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New Pathways into Robotics: Strategies for Broadening Participation

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Abstract

This paper suggests new strategies for introducing students to robotics technologies and concepts, and argues for the importance of providing multiple entry points into robotics. In particular, the paper describes four strategies that have been successful in engaging a broad range of learners: 1) focusing on themes, not just challenges; 2) combining art and engineering; 3) encouraging storytelling; 4) organizing exhibitions, rather than competitions. The paper describes a new technology, called the PicoCricket, that supports these strategies by enabling young people to design and program artistic creations that integrate light, sound, music, and motion. The paper concludes with an analysis of robotics activities in three educational environments, examining how these new strategies and technologies can engage young people with diverse interests and learning styles.

Introduction

Picture these scenes from two different classrooms. In one classroom, students are building cars using LEGO gears, wheels, and motors. One group is trying to make its car go as fast as possible, while another group writes a computer program to control how the car reacts when it bumps into a wall. Meanwhile, in another classroom down the hall, students are creating an interactive garden. They use a wide variety of materials (including felt, construction paper, pipe cleaners, and LEGO bricks) to create flowers, insects, and hanging lanterns. One group writes a computer program to make the wings of a bee flap up and down, while another group programs the lanterns to glow different colors when someone comes near.

In many ways, the experiences in the two classrooms are similar. In both classrooms, students are using the same robotics technology. They are learning similar math and science concepts, and developing similar technical and programming skills. But the differences between the two experiences are also important. Different students are attracted to different types of robotics activities (Bers, in press; Resnick, 1991). Students interested in cars are likely to be motivated to create motorized vehicles, while students with interests in art or music are likely to be more motivated to create interactive sculptures.

This paper examines strategies for introducing students to robotics technologies and concepts, and argues for the importance of providing multiple pathways into robotics, to ensure that there are entry points to engage young people with diverse interests and learning styles.

When people think of robotics, they often think of popular images of robots in movies, such as R2D2 in StarWars. Increasingly, robots are becoming available as consumer products, such as the Roomba vacuum-cleaner robot and the Aibo walking robotic dog. But these stereotypical images can be misleading. Walking and rolling robots represent just one type of robotics. Robotics includes all types of programmable machines that perform actions based on inputs from sensors—everything from a home security system that sounds an alarm when it detects motion to a greenhouse that regulates its temperature and humidity.

In recent years, robotics has become popular as an educational activity internationally. A growing number of schools and other educational organizations are offering opportunities for young people to build their own computer-controlled robots, using programmable construction kits such as LEGO Mindstorms. For example, the FIRST LEGO League robot challenge, open to students ages 9-14, grew from 200 student teams in the United States in 1998 to more than 4,600 student teams in the United States in 2006—and more than 2,800 student teams elsewhere in the world (FIRST, 2006).

One reason for the educational appeal of robotics activities is that they involve multiple types of design: physical design of structures and mechanisms (building a creation using construction materials, motors, and gears) as well as computational design of behavior (writing a computer program to determine how a creation should move and respond). In the process of designing and programming robots, students learn important engineering, math, and computer science concepts (Druin & Hendler, 2000; Martin, 1996; McCartney, 1996).

However, the way robotics is currently introduced in educational settings is unnecessarily narrow. In most classrooms and workshops, the first robotics activity begins with everyone building a car. Exploring a wider range of possible applications has the potential to engage young people with a wider range of interests. Young people who are not interested in traditional approaches to robotics become motivated when robotics activities are introduced as a way to tell a story (for example, creating a mechanical puppet show), or in connection with other disciplines and interest areas, such as music and art (Bers, in press; Resnick, 1991).

Although popular, robotic competitions tend to attract a much higher percentage of boys than girls, particularly in free-choice learning environments such as after-school programs and museum classes. Even with efforts to increase female participation, only 30% of the FIRST LEGO League participants are girls (Melchior, Cutter, & Cohen, 2004). Researchers have noted a gender imbalance in the overall participation rates, at both the K-12 and university levels (Melchior et al., 2004; Turkbak & Berg, 2002).

As explained in a report from the American Association of University Women (2000): “Girls and other nontraditional users of computer science—who are not enamored of technology for technology’s sake—may be far more interested in using the technology if they encounter it in the context of a discipline that interests them” (p. v). The AAUW report proposes that “computation should be integrated across the curriculum, into such subject areas and disciplines as art, music, and literature, as well as engineering and science” (p. xii). The AAUW report cites a study by the National Research Council (1999) that concludes “fluency is best acquired when students do coherent, ongoing projects to achieve specific goals in subjects that are relevant and interesting to them” (AAUW, p. xi).

This paper introduces several strategies we have found successful for engaging a broader group of young people who might not otherwise become engaged in learning opportunities with robotics. Then, the paper describes how these strategies have been applied in three different educational environments with three different communities of learners. Finally, the paper considers learning outcomes and challenges associated with these strategies for broadening participation.

Strategies for Broader Participation

In our fieldwork, we introduced robotics activities and ideas to children, teens, families, and educators. This fieldwork has included workshops for children and families at museums (Resnick et al., 2000), activities for teens and staff in after-school centers, and a robotics course for undergraduates (Turbak & Berg, 2002). From this work, four key strategies have emerged that frame the way we approach introducing robotics in order to engage diverse audiences.

Focus on Themes (Not Just Challenges)

Robotics workshops typically focus on a particular engineering challenge, such as “Make a robot that can maneuver through an obstacle course.” Instead of focusing on a single design challenge, we have found it valuable to structure workshops around a shared theme. For example, in a workshop around the theme of Music Makers, participants create new types of programmable musical instruments; in an Interactive Jewelry workshop, they create different kinds of wearable art; in a Storybook Scenes workshop, they create robotic characters based on a familiar book or movie.

We look for themes that strike a balance between being broad enough to give everyone freedom to work on a project that connects with their interests, and specific enough to foster a sense of shared experience among workshop participants. We have found that workshop participants, by working on projects based on personal interests, are more motivated to persist when they encounter problems in the design process, and more likely to continue to extend their projects to explore new directions (Bers, in press; Resnick et al., 1998). As a result, they form deeper connections to concepts and ideas underlying the workshop activities.

One advantage of organizing workshops around open-ended themes is that it engages participants in "problem finding", not just problem solving. In most real-world design projects, a critical part of the process is identifying and refining the problem to be solved. Theme-based workshops provide students with opportunities to develop their ability to find as well as solve problems—in contrast to most school activities in which students are presented with fully-framed problem.

To start classes and workshops based on a theme, we have found it useful to provide at least two different sample projects to spark ideas and give participants a sense of the range of what's possible. For example, in a workshop on creating a machine that can paint, we showed one machine that painted by pulling a brush, and another that spun the paper while paint was dripped from above. In a workshop on creating musical instruments, we demonstrated one instrument that adjusted the pitch of a quacking sound based on light level, and another that played beats in response to squeezing it.

Combine Art and Engineering

An engineering assignment typically consists of a problem to solve, such as dropping a box without breaking the egg inside. We have found that many young people become more engaged if they learn engineering concepts in the process of creating interdisciplinary projects that combine art and engineering—for example, designing a painting machine, building a machine that can read and play music, or making a programmable water fountain.


Figure 1 A jukebox that uses PicoCrickets and craft materials in a "wearables" workshop.

People are able to use materials most creatively and productively when they are already comfortable and familiar with the materials. Boys often come to robotics workshops with many years of experience building with LEGO materials, so they can quickly integrate LEGO materials into their robotics projects in creative ways. Many girls have more experience with art materials, and thus they are better able to use art materials as a source of inspiration for creative robotics projects.


Figure 2 A boot with lights in ping-pong balls programmed to change colors when walking.

Combining craft materials, mechanical parts, and programmable devices can inspire both girls and boys to think more creatively about what is possible and what they want to create. Instead of just providing mechanical components (such as pulleys, gears, beams, and axles), we arrange a larger palette of construction materials that include craft supplies and recycled materials (such as pipe cleaners, paper towel tubes, pompoms, and pieces of fabric). We choose the materials to support the workshop theme—for a design a park workshop, we provided leaves, branches, and other natural materials; for an interactive light workshop we gathered frosted plastic cups and glittery and reflective papers. In addition, familiar objects can spark new ideas: for a workshop on future fashions youth participants brought in old belts, gloves, and boots to transform into interactive "wearables" (Figures 1 and 2).

Encourage Storytelling

Researchers at Harvard's Project Zero (Shotwell, Wolf, & Gardner, 1979) studied how children interact with their toys, and identified two primary styles of play. They described some children as "patterners"—that is, they were most interested in patterns and structures, preferring to play with blocks and puzzles, and exploring the mechanical properties of objects. They described other children as "dramatists"—preferring to play with dolls and toy animals, and using their toys for pretend play and social interaction.

Traditional robotics activities tend to be more appealing to patterners. But the same technologies, if introduced in the appropriate way, can also be appealing to dramatists. For example, in a workshop based on an amusement-park theme, one group of students took a patterner approach, building a merry-go-round and then programming it to turn a specified number of revolutions. In the same workshop, another group of students took a more dramatist approach, developing a story about a family spending a day at the amusement park and riding on the Ferris wheel.

It is possible to adapt existing robotics activities to make robotics more appealing to dramatists by incorporating storytelling. The theme of a workshop can center around a story, with students recreating scenes from a fairytale, myth, or other storybook. For example, students at an elementary school in Minnesota created dioramas based on folktales, creating mechanisms to bring to life characters from each folktale.

Many science centers offer workshops in which young people create Rube Goldberg contraptions, where each device triggers the next. As a variation on this idea, we have offered chain reaction workshops in which participants read a picture book, and then design contraptions that follow a narrative series of events.


Figure 3 PicoCricket.

By encouraging storytelling within robotics activities, it is possible to engage a wider diversity of students, from early childhood (Bers, in press; Bers, New, & Boudreau, 2004) to college level (Turbak & Berg, 2002). Incorporating storytelling and narrative into robotics can also strengthen reading, writing, and literacy connections. Students can keep journals about their design process—introducing their plans, recording steps along the way, explaining problems they encountered, and describing how the finished project worked. (For examples of elementary school student robotics journals see http://ltc.smm.org/museummagnet/).

Organize Exhibitions (Rather than Competitions)

Many robotics activities are structured as competitions. For example, FIRST LEGO League announces a challenge with rules each year, and thousands of teams of young people compete in local, national, and international tournaments. Competitions are motivating for many students, but alienating for others. An alternative approach is to offer young people the opportunity to display their work in an exhibition rather than a competition.


Figure 4 PicoCricket output devices: multi-colored light, sound box, numerical display, and motor.

For example, the Robotic Design Studio course at Wellesley College culminates in an exhibition where family and community members of all ages are invited to informally mingle and interact with each project and its creators (while snacking on cheese and crackers), much like at the opening of an art exhibition (http://cs.wellesley.edu/~rds/). The open-ended nature of the exhibition format accommodates a wider range of abilities and allows room for a greater variety of creative expression—while still maintaining the motivational benefits of a public display of projects (Turbak & Berg, 2002). This variation aligns with math and science reform recommendations for educators to further equity efforts by supporting more collaboration and less competition (Beane, 1992; National Research Council, 1996; Sadler, Coyle, & Schwartz, 2000).

New Technologies to Support New Pathways

Robotics construction kits can be used in many different ways, to support many types of activities and many different learning styles. But each construction kit supports some types of activities and learning styles better than others. For example, the LEGO Mindstorms robotics kit (which grew out of research at the MIT Media Lab) is particularly well-suited for developing mobile robots, and has been the foundation for many robot competitions around the world.


Figure 5 PicoCricket sensors: light sensor, touch sensor, sound sensor, and resistance sensor.

More recently, we have been involved in the development of a new type of robotics construction kit that explicitly aims to combine art and technology, enabling young people to create artistic creations involving not only motion, but also light, sound, and music. At the core of this new kit is a small programmable device called a PicoCricket (Figure 3), which children can embed in their physical creations (http://www.picocricket.com). Children can connect PicoCricket output devices (such as motors, colored lights, and music-making devices, Figure 4) and sensors (such as light sensors, touch sensors, and sound sensors, Figure 5) to the PicoCricket, then write simple computer programs to tell the PicoCricket how to behave.

For example, a young person might create a cat using craft materials, then add a light sensor and a sound-making device (Figure 6). She could write a program (using the PicoCricket's easy-to-use graphical programming language) that waits for the light sensor to detect someone petting the cat, and then tells the sound box to play a meowing sound (Figure 7).

Figure 6 Cat made with PicoCricket, light sensor, and sound device.

Figure 7 Program for PicoCricket: waits until a light sensor detects a low light level, then makes a meow sound.

Although the activities might seem different on the surface, programming a cat to meow when you pet it is actually quite similar to programming a robot to react to an obstacle, in terms of underlying computer-science concepts. For example, to tell a robot to change direction when it hits the wall, a program could wait until the touch sensor is pressed, then tell the motors to reverse direction. The program for the cat waits until the light sensor detects low light, then tells the sound box to play a sound. The programming skills and concepts are the same, only the context is different.

Figure 8 Software for programming PicoCrickets.

The PicoCricket kit includes not only electronic parts but also a collection of LEGO bricks and an assortment of craft materials. Each electronic part has a LEGO plate on the bottom to allow easy connection to other LEGO materials; each part also has two loops to make it easy to attach craft materials such as pipe cleaners, string, and other connectors.

The software for programming the PicoCricket features a palette of more than 50 graphical programming blocks, a melody editor, a rhythm editor, and tools for data collection and graphing (Figure 8). In addition to the graphical interface, the software also provides a text-based programming language.

Examples

This section describes how we have applied these strategies and technologies to broaden participation in a variety of settings. We present examples that span three different contexts with three different audiences:

1) a museum workshop for families
2) a series of after-school program for girls
3) a professional-development workshop for educators

These examples represent a diverse range of learning environments, illustrating how these strategies can be used to engage learners with diverse styles and interests.

A Museum Workshop for Families: A Day in the Park

The "Day in the Park" workshop invited visitors to collaborate on the creation of a park scene, filled with interactive trees, flowers, animals, and other robotic contraptions. The hour-long workshop was offered several times over the course of the day as part of a free public event (organized by the Lemelson Center for the Study of Invention and Innovation) at the Smithsonian's National Museum of American History. Each workshop involved approximately 30 participants, with parents and children working together on projects. The workshop was planned and facilitated by staff from MIT Media Lab and museums participating in the Playful Invention and Exploration Network (Resnick et al., 2000; Hermos et al. 2005).

Theme

We promoted the workshop with the following description: "A Day in the Park! Would you like to make a flower that spins when you shine light on it? How about a frog that jumps into a pond when it gets too hot? A swing that moves whenever you breathe? Then join this workshop! We'll use craft materials, motors, sensors, and tiny computers to create interactive inventions that can respond to light, temperature, and wind. Put yourself in the shoes of a designer, and contribute to the construction of a miniature dream-park display!"

This description contrasts with the descriptions of most robotics workshops, which often highlight the technologies. The theme-based description for the Day in the Park workshop attracted a diverse audience of families, with equal participation across genders.

This theme inspired a wide range of projects, but also served as a unifying thread so that all participants felt that they were part of a collaborative effort. Facilitators started the workshop by asking participants to brainstorm about things they had noticed in parks, and participants came up with a diverse list of ideas, including squirrels, trees, swing sets, and people skateboarding.

Art and Engineering

Figure 9 Setting up the park landscape.

The mix of art and engineering was apparent as soon as people entered the room. On a large table, facilitators had created the basic landscape for the park, with rolling hills covered with artificial grass (Figure 9). A couple sample creations were already set up in the park: a robotic caterpillar that crawled when approached (Figure 10) and a plant that wiggled when touched.

At the front of the room was a large collection of supplies, with neatly arranged sections for various craft materials (including pipe cleaners, googly eyes, construction paper, glue sticks, crayons), natural materials (including leaves, sticks, and stones), various LEGO parts (including bricks, gears, axles, and motors), PicoCricket parts (including lights, sound makers, and sensors), and pre-built motion modules (simple LEGO mechanisms each with a different type of motion).

Figure 10 A caterpillar triggered by a light sensor. The message reads, “Get close to the light and see what happens!”

Participants started in different ways. Initially, some focused on craft materials, some on mechanisms, some on programming. But by the end of the workshop, everyone had integrated art materials into a robotic construction programmed to respond to sensor input.

Storytelling

The park theme provoked people to remember stories from their own experiences in parks—and to imagine fanciful scenes that they would like to see in an imaginary park. For example, two sisters created and programmed a cat to chase a dog through the park.

Once participants finished their creations, they filled out “inventor cards,” small labels that described their creations and explained how they worked. This process encouraged participants to reflect on what they had made and helped provide closure to the workshop.

Exhibition

The park theme sparked the creation of a wide variety of robotic projects, including chirping birds, rolling skateboarders, interactive playground rides, and an automatic sprinkler system. Participants added their creations, with inventor cards attached, to a collaborative window display, which attracted attention from other visitors throughout the day. The park attracted lots of interest and became a focal point for conversation. Kids and their families kept coming back through the course of the day to look at the ever-growing collection of projects, demonstrating the value of collaborative exhibits that continue to evolve and grow over time.

A Series of After-School Activities for Girls: Crickets and Crafts

At a local Boys and Girls Club, we offered a series of “Crickets and Crafts” activities once a week for a group of 15 girls, ages 9-12. We originally intended to offer the activities for just a few weeks. But due to the popularity of the activities, we extended the program over the course of an entire year, with two themes in the fall and another theme in the spring.

Figure 11 A birthday cake programmed with lights and music.

Theme

On the first day, we showed several examples of PicoCricket projects around the theme of Birthday Surprises. The girls all became fascinated with one of the projects: a birthday cake that plays a Happy Birthday song when you blow out the “candles.” The cake used a sound sensor to detect the blowing and flickering lights to represent the candles. The girls decided that they wanted to create their own cakes. One pair of girls focused on decorating their cake with colored gem stones (Figure 11). Another group planned a “Hello Kitty” cake, but invested most of their effort in programming the music for the birthday song. A third group, inspired by their interest in the local Boston Celtics basketball team, created a cake with the Celtics logo and colors.

A few weeks later, with Halloween approaching, the theme of Halloween was suggested, and some girls began creating Halloween-theme projects, while others choose to continue working on their birthday-theme projects. Within the informal after-school setting, this mixture of themes worked well. One pair of girls created a ghost, attached it to a motor, and programmed it to spin and make spooky-goblin noises whenever its sound sensor detected the voices of trick-or-treaters.

The girls wanted to keep working on Cricket and Crafts projects in the spring, so we proposed a theme of "secret garden" (inspired by the book and movie of that title). This theme proved successful since it allowed for both patterner-style projects (e.g., flowers spinning in the garden) and dramatist-style projects (e.g., friends meeting in the garden).

Art and Engineering

Arts and crafts is a popular activity within Boys and Girls Clubs, so the girls started with familiarity with craft materials and immediately took ownership of the materials. We provided a wide range of craft materials, but made a special effort to include materials (plastic cups, aluminum foil, tissue paper) that would allow the girls to explore reflection and diffusion of light. These materials encouraged a back-and-forth between art and engineering, as the girls programmed different color patterns for the PicoCricket lights and experimented with different craft materials to explore various lighting effects.

As they worked on their projects, the girls became actively engaged in many different forms of problem-solving—debugging computer programs, making physical structures sturdier, figuring out how to securely attach both LEGO and craft elements. One particular challenge was how to make three-dimensional objects (like a layered birthday cake or ghost) from two-dimensional materials (such as construction paper and cardboard).

Storytelling

The secret-garden theme, in particular, encouraged projects based on narrative and storytelling. One of the girls wanted to build off the story of the Secret Garden, so she checked the book out of the library and began reading it. Three other girls developed an elaborate story about a camping-trip sleepover, with the campsite situated within the secret garden. They printed out photos of themselves, and placed the photos around a glowing campfire programmed to change color at different parts of the story.

Exhibition

Both the fall (birthday and Halloween) and spring (secret garden) themes culminated in a lively open-house event. Knowing that friends and family would be coming to see their creations was an important source of motivation. The girls became deeply invested in planning for the event—creating invitations to give to friends and family, arranging for snacks to serve, and checking guests off of the list as they arrived.

At the open houses, the girls showed pride in demonstrating their projects. The boys from the Boys and Girls Club had never seen the PicoCrickets before, so they began asking questions about how the technology worked, providing the girls an opportunity to share what they had learned (Figure 12).

Figure 12 Girls get ready to share their "secret garden" robotics projects at the open house.

A Professional Development Workshop for Educators: Celebrations

In Mexico, we organized a two-day workshop for a wide-ranging group of 30 educators who had expressed interest in the PicoCrickets. Participants included elementary and secondary-school teachers, university researchers, policy makers from the Ministry of Education, curriculum developers, staff from local after-school centers, and producers for children's television.

Theme

We chose a theme of "celebrations" for the workshop. We defined the theme broadly, so that people with diverse interests could all find ways to engage with the theme. We gave examples ranging from holiday celebrations to sports celebrations.

Several groups worked on projects based on Mexican national holidays, creating mechanisms to spin Mexican flags and composing versions of the Mexican national anthem. Several other groups focused on the Día De Los Muertos (Day of the Dead) holiday; in one project, a skeleton popped out of a coffin whenever anyone approached. Another group created a soccer project, with cheering fans that bounced up and down when the soccer ball went through the goal.

Based on the success of this workshop, we used a similar theme for the PicoCricket workshop at the Teen Summit, a gathering of teenagers from Computer Clubhouse after-school centers (Resnick et al., 1998) from around the world. The celebration theme took on an added dimension in this context, since it allowed participants to share cultural traditions with one another.

Art and Engineering

The soccer project is an example of fluid integration of art and technology. For the cheering fans, the educators drew pictures of people on construction paper, but then attached them on top of a LEGO mechanism in which cams pushed axles up and down (Figure 13). To detect the scoring of a goal, the group took two pieces of aluminum foil, and placed one on top of the other, separated by a small piece of cotton. When the soccer ball rolled on top of the foil, it pressed the two pieces of foil together, completing an electrical connection (as measured by the PicoCricket's resistance sensor) and triggering a celebration with music, cheering fans, and a scrolling scoreboard.

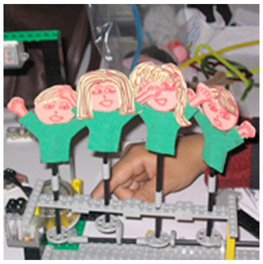

Figure 13 A LEGO mechanism with cheering fans that moved up and down when a goal was triggered.

Craft materials vary from one part of the world to another. The use of local materials provides a palette for a PicoCricket workshop, influencing the color and texture of the resulting projects.

Storytelling

Stories are an integral part of celebrations and cultural traditions. The projects about Mexican festivals were interwoven with stories about the ways families celebrated those holidays.

Other researchers and educators have also found cultural traditions to be a source of inspiration for robotics workshops. For example, in the Con-science project, families within a synagogue created robotics projects based on the Jewish High Holidays as a way to reflect on values (Bers & Urrea, 2000). In Project Inter-Actions, parents and children worked together on robotics projects as a way to share cultural traditions and family heritage (Bers et al., 2004).

Exhibition

The theme of celebration lends itself well to a lively, culminating exhibition—a celebration of celebrations. Within the Mexico workshop, the exhibition provided a way for participants and visitors to share what they valued within their culture, with individual projects serving as conversation pieces to spark discussion and reflection. In cross-cultural workshops, such as the international Teen Summit, the exhibition provides a way for participants to learn about one another's favorite cultural celebrations and traditions.

Discussion

The examples in the previous section illustrate how new strategies and technologies can provide multiple paths for engagement for children, teens, families, and educators. But implementing these strategies is not necessarily easy. This section addresses some of the challenges that arise in putting these strategies into practice.

Themes

We sometimes describe our workshops as "open-ended," since we select themes that are broad enough to encourage a diversity of projects. But open-ended does not mean that there is no structure. We are also careful to select themes that are specific enough so that participants can share ideas and learn from one another. We also try to select themes that highlight particular ideas and concepts, making it likely that participants will engage with powerful ideas in the natural course of working on their projects. For example, we have organized chain-reaction story workshops to highlight concepts related to cause-and-effect, and we have organized musical-instruments workshops to highlight ideas about sensors and variables.

Art and Engineering

Combining art and engineering provides an opportunity for learners to start from their own comfort zone, but then reach out to learn new things. Children and teens who are more familiar with art and music can explore engineering ideas, while those with more experience in building and constructing can learn about design and aesthetics. But this type of cross-disciplinary activity presents additional challenges for workshop organizers. Additional preparation is needed to gather and set up both craft and construction materials, and additional mentoring is needed to support participants as they work on activities that involve artistic expression as well as mechanical construction and programming.

Storytelling

One of the core educational reasons for introducing robotics is to provide learners with an opportunity to explore ideas of sensing and feedback. These ideas arise naturally when learners build cars and mobile robots, and program them to move in different ways based on sensor input. But sensing and feedback do not fit as naturally with traditional linear stories with a beginning, middle, and end. To combine narrative and robotics, workshop facilitators need to help learners think of stories more interactively, so that characters and scenes respond to inputs from sensors.

Exhibitions

Robotics competitions have proven to be very motivating for some young people. A challenge is to make sure that robotic exhibitions provide the same level of motivation and engagement. We have found when participants are deeply involved in the design of their projects as well as the design of the exhibition event, they are excited to demonstrate and share their work through open houses. There are also growing opportunities for workshop participants to share their work in online exhibitions, thus connecting with a larger international community.

Putting It All Together

Robotics activities offer rich educational opportunities, but the impact and reach of these activities has been limited by the narrow way in which robotics is typically introduced. While projects involving cars, vehicles, and mobile robots are undeniably appealing to some young people, many other young people do not become fully engaged with these types of projects. By offering alternate pathways into robotics that build on students' interests in art, music, and storytelling, we have an opportunity to engage a larger and more diverse audience in new learning experiences.

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