



# Ode to Barelas: Supporting Youth Agency, Cultural Expression, and Community Engagement through an Interactive Mural



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## Abstract

Community mural projects provide youth with the opportunity to learn new skills, have a voice, and deepen their connection to their communities. This pictorial reflects on a participatory community-based STEAM project in which a group of teenagers collaborated with a muralist (Author 2) and two interaction design researchers (Authors 1 and 5) to create an Interactive Mural—a traditional mural with embedded electronics. We analyzed students' experience of agency, expression, and connection to community throughout the project. We discuss how large-scale community-centered projects that provide opportunities for student agency and expression are rich learning environments that can promote technological fluency.

## Authors Keywords

interactive murals; steam; computing education; educational technology; participatory design

## CSS Concepts

- Human-centered computing→Collaborative and social computing

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# Introduction & Related Work

Murals are a public and community-driven art form that serve as means of cultural and political expression for marginalized groups [14, 19, 40]. Community murals are produced by the communities they are in and offer "a different perspective on cultural identity and can ideally transform it from a marginalized, alienating identity to one that is a source of pride and solidarity ... The size and location of community murals function to insert local communities into public space, into the center of their own communities." [24].

There is a longstanding tradition of community mural projects that engage youth. These projects enable young people to acquire a broad range of skills related to art, math, and communication [3, 4, 6, 7, 22, 27, 40]. Youth learn how to translate their ideas into meaningful visual representations. They learn how to collaborate with others and gain the experience of working on large complex projects. They also learn about themselves and their community. As a youth participant in several of Boston's Dudley Street Murals explained: "... murals give the youth the opportunity to express loudly on these walls what they feel and hope for the community ... we're proud of where we live and this mural shouts a beautiful story about us" [40].

Our work builds upon these traditions, introducing youth to an *Interactive Mural* as a community-based art and technology project. Our aim was to provide minoritized youth with an opportunity to learn foundational skills in electronics and programming while serving as authentic authors of an ambitious and real-world interactive artwork.

Our project took place over two workshops. The first, held in spring 2022, introduced students to programming and electronics[9]. The second, held in the summer 2022, students designed and constructed the mural. In these activities, we employed well known materials (e.g., copper tape and copper paint [2, 25, 28]) and techniques from paper-based electronics [8, 32-34] to expand on and contribute to a body of research in large wall-based interfaces [12, 42, 43].



While previous work has engaged youth in programming and electronics through similar materials and techniques, our interactive mural is unique in its scale and location—it is 32' x 10' (10 m x 3 m) and permanently located outside. The community context and the artistic ambition of the work are also distinct and fundamental to the project. The interactive mural is designed to function for many years as a functional public art installation.

In these workshops, we introduce youth to programming and electronics through a series of activities that honor and employ their pre-existing skills and interests in visual art. The activities we designed are intended to provide students with opportunities for creative expression through painting, building electronics, and programming. Our goal is for students to feel a sense of ownership over the entire mural—its visual, "technological", and integrated artistic content.

Employing culturally responsive strategies, we take care to situate our workshop activities in a community in which students are already comfortable, and provide opportunities for students to connect their work to their personal lives and cultures [5, 20, 36-38]. We also strive to leverage and build on students' strengths (e.g., a skill in painting or drawing) instead of focusing on their deficits (i.e., a lack of programming experience). Deficit models of learning are especially prevalent in STEM and ultimately contribute to an educational landscape that often disserves students of color.

Our work proposes interactive murals as a new and unique site for STEAM learning [9]. This pictorial focuses on the opportunities that Interactive Murals can provide for student agency, cultural expression, and community engagement. We argue that these opportunities are grounded in the distinctive affordances of Interactive Murals including their enormous scale and the fact that they are physically and indelibly embedded in communities.

# Research Team and Collaborators



The interdisciplinary nature of our team was essential to the project. Author 2 is a Dine (Navajo) and Latina professional muralist and painter. Her practice is community-centered and she has created several murals with youth in our community. Authors 1 and 5 contributed expertise in programming and electronics. Author 1, who taught and organized the electronic components of the project, is a Hispanic/Latina Ph.D. student and interaction design researcher whose work focuses on HCI, ubiquitous computing, and technology education. Authors 1 and 2 led and co-designed all learning activities. Author 3 is a comic artist, STEM educator, and postdoctoral researcher focusing on the design of STEAM learning environments for Black and Brown youth. Author 4 is a postdoctoral researcher in HCI and Author 5 is a professor and interaction designer who runs an HCI research lab.

Another critical partner in this project was the local non-profit arts organization, Working Classroom (WC) [9, 13], which is dedicated to engaging minoritized youth in public art. WC recruited students and provided classroom and working space for our activities. Our mural is painted on the side of their building.

All of the students who participated in this project have participated in other WC community mural projects. Seven students of various races/ethnicities (Hispanic or Latina/o, American Indian, and Black or African American), ages 15-19, enrolled in our spring workshop, and four (out of these seven) continued on to build the interactive mural in the summer workshop. Each student is referred to by a pseudonym in this paper. The four students who built the mural are Marley, Elena, Enrique, and Alexa.



All sketches were drawn by student participants



# The Barelas Neighborhood

This work took place in a low income, culturally significant and historic neighborhood called Barelas, within a diverse, majority-minority city. Our city is located in the western United States, where approximately 50% of the population is Hispanic, 5% is American Indian/Native American, and 10% is mixed race [41]. Barelas is a residential neighborhood, one of the oldest in the city, that is located close to downtown. The walls of many local establishments are adorned with large murals. Our project contributes to and draws from the area's rich history of American Indian and Hispanic mural painting [18, 35, 39].

Community-based murals and youth mural projects are practices that are well-established in this community [10, 17]. Working Classroom, which was founded in 1988, is located in Barelas and has led many youth mural projects here. These include several projects to decorate the exterior of their building, which showcases four murals painted by local artists and youth.

Our mural celebrates plants and animals from Barelas. This theme was chosen by Author 2 to support our artistic and pedagogical goals. It provides a structure that strengthens the mural's connection to the local community while supporting a natural way for all students to contribute individual elements to an artistically cohesive whole. The mural highlights one aspect of the vibrant and beautiful neighborhood of Barelas. The full title of the interactive mural is: *Flora and Fauna: A Luminescent Ode to Barelas*.

*Snapshots of the Barelas neighborhood where our mural is located*



WC Building



# Research Goals



We aim to help minoritized youth develop fluency in STEAM through the process of building an interactive mural. The focus of this pictorial is on two components of this larger goal. **Student Agency:** Can interactive murals provide opportunities for students to feel a sense of ownership over the visual, interactive, and technical components of the mural?

**Cultural Expression and Community Engagement:** Can interactive murals enable students to connect to their communities and cultural backgrounds?

# Project Overview



Our project took place during the spring and summer of 2022. The first workshop, taught in spring 2022, was designed to introduce students to electronics and programming in an arts context and provide students with skills they would need to build an interactive mural. The spring workshop was followed by an intensive summer workshop in which the interactive mural was designed and constructed. Students employed the skills and techniques they learned in the spring workshop during the summer workshop. A more detailed description of the workshops, along with a discussion of further research results can be found in [9].

## Spring Introductory Workshop

Authors 1 and 2 taught a six-week workshop in which seven students created individual interactive paintings using the same materials we would use to build the interactive mural. The workshop met two days per week for three hours. Author 1 began the workshop by introducing students to electronic circuits via a paper circuit project and then led a series of programming activities, employing the AdaFruit Circuit Playground [1] and the MakeCode visual programming environment [26]. She focused on teaching students how to use LED lights and capacitive touch sensors, which would be employed in the summer mural. Author 2 led a series of activities focused on the mural-making process. Students then worked to create their interactive paintings. A showcase of the students' work was held at the university that the research team is affiliated with. Students, friends, family, and WC community members attended.



Alexa working on her interactive painting during the spring workshop



Photos taken by students in the Barelas neighborhood



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## Summer Interactive Mural Workshop

Our interactive mural was designed and installed over a six-week workshop held during the summer of 2022, approximately one month after the spring workshop concluded. The interactive mural is located on the east-facing wall of WC's building. Authors 1 and 2 worked with four of the seven students (from the spring workshop) over the six weeks for five hours per day, four days per week.

In the months preceding the workshop, Authors 1 and 2 developed a workshop plan and a set of visual and technological constraints to help insure the feasibility of the project. We decided to limit interaction to touch, light, and sound—electronic elements students were familiar with from the spring workshop—and we decided on a mural theme of local flora, which the students later extended to include fauna.



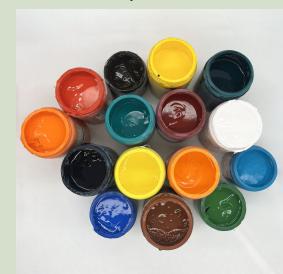
Students began the summer workshop by exploring the Barelas neighborhood and taking photos of local plants. They then created sketches based on their favorite photos. Students combined these sketches into a cohesive design for the entire mural. Once the visual design was complete the students designed the interactions that the mural would support, based on the technological constraints that were given. Next, students designed an electrical layout that incorporated all the required electronic components; each student led the electrical layout of a section of the mural. After finalizing all aspects of the design, the students began construction of the interactive mural. First, the visual design was mapped onto and drawn on the wall. Students laid out copper tape and electrical components on top of this design and soldered everything together. Then, paint was applied over the electronics. Programming and troubleshooting occurred throughout this process.

The completed mural was introduced to the community as part of an art walk event in our city. This event was attended by students and their families and friends, as well as local community members, art enthusiasts, and members of the university community—including art and computer science professors.

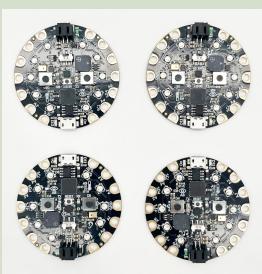
## Workshop Materials



Copper Tape



Nova Mural Paint



Microcontrollers

# Methodology

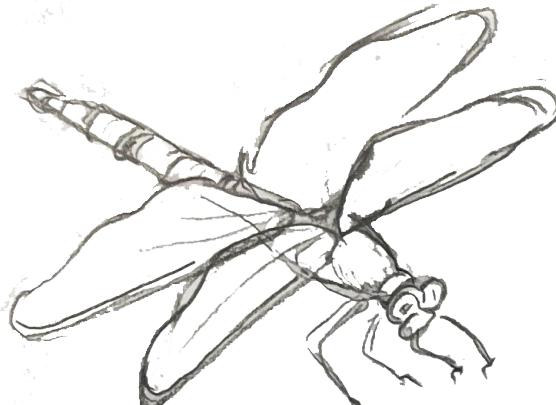


To structure and document the students' participation in the project, we employed Participatory Design methodologies [16, 21]. Our priority was to give participants a genuine voice in the mural design and construction process.

We carefully documented each aspect of the spring and summer workshops, primarily focusing on student work. We took photos and videos of student work each day and wrote field notes. We saved programs written by the students. This documentation, along with lesson plans we developed for each day, enabled us to explore and better understand the relationships between: the design and construction process, the completed mural as an artwork, and student experiences of the project.

At the conclusion of each workshop, Author 1 conducted one-hour semi-structured interviews with each student participant. We focused on students' experience of the process, exploring each student's understanding of their own learning, their sense of investment in and ownership over the artwork, and their engagement with the experience.

Throughout this paper, we encourage readers to approach the included documentation of student work as an important type of data. In particular, students' artistic skill and commitment to artistic excellence are best communicated in photos of their sketches and the completed mural.



## Thematic Coding of Interview Data

We used a grounded theory approach to analyze the data [11], examining students' experience of working closely with researchers on a large-scale art and technology project. Authors 1 and 3 first conducted open coding of two students' interview transcripts from the summer workshop to generate a set of approximately 200 preliminary conceptual codes [15, 29, 30]. We then extracted seven of the most prominent codes and refined them. Sub-codes were then defined for these seven prominent codes. We refined these sub-codes and coded the remaining interview data. Based on this analysis, seven primary codes and seventeen sub-codes were defined.

After analyzing the additional data, the final round of analysis focused on developing thematic categories concerning students' learning in the context of creating an interactive mural. See Appendix A for the final codes and sub-codes that resulted from this open-coding process. The following are the primary themes that we developed through this process.

- *Student agency*: providing opportunities for personal expression and project leadership lead to students feeling an investment in and ownership over the mural and what they learned.
- Providing opportunities for *cultural expression and community engagement* were key to establishing youth's sense of belonging and connecting what they learned to their life experiences.
- Engaging students in an integrated technology and art-*STEAM*-activity supported technical learning and positive shifts in students' perspectives on technology [9].
- Fostering *collaboration*, by creating a rich social ecosystem and leveraging the murals' large-scale, helped students navigate complex problems together respectfully and generously [9].

This pictorial focuses on the first two themes – *student agency* and *cultural expression and community engagement*. We want to highlight the fact that these two themes are intertwined. An environment that supports student agency enables students to express their culture and explore connections to their community. Together these themes facilitated deep engagement and helped students develop complex technological and artistic knowledge.

## Student Agency

To investigate student agency, we examined how the students described leading the design of the mural. We specifically wanted to know how the students described their input in the visual and interaction design process. We defined two primary codes that captured the students' views on their agency.

**SA1: Visual Design Process** — how the students described their input in the visual design

**SA2: Interaction Design Process** — how the students described their input in the interaction design of the mural and their input on how the electrical components will be incorporated

## Cultural Expression and Community Engagement



To examine cultural expression and community engagement, we looked at how the student's previous artistic competencies and interests support their confidence in learning new technical content. We also explored how students describe the importance of community and their culture. We defined the following four codes to better understand students' expression of their culture and connections to their community throughout the project.

**CE1: Youth's Art Expertise** — how youth bring their art expertise and confidence in artistry into the project

**CE2: Youth's Art History** — how youth described their family ties to art and how youth described their own history with art.

**CE3: Youth's Cultural Expression** — how youth express their cultural backgrounds to connect to their community

**CE4: Youth's Ties to The Community** — how youths' perceptions of belonging in the art community encouraged their engagement

# Student Agency

A foundational aim of our project was to enable students to be primary authors of both the artistic and technological components of the work. We wanted students to feel a sense of investment in and ownership over all aspects of the mural. For Author 2, this approach is related to values embedded in her mural practice. When collaborating with youth, she engages them as co-creators and not merely sources of labor giving them a genuine voice in the work. For Authors 1 and 5, the emphasis on student agency is grounded in constructionist educational theory a belief that students are uniquely positioned to learn when engaged in personally meaningful and constructive activities [23, 31].

Perhaps the clearest theme to emerge from student interviews during the summer workshop was their sense of ownership over the mural design in both the visual and technological components. The students truly saw themselves as art and technology designers throughout the project.

*Almost every mural I've done, they already have a design and they put it on the wall and we just go there to paint... This was the first I've done, where we started from scratch and actually came up with a mural and how to put it up on the wall and how to really design —Elena*



*Students designed the mural through a collaborative process. They combined their sketches on a light box, layered additional drawings, and negotiated the visual design of the mural*



The mural's theme was designed to allow each student to contribute components (individual flora) that were combined into a cohesive design. This process began with students taking photos and sketching flora they found around the Barelás neighborhood. The students then made photocopies of their sketches at different scales and worked together to layer them into a single visual design on a light box. While working, students added new sketches of local fauna, including bugs and a lizard. After finalizing the visual design, copies were printed out for each student to create a color study (i.e., a full color sketch of the entire design). They then collaborated with Authors 1 and 2 to decide what colors would be incorporated into the final color palette. When we interviewed the students, they proudly highlighted their individual contributions to the design.



Once the visual design was complete, the students collaborated on the mural's interaction design. Through a group brainstorming activity, the students discussed the interactions they envisioned. They articulated their sense of ownership and agency about their contributions to this aspect of the project in interviews. Elena described why she wanted to animate dandelions that started in her section and spanned the entire mural.

*I wanted ... the dandelions to light up, and I wanted it to be programmed where they turn yellow, but I didn't want them all to light up like a studio as (the touch sensor in her section) was touched. I wanted it to be like one after another ... then the offspring (dandelion seeds) would turn on, and then the next one, and then the next one. I didn't want everything to be (all at) once. I wanted it to be ... in steps ... because ... it catches more people's attention. -Elena*

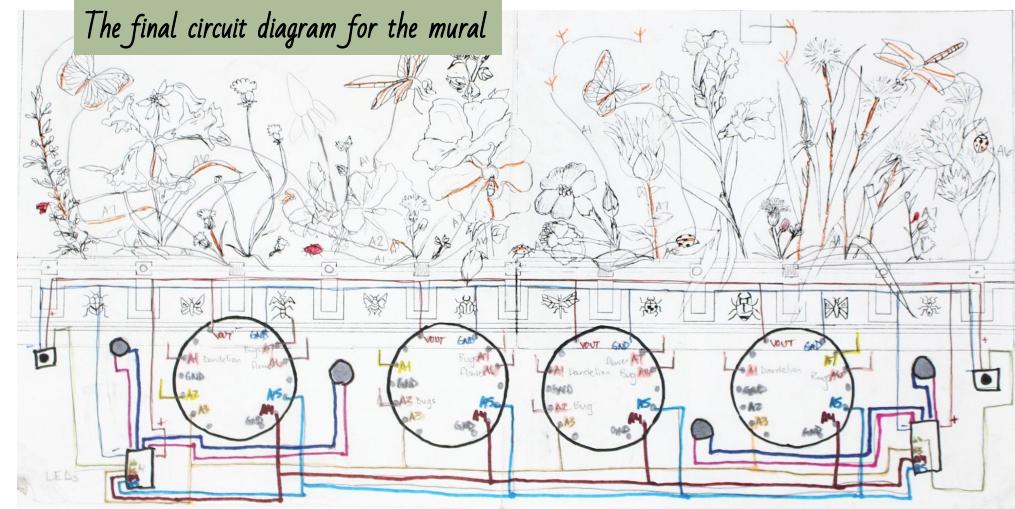
She provided reasoning as to why she wanted this type of interaction for the dandelions.

*(As) you're actually looking around of...where it's going as if it would pop up...you don't really know where to look. I mean, if something right here (or) something right here popped up at the same time (Elena points to different locations of the dandelions). I mean, like, which one do you look at first? I really wanted it to be laid out in (a sequential) way. I thought it was pretty cool. -Elena*

Once the interactions were identified, each student worked on a section of the mural to create a circuit layout diagram that detailed where electronic components would be placed and how they would be connected. The students were then in charge of building out the circuitry, programming the microcontrollers, and embedding all of the components within the mural with guidance from Author 1.



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*Students designed the interactions and the electrical circuitry for the mural. They tested, soldered, and installed all the hardware embedded into the mural*

# Cultural Expression and Community Engagement

One of our goals for the project was to foster meaningful community connections. We strove to do this physically (by painting the mural in Barelas), thematically (by choosing to focus on local flora and fauna), and through the people (students, collaborators, and other partners) we engaged in the project.

We chose to partner with WC and hold our workshops there to situate our workshops in a learning environment in which students felt comfortable. All of our students were long-standing community members of WC and described their sense of community and connection to WC in interviews.

*It's the community really. I made a lot of friends (at WC) that I'm really close to. —Alexa*

*I really like the people (at WC) .... everyone is really supportive and super friendly. —Elena*

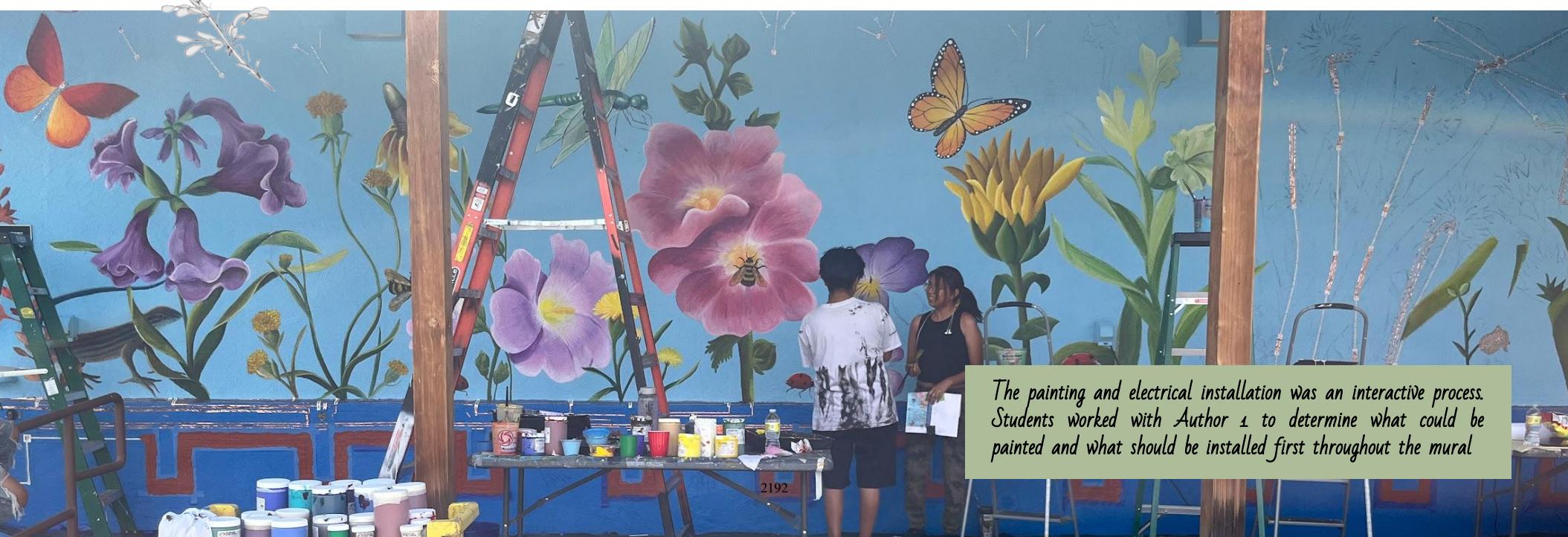
*Well, growing up, I saw my dad and uncle make a lot of art and stuff. They did a bunch of different things ... I really like making digital art. —Marley*

Each of our students had a long-standing personal history of art making. Our interviews revealed that for most of our participants' this was deeply connected to their community, particularly their families.

*I have a really close cousin...and she is such an amazing artist. Every time I go over, she's always doing art ... and it's just so fun to hang out with her ... And then her dad, her dad is an artist too. He is a painter...and he makes these huge sculptures ... I've just grown up with art around me, so I took it on. —Elena*

*I've kind of been drawing my whole life. My mom's always loved art and drawn all the time ... My stepdad, he used to be a graffiti artist, and I really love graffiti art. I think it's really interesting. —Enrique*

*I think I just always gravitated toward (art) because my family is very artistic. So I was around that area of art, of just drawing and stuff. I don't know, it's just something that really makes me happy. —Alexa*



*The painting and electrical installation was an interactive process. Students worked with Author 1 to determine what could be painted and what should be installed first throughout the mural*

We observed students using the mural theme as an opportunity to connect their to their personal, social, and cultural identities. We found it noteworthy that students, in interviews, described how they brought layered and complex aspects of themselves—their interests, their cultures, and their histories—to the project.

With the...Navajo tea flower...I knew that I wanted to represent more of my culture 'cause we pick those and dry them out to drink tea, and they are around my house. So, I wanted to connect back to my culture and where I live. —Alexa



I noticed the bees on that pink flower ... I really like bees. I almost chose to major in environmental science and bees are really important. They pollinate and they (are) really connected to nature too. And I just think they are cute and I really like bumblebees. —Alexa



I took a picture of little dandelions, like the flower ones, not the dandelions you blow. I took a picture of the little yellow dandelions...because whenever you guys had said pick or take pictures (of plants) that you mostly grew up with...whenever I saw those little yellow dandelions, it really just...reminded me of like whenever I was five or something...cause we'd always go to the park and we'd always try to make crowns out of them...those flowers are what I grew up with. —Elena



## Discussion



We designed our learning activities to support student agency, expression, and community engagement. This section highlights the pedagogical decisions that we feel did the most in supporting these goals.

We structured our workshops so that students would serve as the authors of all aspects of the work. They designed the visual layout, the interactions, and the electronic layout. They did all of the electronics building, painting, and programming. Providing these opportunities for student authorship necessitated the careful design of structures and constraints.

The importance of choosing an appropriate theme for the mural cannot be overstated. The theme of local flora and fauna allowed for student agency and artistic cohesion. Each student was able to photograph, sketch and then contribute their own design elements to the larger whole. Critical guidance, provided by Author 2, enabled the students to combine the elements into a unified mural design. Moreover, the series of theme related activities, including the walk around the neighborhood, encouraged community engagement. Students began the session by noticing and documenting the natural beauty of their neighborhood and community.

Giving each student a section of the mural to design interactions and electronics for further supported agency and independence. For this part of the activity, we constrained the type of interactions to input via touch and output via light and sound. We also constrained the number and type of electronic components students could employ to a single Circuit Playground, strands of LEDs and four touch sensors. Limiting students to a small set of electronic components that they had learned to use in the spring workshop enabled them to design and experiment with confidence.

We believe that situating electronics design in a visual context helped connect and integrate the visual and technological elements of the project. For example, having students create circuit diagrams directly on top of the mural design—rather than in a more abstract format like a schematic diagram—reinforced the connections between visual design, interaction design, and circuit design. The iterative workflow, which moved back and forth between visual, electronic, and programming activities also helped students connect and feel ownership over the different strands.

Finally, we believe that the openness, creativity, and enthusiasm students exhibited are largely a result of the fact that we spent a considerable amount of time building genuine relationships with students, their families, and the Working Classroom community.

*(In) my culture, we believe ... everything is connected. —Jen*  
*(A student from spring workshop)*



## Conclusion



This project demonstrated that students can serve as primary authors of large-scale, technically complex, and novel interactive artworks. Through a collaborative project they were able to feel a sense of agency and ownership over the work they created. They were able to make meaningful connections to their culture and community, while creating a community-based mural honoring Barelas, a neighborhood they are apart of. Students expressed pride and deep engagement in the project, and they began to develop new fluencies in electronics and programming.

We see this project as an initial foray into new and exciting territory. Interactive murals, when approached as serious works of community-based public art, have unusual and unexplored affordances. Situating computing and electronics in the context of community murals provide new opportunities to engage minoritized youth and minoritized communities in technology in a deep and meaningful way. We believe that interactive mural activities could encourage new kinds of technological appropriation and expression in addition to providing new pathways to technological knowledge and skill acquisition. Interactive murals also provide opportunities to explore collaboration and to develop new models for collaborative technology design.

Finally, interactive murals are compelling and novel artifacts in and of themselves. They could introduce new opportunities for artistic expression, interaction design, and citizen science. Mural's large scale and public nature insure that developments are highly visible. Young people could be involved in researching and exploring not only the construction of murals but their ongoing impact on communities. We are excited to explore some of these opportunities and directions in our future work.

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# Appendix A Themes And Focused Codes



Themes	Primary Codes	Sub-Codes
Student Agency	<b>Youth agency:</b> How youth describe having agency to be in charge of the design (i.e., visual, interaction, etc.)	<b>Visual design process:</b> How the students describe their input in the visual design process. <b>Interaction design process:</b> How the students describe their input in the interaction design of the mural and their input in how the electrical components will be incorporated.
STEAM Learning	<b>Technical skills learned:</b> How youth describe the skills they learned during the construction of the interactive mural.	<b>Technical skills learned:</b> How youth describe what they did technically when constructing the mural. <b>Troubleshooting challenges:</b> How youth describe the challenges they faced, and how they overcame them.
	<b>Shifting perspectives of CS:</b> How youth perceptions of CS (e.g., development of technology, conducting research in CS) changed after participating in the workshop.	<b>Shifts about how difficult CS is:</b> Youth's shift in perspectives of how they view the difficulty of CS. <b>Shifts about who can do CS:</b> Youth's shift in perspectives on if people that they relate to can do CS. <b>Shifts about what they can do with CS:</b> Youth's shift in perspectives on what they can do now with CS that they couldn't before. <b>Shifts about what you can do with CS:</b> Youth's shift in perspectives on the possibilities that people can work with CS.
Cultural Expression and Community Engagement	<b>Youth's art histories and competencies:</b> How youth's previous artistic competencies and interests support their confidence in engaging and succeeding in learning the technical content.	<b>Youth's art expertise:</b> How youth bring their art expertise and confidence of artistry into the project. <b>Youth's art history:</b> How youth describe their family ties to art and describe their own history with art.
	<b>Youth's cultural backgrounds and connections to the community:</b> How youth describe the importance of community and their culture.	<b>Youth's cultural expression:</b> How youth's express their cultural backgrounds to connect to their community. <b>Youth's ties to the community:</b> How youth's perceptions of belonging in the art community encourage their engagement.
Fostering and Understanding Collaboration	<b>Layers of collaboration:</b> How youth worked together and with others to accomplish design goals.	<b>Collaboration of youth with each other:</b> How youth worked together to accomplish design goals. <b>Collaboration of youth with research team:</b> How youth worked together with the research team members to accomplish design goals. <b>Collaboration of youth with partner organization:</b> How youth describe their experience working with partner organization.
	<b>Interactive mural driven collaboration:</b> How the mural scale and design of the interactive mural shapes the nature of collaboration.	<b>Scale of murals:</b> How painting murals provides natural collaboration. <b>Troubleshooting electrical components:</b> How students had to work together to troubleshoot electrical components due to the large areas the components covered.