Interactive Murals: New interactions and educational opportunities for diverse youth

Interactive murals integrate electronics into traditional murals to create a new kind of public art as well as a new kind of large-scale and community-situated technology. This article introduces interactive murals along with a set of activities designed to engage young people in technology and the arts. We describe the process and outcome of workshops in which a muralist, two interaction design researchers, and a group of diverse teenagers designed and built a large-scale interactive mural on the exterior wall of a local building.

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A significant body of research has demonstrated that STEAM (science, technology, engineering, art, and math) activities can help students develop skills in programming and electronics. Activities combining technology with the arts can also support culturally responsive learning environments by providing youth and educators with familiar, unintimidating, and culturally responsive entry points [1–7]. We contribute to the tradition of culturally responsive STEAM learning by introducing a new way of working with electronics and computing, as well as developing and exploring the potential of interactive murals. This new domain connects to the deep expertise that many young people have in painting and drawing, and provides new opportunities for culturally expressive and community-based learning. Interactive murals are large-scale, wall-based artifacts that integrate electronics and traditional murals. In the interactive mural workshops we have held, students expressed a sense of authorship and pride over their work, newfound technological competence, and excitement.

This project is a collaboration between HCI researchers (Alyshia Bustos and Leah Buechley) and a professional muralist (Nanibah Chacon). We also partnered with a local non-profit organization, Working Classroom,[a] that has a longstanding public art program in which diverse youth collaborate with muralists to paint murals around our city of Albuquerque, New Mexico. Our interactive mural activities take place in the context of this program.

Our murals are constructed from copper tape, conductive paint, standard electronic components, and mural paint. Each piece includes embedded microcontrollers, sensors such as painted-on capacitive touch, sound and air quality sensors, and actuators, specifically speakers and LEDs. Electronics are integrated into the mural's visual design, and we strive to meaningfully integrate visual and interaction design. The mural shown in Figure 1 was designed and built by the authors along with a group of middle-school and high-school students during a six-week summer workshop. As we design and build murals, we are also designing and building activities that use interactive murals as a context to introduce youth to electronics, programming, and interaction design.

To prepare students to work on large-scale projects, we first intro-

a https://workingclassroom.org/

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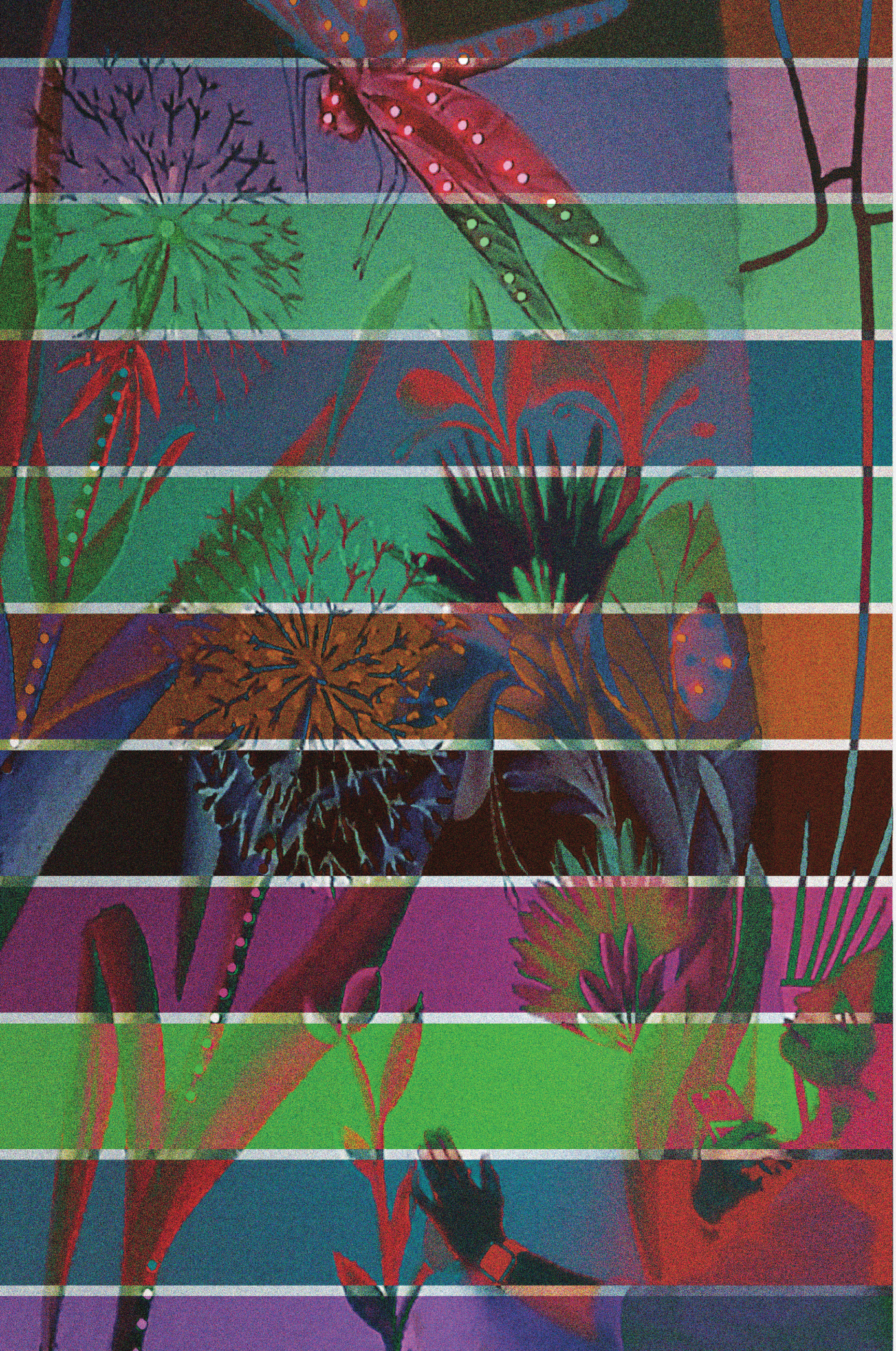


Figure 1. The first summer interactive mural, which was led by our students.

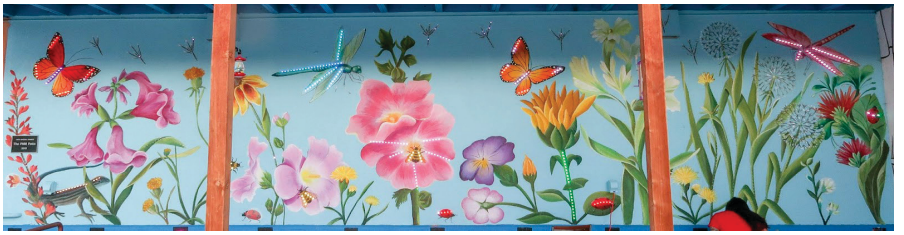


Figure 2. Students working on the construction of their interactive paintings.

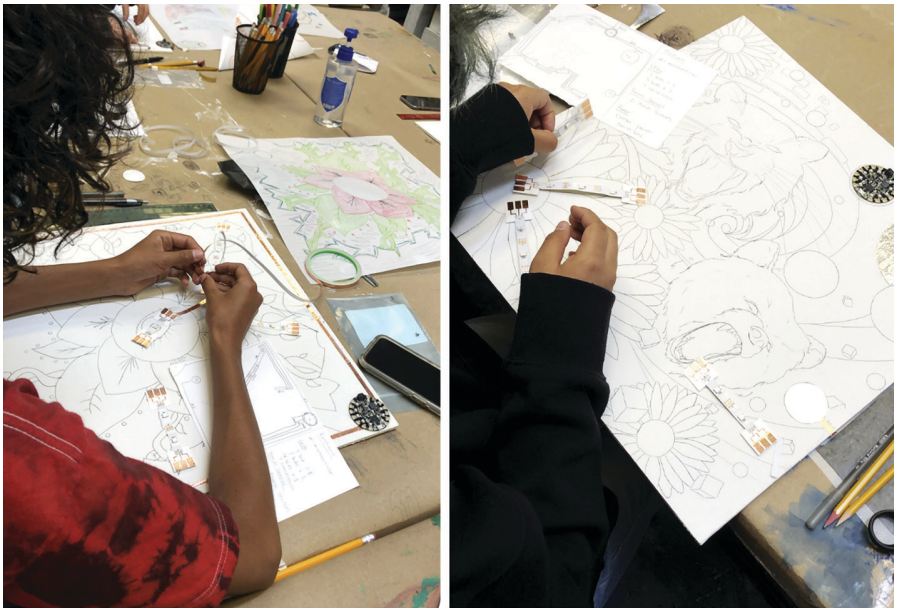
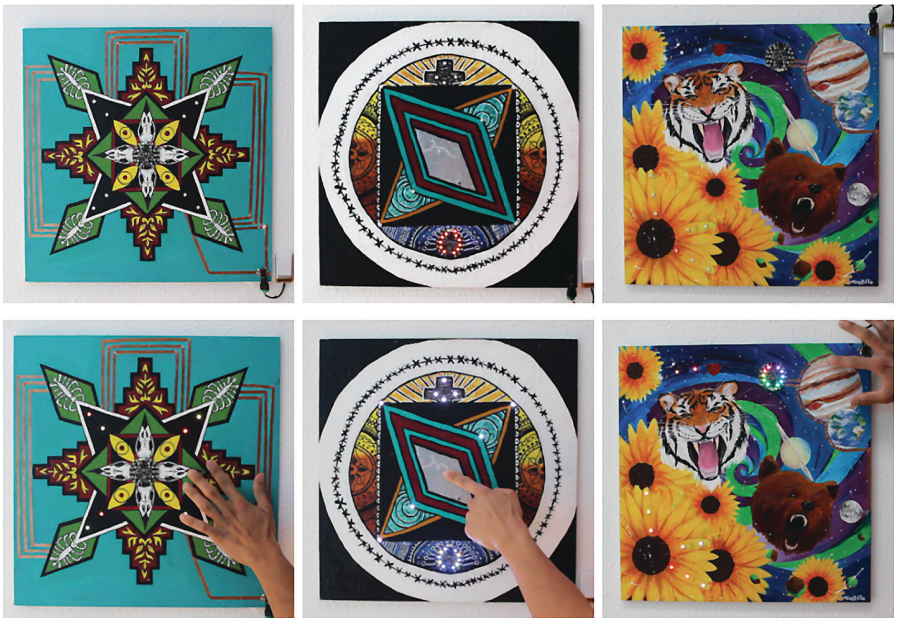


Figure 3. Three completed interactive paintings. The top row is of their work when no one interacts with the piece, and the bottom row shows the lights the students programmed to turn on when a user interacts with the painting.



duced them to foundational materials and tools in smaller-scale interactive painting workshops.

SPRING 2022 INTERACTIVE PAINTING WORKSHOP

In our interactive painting workshop, students aged 14–18 who had no previous technological experience were introduced to electronics, programming, and basic painting techniques. The workshop met for two hours per day, two days a week, for six weeks. Every student designed, built, and painted a 2 x 2 feet (60 x 60 centimeters) interactive painting. The first two weeks of the workshop were devoted to an introduction to electronics and programming. On the first day, students were introduced to basic electronics and circuits by building different variations of paper circuits. For the subsequent three sessions, students were introduced to programming using the Adafruit Circuit Playground and the MakeCode programming environment. The third week focused on painting techniques led by Nanibah Chacon. The final three weeks were devoted to helping students design, build, and paint their interactive paintings.

Each painting held an Adafruit Circuit Playground and at least one capacitive touch sensor made from copper tape, aluminum foil, and several multicolored (RGB LED) light strips. Students sketched visual designs; decided where to place their circuit playground, lights, and sensors; and mapped out their connecting circuitry on top of their sketches. Figure 2 shows two students working

Students expressed a sense of authorship and pride over their work, newfound technological competence, and excitement.

on laying out their electronic layout over their visual designs.

Students then assembled (taped, glued, screwed, and soldered), tested, and programmed their electronics. They used conductive copper tape to complete the electrical circuits in their design. Finally, they painted over their electronic circuitry. Some students chose to expose parts of their circuitry as part of their design, as seen in the image on the left of Figure 3. Each painting responded to touch by playing music and/or generating different lighting patterns. Figure 3 shows examples of completed projects and a person interacting with the projects by activating the touch sensors.

This workshop was designed to introduce students to the knowledge and skills needed to construct a larger interactive mural. From the eight students who participated in the interactive painting workshop, we selected four volunteers to participate in the project's next phase.

SUMMER 2022 INTERACTIVE MURAL WORKSHOP

The mural workshop took place over six weeks. The team met for four hours per day, four days per week. Two instructors, Alyshia Bustos and Leah Buechley, and four students collaborated on designing and building an interactive mural that measured 10 x 32 feet (approximately 3 x 10 meters). The mural was constructed on an exterior wall of Working Classroom's headquarters. A patio provided protection from the sun and adverse weather for the students and the mural, which was helpful during construction. We found the location and developed constraints to guide the project before it began. We decided on a botanical theme of local plant life, and chose to focus on interaction via touch, light, and sound. Within this framework, we helped the students design and build the mural, striving to give them as much authorship as possible over the work's visual and interaction design.

The first week we had the students walk around the community observing plant life in the neighborhood and asked them to take photographs and record sounds from the neighborhood. After observing the environment, the students began sketching images of the plant life they captured. Students used these sketches as the basis for the mural's visual design. Students cut out botanical elements from their sketches and arranged them on a light board to collaboratively develop a mural design that included contributions from everyone (see Figure 4).

After finalizing the visual design, the students worked together on interaction design and electronic layout. They decided how people would interact with the mural and where they would incorporate LEDs, speak-

Interactive murals have several unique and relatively unexplored affordances of community engagement.

Figure 4. Students tracing their first rough draft of the visual design for the mural (top) and students discussing how the electrical components will fit into their interaction design (bottom).

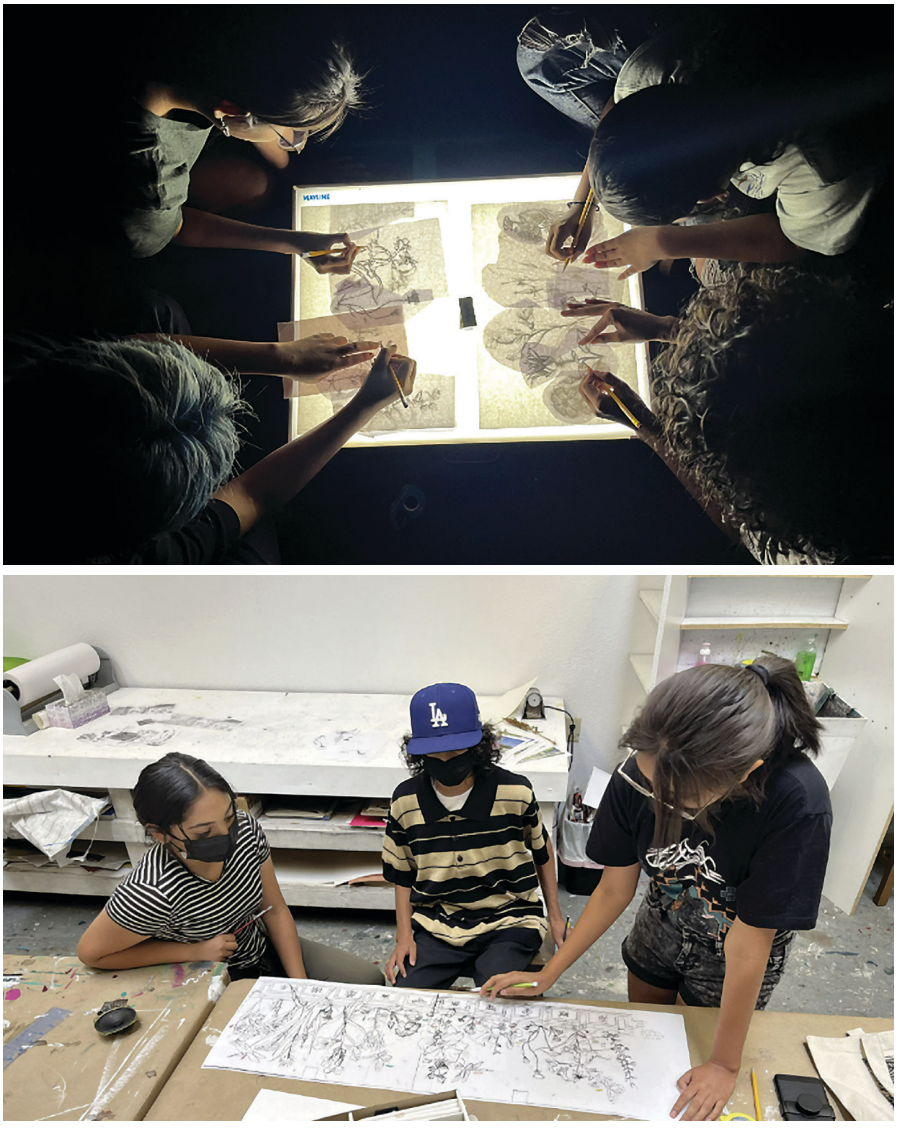


Figure 5. Students working on the construction of the interactive mural.

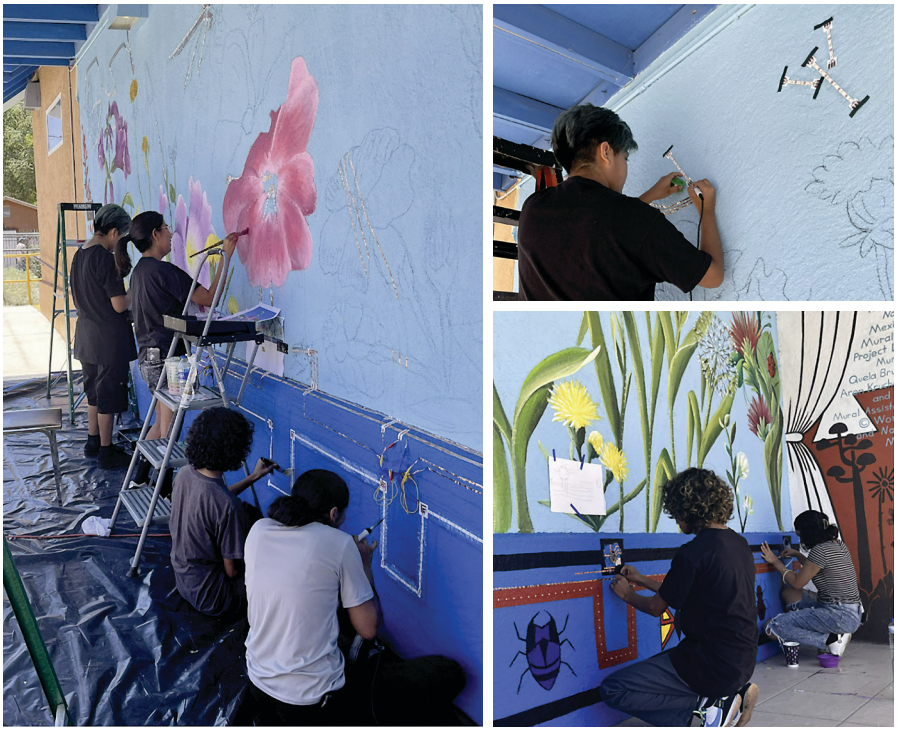
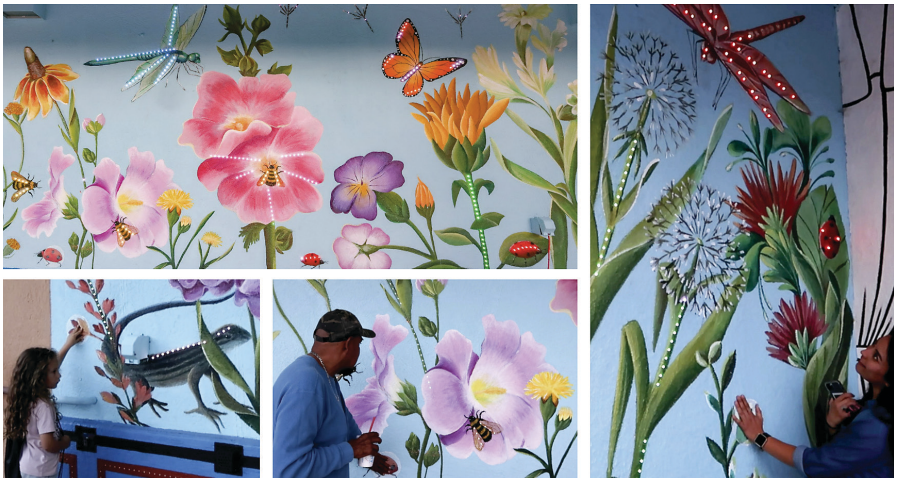


Figure 6. People from our community interacting with the mural during our showcase.



ers, and microcontrollers. Figure 4 shows the students working with the light board and discussing where the electrical components will be integrated into the visual design.

Students then began electronic installation and construction. The authors used a projector to sketch the mural design onto the wall. Students then installed electronics on top of this sketch, soldering, and testing connections as they progressed. Working collaboratively during this process was essential and the mural's large scale meant two or more people could only accomplish some physical tasks, which enhanced the collaboration efforts of this project.

After installing all of the hardware, students tested their programs. Each touch sensor, highlighted with a white circle in the final painting, activates a sequence of LEDs. Two motion sensors were programmed to play the sound of a barking dog when someone walks by and the sound of someone walking on gravel when they walk by. Finally, students painted over the electronics to create the final mural. Figure 5 shows the students working on different phases of mural construction, including soldering, painting, and debugging.

The mural was unveiled and exhibited as part of a community art walk attended by participants' families, friends, community members, and art enthusiasts. Figure 6 shows people engaging with the mural during the unveiling event.

REFLECTIONS ON WORKSHOPS

We conducted interviews with participants after each workshop to document and understand their experiences. This section focuses on exploring students' technological learning and self-confidence after participating in our interactive workshops. To protect our student's privacy, we will use pseudonyms in this section.

Prior to participating in our workshops, students reported on surveys having no knowledge of computing classes at their school and no knowledge of or access to these kinds of activities outside of school. Almost none of the students knew what "computer science" or "computing" meant. At best, students had a vague understanding of these terms associated with harmful stereotypes.

> *"Before this workshop I was kind of blanked on computer science."—Alexa*

> *"I didn't even know what (computer science) was. When someone brought that up, I thought it was some crazy stuff... like, in the future."—Enrique*

> *"Whenever I heard computer science I (thought) you must be really smart in order to do that... you must have a really big brain in order to do that... I can't picture myself doing that."—Elena*

The interactive mural project provided a context in which students could develop skills and interests in these new areas in a familiar and supportive environment. Students quickly developed

significant technological skills along with self-confidence. While electronics design and soldering were highlighted as particularly satisfying, programming was described as more challenging. Nonetheless, students also expressed excitement about and interest in what they learned in this area.

> *"I was kind of confused the first day (designing electronics) ... I really didn't know how we're gonna put the lights on the mural... But after like the second day I thought it was going pretty smoothly."—Enrique*

> *"We had to solder the LEDs... and that took a while. And then once (they were) on the mural we had to solder...the copper tape and then we had to solder our own circuit boards... I think I'm pretty okay with soldering."—Alexa*

> *"Before this... I could barely turn on a computer... I learned a lot on the computer that I probably would never have learned in my life if I didn't work on (this project), but you guys showed me how to work the programming stuff."—Enrique*

Student learning took place in the context of an activity they engaged in enthusiastically and seemed to enjoy. Students expressed pride in both the work that they did and in what they learned.

> *"I think it was a really great experience... I really like experimenting and learning what computer science has to offer and I think it's... overall a really great thing I experienced."—Alexa*

> *"I thought (this project) was pretty fun."—Martha*

> *"I've learned new things. I've learned things that I never really thought I would be able to do or really have an interest in... I wanna do another one... It's just really cool, and I feel like I learned a lot from it."—Elena*

All students said they were interested in taking art and technology-related classes in the future and that they were interested in participating in another interactive mural project. Some students also reported a new interest in participating in computing, electronics, and technology-related activities in the future.

> *"I think I might (take a class in computer science), I was actually thinking of taking one next year, for school because they actually have some classes for that."—Enrique*

> *"I would definitely want to add LEDs to my artwork... because I think it just makes it look more pretty and to have that... challenge...I know people (who do) cosplay. They have these LEDs and stuff. Now I want to do something along those lines."—Alexa*

> *"[Before the workshop] I wasn't really the person that'd be coding anything or wiring... nothing like that. But ever since we did this workshop, being able to say I did that, or I learned this... I feel... like now I'm starting to look at things. Like I was putting up these fairy lights in my room and I'm like, I wonder how you program these... I wanna learn now. So just having a greater interest in things... I think it's cool now."—Elena*

We see this project as an initial foray into new and exciting territory within STEAM-related projects. Interactive murals have several unique and relatively unexplored affordances of community engagement and acquiring computing and interaction design skills. Situating computing and electronics in the context of community murals provides new opportunities to engage minoritized youth and minoritized communities with technology. This recontextualization 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 new opportunities to explore collaborative learning and develop new models for collaborative technology design.

Interactive murals are also 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 ensure that new developments would be highly visible. As we have touched on briefly, young people could be involved in researching and exploring the construction of murals and their impact on communities.

We are excited to explore some of these opportunities and directions in our future work. As we continue learning from the talented and capable young people in our community, we can't wait to see what they can build when given access to a new set of powerful creative tools.

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Biographies

Alyshia Bustos is a Ph.D. student in computer science at the University of New Mexico. She is a research assistant in the Hand and Machine Lab, where she leads the Interactive Mural project and workshops.

Nanibah Chacon is a Dine (Navajo) and Chicana artist and an internationally recognized painter and muralist. Chacon's work is celebrated for its unique style, site specificity, and integration of socio-political issues affecting women and indigenous peoples.

Leah Buechley is an associate professor in the Computer Science department at the University of New Mexico, where she directs the Hand and Machine research group.

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