Excerpted from

Getting Started with LEGO Robotics
A Guide for K-12 Educators

Mark Gura

LEGO Robotics is a hands on, multidisciplinary, collaborative, authentic learning experience, and Mark Gura wants you to give it a try. Although starting a robotics program may seem like a daunting task, he brings together the information you need and presents it in a manageable, organized way. You will learn what LEGO Robotics is, what student activities look like, how to begin, how to manage a class, how robotics relates to standards, and much more. Gura concludes with more than a dozen interviews with educators, trainers, and even a student, who all provide first-hand advice and recommendations. After reading this book you will be on your way to introducing your students to LEGO Robotics activities and competitions!

Chapter one explains the basics of LEGO Robotics including what is needed, who can do it, and what the benefits are. By breaking down each essential component, Gura makes learning and teaching LEGO Robotics easy.

CHAPTER 1

Robotics Basics

What Is LEGO Robotics?

LEGO Robotics is a body of teaching and learning practice based on LEGO Robotics kits, popular sets of materials that enable individuals without formal training in engineering and computer programming to design, build, and program small-scale, robots.

Students typically design and build a robot in three ways: 1) through imagination and playful exploration, they may create their own robot; 2) they may follow a cookbook-like recipe of directions by someone who has designed and built a robot—and they may modify the directions to create their own versions; or 3) a teacher or a more advanced student may create a "Challenge," a description of a problem that needs to be solved by the creation of a robot, together with a set of parameters the student must work within to create that solution. All of these approaches have value. There is something to be learned from each of them, particularly if teachers view student growth with robots as having a trajectory and understand that one approach may be of more value at a particular time in students' development. A full robotics program may offer several projects in each of the three modes for a balanced whole.

In all three modes, the process is likely to include the following elements:

- Envisioning what the robot will be like and what it will do
- An initial "build"
- An initial attempt to write a program
- Early trial runs of the robot to see if it will do what it has been designed for
- Design modifications and/or program modifications
- Feedback, reflection, and finish

To accomplish the above elements, students will put the robot's body together from construction pieces. This may include programmable "bricks" and/or specialized pieces and connectors, as well as axles, wheels, gears, and other parts. A programmable brick (the robot's central processor) will be incorporated into the design from the beginning; it often serves as a power source and a processor on which the software program runs and as an armature or support that makes the rest of the robot's construction possible and functional. Usually the programmable brick is thoroughly integrated into the structure of the robot.

Shortly after the early form of the robot is constructed, or perhaps in a step-by-step, back-and-forth manner, students will go to the computer to write the program needed to run the robot. Once this has been accomplished, students download the program to the brick or central processor and test the robot to see if it works. The rest of the process is one of back-and-forth, trial-and-error testing, followed by modifications of the robot, the program, or both.

More about LEGO Robotics Kits

LEGO Robotics kits contain the things needed to construct a fully functioning robot: parts needed to construct the robot's body; sensors (small electronic devices that detect and measure things in the robot's environment, such as light, electricity, and temperature); motors to power the robot; gears and other mechanical components; and a small processor, a programmable brick called the "brick." This small computer holds the robot's battery power and program, the commands that the robot will follow to carry out instructions, perform tasks, and solve problems. The processor is typically built into the robot's body as its core. The program is generally created on a conventional computer, using LEGO Robotics software; the program is transferred to the processor, although the newer NXT generation of materials also has a limited capacity to run commands that originate in the processor itself.

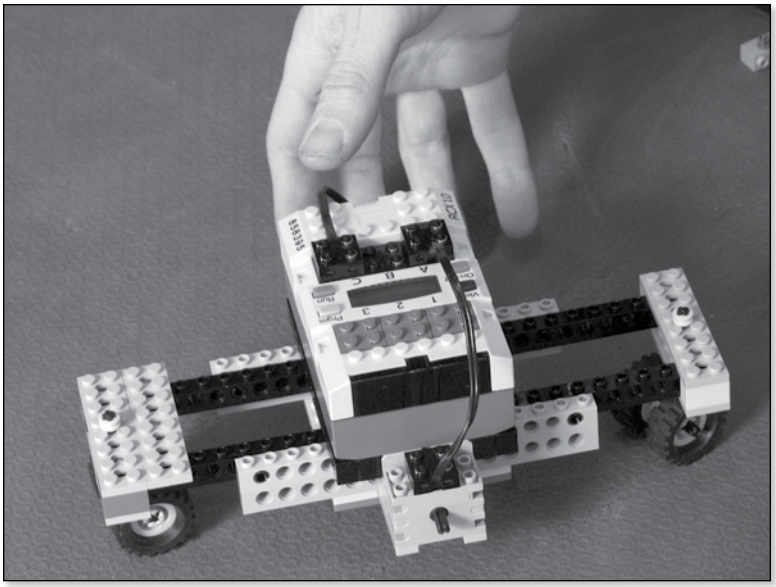

Figure 1.1 A student-created robot contains a programmable "brick," or processor, in the center.

While the range of materials included in a kit is generally complete enough to provide everything needed to construct a wide range of basic robots, purchase of additional components may be required for more advanced or elaborate robots. Generally, after completion of a robotics project, the robot is disassembled so that the parts may be used again for subsequent projects.

While some teachers may use a single LEGO Robots kit to demonstrate or illustrate science, mechanical, or engineering concepts and practices, the far more common practice of using them for hands-on student activities requires numerous kits. Students generally share kits for both instructional reasons (collaborative learning) and practical ones (cost and storage). The ideal ratio of kits to students is from one kit to two students to one kit to three or four students. The kits come in durable plastic bins that are convenient for storage. Over the years, the manufacturer has produced many varieties of kits; some come with software, and others require that additional software be purchased.

What Purposes Might Robotics Serve in the Classroom?

LEGO Robotics materials and practices represent a highly motivating, highly engaging basis for standards-based learning across the curriculum, with particular value in the four STEM subject areas. LEGO Robotics enables and facilitates progressive approaches to instruction, such as project-based learning and problem-based learning, hands-on learning (learning by making things), collaborative learning, authentic learning and assessment, and constructivist learning. The kits and practices are also used as the basis for the very popular FIRST LEGO League extra-curricular and after-school activities and competitions.

While a majority of students will not seek careers in engineering or become information technology (IT) specialists, there is value in giving them solid understandings of how these things work and affect our society. LEGO Robotics is a convenient, practical way to give students a good understanding of programming and how it directly influences our physical environment. This is potentially of great value to schools looking for meaningful ways to make technology-based learning part of the curriculum.

Beyond specific connections to science and math curricula already being implemented and curriculum areas on the radar screen for implementation in the near future (namely, STEM learning), LEGO Robotics offers advantages in the areas of how students learn and in learning unspecified or nonmandated curriculum that will significantly enhance students' success in higher education and the world of work.

LEGO Robotics represents one of the few practical opportunities at this time for schools to implement the following teaching and learning approaches and new curriculum items.

Teaching and Learning Approaches:

- Hands-on activities
- Learning by making things
- Problem-based and project-based learning
- Authentic assessment (products and performances)
- Collaborative learning
- Constructivist learning

New Curriculum Items:

- Collaboration as a reflective body of knowledge
- Learning activities that foster creativity
- Cross-discipline, applied learning

For What Grade Levels Is Robotics Appropriate?

LEGO Robotics may be used with a broad range of ages and ability groups. Robotics activities are flexible and adaptable to the needs of specific student populations. LEGO Robotics has become popular with upper elementary through middle school students, although the activities and concepts may be applied practically and meaningfully in high school level courses. The relatively recently introduced WeDo Robotics kits extend the appropriate applicability of LEGO Robotics to lower elementary grades and into the area of language arts in addition to its STEM connections.

Figure 1.2 Even younger students can participate in LEGO Robotics. (*Photo courtesy Flickr user SpecialKRB.*)

Who Can Teach LEGO Robotics?

More and more frequently, teachers are becoming interested in bringing the impact of high motivation, technology-driven relevance, and STEM-enriched content and skills instruction into their classrooms. Though these ideas are appealing, do you ever wonder if you are sufficiently qualified or prepared? Taking the measure of one's abilities is smart and responsible if it is done in reference to an understanding of what's actually needed.

Most primary and secondary teachers wonder about their technical abilities. In reality, the level of technical skills needed to create robots has been pared down by the LEGO Robotics kits, as they are designed to engage and instruct students in ways that they can handle and learn from. You should have a reasonable comfort level with computers, but you don't need to know advanced things like programming. If you can navigate the web, using sites that require a degree of user interaction to fill in information, click buttons, and select "check off" options (common to online shopping or travel sites), if you use email and are comfortable sending and receiving attachments, and if you can use a word processor, perhaps inserting a graphic or other element

and manipulating it within the page, then you probably know enough about today's user-friendly computers and software to handle managing your students as they learn with LEGO Robotics.

Robotics involves designing and building machines. Most teachers who are experienced in teaching engineering concepts, such as Simple Machines, or who coach students in building robots to perform tasks, including the experts who are interviewed throughout this book, agree that the optimal skill needed is coaching—prompting and guiding students to experiment on their own to find out what they need to know or to research problems. The web abounds in examples of specific solutions to the myriad little design and construction problems students will encounter. You don't need to be an encyclopedia of experience and knowledge, but rather a learning coach who directs students to the wealth of available materials when they aren't learning from their own trial-and-error experiments and comparisons with their peers' efforts.

LEGO kits are designed so that the robots students are likely to want to build can be constructed by putting well-designed parts together in workable combinations. LEGO Robotics is compatible with a trial-and-error approach, and so the majority of teachers who don't have backgrounds in engineering can guide students through learning experiences that are every bit as valuable as those provided by that small minority of teachers who are specifically teaching engineering-oriented design and build processes.

What may be more challenging for educators new to robotics are the instructional and classroom management dimensions of LEGO Robotics–based activities. With thought, reflection, and the kind of planning teachers typically learn to do on the job, you will be able to master these techniques, especially with the advice given in this book (see Chapter 3: Managing the Robotics Classroom). While LEGO Robotics activities excite and engage students powerfully and provide opportunities to learn science and engineering concepts and skills, as well as a host of subsidiary skills in areas like math and language arts to support these efforts, they tend to be implemented in a way that is far from the traditional lecture-based, teacher-centered, whole group lesson approach that we associate with 19th- and early 20th-century classrooms. For example:

- LEGO Robotics activities tend to have students work independently, although portions of the experience may be done in the traditional whole group setting.

- Students will probably work in teams or small collaborative groups. This is done for practical reasons, to share materials and space, as well as to optimize instructional time and to foster effective learning.
- Out of necessity, the LEGO Robotics classroom gives students a good deal of freedom to move about, interact with peers, and select specific tasks they wish to address at the moment.
- Activities embrace the qualities associated with project- and problem-based learning.
- Designing and building robots is open-ended; to a degree, students will identify what they want to do and work at their own pace, following approaches and processes they feel most comfortable with.
- There is often a social learning, constructivist dimension to LEGO Robotics activities. Students make discoveries about "what to," "why to," and "how to" continually, enjoying and benefiting from sharing their experiences, both successes and failures. Significance, meaning, and practical lessons about how to assimilate what's been learned come from shared, communal aspects of learning to a large degree.

Educators have long sought practical approaches for implementing the aspects of teaching and learning listed above. The good news is that a great many teachers, together with students of varying ages and ability groups and in various subject areas, have made all this happen in their classrooms through LEGO Robotics. This book shares the hard-won advice of those who've already succeeded, offering insights into how classroom organization and management as well as integration into the curriculum can be achieved reasonably easily.

In short, with an open mind, the willingness to try new things and learn from one's initial efforts, a little forethought, and a bit of preparation, LEGO Robotics is something that unspecialized teachers can bring into their classrooms. It does not require long-term, formal study—especially not to get started!

Why Are Robotics Activities Satisfying?

As an example of project-based learning, robotics is, to a significant degree, student self-directed. Students define for themselves the challenges they will tackle, such as: What type of robot will I create? What will I make it do? How will I design and program it to retrieve a ball? LEGO Robots are toy-like; they are made on a scale that is familiar for play objects. And, in many ways, LEGO Robotics activities feel like play. While a great deal of learning is involved, it is informal, experimental, and discovery-oriented. Learning with robotics is risk free. Try something, and if it doesn't work, simply try something else. Above all, LEGO Robotics is learning by making things. Each project involves identifying a challenge to be solved by creating a personal invention. Students start with the creative spark-driven, hatch-an-idea-and-make-it-work design and programming process; move on to the testing and trial phase (and perhaps a modification and re-testing phase); and, finally, present their robots to peers, teachers, and others. A robotics activity has a clearly defined start, middle, and finish; an easy-to-identify "It works!" point of success. Students understand that through their teams' trial-and-error experiments, brainstorming for solutions, and accomplishments they have learned a great deal. As coaches through this creative, scientific process, teachers are drawn into their students' excitement.

What Are the Instructional Goals and Advantages of LEGO Robotics?

The inclusion of a course in robotics, per se, within the overall curriculum is a rare thing as of this writing. But the need to study robotics as an end unto itself is a narrow one—a study for future engineers and roboticists, one from which most students will not derive great benefit.

The application of robotics across the curriculum, in providing practical, hands-on activities in the subject areas of science and math and especially in cross-disciplinary activities considered STEM (science, technology, engineering, and math) is where LEGO Robotics excels. It also has important, effective applications in language arts and other subjects. These curricular connections are fully explored in Chapter 7: Robotics in the Curriculum and in Chapter 8: Connections to Learning Standards.

Mark Gura has been an educator for more than three decades and has been involved with the implementation of LEGO Robotics in schools for almost 20 years. A former staff and curriculum director and director of instructional technology for the New York City public school system, he currently works with Touro College and Fordham University, among other organizations. Gura has authored a number of books, including *Visual Arts Units for All Levels*, and is the co-host of the popular series *The Teacher's Podcast*.

July 2011
270 pp. 7 x 9¼
Product code: ROBOTS
978-1-56484-298-5

Order now by phone, fax, or online. Single copy price is $37.95. ISTE member price is $26.57. Special bulk pricing is available. Call 1.800.336.5191 (U.S. and Canada), 1.541.302.3777 (International), fax 1.541.302.3778, or go to www.iste.org/robots.