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14 When robots tell a story about culture . . . and children tell a story about learning

Marina Umaschi Bers

C.P. Snow, in his classic book *The Two Cultures*, describes two different ways of thinking and knowing (i.e. epistemologies) used in the sciences and the humanities (Snow, 1959). This observation is echoed by Bruner's distinction between the logico-paradigmatic way of knowing, traditionally held by scientists, and the narrative mode of knowing of humanists (Bruner, 1986). Although the 'two cultures' metaphor is limited as people hardly fit into binary stereotypes (Brockman, 1996; Brown and Clewell, 1998), the epistemological divide still permeates society.

Schooling often has the responsibility to introduce and expose children to a variety of ways of knowing. However, there is frequently a 'division of labour' between those who enjoy and are good in science, mathematics, engineering and technology (SMET) and those who enjoy and are good at reading, writing and the social sciences. Early on, students label themselves (or are labelled) as belonging to one or the other group (Swan, 1995; Frierson, 1996). This results in a great majority of students, mostly women and minorities, ruling out SMET in their career paths (Alper, 1993; Hammrich, 1997; Erinosh, 1999; Pulis, 2000). In consequence the United States, among other countries, struggles to diversify the engineering workplace (Holden, 1989) and involve women and minorities in scientific careers (Kubanek and Waller, 1995; Bae and Smith, 1997; Thom, 2001).

Early childhood education provides a wonderful opportunity to address this challenge. In the early years, most educational settings expose all children to both narrative and logico-paradigmatic ways of knowing. Compared to other segments of the educational experience, early childhood has an advantage when attempting to integrate these two realms of knowledge (Badra and Pallechi, 1993). There is consensus in the field about the importance of emergent and integrated curriculum that derives from the child's own interests.

In contemporary times, epistemological pluralism, or the ability to build

knowledge in diverse ways (Turkle and Papert, 1992) can be facilitated by the use of new technologies that allow young children to become 'little storytellers' and 'little engineers' (Bers, 2008b). In this context, the use of robots and robotic kits that extend the tradition of early childhood 'manipulatives' and add on a technological component are powerful tools to engage young children in designing, building and programming interactive projects (Bers, 2008b).

This chapter starts by presenting the theoretical, pedagogical and technological frameworks for working with robotics and young children. Most specifically, the chapter focuses on integrating robotics with cultural narratives and presents two learning experiences. In the first one, educators encounter technologically rich design by first developing a robotics curriculum that integrates social sciences with SMET, and then adapting it to their classrooms. In the second experience, parents and young children engage in the construction of robotic projects to represent an aspect of their family's cultural heritage.

Both learning experiences integrate robotics with cultural narratives. Similarly, both highlight the possibilities of new technologies to bridge the divide between the different epistemologies or ways of knowing. The chapter closes by proposing that a technologically rich design-based approach to learning that integrates the narrative and the logico-paradigmatic ways of knowing might act as a catalyst for engagement with SMET ideas for those who are traditionally marginalized from it. Simultaneously, it might encourage those who feel more aligned with SMET to enrich their experiences with a more social or humanistic aspect that embraces narrative perspectives.

Foundations

A design-based approach to learning that encourages the use of new technologies is based upon the design process used in engineering and software development (Bers, 2008a). It engages learners in several steps:

- 1 Identifying a problem (it can be personally meaningful or a real-world need)
- 2 Doing background research or needs analysis
- 3 developing possible solutions
- 4 Implementing working prototypes
- 5 Testing and evaluating the prototypes
- 6 Communicating findings
- 7 Redesigning the solutions based on the information gathered. This iterative design cycle repeats itself in the creation of technological artefacts.

By providing contexts in which young children can experience the process of design, the children are able to acquire knowledge, skills and habits of mind that apply to both ends of the spectrum of the epistemological divide: the sciences and the humanities (Davis, 1998). For example, the iterative design cycle can be used in building a robotic toy car as well as for writing an essay or creating a storytelling character (Bers and Cassell, 1998; Bers et al., 1998). Although there are differences in the language used, for example we might talk about debugging software, fixing a broken artefact or editing a story, the core idea of designing and revising in a systematic way based on feedback, is found in all of these activities.

Design-based projects can also provide ways for children to make personal connections with new areas of knowledge and skills, and to engage in problem solving, seeking multiple strategies, decision making and collaboration as they approach new problems (Schleifer, 1997; Rogers et al., 2001). The constructionist theory of learning (Papert, 1980) pays particular attention to the role of new technologies in supporting children to become designers. Constructionism has its roots in Piaget's theory of constructivism. However, whereas Piaget's theory was developed to explain how knowledge is constructed in our minds, Papert pays particular attention to the role of constructions in the world (concrete) as a support for those in the mind (abstract) and is a pioneer in proposing computers as powerful tools to create and facilitate design projects.

Constructionism has two fundamental ideas that inform educational practice: (1) powerful educational technologies engage children in design-based activities that are epistemologically relevant, personally meaningful, and have resulting products that can be shared with a community; and (2) the importance of manipulative objects that have computational power, such as robotic construction kits, for supporting the generation of concrete ways of thinking and learning about abstract phenomena (Bers et al., 2002).

Constructionism shares with other educational approaches, such as 'learning by designing' (Kolodner et al., 1998), 'knowledge as design' (Perkins, 1986), 'design education' (Ritchie, 1995), and 'design experiments' (Brown, 1992), the tenet that design-based activities are good ways for students to engage in learning by applying concepts, skills and strategies to solve authentic problems that are relevant and personally meaningful (Resnick et al., 1996a). While in early childhood education there is a strong tradition of engaging children in making objects, machines and tangible models with low-tech materials, constructionism has paid particular attention to newer technologies, in particular robotics.

Robotics: tools for design-based learning

Most new technologies that propose a design-based approach to learning belong to the family of constructionist tools (Resnick et al., 1996b). For example, the Lego Mindstorms robotics kit, which is used by all of the projects described later in this chapter, provides opportunities for design involving both programming and building activities, thus promoting both technological fluency and engineering design skills. Lego Mindstorms is a commercially available construction kit composed of a tiny computer embedded in a specialized Lego brick, called RCX, which can be programmed to take data from the environment through its sensors, process information, power motors and control light sources to turn on and off (see Figure 14.1).

The robot can be programmed or 'taught to move' using a graphical language, ROBOLAB, with tiered levels of programming that allows users to drag and drop graphical blocks of code that represent commands (i.e. left and right turns, reverse direction, motor speed, motor power) to produce behaviours for a robotic construction (Portsmore, 1999). Users can drag the icons together into a stack, in a similar way to assembling physical Lego bricks, and arrange them in logical order to produce new behaviours for a robotic construction

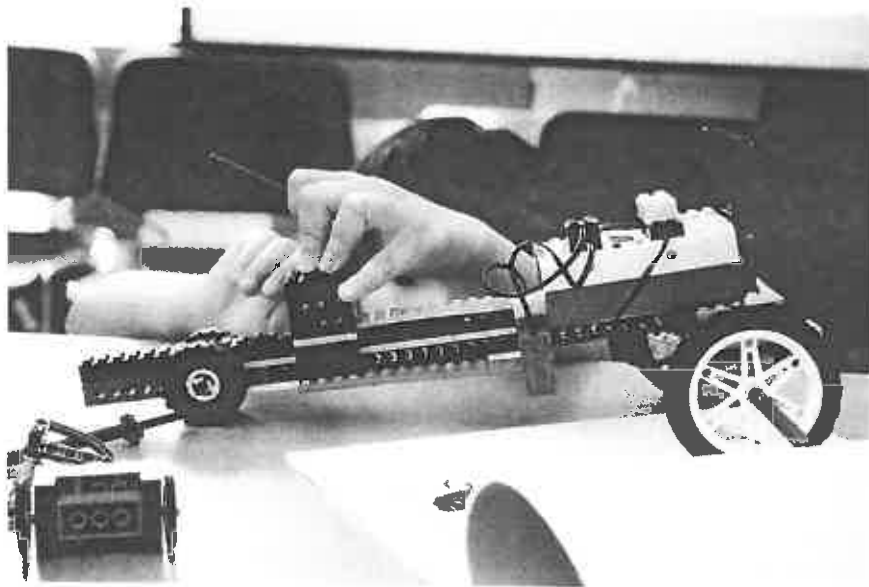


Figure 14.1 The RCX programmable brick with wheels, motors and sensors.

(see Figure 14.2). Lego Mindstorms and ROBOLAB have successfully been used in early childhood education (Resnick, 1998; Bers and Urrea, 2000; Rogers et al., 2001; Beals and Bers, 2006; Bers, 2008a).

Three major factors make this technology particularly appealing for design-based activities that engage both ways of knowing described by Bruner (1986). First, the physicality of the robotic construction kit supports the integration of art materials. Second, the ubiquity of the technology, so that once the robot is designed, built and programmed, it can exhibit its interactive behaviours anywhere.

Learning stories

This section presents two different approaches to use robotics that attempt to bridge the gap between the two 'cultures' and the two 'ways of knowing', the narrative and the logico-paradigmatic. In the first experience, educators encounter the concept of technologically rich design by first experiencing the development of a curriculum that integrates social sciences with SMET via the use of robotics, and then adapting it to take to their own students. In the second experience, parents and young children engaged in the construction of robotic projects to represent an aspect of their family's cultural heritage.

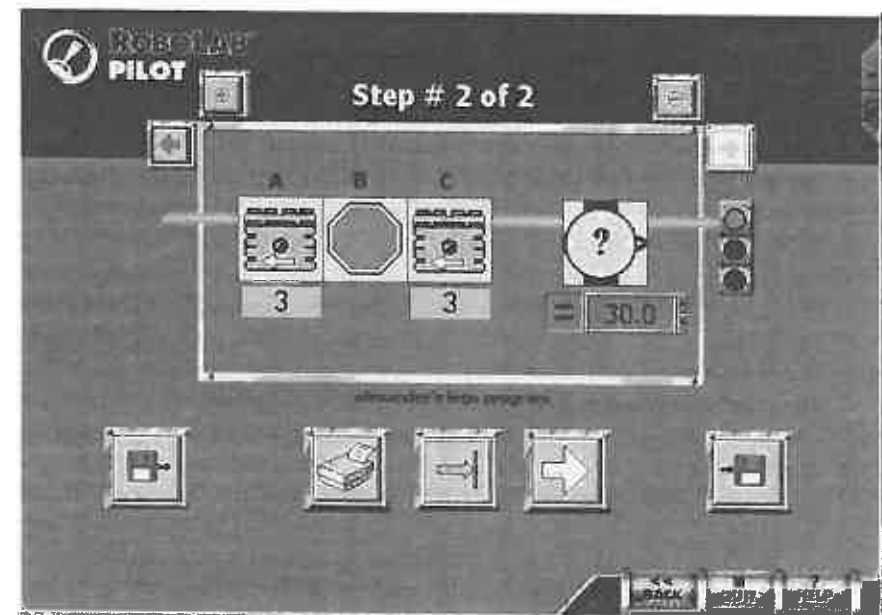


Figure 14.2 The ROBOLAB programming environment.

Both learning experiences integrate robotics with cultural narratives. Both highlight the possibilities of new technologies to bridge the divide between both epistemologies.

Educators exploring the Aztec culture: chinampas and the agricultural system

The first learning story tells of early childhood educators who developed a curriculum unit that integrates the social science frameworks, most specifically the Aztec civilization, with the science and technology state frameworks in Massachusetts, which focus on 'materials, tools, and machines [that] extend our ability to solve problems and invent . . . and engineering design [that] requires creative thinking and strategies to solve practical problems generated by needs and wants' (Massachusetts Departments of Education, 2006: 86). Teachers first experienced the curriculum themselves and then adapted it to work with their students. In this chapter, I will focus on the educator's learning experience. This is important as teachers need to feel competent and confident regarding the use of robotics, otherwise the likelihood of projects such as this to succeed is reduced.

As a first step, teachers were introduced to the Lego Mindstorms robotic kit and the ROBOLAB programming language. Most of them were familiar with Lego but had not worked with robotics before. They understood how to work with the traditional blocks but the addition of gears, sensors, the RCX and programming was challenging. They were introduced to the 'culture' aspects of their project through a short video entitled *Mystery Quest: Alien Adventures into Lost Worlds* (National Geographic Television, 1998) and were asked to discuss two questions: What is an archeologist? What is culture?

The educators were assigned to work in 'archeological teams' to explore the Aztec culture. They used classroom resources such as pre-selected texts, computers - internet searches, encyclopedia software - and they chose an Aztec artefact (object, place or process) that they found to be most characteristic of the civilization. They kept a design journal to brainstorm ideas about how to reproduce the artefact with the robotic kit and to reflect on their learning processes. Finally, each archeological team presented its work.

Some archeological teams chose the Aztec's religious ceremonies, the Aztec calendar, the Aztec waste management, and transportation systems. In this chapter I report the experience of the team who chose the Aztec's agricultural system. One of the participating teachers reports in her design journal:

We learned that the Aztecs built their empire on swamp lands, clearly not an ideal place for development. In order to build or farm, the Aztecs first had to create solid ground. Using a technique of laying down layers of mud and logs to build the land up above water, they

were able to create land for the city's development. The farming landmasses were called 'chinampa's and they could be dragged around by wooden boats at the early stages and brought to a farming site where they would root.

Chinampas was a good choice for a design project. From an engineering perspective, the system itself seemed fairly easy to build, although it had a variety of moving parts. From a social sciences or humanities perspective, it would demonstrate the challenges faced by the Aztecs in their need to have solid land upon which to develop their culture.

Once the team chose the Aztec agriculture system, the members looked at the aspects of a chinampa field which they thought could be transformed into 'moving parts' with robotics. The reflective design journal shows the iterative nature of this design process:

Our first idea was to make a boat that could travel through the Chinampas. It would show how people traveled around the fields to tend the crops and how the Chinampa fields could be set up in an orderly fashion. Our next idea was to make a Chinampa to 'sway' in the water. While we were not sure that Chinampas actually swayed, it would illustrate the period of time where Chinampas are not solid grown yet. It was also possible that the Chinampas could move due to tidal changes, boats moving through the fields, or people walking on top of them. We decided to make a Chinampa field that was a mixture of art and Lego. It would include one or two boats that could travel through the field. At least one of them would be dragging an early Chinampa. We would also include one or two swaying Chinampas surrounded by stable Chinampas growing a variety of crops. One stable Chinampa would have an Aztec house. We also wanted to include a 3D aspect, which would show a cross section of the different levels of root growth in a maturing Chinampa. It would show an immature Chinampa where no or few roots were visible, a medium Chinampa where the roots were beginning to be substantial, and a mature Chinampa where the roots had anchored into the ground beneath the swamp.

One of the teachers, with no previous engineering or technological experience, relates her iterative process of design while building the boat that would navigate the Chinampa.

After experimenting with a few designs, I decided that the motor and necessary gearing was too bulky . . . My next idea was to use a belt that could be attached to the motor through gears, and the boat could sit

on top of it. Then, when the motor rotated, the belt would rotate, and the boat would move . . . I used a medium sized, flat Lego piece to stabilize each end. The end without the motor had a large gear, connected to the chain, and supported over the Lego floor by a bar. The end with the motor had some additional gears to slow down the rotation of the motor. Next, I wrote the program that governed the motor. When one of the touch sensors was held down, the motor would move in one direction. When the other touch sensor was held down, the motor would move in the other direction.

A second teacher, who built a floating chinampa, wrote about her design process.

Our idea was to have a moving Lego piece that would represent an unsecure chinampa. The chinampa would tilt back and forth in time to the rhythmic movements of surrounding water. The first step was to determine what tool I would use to simulate the movement of the chinampa. When I realized that I could control the specific distance that the motor rotated through the amount of time that it moved, I decided to create the tilting chinampa through a system of gears. This was an unsuccessful prototype because the gears did not turn properly with a flat surface positioned on top. I realized that I needed to raise the chinampa above the gears. I made a support system that attached to one long rotating bar. This support system successfully held up a flat LEGO piece that represented the bird's eye view of a chinampa. The support system would bounce back and forth of two side walls that along with the computer program controlled the chinampa's movement. The trickiest part for me was developing the program for the chinampa's movement. I had the most trouble wiring my pieces and understanding the order of the programming blocks . . . I found that if I gave the Chinampa a break by stopping the program for a couple seconds the Chinampa fared much better.

In their design journals, both of these educators show their learning process through trial and error. They brought to their final design the use of art materials, with which they were already familiar, and incorporated recyclable materials to make the simpler and non-moving parts, such as rectangular sponges with brown boards for non-moving chinampas, green stickers for grass, pipe cleaners for tree and wooden manipulatives for other building structures (see Figure 14.3).

After the experience, before setting out to work with their young children in a modified version of this project, one of the novice teachers reflected on her learning experience.



Figure 14.3 A working interactive prototype of the Aztec agricultural system built by educators.

Having never previously worked with robotics before, I was incredibly proud and surprised at my abilities with the technology. I really enjoyed having a final project to show. My time spent just simply playing with the manipulative did not go wasted. It was definitely the main reason that I was able to design and create what I did. Before I spent time just playing with the manipulative, I felt like I was overwhelmed by how to get gears to turn and rods to connect. Just playing with the pieces helped me to understand how pieces could connect and work together. The most challenging piece of this project was creating a design for what I wanted to build. I didn't feel as though I'd had enough experience with the manipulative to be able to design what I had on paper, although I felt that once I started building, I would surely know where to go from there. We used the technique of changing and analyzing as we built the systems. This was a very effective technique for me because I didn't feel skilled enough to guess where steps would go wrong and not work. After I'd finished working on the floating chinampa, I realized that I could've done a more proficient job. Instead of building a system of levels and rods, I could've

used a couple pieces that Mindstorms had already been designed to do what I'd done with a bunch of smaller pieces. I was pleased that I discovered different ways of looking at building technology, and that there really wasn't just one way to do it.

This teacher is reflecting on her growing technological fluency gained through the iterative design process, but most importantly she is also discovering a new sense of confidence in her own learning potential. A different teacher, with more knowledge of robotics who had participated in previous robotic experiences, wrote:

The process we used for this project was very different from how I worked in groups in the past. Traditionally, people split up and work on aspects that they feel they can do best. But we tried to do each part together giving everyone the experience of being both the learner and the teacher. At times it was frustrating because it seemed inefficient, but overall I think we all learned more from the project than we would have if we just split up the tasks . . . I felt that this experience was telling us as to how students coming from multiple learning backgrounds might contribute to the project.

After participating in this experience, the teachers went on to work with students and adapted the overall idea of the project to fit their individual groups. They kept the core idea which was to integrate both social sciences and SMET into a single project. For example, some of them adapted activities suggested in the Massachusetts Science and Technology/Engineering Curriculum frameworks for older children, such as Local Wonders. This activity engages students in constructing prototypes of a significant structure or building in their community and investigating the related engineering concepts as well as the building's socio-historical impact. Other teachers focused on students' design, implementation and programming of technological systems as a window into exploring the worldviews of cultures traditionally studied in the social science curriculum. For example, while one teacher worked with a team of children studying ancient Rome and developed and tested an early form of a Roman catapult, another worked on China and experimented with ways to build walls that could not be knocked down.

Families exploring their culture through robotic project

The second learning story introduces Project InterActions, a research programme that explores the different types of interactions that can occur in a learning environment where parents and their young children come together to learn about robotics and explore their cultural heritage (Bers, 2007).

Following the design experiments research methodology (Brown et al., 1989; Cobb et al., 2003; Barab and Squire, 2004; Fishman et al., 2004), as part of this project six different studies were conducted over a period of three years. Each study consisted of family workshops that met for two and a half hours during the weekend for a period of five weeks. A total of 132 learners participated in all the design experiments studies.

Previous research has looked at the many interactions that exist when parents and young children come together to program and build meaningful robotic projects that represent a shared family value or cultural heritage (Bers et al., 2004; Beals and Bers, 2006; Bers, 2007). For example, families created final robotic projects such as the 'Easter Bunny', a cardboard bunny mounted on a robotic car that would carry a basket with chocolate eggs; the 'Go-Lem, a Matzoh-Seeking Robot' that goes forward, lights up, and plays the Passover melody 'Dayenu' at the push of a button; a birthday cake that sings an Armenian children's song, to reflect the mother's cultural heritage, with flashing lights as candles; a flashing Christmas tree, and a manger for Jesus with a hovering moving angel. The idea of integrating the use of technology with cultural heritage stems from the desire to help all children, and not only those who already have a technical mindset, to develop technological fluency (Bers and Urrea, 2000). The narratives behind the different cultures have the power to engage both the 'little storytellers' and the 'little engineers' (Bers, 2008b).

During one of the workshops, 6-year-old Gary and his dad decided to build a Christmas tree that would light up, sway, and play music. The pair started by collecting small, coloured, translucent Lego pieces and placing them in their Lego tree. As Gary began to experiment with the lighting system on his tree, he ran into a problem: the tree was colourful but did not light up. So Gary set out to explore how to fix the problem by finding new pieces, such as bright white lights that could be powered by the RCX. However, these new pieces did not provide any colour to the tree. Gary was not willing to sacrifice colour for brightness, so he asked his dad for help. They talked about creating a system in which the lights on the Christmas tree will turn on in a serial order, beginning from left to right, so it would display an interesting pattern.

Gary is an active 6-year-old who is beginning to encounter the principles of design-based learning by first identifying a problem (colourfulness versus brightness) and testing different options. Gary decides that only one wire needs to be connected to the RCX. The other wires could be used to connect each light to the next so that when the program is turned on, the power flows through the wires sequentially. At first, Gary does not know how to connect the wires. He often puts them in backwards while he talks to his dad: *'I'm not sure which way I put it [the connecting wire] in, but I'll try and see.'* To see if he is right, Gary turns on the program. He knows that if the light turns on, he attached the wire correctly and if it doesn't, he has to go back and

reverse the wire(s). This understanding clearly demonstrates his developing sense of trial and error and the iterative nature of the design cycle. Once all the lights are working, Gary again becomes concerned with the aesthetics of his project. He sets out to make all the lights on the tree symmetrical in placement and colour. In doing this, Gary decides that he wants to add more lights.

To keep everything symmetrical, he puts the new lights on top of the existing lights (same colour). He now faces the task of connecting these new lights. Despite his father's comment that there might be too many wires on the tree, he continues working on it. In his eagerness, he does not use the same method of trial and error to check his work, but decides to just connect them all at once and try it out at the end. Gary turns the power on and, to his dismay, only the first few lights work.

Gary begins a ten-minute effort to try to reconnect the wires, this time in a systematic way. After each attempt, he turns on the power to see if he was successful. When he is not, he tries again. The multitude of wires, thirteen in total, is very confusing, and Gary turns to his father for help. Gary's dad helps him check each wire, looking first to see if any of them are reversed. When they don't find any problems in the wiring, his father explains to him that they need to take the lights off one by one, starting from right to left, and then turn on the power to see if they can determine where 'the system breaks down'. In this way, the father models the process of debugging or systematic trial and error. Eventually, Gary's dad withdraws and lets Gary take over. The problem wire has been identified and fixed. By the end of the session, Gary's Christmas tree is shining brightly and he proudly shares his accomplishments (see Figure 14.4).

Gary's father took a supporting stance and let Gary experiment with the technology, make mistakes and fix them. Although he did not have formal background in education, his natural instinct was to let his child play with the materials and to support him in trying out his own ideas, even if some of them were time consuming and probably doomed to failure. However, when needed, he introduced the concept of systematic debugging, as opposed to just unsystematic trial and error.

Gary and his dad decided quickly to build a Christmas tree; not much conversation about culture happened between them. However, for other parent-child dyads, choosing a culturally relevant theme posed multiple challenges. For example, a father-daughter dyad spent a long time discussing what things were important to them and decided that spending time together was an important value for them. So they chose to make a project that reflected one important aspect of spending time together: the bedtime story. They chose their favourite character from a book the father would read in the evenings to the daughter. They created 'Uncle Feather' that flaps its wings, turns and drives forward and backwards (see Figure 14.5).

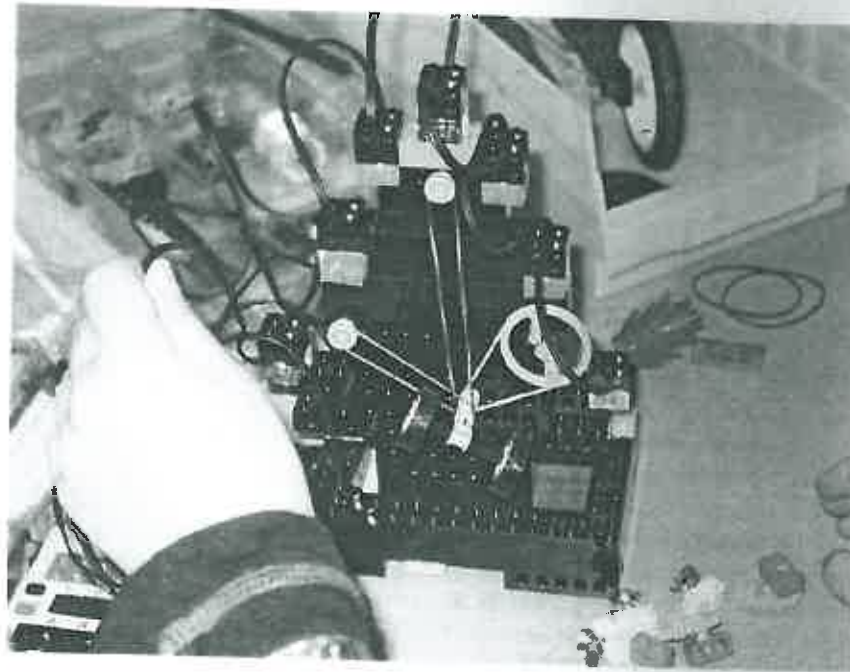


Figure 14.4 A Christmas tree with blinking lights.

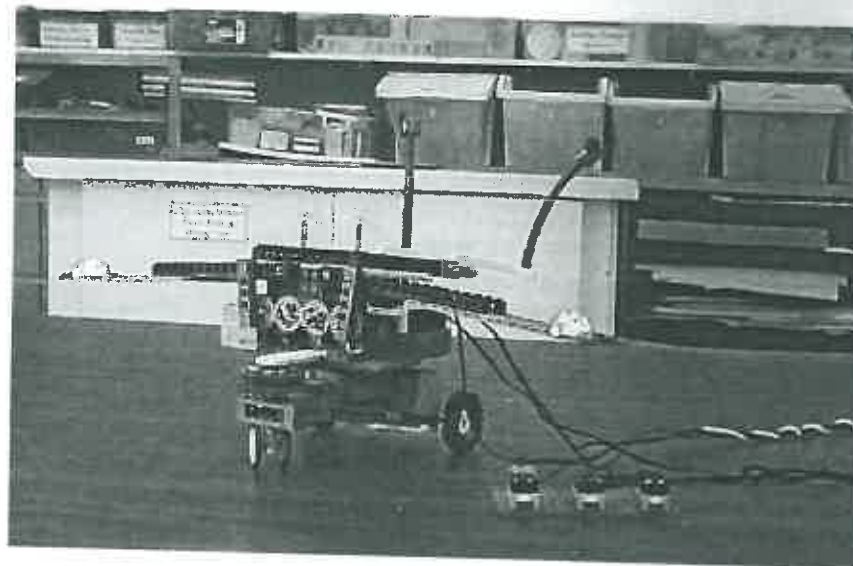


Figure 14.5 Uncle Feather.

This dyad had to negotiate the daughter's intent to make a 'perfect' bird with their limited technical capabilities. As they had agreed on making the bird move back and forth, the daughter found large green grass plates and combined them with long black girders and called them wings. Next, she wanted the bird to fly. After several exchanges in which the father explained that he could not make that happen, they agreed on having the bird flap its wings. This posed many technical challenges and the father set out to work on his own. In his journal he wrote:

I was very interested in using the differential [gears] and using a third motor to control the steering . . . We used the software at home and used a pair of tasks to control the steering, the flaps and the direction. We made use of techniques we had learned earlier to combine three touch sensors as digital inputs and three long wires to make it a remote control bird.

This project quickly became technologically sophisticated and the 6-year-old daughter was not able to understand most of its workings. However, when requested, she proudly showed her bird and explained how her daddy made it for her. Although her role in making Uncle Feather was very different from the one played by Gary in making his Christmas tree, both of these young children engaged, together with their parents, in problem solving and different aspects of the design process. As both of them grow, hopefully this first experience with robotics will contribute to their curiosity for learning about SMET. Regardless of their fathers' approach to working with them (supporting them versus taking over), both men became special role models for approaching technical challenges.

Figure 14.6 shows a different kind of project in which a father and his daughter had a hard time coming up with a project idea. After much conversation, they realized that keeping the house in order was an important family value. So they decided to create a machine that could help the child organize her room. The 6-year-old who worked on this project reflected:

The hardest part was to put it together. I learned that you cannot just go and say 'I'm going to build a robot'. You actually have to think about what you are going to do and you have to build it piece by piece.

While this project was not complex in terms of its technical implementation, the father and child spent a long time choosing a project that was important for them as a family and talking about family values. For them, the meaning of culture was not associated with a particular tradition, religion or heritage, but to their daily rituals, such as cleaning up.



Figure 14.6 The picker-upper.

In order to engage families in thinking about culture and integrate it into their robots, Project InterActions exposed them to cultural narratives through picture books and cultural objects from different traditions. We did not teach about culture but rather we provided an open environment and let parents and children talk to each other. Our hope was that they would engage in conversations that they would not have otherwise. For example, the mother of a 5-year-old told researchers:

Because [my daughter] comes from more than one cultural tradition, the notion of culture in our family is complex, and this project provided us with an opportunity to discuss culture in our family . . . It raised thought-provoking questions for her such as what is culture? Why are there different languages? How are grandma and grandpa Armenian if they don't live in Armenia? and so on . . . During dinner she asked her dad, 'What is a Muslim?' This is the first time she has taken any interest in culture and understandings of it.

In the same way as families approached culture differently, they also took on different working styles - during the workshop we noticed a variety of interaction styles between parents and children, some more effective than others (Beals and Bers, 2006). For example, some parents initiated and directed their work together, some put the child in charge, and some parent-child dyads seem to enjoy taking turns being in charge. It was not easy for all of the parent-child dyads to become comfortable with each other in new roles as both teachers and learners. In most of the cases, it was the parents, and not the children, who had the most difficulty adjusting to this. It often initiated anxiety for a parent when they were required to learn something new and, at the same time, support and scaffold their child. This was

true regardless of the previous level of confidence that parents had with technology.

For most parents, Project InterActions was an opportunity to spend time with their children doing something together: *'My son and I never play with LEGO together. This is the first time. I am learning too. I have never done anything like this.'* The same was true for the children, who enjoyed the chance to have their parent's devoted attention. A 4-year-old boy said: *'I am not sure what I want to make today but I am going to think about it and figure it out. I think that this class is fun. I like working with my dad. It's the best thing.'*

It was difficult for parents to understand that the process of learning was as important as, or even more important than, the final product, the working robot. Some of the parents were worried about getting it right, and in some cases their attitude was getting in the way of their working together with their children. Thus, as the conveners, we gave all participating adults a handout containing suggestions that reflected the learning philosophy of the workshop:

- This is a pilot research project. We are all exploring together.
- Families have different ways of working together. Find a way that works for you and your child.
- Learning new things is hard . . . sometimes it is harder for adults than for children.
- Learning about technology can be very frustrating and anxiety provoking.
- Are you passing your own anxieties to your child?
- Don't worry, nobody gets it right the first time or even the tenth time. In fact, there is no 'right' way.
- Adults and children can learn in very different ways.
- We are not expecting families to have perfectly working projects.
- Play with the materials and the ideas. You don't have to get it right.
- Success is measured very differently for children and for adults.
- Ask questions (to your child, to us, to other families).
- Talk to each other, look at each other's projects, copy the things that you like . . . you are not cheating.
- We learn by doing and by making mistakes.
- Have fun and relax! This is a time to spend together with your child.

Most of the parents reported that the single thing they enjoyed most during the workshop was working together with their children. One mother with a strong IT background shared how happy she was that her child had learned to 'deconstruct an action into a sequence of steps' and therefore was able to

talk with her about programming. This new connection with her son was very important to her since she was used to expressing herself through programming. *'This [workshop] has gotten us started, and I think we will continue together [programming] at home.'* Other parents also expressed how rewarding it was for them to see their children showing *'keen interest in working on a project from an original idea to accomplishing their goals by solving problems and proudly presenting and demonstrating their projects to us'*.

Other parents felt that their children's presence in the workshop was critical for their own learning, as stated in the final project website by one of the fathers:

The hardest thing was to develop designs that we could then create to make what we wanted. We just never were able to pull the construction off. And while I was disappointed and ready to give up, Paul [the son] never wanted to quit. I learned that he has a great perspective on projects like this and knows that with the right time, parts, and design, we eventually were able to create our project.

Conclusions

This chapter has suggested that robotics can be a powerful activity for engaging young learners in a technologically rich design-based experience. It also suggests that, while there are many ways of working with design projects and robotics, most of which involve the use of competitions and challenges aimed at solving problems, an approach that integrates the use of cultural narratives with the development of technological fluency can be successful at providing a bridge between two different epistemologies or ways of knowing: the narrative (mostly used in the social sciences) and the logico-scientific (mostly used in SMET disciplines).

Here, I have chosen to share two different kinds of learning stories: experiences done by early childhood teachers and experiences done by young children and their parents. Both of these cases are different in their approach to 'culture' work. While the activities with teachers focused on the social sciences state frameworks traditionally aimed at older grades, the work with parents focused on the family's culture, through the multiple windows they thought about shared meaning by a group of people who hold common values and beliefs. However, both groups took the design process used in engineering and software development, and the steps involved in systematic design, debugging and implementation, from an idea to a working robot. And both used culture as the context for becoming technologically fluent.

The core message of this chapter is that by creating learning contexts for young children that incorporate powerful machines, such as robotics, these

experiences constitute natural digital extensions of traditional early learning manipulatives, which have long been posited as essential for early learning. Further, they are active learners who are producers of new knowledge rather than consumers of what already exists. Early childhood is a time of fluidity and experimentation between roles and epistemological styles. While most ways of using technological tools such as robotics, focus on 'little engineers' who will grow into 'big engineers', the ideas inherent in this chapter advocate the importance of respecting and inviting different ways of knowing and motivations while working with robotic manipulatives. By taking an integrated approach that spans two 'cultures', two 'ways of knowing' and two kinds of epistemologies, we can not only support children to develop the skills and ways of thinking needed to solve problems using technology, but also encourage them to think about the cultural needs of society at large.

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