Learning with Robotics in PreK-2: The case for KIBO

Summary
Robotics engages young children in learning concepts and skills from disciplines such as computer science and engineering in a developmentally appropriate by integrating them with other curricular areas (including, math, literacy, physical movement and the arts), and with opportunities for socio emotional growth.

There is a growing interest in robotics as an educational tool. However, little has been focused on the foundational schooling years. However, research shows both from an economic and a developmental standpoint, that educational interventions that begin in early childhood are associated with lower costs and more durable effects than programs that begin later. Extensive research also shows that introducing STEM in early childhood might help to avoid stereotypes and other impediments to entering the innovation pipeline later on. The National Science Board urged the Obama administration to make STEM education a priority in early childhood education.

Building on this need, Prof Marina Bers and her DevTech team at Tufts University have developed an early childhood robotics program that has been successfully piloted with over 400 children and 50 teachers in the US. The program consists of a robotics curriculum and assessment instruments that can be easily integrated with other curricular themes and that is aligned with Common Core standards, a pedagogical approach based on the Positive Technological Development (PTD) theoretical framework, and the KIBO robot kits, developed by KinderLab Robotics, Inc, which are specifically designed to be developmentally appropriate.

WHAT IS KIBO?

KIBO is a robot kit specifically designed for young children aged 4-7 years old. It is different from any other kit out there because it appeals to both technically minded kids and those that connect more to arts and culture or physical activity. Young children learn by doing. Children build their own robot with KIBO, program it to do what they want, and decorate it. KIBO gives children the chance to make their ideas physical and tangible. And KIBO does all this without requiring screen time from PCs, tablets or smartphones.

Designed for open-ended play, KIBO lets children make almost anything - a character from a story, a
carousel, a dancer, a race helicopter - anything that they can think of. The child creates a sequence of instructions (a program) using the wooden KIBO blocks. They scan the blocks with the KIBO body to tell the robot what to do. They press the button and the robot comes alive.

With KIBO, young children can become programmers, engineers, designers, artists, dancers, choreographers and writers. KIBO is based on over 15 years of research in learning technologies and child development by Prof. Marina Bers at Tufts University and her previous work at the MIT Media Lab with Seymour Papert. It is being commercialized by KinderLab Robotics, Inc.

**WHAT DO CHILDREN LEARN?**

Coding (or programming) is a new kind of literacy. But it exercises mental muscles that are useful for many other activities and skills. When playing with KIBO, young children learn programming ideas that are directly related to foundational concepts in math, literacy, science and humanities. These include sequencing, modularity, cause-and-effect, and patterns.

Research shows that sequencing is foundational for academic success, for math and literacy development, as well as for executive function. Furthermore, children engage in habits of mind such as: design process when they iteratively develop and test an idea; problem solving when their KIBO programs don’t work the way they want; executive functions when they plan and execute their projects with different kinds of constraints such as time, resources or materials; emotional resilience when they learn persevere and learn how to manage frustration.

Our robotics curriculum engages young children in learning powerful ideas from computer science and engineering while integrating them with other areas of study. Our methodology incorporates the use of robotics into a pre-existing curricular unit and also provides stand-alone curriculum units that were developed and tested over the years. All of our curriculum units include developmentally appropriate assessment instruments to evaluate learning outcomes.

**WHAT ARE EXAMPLES OF CURRICULUM UNITS?**

Here are some examples of robotics and programming curriculum specifically for early childhood classroom use (Pre-K through 2nd grade) with KIBO:

* **How Things Move** is a beginners level curriculum that explores foundational physics connections related to motion, light, and friction, while engaging children in learning about engineering and developing computational thinking skills.

* **Sensing the World Around Us** is an intermediate curriculum for students who have
completed the How Things Move curriculum (or equivalent). This curriculum builds on the introductory concepts students have mastered and takes and in-depth look at how sensors work, particularly the three KIBO sensors: Light sensor, Distance sensor, and Sound sensor. Additionally, this curriculum makes foundational biology connections related to animal/human senses, and characteristics of different animals.

*Dances from Around the World* integrates the use of robotics with social sciences and engages children in making and programming robots that perform dances from around the world. Over the course of several weeks, students work in groups to build and program a dancing robot from a cultural background of their choice. A final robotic performance is organized to showcase student work for parents, siblings, and schoolmates.

*My community* integrates the use of robotics with social studies and engages children in learning about their own communities. They start with the study of maps and develop a large floor map with key locations in their own community and program their robots to travel from place to place.

*Everyone Feels* focuses on social-emotional learning competencies as children learn to program their robots. Students work independently and in large group settings to create a robot that expresses their feelings, after reading and discussing “The Feelings Book” by Todd Parr.

### WHY PROGRAMMING ROBOTS FOR YOUNG CHILDREN?

Young children love to make things, and they love to make things that move and respond to their commands. Robotics brings together the physical world and computational world. Robotics is a natural fit for young children’s interests and curiosities. Research shows that young children will learn programming and engineering at a very early age if they are given tools that are developmentally appropriate.

Research also shows that children are most open to new ways of thinking about themselves when they are under the age of eight. So to ensure that their self-image includes enjoyment, understanding and competence in working with technology, it is best to expose them to it while they are open to soaking it up. That way they will grow up to have skills that give them both improved employment opportunities and a healthy outlet for self-expression.
Furthermore, research shows that from an economic and a developmental standpoint, educational programs that begin in early childhood are associated with lower costs and more durable effects than interventions that begin later on. Research also shows that introducing STEM (Science, Technology Engineering and Math) in early childhood might help to avoid stereotypes. However, one of the major impediments for bringing technology and engineering into early childhood education is the lack of developmentally appropriate technologies. KIBO addresses this need.

**WHY IS KIBO DEVELOPMENTALLY APPROPRIATE FOR YOUNG CHILDREN?**

KIBO is designed on a firm understanding of the cognitive, social, emotional and motor abilities and needs of young children. With KIBO young children can program without a PC screen, tablet or mobile phone. Children play with KIBO using their hands to manipulate wooden blocks with pictures of programming instructions.

Programs made of wooden blocks are tangible, so they can be shared easily. They can be talked about and debugged in a social circle. Wooden programming blocks are naturally familiar and comfortable for children, in the tradition of learning manipulatives already used in early childhood classrooms to teach shapes, size and colors.

KIBO is based on over 15 years of research, funded by the National Science Foundation by Prof. Marina U. Bers, professor of Child Development and Computer Science, and director of the DevTech research group at Tufts University’s Eliot Pearson Department of Child Development. KIBO's life started as the KIWI research prototype. She dreamt with a robotic kit that her three young children could play with. In 2013 she co-founded KinderLab Robotics, with veteran robotics start-ups executive Mitch Rosenberg, with the goal of making robotics available for every young child. This dream and goal are becoming a reality with funding from the National Science Foundation through an SBIR grant and a successful Kickstarter campaign.

**WHAT DO PARENTS SAY?**

- “I really was scared and skeptical, but when my son did get to use it I was just blown away with how great everything was and the kinds of things he was able to do.”
- “My daughter loved it because she and her friends created a puppet show and the puppets sang and danced.”

**WHAT DO YOUNG KIDS SAY?**
• “Look, look what I did. I made it myself!”
• “It is not a robot. It is something that you can program to do what you want. It is much better!”

WHAT DO TEACHERS SAY?

• “I loved it the design of it in particular. It is very clean, very clear, and so that focus on programming is definitely going to translate. If I put this block here, this happens.”
• “This can pervade every aspect of the curriculum, and it can hook kids that aren’t traditional learners. Maybe their intelligence lies in a different area than what we emphasize in the traditional schools. I think it will be very powerful to get those kids hooked and teach them with this.”
• “I think those children that wouldn’t necessarily be interested in LEGO would be interested in it because they can use arts and crafts and recyclables in their robots and it is a lot easier.”
• “In a Montessori classroom we use wood, we use glass beads, we use things that are beautiful because it shows respect for the child as being able to take care of these things. KIBO fits right in there. The hardware itself doesn’t remind you of hardware, it reminds you of something more organic.”
• “I like KIBO because it is very versatile, like a platform for staging something, I think that’s really cool.”

MORE INFORMATION?

To purchase KIBO, go to the KinderLab Robotics website:
http://www.kinderlabrobotics.com

To learn more about the research behind KIBO, go to the DevTech webste at Tufts University:
http://ase.tufts.edu/DevTech/ReadyForRobotics/index.asp

To see a short video (1 min long) of a 5 year old using a prorotype to make a "Confused Robot", go to:
http://www.youtube.com/watch?v=dg7eWKvL3Rk

To see a longer video (approx. 5 min long) at an East Boston school using the Me and MY Community curriculum, go to:
http://tkroboticsnetwork.ning.com/video/me-and-my-community