gabriel | Latinx | Male | Spanish |
| Henry | White | Male | English |
| Juana | Latinx | Female | Spanish |
| Kimberly | White | Female | English |
| Leah | White | Female | English |
| Margarid | Armenian | Female | Armenian |
| Matt | Latinx | Male | Spanish |
| Rosa | Latinx | Female | Spanish |
| Ruby | White | Female | English |
| Sam | White | Male | English |

Students were asked to draw a picture of what it looks like to "do science" at two different times. These illustrations were collected and analyzed using recursive and comparative qualitative content analysis (QCA; Mayring, 2000). QCA provides a holistic approach to understanding the meanings expressed in participant-generated illustrations. A holistic approach involves going back and forth between taking notice of the details and the "whole picture" to understand the illustration (Haney et al., 2004). I considered low- to mid-inference features, that is, only those elements clearly exhibited in the drawings themselves (Freeman & Mathison, 2008). These features were examined within the context of the individual drawing and then compared with identified features across the entire set of drawings to generate a list of themes based on similarities and differences. Next, each student was interviewed and asked to describe their illustration, and the students' explanations were compared with the generated list of themes. The explanations were used to refine the list of themes and generate written vignettes (Van Maanen, 2011) for individual student illustrations.

All observations and interviews were recorded with an audio recorder, and I took field notes and wrote daily research memos. The observational and interview data analysis process was through a vignette analysis approach (Van Maanen, 2011), aimed at "…present[ing] the reader with the stories identified throughout the analytical process, the salient themes, recurring language, and patterns of belief linking people and settings together" (Anfara et al., 2002, p. 31). Collected artifacts, observational data, and research memos and field notes were coded using the Atlas.ti qualitative data analysis software over several rounds. I drew upon established constructs for adhering to standards of quality and rigor (Anfara et al., 2002; Howe & Eisenhart, 1990).

## FINDINGS

This section is divided into three parts, first, an exploration of the role of the teacher, and then two parts based on a methodology to understand the students' perspectives: a pile and a prompted drawing activity. The exploration of the role of the teacher provides a grounding into the operations and approaches promoted in the class as a whole. At the same time, the methodology-based parts demonstrate different perspectives on approaches to STEM learning that intersect with students' sociohistorical and cultural contexts.

## SETTING THE (TEACHER) STAGE: SCIENCE-AS-GAINING-KNOWLEDGE

It is essential to understand the classroom context in which formal STEM learning occurs to fully interpret from where some of the ideas being conveyed by the students arise. During one of the early ethnographic observations of the class, Ms. Stoneham initiated a discussion with her students on the meaning of science:

Ms. Stoneham: What does the word science mean?

Eduardo: This class.

Ms. Stoneham: Does anyone remember way, way, way at the beginning of class? Does anyone remember what science is? We cleaned out our binders, so this is going to be a tough one. Science, the word, means to gain knowledge. Remember? Gain knowledge. Yep [pointing to Margarid].

Margarid: Yeah, but you gain knowledge in every class.

Gabriel: The science of...

Ms. Stoneham: Yup, the science of what? The science of history. Yup, everything is kind of like a science. Right?

Margarid: But why is this class specifically called science? In this class?

Ms. Stoneham: OK, what are specifically studying in this class?

Multiple Students: Bi-ol-o-gy.

Ms. Stoneham: Which is what?

Gabriel: The study of life!

Ms. Stoneham: The study of life. Alright! And how does that apply to you?

Gabriel: We're life.

Amanda: We're...

Ms. Stoneham: We're... we're...

Amanda: Living things.

Ms. Stoneham: Right! Living things!

Gabriel: We're life.

Ms. Stoneham: So we're trying to make sense of...

Multiple students: Ourselves.

Ms. Stoneham: Exactly. And how we fit into what.

Rosa: The world.

Ms. Stoneham: And other living organisms. OK? And as a scientist, as in the room, here, with me, we are gaining knowledge, right? Yes?

Eduardo: Yeah.

Ms. Stoneham: Yay. We're all so happy to have all this knowledge. What are we looking for when we are scientists? What's the goal of a scientist?

Henry: Information.

Ms. Stoneham positioned science for her students as a process to "gain knowledge." She further positioned gaining knowledge as independent of a particular discipline, a universally-applicable mode of gaining knowledge. During an interview, the teacher reiterated her definition of science, stating that "...the word 'science' is an umbrella for gaining knowledge on everything… For me, [science is] a learning process, the art of gaining knowledge." As an "umbrella" and as an "art," science as a concept is decoupled from the specificities of science as a practice, involving a general methodology, approach, and set of questions to be explored (Grinnell, 2009). While she generally discussed science in a universalistic manner, the teacher also worked to make this "art of gaining knowledge" accessible and authentic to students; biology—which could be treated as an abstract study of living organisms—was turned into an exploration of the students as living things themselves. These turns of language were intentionally deployed to help her students "gain knowledge," as Ms. Stoneham expressed her process of helping her students engage in the "In other words, I have to understand how people learn to get them to, what actions do they need to take, to get that content knowledge. And that's kind of ever-evolving because it takes you a while to figure out how each of your students learn."

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Students represented and resisted how Ms. Stoneham described science during the pile sorting and drawing activities. To fully recognize how youth understand a concept like science and how they wish to engage with and learn science, it is necessary to understand the influences on the meanings they assign to science. Teachers and educators generally exert a great deal of influence in American society, so we see in the following sections how the students worked to show that they've learned from their teacher but also that they often go beyond what is discussed in the classroom.

## UNDERSTANDING THE CONTOURS OF SCIENCE-IN-ACTION

By examining the diagram generated through the MDS analysis (Figure 1) and comparing the diagram with the interviews, I could interpret the scales of the two dimensions represented in the diagram. The x-axis (left-right/horizontal) exhibits a continuum identified by the students between "People" on the left and "Things" on the right. The y-axis (up-down/vertical) exhibits a continuum between "Contributing to a Greater Community or Enterprise" along the top and "Individual Enjoyment" along the bottom.

## CONSENSUS CATEGORIES OF SCIENCE

The MDS diagram (Figure 1) represents a composite view of how the class categorized different aspects of "doing science" based on the provided vignettes. Every student was also interviewed to provide an overview of their sorting, outlined in Table 1. Each cluster will be examined in turn.

**Figure 1**
*Multidimensional Scaling (MDS) of Student Pile Sorting Activity*

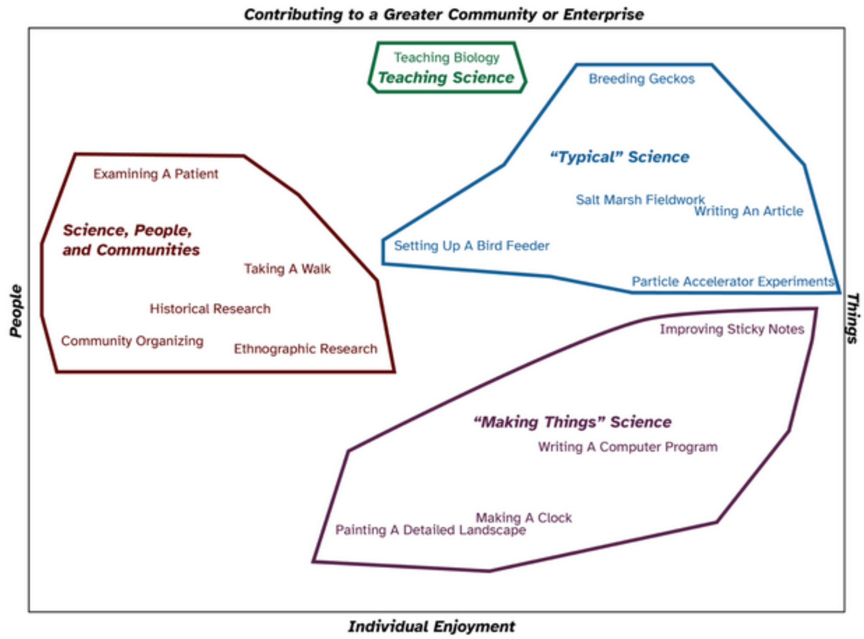


**Table 2**
*Identified Clusters with Vignettes and Example Quotes*

| Cluster | Vignettes | Example Quotes |
|---|---|---|
| **“Typical” Science** | Salt Marsh Fieldwork, Writing An Article, Setting Up A Bird Feeder, Particle Accelerator Experiments | “It’s all pretty much like what people would think of biology...” (Kimberly)<br>“This group had to do with, like, helping out science…” (Beryl) |
| **“Making Things” Science** | Improving Sticky Notes, Writing A Computer Program, Making A Clock, Painting A Landscape | “[T]rying to make things better…” (Matt)<br>“[T]hey were all basically all experimenting on what they wanted to do.” (Dylan) |
| **Science, People, and Communities** | Examining A Patient, Taking A Walk, Historical Research, Community Organizing, Ethnographic Research | “They are the ones that like help the people.... Like learning about people.” (Gabriel)<br>“These all had to do with like a community that... or like a group of people that, like, were, she wanted to get to know or help.... [L]ike the community is part of nature.” (Beryl) |
| **Teaching Science** | Teaching Biology | “...she’s teaching like a biology class, so it’s like directly science.” (Ruby) |

The first group, “Typical” Science, is what the students considered “normal” science activities. Students tended to relate items in this cluster regarding contributions to the scientific community or the scientific enterprise.

The next group, “Making Things” Science, represents a sense of making or improving things rather than just contributing to science or engaging in an investigation. Students typically used words such as “invent” and “experiment” to describe these activities. A common thread that ran through these descriptions identified the goals of these activities as the things themselves rather than contributing to a larger community or enterprise.

The Science, People, and Communities cluster represents activities centered around helping people and contributing to (non-scientific) communities. There was a relatively strong consensus among the students as to this group. Some of the activities, such as taking a walk, were accounted for by positioning the social community as part of the larger natural community.

The vignette which described the activity of teaching biology is situated within its cluster, Teaching Science. Students did not consistently place the act of teaching biology in a particular pile so that it could fit into another cluster. Some students placed teaching biology as a core science activity, while others positioned teaching on the periphery. This lack of consensus accounts for teaching biology as a cluster in and of itself. When viewed against the dimensional scales, students viewed teaching as an activity contributing to a broader community and enterprise.

## INDIVIDUAL CATEGORIES OF SCIENCE: LEAH'S SCIENCE IDENTITIES

Not all students took an activity-centric approach to the pile sort. Rather than sorting according to activities-in-process, Leah, for example, focused primarily on identities and what their activities said about them. In describing her reasoning behind her sort procedure, she constructed identities and tacit narratives of being in the world for each person featured in the vignettes (Figure 2). The narratives and identities she discussed served as an interesting counterpoint to the consensus-oriented MDS analysis above.

Leah divided the vignettes into three separate groups. The first group, Normal People/Everyday Activities, "...is just like what normal people can do." Glossing over the expertise, skill, craft, and talent necessary for some of these activities, Leah described them as "...what normal people do in their normal day lives." Leah pulled these activities away from the purview of scientists and described them as "normal

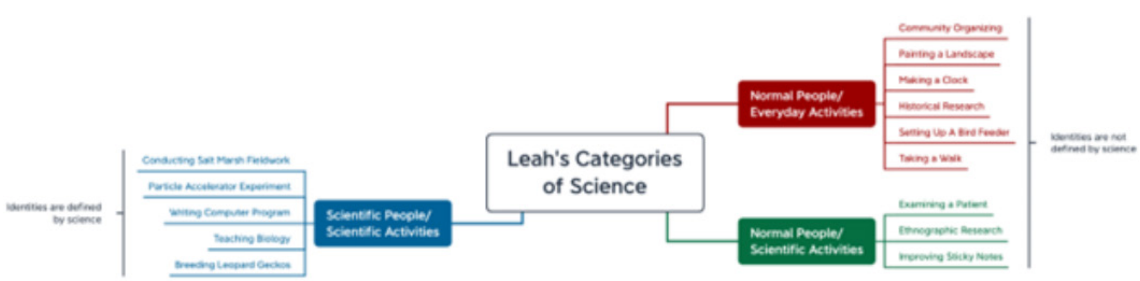
Leah's second group, Normal People/Scientific Activities, included "...advanced people, who like you know, like had an education, do like scientific stuff. Like that's their field." According to Leah's classification, these three people are educated in science but are not defined by science. Part of her classification is that she sees their work in a direct way benefitting people. Commenting on the improving stick notes vignette, she related that such work "...might contribute to helping us, in some sort of awkward way." Leah's final group, Scientific People/Scientific Activities, according to Leah, "...have to do with the world," rather than with people: "it's more like outside of like, nothing that has to do with humans." These are people defined by science. She further says, "It's just like, what scientists would, what scientists do in their spare time." These are activities that scientists—people defined by their activities in science—engage in when there is nothing else of importance that needs to be done.

## SEEING SCIENCE IN PRACTICE

As noted above, the analysis of the first activity revealed the core five categories of drawings: Gaining Knowledge, Science as Collection, Science as Activity, Science as Nature, and Scientists Helping and Improving Communities and the World. These categories will be presented in turn, and then move on to looking closely at Debra's illustrations.

Drawings included in the Gaining Knowledge category (Figure 3) directly interpreted how Ms. Stoneham described science as "gaining knowledge." While Ms. Stoneham described gaining knowledge as an active process, the students interpreted the process as passive. Elements were drawn around heads or brains with arrows indicating that they were being put inside. The things which represented "knowledge" tended to involve a "typical" sense of science content (illustrations of viruses, cells, DNA strands, etc.), although at

**Figure 2**
*Leah's Categories of Science*



times included a broader and more general sense of “knowledge” to include other subject areas as well. One student drew a picture that depicted the Earth floating in space, connected with arrows to a disembodied brain also floating in space.

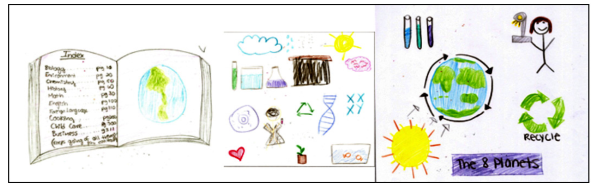
The second group, Science as Collection (Figure 4), represented doing science as collections of ideas, concepts, and paraphernalia. These collections did not tend to be tied to a particular place, nor did they typically involve human activity (with one exception, in the drawing on the right with a person holding what appears to be a light or microscope). One student drew science as a book to depict knowledge across various subject areas collected in one place. The knowledge

**Figure 3**
*Representative Drawings in the Gaining Knowledge Category*

collected in this book included biology and other school sciences topics (e.g., math, English, and business) and even childcare. This student’s representation is a different interpretation of Ms. Stoneham’s general description of science as representing all subject areas. Other students drew other objects and ideas, such as plants, test tubes, DNA strands, and the recycling symbol. It is also interesting to note that the lab bench depicted in the middle drawing—with a black top and a brown wooden bottom— directly reflects the form of the lab benches in the classroom.

Drawings of Science as Activity (Figure 5) were typically tied to particular places and included people in these places. Although the middle picture in Figure 3

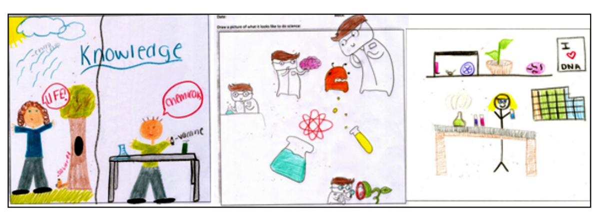
**Figure 4**
*Representative Drawings in the Science as Collection Category*




was not tied to a specific place, it was included in this category because of the strong presence of the person in the drawing. The places were either outdoors in nature or a laboratory setting (or both, as in the drawing on the left). The laboratory-like settings reflected the classroom’s lab area, including the black-and-brown lab benches. The people in the drawings were usually doing things such as investigating and examining or working with test tubes. The drawings in this category were active rather than passive. Any paraphernalia or props were tied together and oriented to doing a particular task, unlike the drawings in the Science as Collection category.

The drawings in the Science as Nature category (Figure 6) ranged from general to specific. These drawings depicted “doing science” as nature, with scenes of grass, trees, animals, water, and suns. They also brought in specific content from the curricular unit being studied.

**Figure 5**
*Representative Drawings in the Science as Activity Category*

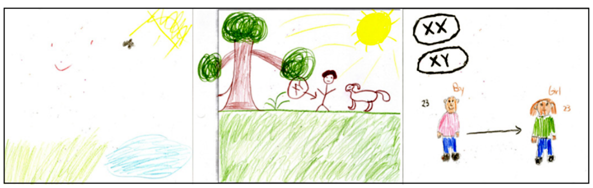



These drawings tended to reflect the notion that doing science is connected to nature and that “science is everywhere," a theme often invoked in interviews and classroom discourse.

Rosa's and Juana's drawings in Figure 7 fell into their category, depicting the idea that science can improve society and make for a better life (Scientists Helping and Improving Communities and the World). Rosa labeled her drawing, "Scientists will help their community so the world will improve!!" Juana referenced specific social issues that have roots for understanding—and potential solutions—in STEM, energy conservation,

**Figure 6**

*Representative Drawings in the Science as Nature Category*




and the life of people with disabilities. In doing so, she brings in a political dimension as well. These illustrations indicated that these two students expanded their sense of what science is and what it can be used for.

## DEBRA'S DRAWINGS: BEING CENTERED IN SCIENCE-IN-ACTION

Debra was a student who expressed a high degree of intrinsic motivation to engage and participate in science class. As a temporary resident of the United States from

**Figure 7**

*Representative Drawings in the Scientists Helping and Improving Communities and the World Category*


Brazil, she found her English language skills to be an important mediating factor in her learning process. While she indicated visits to her grandmother's farm exposed her to nature and the environment, Debra brought up another experience that reinforced her interest in science. She recalled being present through her stepmother's pregnancy and stepsister's birth:

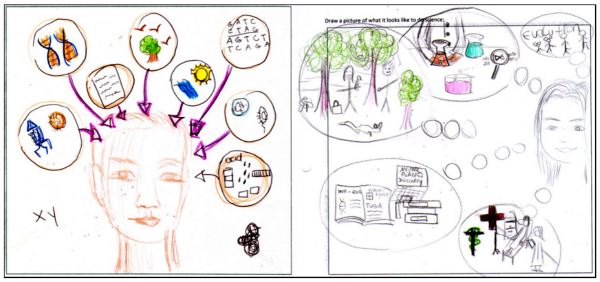
> She [stepmother] had a baby, so I followed her pregnancy, and I got to watch the, like, the labor. And it was really amazing…. I want to be a midwife, so it was like a great experience. It was like, oh, that gives me an idea of how it's going to be like. And I got to help them too. It was really cool!

**Rosa labeled her drawing, "Scientists will help their community so the world will improve!!" Juana referenced specific social issues that have roots for understanding–and potential solutions–in STEM, energy conservation, and the life of people with disabilities. In doing so, she brings in a political dimension as well.**

With this background in mind, Debra drew two illustrations (Figure 8). Her first illustration (on the left) was an example of the Gaining Knowledge category, with bubbles of science content and concepts entering a person's head through inward-facing arrows.

Her second drawing (on the right) was more complex. Illustrated through the conventional comic strip thought bubbles, Debra indicated that the main figure was herself, and she is thinking about five different aspects of science. The first aspect is the concept of evolution, which she described as one of the main organizing principles of biology. The second aspect is a laboratory investigation, replete with different colored substances in beakers and containers. The third aspect is two people experiencing nature. There is a bucket or container with a handle, which may indicate that the people are collecting something from the outdoors. The fourth

**Figure 8**
*Debra's Drawings of Science in Action*



aspect is a depiction of a pile of books. Lastly, Debra drew a person in a bed being attended to by a healthcare worker, as well as a range of medical paraphernalia. She also drew a red cross and a caduceus, symbolic of the medical profession.

While at first glance, Debra's second drawing could be considered Science as Collections, her illustration demonstrated a range of scientific activities. It highlighted several functions of science, including understanding the natural world, serving as a repository of these understandings, sharing these understandings publicly, and using these understandings to improve human life. She included a medical scene to not only connect her career goal of becoming a midwife; it also represented science in a way many people can connect and identify.

Similarly, her depiction of the books and the laptop showcased not only the specific scientific content knowledge canonized in the books but also the publicly-accessible and public-oriented Animal Planet and Discovery television channels. In an interview, Debra pointed to a role model from television who influenced her engagement in the classroom, Richard Rasmussen, on the Brazilian nature program Selvagem ao Extremo ("Wildness to the Extreme"). There was another way that Debra aspired to be like him, in terms of how Richard Rasmussen talked and expressed himself, noting that Richard Rasmussen was able to "talk about science and pronounce the words... without a problem." Debra also described her idea of a "successful career," framing markers of success in terms of helping people and the environment.

## DISCUSSION AND CONCLUSIONS

Moving deliberately back and forth between consensus and individual—while recognizing and understanding the identities, communities, and sociohistorical ecologies students represent—provided a deep understanding of how students understood STEM education and how STEM learning experiences can be structured in a community-engaged setting to honor the experiences, cultural wealth, and overarching goals of students. This research helps to highlight the need to make learning not only authentic but meaningful and valuable in the sense that their learning connects with and expands their understandings of their personal histories, their sense of their life's trajectories, and their circumstances and relationships.

Through these research activities, students were able to find chinks in the armor of the textbook "public science" (Holton in Girod, 2001), the overly logical and well-ordered side of science, in which universal laws and discrete facts trump the emotional and exciting process of science in the making. There were clear indications that companion meanings of science (Roberts & Östman, 1998), meanings passed on uncritically from curriculum or teacher to students, were evident in the students' representations. Students picked up the idea of science as "gaining knowledge" across disciplines and fields and even took the act of "gaining" to be a passive, rather than active, process.

Yet there was also evidence that students not only built upon but contradicted some of the prevailing meanings of science in the classroom by extending science not in content but in applicability. While they may not become scientists themselves, they were able to experiment with meanings and identities, which included the consideration of scientific understandings in a variety of contexts. Some students, such as Rosa, Juana, and Debra, saw the "usefulness" of science and scientific knowledge grow and expand. They saw the broader scientific endeavor as potentially having a place for them in a STEM career (Debra) or as a way to use STEM to accomplish inclusive and just goals (Rosa and Juana). For students like Leah, it would be important to understand ways to decouple the doing of science from a science identity, even though a plethora of research—based on the pipeline metaphor—advances just that approach (Lyon et al., 2012).

**This research helps to highlight the need to make learning not only authentic but meaningful and valuable in the sense that their learning connects with and expands their understandings of their personal histories, their sense of their life's trajectories, and their circumstances and relationships.**

Beyond the movement from consensus to individuals, the methods themselves proved to be an effective way of understanding how students saw STEM and what they hoped to gain from it. This drawing activity provided unique and essential insights into how meanings are negotiated within a larger context. Especially with Rosa, Juana, and Debra, a field change occurred regarding how the students represented the actions and activities in science. Each of these students represented science so that they could relate to it and engage with it. Asking students to draw pictures rather than write provided a holistic perspective experience into students' worldviews and meanings around science and science learning. Similarly, the pile sorting activity provided an understanding of how students organize their thinking about STEM and provided insight into their motivations as to why they would consider engaging in community-engaged STEM learning.

As we continue to encounter issues that are deeply embedded in understanding STEM, such as global climate change and local climate crises, health outcomes, and material inequalities, it is critical to understand how students, as members of communities and representatives of communities, see STEM, how they see themselves connected to it, and their goals. Without these insights, we will continue to push the same people through the STEM pipeline, serving to maintain the destructive and unjust status quo.

**Each of these students represented science so that they could relate to it and engage with it. Asking students to draw pictures rather than write provided a holistic perspective experience into students' worldviews and meanings around science and science learning.**

# References


Anfara, V. A., Brown, K. M., & Mangione, T. L. (2002). Qualitative Analysis on Stage: Making the Research Process More Public. Educational Researcher, 31(7), 28–38.

Blacker, S., Kimura, A. H., & Kinchy, A. (2021). When citizen science is public relations. Social Studies of Science, 51(5), 780–796. https://doi.org/10.1177/03063127211027662

Boster, J. (1994). The successive pile sort. Cultural Anthropology Methods, 6(2), 7–8.

Bronfenbrenner, U. (1986). Ecology of the family as a context for human development: Research perspectives. Developmental Psychology, 22, 723–742. https://doi.org/10.1037/0012-1649.22.6.723

Cannady, M. A., Greenwald, E., & Harris, K. N. (2014). Problematizing the STEM Pipeline Metaphor: Is the STEM Pipeline Metaphor Serving Our Students and the STEM Workforce? Science Education, 98(3), 443–460. https://doi.org/10.1002/sce.21108

Crenshaw, K. W. (2017). On intersectionality: Essential writings. The New Press.

Emerson, R. M., Fretz, R. I., & Shaw, L. L. (1995). Writing Ethnographic Fieldnotes. University of Chicago Press.

Fensham, P. J. (2009). The link between policy and practice in science education: The role of research. Science Education, 93(6), 1076–1095. https://doi.org/10.1002/sce.20349

Fraser-Abder, P., Atwater, M., & Lee, O. (2006). Research in urban science education: An essential journey. Journal of Research in Science Teaching, 43(7), 599–606.

Freeman, M., & Mathison, S. (2008). Researching Children's Experiences. Guilford.

Gebeyaw, M. (2017). Using MCA and variable clustering in R for insights in customer attrition. DataScience+. https://datascienceplus.com/using-mca-and-variable-clustering-in-r-for-insights-in-customer-attrition/

Girod, M. (2001). Nobody likes soap in their eyes: Portraying a more inviting science by teaching for aesthetic understanding. CESI Science, 34(2), 20–24.

Grinnell, F. (2009). Everyday Practice of Science: Where Intuition and Passion Meet Objectivity and Logic. Oxford University Press.

Haney, W., Russell, M., & Bebell, D. (2004). Drawing on Education: Using Drawings to Document Schooling and Support Change. Harvard Educational Review, 74(3), 241–272.

Hernández-Saca, D. I., Gutmann Kahn, L., & Cannon, M. A. (2018). Intersectionality dis/ability research: How dis/ability research in education engages intersectionality to uncover the multidimensional construction of dis/abled experiences. Review of Research in Education, 42(1), 286–311. https://doi.org/10.3102/0091732X18762439

Holland, D., & Lave, J. (2001). History in person. Enduring Struggles: Contentious Practice, Intimate Identities, 1–32.

Howe, K., & Eisenhart, M. (1990). Standards for qualitative (and quantitative) research: A prolegomenon. Educational Researcher, 19(4), 2–9.

Lewenstein, B. V. (2022). Is Citizen Science a Remedy for Inequality? The ANNALS of the American Academy of Political and Social Science, 700(1), 183–194. https://doi.org/10.1177/00027162221092697

Lyon, G. H., Jafri, J., & St. Louis, K. (2012). Beyond the Pipeline: STEM Pathways for Youth Development. Afterschool Matters. https://eric.ed.gov/?id=EJ992152

Mahmoudi, D., Hawn, C. L., Henry, E. H., Perkins, D. J., Cooper, C. B., & Wilson, S. M. (2022). Mapping for Whom? Communities of Color and the Citizen Science Gap. https://doi.org/10.13016/m2oveu-gfbf

Polman, J. L., & Miller, D. (2010). Changing stories: Trajectories of identification among African American youth in a science outreach apprenticeship. American Educational Research Journal, 47(4), 879–918. https://doi.org/10.3102/0002831210367513

Rautio, P., Tammi, T., Aivelo, T., Hohti, R., Kervinen, A., & Saari, M. (2022). "For whom? By whom?": critical perspectives of participation in ecological citizen science. Cultural Studies of Science Education, 17(3), 765–793. https://doi.org/10.1007/s11422-021-10099-9

Roberts, D. A., & Östman, L. (Eds.). (1998). Problems of Meaning in Science Curriculum. Teachers College Press.

RStudio Team. (2022). RStudio: Integrated Development for R (2022.7.1.554). RStudio, PBC. http://www.rstudio.com/

Ryan, G. W., & Bernard, H. R. (2003). Techniques to Identify Themes. Field Methods, 15(1), 85–109.

Seiler, G., & Elmesky, R. (2007). The role of communal practices in the generation of capital and emotional energy among urban African American students in science classrooms. Teachers College Record, 109(2), 391–419.

Spradley, J. (1979). The Ethnographic Interview. Harcourt, Brace, Jovanovich.

Stern, J. A., Barbarin, O., & Cassidy, J. (2021). Working toward anti-racist perspectives in attachment theory, research, and practice. Attachment & Human Development, 1–31. https://doi.org/10.1080/14616734.2021.1976933

Tan, E., & Barton, A. C. (2016). Hacking a Path In and Through STEM: Unpacking the STEM Identity Work of Historically Underrepresented Youth in STEM. https://repository.isls.org//handle/1/144

Tan, E., & Calabrese Barton, A. (2018). Towards critical justice: Exploring intersectionality in community-based STEM-rich making with youth from non-dominant communities. Equity & Excellence in Education, 51(1), 48–61. https://doi.org/10.1080/10665684.2018.1439786

Van Maanen, J. (2011). Tales of the Field: On Writing Ethnography. University of Chicago Press.

Yosso, T. J. (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. Race Ethnicity and Education, 8(1), 69–91. https://doi.org/10.1080/1361332052000341006