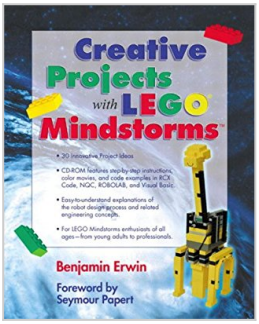

Creative Projects with LEGO Mindstorms¿

By Benjamin Erwin

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LEGO(r) Mindstorms(TM)TM has already turned hundreds of thousands of people into active robotics hobbyists. Now, there's a complete, serious guide to building LEGO Mindstorms robots. LEGO Mindstorms insider Benjamin Erwin presents 16 highly-creative, start-to-finish projects -- all explained step-by-step in the book, and presented in full color on the accompanying CD-ROM, with accompanying movies. This is far more than a "cookbook": Erwin shares unparalleled insight into the critical thinking and programming skills behind successful robotic building, stressing the connections between LEGO engineering and real-world engineering. He focuses on practical construction and programming techniques, drawing upon his extensive experience to help robot-builders avoid the pitfalls that often frustrate them. Every chapter starts with "Inspirations" that help readers understand where the ideas for the robot came from, and ends with "Further Work" suggestions for improvements or modifications. From "Tickle Me LEGO" to "Flashlight Follower," "Animal Feeder" to "Bubble Machine," each project is supplemented with even more detailed, full-color instructions, movies, and other resources on CD-ROM -- including code built with RCX, NQC, ROBOLAB, and Visual Basic.

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Editorial Review

From the Inside Flap
The greatest thing about LEGO is that when you are building something and have a problem, you can take some of it apart, change things, and then keep building.
--Cale Putnam, eighth grader When the way comes to an end, then change; having changed, you pass through.
--I Ching

The LEGO Mindstorms product line is a breakthrough in the world of technological toys. With plastic gears, pulleys, beams, bricks, axles, connector pegs, and other building elements, you can create mechanical contraptions that would make Leonardo da Vinci jealous. Combine these mechanisms with motors, sensors, and a programmable LEGO brick, the Robotic Command Explorer (RCX), and your creation can run on its own, interacting with and responding to you and its environment, including other robots. There are limitless possibilities to building and programming with LEGO Mindstorms. Mobile robots, kinetic works of art, toys, robotic animals, and robots that gather data are just some of the types of projects that you will see in this book.

It's unfair to simply refer to LEGO Mindstorms as a "toy," however. The robotic devices that you can create can serve very real, practical, and serious purposes. More importantly, building and programming a robot is a rich learning experience. Your creation will never work right the first time you test it, and the process that you go through to figure out what went wrong is when the learning takes place. This book is about that process.

At the Massachusetts Institute of Technology (MIT), Gene DiSalvatore has this saying on a piece of paper in his office: "Good judgment comes from experience, and experience comes from bad judgment." Applied to LEGO robots, this statement means that building a robot that works involves building a robot that doesn't work and then figuring out what is wrong with it. The more robots you build, the better your mechanical and programming skills will become.

The LEGO Group has been designing educational products for many years. LEGO Dacta is the educational division of the LEGO Group, in the same way that LEGO Mindstorms is the new "robotic" division of the LEGO Group. In the early days, LEGO Dacta models that were connected to a serial interface box could be programmed from a computer with a language called LEGO LOGO (see Figure 0.1).

Figure 0.1 The LEGO Dacta serial interface box

LEGO LOGO was an extension of the kids' programming language LOGO, developed by Dr. Seymour Papert and others at the MIT Media Laboratory. After the serial interface box came a prototype for a programmable brick, which later became the RCX. More work has been done since the development of that first programmable brick, too. Smaller programmable bricks called crickets are less bulky than the

Mindstorms RCX (see Figure 0.2).

Figure 0.2 The RCX, the brain of the LEGO Mindstorms Robotics Invention System, next to a third generation programmable brick prototype, the cricket.

But Dr. Papert and his colleagues aren't just developing hardware and software; they're developing ideas, philosophies, and theories about the nature of learning and learning environments. Dr. Papert has coined the phrase constructionism to describe his philosophy of learning. The earlier theory of constructivism states that knowledge has to be constructed--put together into coherent understandable pieces--inside of the head, and that knowledge cannot be forced into your head or passively absorbed. Constructionism adds to these ideas the notion that by constructing something of personal interest outside of your head--a robot, a work of art, or a computer program, for example--you're better equipped to construct knowledge inside of your head, using the experience that you've gained from the physical world. Those experiences give you "objects to think with" and become the tools with which you can construct knowledge. Building and programming a LEGO robot is such an experience.

For the past four years, my life has revolved around LEGO in one way or another. In 1996 I graduated from MIT and went to Tufts University to work on a project with Professor Chris Rogers to create an engineering curriculum for young students using LEGO. Dr. Rogers and his graduate students had already created a graphical programming environment for the LEGO Dacta serial interface box. Borrowing some ideas from LEGO LOGO, I made modifications to this graphical programming environment and gave it a name--"LEGO Engineer." We showed LEGO Engineer to LEGO Dacta, and they liked the concept. We were then asked to create the educational version of the software for the RCX, which is now called "ROBOLAB." Our philosophy for ROBOLAB was to create software that could be used by anyone from preschool to graduate school. ROBOLAB has easy-to-use programming interfaces that very young students are using in elementary schools, and a high-level programming environment, which includes data analysis capabilities, that is being used in middle schools, high schools, and colleges around the world.

Being involved with LEGO spread to the people around me as well. Around the same time that we were working on ROBOLAB, we were asked to recommend people who could design robots that would push the boundaries of what the RCX could do. Among other things, LEGO wanted some "cool" examples of complex mechanical creations on the cover of the upcoming Robotics Invention System box. Dr. Rogers and I recommended my housemate Anthony Fudd, who had designed a LEGO airplane complete with hot-wire airplane wing cutter. Now Anthony is employed by LEGO Mindstorms as a master builder. He is the designer of the LEGO copy machine, ATM Machine, Refrigerator Fred, Card Dealer, a robot that can clean up LEGO bricks from the floor, an elephant that squirts water, and numerous other creations.

Because of the popularity of the RCX and the growing online community surrounding it, the LEGO influence spread even further than among my housemates. When looking for beta testers for ROBOLAB, I thought of Dave Baum, a fellow MIT Phi Kappa Theta alumnus1 like Anthony Fudd and someone I had met on the LEGO User Group Network at lugnet. Dave beta-tested ROBOLAB and became one of the first users of the RCX. Although Dave loved ROBOLAB, his first love was C. After learning ROBOLAB inside and out, Dave went on to create NQC, which stands for Not Quite C. It's a C-like programming environment for the RCX.

While at Tufts, I also worked toward a master's degree in education. One of my favorite classes was "Technological Tools for Thinking and Learning" with Professor Uri Wilensky. One of the first assignments in this class was to read a little book called Mindstorms: Children, Computers, and Powerful Ideas, written in 1980 by Seymour Papert. It was a powerful experience to read about ideas that were coming into their full fruition with the preparation of the launch of the LEGO Mindstorms product line. It was inspiring to be a part of it.

In Dr. Papert's books and papers, he writes about his and others' experiences as educators working with students on various LEGO design projects. In this book, I wanted to do the same, to convey what it's like to design and build a LEGO robot. I didn't want to write a book full of instructions that show you how to build my robots. I wanted to write a book that would help you build your robots. To accomplish this, I've filled this book with descriptions of problems that were encountered when trying to design various LEGO robots, and how those problems were solved. Dr. Papert calls his stories "learning stories." The following chapters are my "learning stories" for you.

There are several reasons why I chose to write a book about LEGO robotics that would be accessible to young adults as well as full-grown ones. In my experience with LEGO robots, I have seen lots of examples of wonderful creations that have been built by adults and kids alike. By looking on the Internet or attending a robotics festival such as Mindfest at the MIT Media Lab (media.mit/mindfest/), it's tempting to think that everyone who has used a Mindstorms kit has had success in creating wonderfully creative projects. In my experience of teaching hundreds of students and educators how to build LEGO robots, and talking to hundreds of parents and educators in person and online, however, I've seen that this isn't the case.

Students and novice adults usually encounter two problems when they make a LEGO robot. I have seen many of these same problems, frustrations, and mistakes repeated over and over again. First, the largest frustration is when the robot "falls apart." Some people blame the robot's "falling apart" on the robot, without thinking about how they can use the LEGO building elements to make their robot stronger. Parents have told me stories of kids in the home setting who have given up completely on their Mindstorms kit out of frustration because they cannot get their robots to be crash-proof, or even stay together at all. I chose, therefore, to concentrate on construction techniques throughout the book. Second, I have heard from a lot of student

From the Back Cover

With its emphasis on building technical skills *and* having fun, LEGO Mindstorms has become a popular "toy" for technological tinkerers of all ages. This book-CD package helps you build a variety of exciting robots, and in the process expands your programming knowledge, enhances your problem-solving skills, and boosts your creativity.

Creative Projects with LEGO® Mindstorms™ walks you through the creation of several different kinds of robots: basic mobile robots, kinetic sculptures, robotic animals, data-gathering robots, and robots that can communicate over the Internet. As the book progresses, the robots become increasingly sophisticated and the programming becomes more complex. Specific projects include:

- Walking Dog
- Line Follower
- Animal Feeder
- The Painter
- Bubble Machine
- Flashlight Follower

- Smart Acrobot
- Giraffe

The ultimate goal of this book, however, is not just to help you build the book's model robots, but to transcend the instructions to create robots of your own invention. With that in mind, the author explores the inspiration behind each robot's design, the problem-solving that went into its creation, and further modifications you can incorporate into your own projects.

Clear color photos illustrate each step in the design process, and the accompanying CD-ROM features instructions, color movies of robots in action, and code examples in RCX, NQC, ROBOLAB, and Visual Basic for sixteen robots. NQC software and a demonstration version of the ROBOLAB software are also included on the CD.

You will thoroughly enjoy building the projects in this book, and you'll learn a great deal about the inspiration, design, and construction of robots.

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About the Author

Benjamin Erwin is a LEGO® Mindstorms™ professional who was involved in developing ROBOLAB--the innovative LEGO Mindstorms for Schools software used in educational settings. While at Tufts University, he helped develop an engineering curriculum based on LEGO Mindstorms that teaches middle-school students critical thinking skills. He has taught LEGO robotics at more than ten schools and has given workshops to teachers and professionals in numerous cities in the U.S. and China. He currently works for ATG in Cambridge, Massachusetts.

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Users Review

From reader reviews:

Nancy Dabney:

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Gregory Phipps:

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