A Summer of Robots:
Seeding Creative Robotics Across the Urban Landsdcape

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Abstract. This article describes an urban experiment in community-based robotics deployed in Pittsburgh, Pennsylvania during 2007 and 2008. Twenty-one community-based organizations deployed robotics workshops, exhibits and curated pieces throughout the city, creating a space for technology fluency and exposition throughout the urban landscape, from galleries and schools to parks. The details of the creative design and arts approach employed and the results garnered elucidate our definitions of technology fluency, community-based robotics and the city-wide impact possible through synchronized outreach activities deployed at a large scale.

Keywords: community-based robotics, creative design and arts, workshops, educational robotics

1 Introduction

At the Factory 14 workshop *Neighborhoods and Play* hosted by the Mattress Factory museum, artist and coordinator Tom Sarver led twenty-five participants through a weekly evening course during October and November 2007. Open to any age and any level of prior experience with technology and art, a collection of teams formed, with ages ranging from an eight year old to middle-aged artists unfamiliar with technology, and middle-aged engineers with little background in art. Using a handheld robotic sensor dubbed the Canary, the teams measured ambient noise, light and pollution levels, providing a looking glass through which to quantitatively consider the qualities of green spaces and urban neighborhoods.

Figure 1. The Exquisite Corpse robot and team

As Tom encouraged the students to begin considering their own creation, one team settled on their project idea: an exquisite corpse display that would reflect the diversity of neighborhood residents in nearby parks. Camera and Canary in hand, the team interviewed and documented a dozen strangers in the park, asking them to talk about their sense of neighborhood and community. Images of these strangers were divided into head, torso and leg shots, and the team spent two weeks building a human-size robotic display that would interact with a visitor by spinning to randomly chosen heads, bodies and legs as the visitor shouted, beat their chest, and stamped respectively. To create an interactive art-piece, the team used a Canary to control servomotors, experiment with numerous rotation mechanisms, research and build clutches and sensors, and fabricate a six foot tall responsive robot system (Fig. 1). Nine months later, Exquisite Corpse was one of twenty interactive robots in the Mattress Factory Workshop Showcase, where the creations of *Neighborhoods and Play* became part of the museum's collection for a special two-week exhibition.

From the summer of 2007 through 2008, scenes like this were repeated dozens of times across twenty-one community organizations, art galleries and museums in Pittsburgh as part of Robot 250, an experimental program designed to broadly seed creative-robotic landscapes throughout the urban landscape to foster technological fluency and explore new modes of public engagement with creative technology.

The fusion of creative expression and technological empowerment for civic exploration is a fertile and engaging field of endeavour (Jenkins et al. 2006; DiSalvo et al. 2008). What makes this project distinctive is its breadth and scale. Robot 250 spanned two years, starting with public outreach workshops that engaged 545 participants across 21 host sites and ending with large-scale exhibitions, activities and events that attracted 95,000 visitors with publicly created robotic exhibits and 11 commissioned, professional installations. Yet the focus of Robot 250 was also very narrow: workshops focused on Pittsburgh's history, neighborhood identity and localized civic challenges. Finally, Robot 250 crossed field boundaries to conglomerate a unique set of tools for inquiry and topical communication, tapping community mapping, rhetoric, creative arts, sensor networks, robotic actuation and gigapixel imaging. In this paper we describe the motivations and objectives of Robot 250 and the design of the public programming, from distributed workshops to final exhibitions. Then we present high-level outcomes stemming from analyses of evaluation instruments deployed throughout the Robot 250 experiment and, finally, we re-imagine the emerging theme of community robotics.

2 Problem Statement

Community-based robotics brings together aspects of educational robotics with issues of topic and expression: how can communities of practice learn about robotics, not as a job skill alone, but as a tool for exploring and expressing at the community level. We define this problem by readdressing the role of educational robotics, creative design and arts approaches in the context of community.

2.1 Technological Fluency and Educational Robotics

Our approach to community robotics begins with the simple assertion that technology should enable people to assume more agency and be more creative in their lives. Although we are interested in people becoming more expert with robotics and technology, we do not begin our work assuming that we know what experts necessarily will look like. We are aiming to foster a *fluency* with technology rather than a specific set of skills.

Technological fluency has become an issue of national importance, with many contending that enhancing the technological fluency of all citizens is critical to our nation's continued prosperity and economic success (AAUW, 2000; NRC, 1999; Schunn et al., 2006). In *Being Fluent with Information Technology* the National Research Council proposed that technological fluency is the ability to "express [oneself] creatively, to reformulate knowledge, and to synthesize new information" (p. 2). As the report further states, fluent individuals "evaluate, distinguish, learn, and use new information technology as appropriate to their own personal and professional activities" (p. 3). Similarly, Resnick and Rusk (1996) suggest that fluency involves the ability to be expressive, to explore, to experiment, and to create with technology. Such definitions imply that fluency goes beyond the basic ability to use technology as a passive consumer. Rather, fluent individuals are able to adapt or create new technology to serve their own goals. DeGennaro (2006) takes the definition a step further, suggesting that fluency also implies transfer of technology engagement across diverse contexts.

Studies of the development of technological fluency suggest that youth engage in a number of fluency-building activities (e.g. creating web pages, programming, using desktop publishing programs and media authoring tools), but that there might be gender differences in their patterns of engagement (Barron, 2004). Researchers have also made suggestions regarding the types of experiences that can help promote technological fluency. For example, some have argued design experiences and engaging youth in digital communities can promote technological fluency (Cajas, 2001; DeGennaro, 2006; Resnick & Rusk, 1996).

Drawing upon the original National Research Council report, and bearing in mind the recent work of the NSF-funded center for Learning in Formal and Informal Environments (LIFE) (e.g., Barron, 2004, 2006), our working hypothesis is that technological fluency:

- Is creative, either in the problems posed, the solutions found, or both;

- Enables and is enabled by participation in a design process where ideas are implemented in ways appropriate for the discipline;
- Reflects greater agency in and engagement with a community of practice that includes the discipline.

Our work is based on the premise that the best informal technology experiences view fluency as both a process and an outcome. In the supported conditions of a well-designed informal learning environment, participants would experience technological fluency. This experience creates a desire to seek out other fluent moments and helps to develop the knowledge and skills that learners need to create fluency around them at home, in school, at work, or in other informal learning environments.

It is worth pointing out that our definition of fluency is distinct from the engineering pipleline models that underlie many educational robotics efforts. Challenge-based robotic competitions such as US First, BEST and Botball (Best Robotics 2009; Botball 2009; US First 2009) often provide a simulating engineering experience for participants. The goal, constraints, and process for the activity are set by an external authority and are designed to help participants learn precise models of engineering process and content. This can be a good thing if the goal is to produce more engineers. In this view educational robotics is special because robots are fun and engaging, and therefore less likely to underwhelm the future technologist as she sets into her initial technology coursework.

However our interest in community extends well beyond the engineering workforce, and in this view the purpose and relevance of educational robotics should be reconsidered. The first nearly tautological step in this broad view is to recognize that robotics encompasses all of the engagement and relevance of computation more broadly. The robot is intrinsically connected to a computer, and by virtue of this is tied into our creative design of computational systems and our connection to and interpretation of every piece of information accessible through the computational network- the internet.

Yet computation is inherently non-spatial: it is distributed and capable of manipulating information just as agnostically one mile away and half the world round. The physical robot adds one important quality for the individual and for the local community: embodied locality. Its physicality necessarily suggests a relationship with a specific place and a specific group of people. Its physical connection to the real world, through sensing and action, defines a coupling to the physical world that deems the robot especially relevant to local events and local action. Finally robotics accesses cultural imaginaries, and does so in dramatically different ways for instantiations of popular cultures in various countries and regions. Laden with cultural baggage, wanting for physical connections to real events and actions, the robot anchors and extends computation to a group of people in a place, and therefore we can consider this form of educational robotics as a stimulating medium of designed communication.

The technical know-how that building an interactive robot affords, combined with the expression of a truly local argument, also suggests a form of technological fluency- an ability to use computational and robotic constructions to explore, make sense, design, create and disseminate in the new media of interactive robotics.

2.2 Creative Design and Arts Approaches

The particular approach that we have adopted in Robot 250 begins with the question: *How can creative design and art approaches foster technological fluency with and through robotics?* We have argued that engineering is not the only approach to working with technology. The history of creative design and art offers examples of the imaginative and critical use of technology, which demonstrates novel forms of fluency among professionals. However, there has been little research that explores how these creative design and art approaches might used with non-experts and in community settings to foster technological fluency. Through the Robot 250 programs, we drew from the fields of interaction design, industrial design, sculpture, and public art, as alternatives to engineering, in order to investigate how practices of problem discovery, invention, and expression from these fields might foster technological fluency, and whether new kinds or markers of fluency might emerge from such approaches.

One of the reasons that creative design and art may be a powerful structure for community robotics is that they are inherently expressive disciplines. If technological fluency is to be developed and practiced actively in people's lives, it needs to be daily and local. Programs that are based on engineering pipeline models prepare people for a potential future as an engineer. We want to see a more immediate pay-off in people's lives. We also note that pipeline-based programs are primarily for school students. Most adults, in contrast, are more interested in learning something that makes their current life choices richer. Our bet is that fluent people will want to use technology for self and community expression in their local communities.

How can we design localized technology fluency programs, particularly with robotics*?* Our approach to technological fluency emphasizes socially situated fluency: the imaginative application of technology to express personal and community identities and communicate and address local issues of concern. This requires that the fluency programs be grounded in local desires and conditions. Such grounding is uncommon in robotics programs. More common are abstract problems such as manipulator dexterity or distant scenarios, such as moon landings. While these problems and scenarios are useful for developing content knowledge of robotics, they do not foster the kind of socially situated fluency we hoped to achieve through Robot 250. As such the development of tools, activities, and themes that would enable participants to connect robotics to local desires and conditions, comprised a significant area of research in Robot 250. It also requires that we consider the organizational aspects of developing technology fluency programs and the ways in which researchers might work in concert with community organizations. It is our hope that addressing this problem of developing localized technology fluency programs might begin to give us answers to the broader motivating question of *How can we foster a notion of community robotics?* i.e., a conceptualization of robotics in service to and use by groups of non-experts with shared practices, interests or geographic locale.

3 Setting the Stage

Robot 250 was a localized experiment that derived particular value from its locality. The technology and outreach laboratory as well as the city of Pittsburgh offer unique affordances jointly for topical, local expression with high-technology means.

3.1 The CREATE Lab

The Community Robotics, Education and Technology Empowerment Lab (CREATE) at Carnegie Mellon's Robotics Institute aims to create self-sustaining communities of learning, expression and technology empowerment (Create 2009). Each project at CREATE is funded by a pairing of industrial gift funding for technology innovation and foundation funding for community deployment and evaluation. A project team at CREATE typically includes design, firmware, software, curriculum and evaluation components drawn from within the lab and from close partnerships at Carnegie Mellon and at the University of Pittsburgh Center for Learning in Out-of-school Environments (UPCLOSE). As the cost of rapid prototyping has continued to drop, nearly every CREATE project benefits from in-house production of small quantities of new technological artifacts (50 – 200 copies) for early testing, followed by forging relationships with commercial partners if greater quantities are needed by CREATE or by the public (Rowe et al. 2002; Nourbakhsh et al. 2006). Prior work has included interactive installations at the Smithsonian National Air & Space Museum and San Francisco Exploratorium, programmable robotic devices for local community colleges, the Robot Diaries art and robotics program for middle school girls, and broadly distributed public *kits* including the Telepresence Robot Kit, the Palm Pilot Robot Kit and the CMUcam image system.

3.2 Pittsburgh

Our project was aware of and benefited from taking place within the unique city that is Pittsburgh. Because of its industry and universities, Pittsburgh has had a long history with robotics and local boosters are fond of viewing it as a hothouse for all things robotic. Local foundations were very excited about Robot 250, supporting it as one of a handful of big projects that marked the city's 250 anniversary.

3.3 Strategies for Engagement

To structure the design of the Robot 250 technology fluency programs, we drew on strategies for engagement from participatory design and design-based research in the learning sciences. Within the field of participatory design there is over two decades of literature concerning the development of programs aimed at increasing the role of non-experts in shaping the forms and functions of technology services and products (for an overview see Bødker, Kensing, and Simonsen, 2009). While workplace studies were the origin of participatory design methods, communities and informal learning settings have received increasing attention since the late 1990s. From this research we drew both general inspiration for how to structure our engagement with participants and detailed methods such as the use of design games (Brandt and Messeter 2004; Brandt 2006). Of particular relevance to the Robot 250 programs was research concerning the use of participatory design methods of futuring workshops and grounding imagination in the contexts of museums and community centers (Büscher 2004; Carroll 2001; Taxen 2004) The design of individual activities within the workshops drew from design-based research in the learning sciences and more broadly reflected trends in the learning sciences towards critical design. (Barab 2007) In this model, as advanced by Barab, the researcher takes an active role as a social agent and the program is seen as having decidedly social implications

The structure of our engagement itself was tiered: members of the research staff served as program directors, educators, and facilitators, taking on different roles with different host organizations and contexts. As directors, research staff members would oversee and manage a particular workshop or museum installation. As a director, the staff member would have primary contact with employees of the host organization. As educators, research staff members would lead an individual workshop, thus having regular interaction with participants. As facilitators, research staff members would train others to lead the workshops. As a facilitator, the staff member would have less individual contact with participants and more contact with the educators of a given host organization. The purpose of this tiered structure was both pragmatic and program directed. Pragmatically, we did not have the resources to work as lead educators in all of the workshop locales, we had to have support mechanisms for teaching. Programmatically, we also wanted to explore to what extent we could operate as facilitators in "training the teachers", with the hope of making the programming more sustainable and more connected to the individual contexts and agendas of the host organizations.

4 The Structure of Robot 250

Robot 250 was comprised of five different types of outreach: workshops, open studios, public exhibitions, public events and commissioned robotic art installations. We describe the structure of each such aspect of the whole program below.

4.1 Workshops

Public workshops were the foundation of the Robot 250 program. Over the course of the Robot 250 program there were workshops and studios at 16 sites with 545 total participants exposed to a total of 450 program hours of instruction (Fig. 2). It was in these workshops that participants were introduced to robotics, design, and art, and led through the process of conceptualizing and producing imaginative applications of robotic technology. The particulars of each workshop were shaped by the desires and capacities of the host institution, the specific technology platform to be used, and the capabilities and interests of the participants (which were themselves reflective of the agenda of the host institution). In general the workshops took one of two forms: they were either organized around a theme and accompanied by a relatively structured curriculum, or they were an "open-studio" format, in which there was less structure and more open exploration of design, art and robotics. Regardless of the format, each workshop was led by either a member of the research staff or an employee of the host institution. The duration of the workshops also varied from daily meetings over a 2-week period to weekly meetings stretched over two months. Common to all of the workshops was a hands-on approach, with participants exploring and working with robotics technology from the first session onwards.

Workshop & Studio Sites	Students
Braddock Youth	10
Andy Warhol Museum	25
Brew House Gallery	25
Carnegie Science Center	25
Children's Museum of Pittsburgh	25
C-MITES	16
Computing Workshop	10
Manchester Craftsmen's Guild	25
Mattress Factory	50
YMCA/YWCA Homewood	12
YWCA Downtown	12
YouthPlaces (3 sites)	35

Figure 2. Sites and enrollment sizes for 2007 (1st of 2 years of workshop programming)

The 2007 Summer workshop at the Mattress Factory Museum was characteristic of the open-studio format. The program was supported by the museum's education department and led by an artist-in-residence. Meetings were held weekly at the museum, for three hours in the evening, over two months. Approximately 25 people participated in the workshop, ranging in age from 8 to middle-aged, from designers and artists to those who were simply enticed by the marketing materials produced and distributed by the museum. Rather than following a strict curriculum, the program was organized around a series of activities that would introduce participants to different aspects of robotics on a weekly basis, with the objective of building a working knowledge of the given technologies. In addition, there were weekly design activities intended to scaffold the creative process [refs]. Given the open-studio format, participants were free to create whatever they desired, with no limitations other than their own capacities and imagination.

Figure 3. The robotic cucumber hand

Participants began exploring by experimenting with environmental sensing technologies, exploring and documenting the measurable qualities of the area around the museum, and then proceeded to experimenting with motors and the construction of kinetic mechanisms. Along the way the artist-in-residence led participants through brainstorming and storyboarding activities in order to assist them in developing their concepts. Such activities comprised the first-half of the program, and in the second-half, the participants worked to design and construct robots expressly designed for an upcoming public exhibition. The robots created ranged greatly in concept and complexity. Given the context of the museum, it should not be surprising that most veered towards the experimental and artistic. For example, one participant created a robotic hand sculpted from cucumbers that responded to light, curling up upon itself (Fig. 3). Exhibited together with other forms created from processed food (e..g Rice Krispies) the final exhibit demonstrated an unusual mixture of robotics and edible artifacts.

4.2 Technology Platforms

The technology platforms used by Robot 250, all products of the CREATE Lab, were chosen due to their low-cost, scalability, and their ability to sense local and remote environments along axes of topical interest and their ability to push back on the physical world, manipulating a physical robot's controls or creating new representations of what is sensed.

The Canary, designed originally for Neighborhood Networks (DiSalvo et al. 2008) combines the ability to serve as a portable looking glass into local environmental conditions with the ability to directly manipulate robot motors depending on those same environmental conditions. Specifically the Canary detects ambient sound, temperature and light levels as well as markers for volatile organic compounds (such as may be out-gassed by new carpeting and rubber). Values are shown both on a built-in LCD screen and directly control servomotors on four available ports inside the Canary's corrugated plastic container. Each port embodies a different form of motor motion as a function of sensor value, from linear proportional to amplitude and period control of a cyclic motion (e.g. to repeatedly ring a bell). The Canary was used for the Neighborhoods & Play theme at the Mattress Factory's Factory 14 workshop, the Brew House open studio sessions, the downtown Pittsburgh YWCA and C-MITES workshops.

Figure 4. The Canary environmental sensor and actuator

The GigaPan, originating in a cooperation between NASA/Ames and CREATE, is a robotic device that enables standard point-and-shoot digital cameras to create immersive panoramic images consisting of billions of pixels (Fig. 5). Once uploaded, these images can be explored and annotated, starting conversations between authors and viewers across the world. More than 35,000 such images are publicly shared at www.gigapan.org, and the Gigapan device is used by CREATE in outreach programs with world-leading scientists and, in collaboration with National Geographic and UNESCO, with underrepresented groups of students in the United States and in six other countries. The GigaPan was the principal technology for the History & Heritage theme at three community organizations, Manchester Craftsmen's Guild, YMCA/YWCA Brushton-Homewood and Carnegie Braddock Library. In addition GigaPan was used for Inner and Outer Spaces at the Andy Warhol Museum.

Figure 5. The GigaPan robotic imager

The Telepresence Robot Kit (TeRK) is a hardware device that combined an internet-connected Linux processor with specialized robot control hardware to enable a locally built robot to respond to both local environmental conditions as well as RSS feeds from any internet source (e.g. a robot that shudders when there is a large earthquake in Afghanistan). The TeRK processor thus extended the reach of a robot's senses beyond that of the Canary into any source accessible on the internet. This technology, in conjunction with RSS feeds, was the core tool at Mission Discovery (Carnegie Science Center) under the Neighborhoods & Play theme.

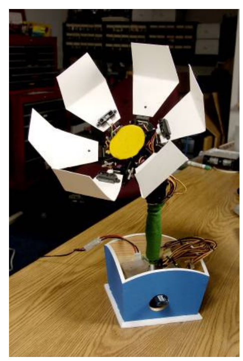

Figure 6. The TeRK flower

The TeRK Flower is a special instance of a TeRK robot with pre-built mechanisms approximating a blooming and wilting flower, affords attendees a chance to design the form of the petals while avoiding the mechanically sophisticated challenge of building a many-petal radial form (Fig. 6). Using local sensors on the petals, the flower can be programmed to wilt and bloom based on local conditions (e.g. there is a hand waving at me) or remote conditions via RSS feeds. The TeRK flower was principal at the Children's Museum of Pittsburgh's Youth Alive! program.

4.3 Exhibitions

Robot 250 culminated in a series of showcase exhibitions, which featured the work of the participants from the workshops. The exhibitions took place in the Summer of 2008, with a two week period in July in which all of the exhibitions overlapped. During those two weeks, there were 4 shocase exhibitions at 4 Pittsburgh museums featuring work from 9 of the workshops and open studios with exhibits created by approximately 80 participants. Through these exhibitions the participants were able to share their work with a larger public.

Figure 7. The Mattress Factory exhibit showcase

Figure 8. The Andy Warhol Museum exhibition

In addition, from the perspective of the research objective of Robot 250, the exhibitions were a crucial element in the programming. The exhibitions were able to communicate across the city a range of interpretations of and experiences with robots. Where possible, the locale of the exhibition mirrored the locale of the workshops. Each exhibition took a different form, reflective of the host institution. So, the exhibition at the Science Center was markedly different from, but complementary to, the exhibition at Warhol Museum. Across differences in local and content, every exhibition shared a common format for visual presentation, signage and mediation of the works (Figs. 7, 8).

Figure 9. Mattress factory road-crossing robot

The Summer 2008 showcase exhibition at the Mattress Factory featured work from the multiple workshops that had been hosted at that same locale from Summer 2007 to Spring 2008. The exhibition occupied the same space as had the workshops, producing a comfortable continuity for the participants and the work. The exhibition design straddled the visual and informative presence one would expect from a science museum exhibit, with the kinds of projects one would expect to find in art exhibit, as was fitting for this given venue and workshops.

To the extent possible, the works included in the showcase exhibitions were operational as they had been when designed and implemented by participants in the workshops. In some cases participants had been contacted in the time in-between the workshop they attended and the final showcase exhibition, and been given the opportunity to complete or expand upon their designs. For example the group that had created the "exquisite corpse" sculpture was able to tweak their input, take new photographs to be used as the faces, torsos and feet, and reinforce the structure of their sculpture. In other cases, due to normal wear and tear a given sculpture might not be as operational as it had been in the workshop. Nonetheless, if the concept and documentation were strong, the piece was still included. For example, a group of youth at a program at the Mattress Factory had constructed a robot that would crawl along the ground in a purposefully pathetic way, intended to solicit the help of passers-by. Although this robot no longer functioned by the time of the showcase exhibit, it was included in the show (Fig. 9).

It is important to note that in addition to the showcase exhibitions being spaces of display, many of the exhibitions were accompanied by an opening, which constituted a significant public event in the Robot 250 programming and research endeavor. Many of the participants were present at the openings, and engaged in discussion with participants from other programs and attendees who had not been participants. In some instances openings overlapped. For example, the Mattress Factory showcase exhibition opening occurred in parallel to the opening of the commissioned robot in the Mattress Factory garden and the curated exhibition *Meet The Made* at the museum. Consequently, the opening for all three intermingled, with a peak crowd of over 200 and attendance throughout the evening topping 500 (Fig. 10).

Figure 10. A robot exhibited during the Meet the Made opening

4.4 Arts Programs

Complementing the showcase exhibitions of workshop participant's robots were a set of commissioned robotic artworks and a curated exhibition at the Mattress Factory museum entitled *Meet The Made.* The commissioning of artworks by professional artists provided yet another perspective on the question of how to imbue a city with a broad experience of what robots are, and could be, in society. It also served to acknowledge the role of the arts in contemporary culture: as a practice that both interpretively reflects our socio-cultural morés and shapes our future imaginaries. Care was taken in both the selection of the artists and in supporting their endeavors.

4.4.1 Commissioned Art

Eleven works were commissioned from 13 regional artists (two works were undertaken as collaborations). The choice of regional artists was intended to reinforce the "localness" of Robot 250. Due to the presence of a first-tier arts program at Carnegie Mellon University, several of the artists have international standing. This combination of artists with such status, along with emerging artists and the works of workshops participant's, put on display an expansive range of expressive possibilities with robotics. Each work had the requirement that the piece be public (either outdoors or in a freely accessible indoor space) and capable of running for the 2-week span of summer festival. To support the artists in their endeavors, each was given a significant commission as well as technical support from the research staff. There was significant diversity across the 11 commissions ranging from numerous large-scale sculptures, to installations of animatronic robots, to networked percussive devices situated within a museum garden.

Figure 11. Golan Levin's Double-Taker (Snout)

The technical complexity of the robotics artworks and modes of interaction between the robots and people varied widely. For example, artist Golan Levin created an interactive robot entitled *Double-Taker (Snout)* that was placed on the roof of the Pittsburgh center for the Arts (Fig. 11). The robot was fashioned from an ABB industrial robotic arm, covered in a black sheath, and the end affixed with a large "eye." Using a vision system mounted on the roof and custom authored software, the robotic sculpture would look for people moving in the areas in front of the building and move, in response to their presence and movement, to face them. This resulted in playful interchanges between the robot and visitors, who would often wave, jump about, and run back and forth to garner “attention” and response from the robot. *The Look-See Tree* by artist Ally Reeves, in contrast, was less technically sophisticated but provided a more intimate encounter with an reflective informal educational purpose. *The Look-See Tree* was a robot sculpture of a tree filled with animatronic animals in what Reeves' described as “mini-theatres” (Fig. 12). The sculpture was attached to the back of a bicycle, which Reeves would ride through city parks, providing planned encounters to groups of school-aged children, and the serendipitous encounter with adults. As people encountered the tree Reeves would engage with them in a kind of storytelling augmented by the animatronic animals, telling tales about how in the future, animals would adapt to their technological environs.

Figure 12. Ally Reeves' Look-See Tree

In addition to the commissions, two members of the research staff were invited to curate an exhibition at the Mattress Factory museum, as part of the museum's annual regional exhibition program. The exhibition entitled *Meet The Made* was different from the commissions in that the works included were not required to include robotics technology, but rather, were artistic reflections about robotics. As such, the exhibit included drawings, sculptures, installations, and performances that engaged various aspects robotics and explored how the idea(s) of robotics intersects with social-cultural issues. For example, artist Bob Bingham and Claire Hoch created the installation-performance *The New R5 Travel Agency: Roving Roof Revision Request Robot Imagine Your Paradise...Your Dream is Your Reality.* In this work Bingham and Hoch created an office space within the museum that proffered services of using robotics to sculpt rooftop gardens or install renewable resource materials such as photo-voltaic cells on rooftops throughout the city of Pittsburgh. Visitors were able to meet with agents from the office to discuss how robots might assist in transforming urban spaces towards more sustainable conditions and participate in co-constructing a future imaginary of robots in the city.

4.4.2 Cymbeline

As part of Robot 250, we also intended to be inclusive of performing artists as a community of practice that can be technologically empowered. One such performing arts troupe, Quantum Theatre, is based in Pittsburgh and reinterprets classic plays in unconventional outdoor and partially built environments. In approaching the application of robotic technology to their upcoming play, Shakespeare's *Cymbeline*, we initiated a series of discussions circumscribing the range of possible senses and actions possible through straightforward robotic-interactive technology, then entered a guided ideation process, where CREATE engineers would provide feedback on cost and complexity as Quantum Theatre considered alternatives for interactivity during the performances. By partnering a CREATE engineer with a former Quantum production manager, the final system was designed, tested and deployed for actual use during every performance in a two week run.

Please turn on your cellphones, and set them to vibrate. This instruction to the audience was their only warning for an SMS-based interaction during the performance. During critical junctures in the first and second act, questions were broadcast via SMS to the audience in real time (e.g. *What is worth dying for?*). As the audience provided text message responses, thermal printers hidden in forty foot cypress trees on-stage presented audience texts in scrolls that wound down to stage level, providing feedback both to the audience and physical props for the actors.

As the success of the thermal printers as a communication device became apparent, Quantum Theatre chose to use them additionally as communication devices to identify locale (e.g. *Rome*) during changes of scene. This collaboration led to interest and documentation from the theatre community in the form of popular articles and an in-depth analysis in Live Design (Napolean 2008).

Figure 13. Robot bug making at the Carnegie Science Center

4.5 Public Programs and Events

Robot 250 also co-sponsored five additional special robot-themed events and programs throughout Pittsburgh timed to coincide with the Exhibition showcases and BigBot displays in a further effort to infuse robotics throughout the city. The *Robot Block Party* was a one-day celebration of industrial, research and entertainment robots at the Carnegie Science Center and attracting the highest attendance of any event in the history of the Science Center. The *Robot Film Festival* featured outdoor movies with robotic themes on four evening in Pittsburgh in collaboration with the city's Parks division. Three sequential special events at the Mattress Factory (Art B-Q BBQ; The Human Hive; Activist Robotics) presented various facets of robotics and society in the context of *Meet the Made*.

Figure 14. Roving Robot Art Cart by CitiParks

Finally, three separate organizations in Pittsburgh worked with Robot 250 to create public, free robot-building activities at the city's Parks (Fig. 14), the Carnegie Science Center (Fig. 13) and the Children's Museum, all coinciding with the two-week exhibit and festival period. These activities were designed to further introduce the public to the potentially empowering concept that they, too, can build robots in a single afternoon.

5 Discussion

The ultimate goal of city-wide robotics is city-wide change, and a critical aspect of the Robot 250 experiment was a broad evaluation instrument deployed to gather information on how, if at all, Robot 250 itself changed attitudes and knowledge within Pittsburgh.

5.1 Audience Research

How does one assess whether a summer of robots has changed anything? Did the citizens encounter the robots? Did they learn anything about robots, about Pittsburgh, or about themselves? To find out, we interviewed visitors at 13 of the Robot 250 BigBot and public exhibition sites. Researchers approaches audience members after they had viewed the robots and asked several questions about their experience. We collected 505 complete interviews.

In the two weeks preceding and following the festival, we also collected a comparison sample of interviews from people who we approached in crowded locations such as parks, shopping districts, museums, and entertainment districts. These 645 people were asked some of the same general robotics questions as in the audience interviews as well as questions about whether they had heard of the Robot 250 project. The purpose of this sample was to compare general responses to robots in the city to the specific responses of audience members who viewed Robot 250 installations. By collecting about half of the comparison sample before the event and about half after the event, we were also able to look for signals of any pre-post change associated with the broader media buzz in the city regarding Robot 250.

One of the questions we asked both the audience and comparison samples was to name five adjectives that come to mind when they think about robots. Findings suggest that the approach we took in Robot 250 was successful in communicating an alternative vision of robotics to our audiences. (Fig. 15).

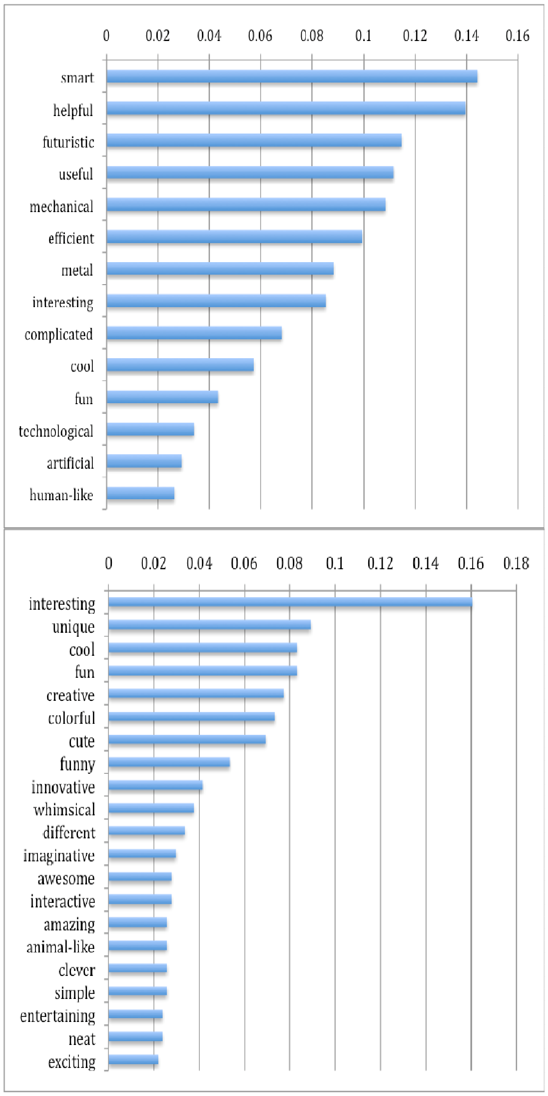

Figure 15: Robot adjectives suggested by more than 2% of respondents in the comparison "person on the street" sample (top) and the Robot 250 audience sample (bottom).

First examine the comparison group data on the upper portion of the Figure 15. As they reflected on their general notion of robots, respondents from the comparison sample tended to view robots as being utilitarian machines. They often used words like "helpful", "mechanical", "efficient", "metallic" and "complicated". They also used words like "smart", "futuristic", and "technological", which we view as consistent with the high-tech mission-oriented robotics that is often in the news, especially here in Pittsburgh.

In contrast, the audiences at Robot 250 events revealed a different model of robots as they answered the adjective question. The top four words used were "interesting", "unique", "cool", and "fun". As opposed to the more utilitarian language in the comparison sample, Robot 250 audiences described robots as "funny", "whimsical", "imaginative", and "creative". While the comparison sample talked of robots as being "complicated" and "technological", our audiences preferred to talk about robots as being "simple" and "interactive".

Because one of the purposes of Robot 250 was to challenge traditional notions of robotics, we asked visitors if the installations struck them as robotic: 48% said yes; 44% said no; and 8% were not sure. When we looked deeper at the reasons why our robots violated normal robot expectations for almost half of the visitors, we heard words similar to those in the adjective findings: 14% told us that the robots did not seem like robots because they did not have a true purpose; 14% said they were not metallic, wired, or angular enough; 13% said they did not look futuristic; 11% said their movements were not robotic looking; 11% said they were too organic looking; and 8% found them more artistic or friendly than the expected, among other responses.

Findings so far suggest that Robot 250 had a clear impact on its audience. Most people viewing our installations saw them as distinct from typical robotics and were more likely to describe the robots in terms consistent with our approach to an engaging, creative form of community robotics. We now turn to the question of whether we were able to detect any changes in the broader population of Pittsburgh. Recall that half of the comparison sample had been collected before and half collected after the event. We did not design our project as a public awareness campaign for the whole region, thus any impact that occurred in the broader population would have been a secondary result of incidental media exposure or word of mouth.

We were moderately successful in increasing awareness of our project in the city. Just before the event, 6% of respondents said that they had heard of Robot 250 compared to 21% just after the event. Most people who knew about the project had seen signs on the buses or stories in the local press. When asked directly whether they had seen a Robot 250 installation, 4% said that they had.

As a first approximation, one might consider that because 4% of our post sample had actually seen our robots while 21% had just heard about them, any pre/post difference closer to 21% might suggest that awareness of the project was sufficient to change people's beliefs about robots, while any changes closer to 4% might suggest that direct participation is necessary.

We found that latter was generally true. For example, because one message in Robot 250 was that all sorts of Pittsburghers could build robots, we asked people on the street whether they thought they could build a robot themselves. We saw a 5-point change in how often people said yes, from 46% in the pre to 51% on the post. Because we thought that Robot 250 would make people more aware of robots around them, we anticipated that the post sample might be more likely to report having seen a robot in the past month. Again, we saw a modest 4-point shift from 21% on the pre saying that they had seen a robot in the last month to 25% on the post. Finally, because we thought Robot 250 would increase the extent to which Pittsburgh is identified with robotics, we asked people to rate how strongly they associate the two. Again, we saw a 4-point rise from 25% of respondents saying there was a strong association on the pre to 29% on the post. Thus it appeared that direct, rather than indirect, experience with Robot 250 was necessary for any changes in Pittsburgher's views of robots, their city, and themselves.

5.2 Collaborations Fostered

In the end, however, the place where one might expect to see the real city-wide impact would be in the organizations that were our collaborators in Robot 250. Our approach was to work with partners who already have the capacity to reach diverse audiences in different parts of the city. The Universities brought technology, design, and program development skills to the table, but we never intended that we would be the location to sustain this program. We structure our work with community partners so that they could take greater agency and control in future iterations of the project. And we expected that new community partners would emerge as Robot 250 and our other associated robotics education work become more widespread in the city.

Several community-based organizations have now entered long-term relationships with CREATE, adopting Robot 250 and similar technologies in their regular community programming and outreach activities. These include the Children's Museum of Pittsburgh, C-MITES, Manchester Craftsmen's Guild, Carnegie Libraries, Saturday Light Brigade, ten Allegheny Country public schools and the Consortium of Public Education. This level of active engagement between community-based organizations and a university research lab has been possible only through the broad introduction Robot 250 has afforded.

5.3 Challenges and Issues

Robot 250 was not without significant challenges and issues, which provide insights for the design and development of future such programs as well as suggesting salient topics for research. Of these challenges and issues, three were predominant and pervasive and serve as broad categories: technical implementation, human resources, and the measurement of impact.

As every engineer and designer knows, the technical implementation of systems is a daunting task. This task is amplified in robotics, where the system by definition involves a hybrid assemblage of mechanics, electronics, and software. These challenges and issues of technical implementation were present throughout the endeavors of platform development and workshops, but it is with the art commissions that these came to the fore in an exacerbated manner. In part, this was due to the particular demands of the art commissions: being public, running 8 -12 hours a day for 2 weeks, and of the 11 works, 10 were outdoors pieces, contributing a significant set of environmental demands and constraints. Of the 11 commissioned artworks five of them endured significant technical problems, which impacted their development and display. These problems included repeated motor-failure due to excessive loads, inoperational mechanisms, and the inability to achieve correct sensor calibration. Notably all of the robots, even those with significant technical problems, were able to remain on display, in some fashion, for the extent of the festival. This was due in part to the determination and creativity of the artists. Each artist worked diligently to maintain a mode of public presentation for their work. In some cases, this even included manually operating the machines, so that they appeared to be functioning autonomously, but in fact, were not.

While some might cast this as a failing, we would not. Rather, we maintain it is the standard condition of "doing robotics", one that need to be accepted in such situations, and considered as reflective of the qualities of the technology and an opportunity for probing the practices of "making robotics work" – regardless of whether the robotics are in a lab or a museum. These problems are common to robotics generally, and so, to an extent are expected, particularly in experimental settings of robotics laboratories. But these art installation too are in fact experimental settings, but of a different kind and in different content. The confounding issue is that while these artworks are in fact experimental settings, they were also public displays, that presumed a certain level of functioning. The challenge then is to negotiate these two overlapping, and contradictory, conditions. As such, these technical challenges and issues can be cast, and from a research perspective analyzed, as an opportunity to reveal and examine the epistemological frames of robotics as a practice, and the differences in those frames between the arts and engineering.

Human resources, and human resource management, proved to be another significant challenge and issue. The art installations provide one example of this: the sheer person power required to assist in the design, production, and maintenance of these works was substantial. But the art installations were only one component of the overall Robot 250 program. Given the 16 workshop sites, the 8 programs, 9 exhibitions and 5 public events, it should not be surprising that constructing a staff reporting and responsibility structure comprised a significant effort. While often the human resource aspect program development is overlooked as a research topic, we maintain this is shortsighted. Indeed, to understand what comprises community robotics, it is imperative we analyze what is structurally needed to support such endeavors. Moreover, these issues of human resources extend beyond the research staff. Nowhere is this more apparent than in the building and maintenance of organizational relationships. Regardless of program size, in working with communities, inevitably this involved working with organizations. The challenge and issue then, from a research perspective, is how are these relationships built and sustained?

6 Conclusion and Future Work

Robot 250 operated at an exceptional and truly unprecedented scale. Precisely because of this, it provides a wealth of examples and lessons for structuring and assessing future community-based robotics programs. Such community-based robotics programs offer multiple research opportunities: how to develop such programs is itself a research question, and once developed, they provide platforms through which to investigate questions of technological fluency, the role of the arts and design in technology learning, and questions concerning the effects of community-based robotics programs across communities, organizations and institutions, and even regions. In this paper we have begun to sketch answers to these questions, which will support our, and others, ongoing research in this area.

In regards to our motivating goals of fostering technological fluency and impacting a city's perception of robotics, we can tout a moderate success. Certainly, throughout the workshops and exhibitions, innumerable fluency moments can be identified, and are exemplified in the diverse ingenuity and creativity embodied in the robots designed by participants. As we report in this paper, audiences at the exhibits also expressed a notable change in perspective concerning what a robot is or could be. Even at the level of the city, we documented a modest change in perception concerning robotics. With further analysis, we will provide greater detail of these fluency moments and changes in perception at the individual, group, and community level.

As we move forward with our research, we remain committed to advancing and investigating community robotics. We are currently in the process of establishing new programs in Pittsburgh, PA and extending our programs to Atlanta, GA. Informed by our experiences and findings from Robot 250, these secondary programs will provide the opportunity to refine our program development and assessments, and to test the sustainability and extensibility of our approaches to community robotics.

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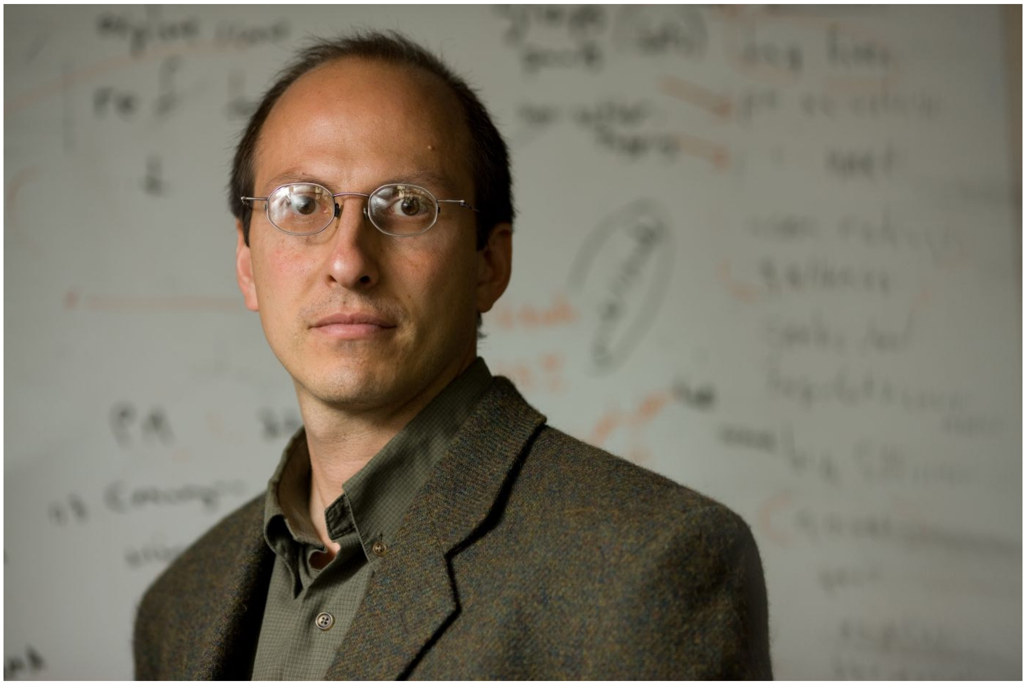

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