

# RoboCupJunior Primer: Expanding Educational Robotics

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## Abstract

This paper describes an online resource designed to aid in the creation of educational robotics programs where teams of mentors work with middle and high school students. This resource, The RoboCupJunior Primer, is based on five years of undergraduate mentoring experience in a local public school. The primary goals of the primer are threefold: first, to expose interested parties to the resources necessary for the creation of a RoboCup team; second, to provide a location for students to communicate with members of other teams and demonstrate specific examples of success; and third, to house an archive of lesson plans as well as tips for creating interesting and efficient lessons.

## Introduction

Since September 2004, undergraduate students from Duke University have mentored middle and high school students from Durham Public Schools as part of the Duke RoboCupJunior program, a project-oriented, team-based academic enrichment program. The objective of the program is to foster interest and competence in computing, science, and mathematics, while simultaneously developing problem-solving skills, enabling creative thinking and design, and providing a domain for application of scientific concepts. Robotics is a popular domain for attracting students to computing and engineering (Sklar, Parsons 2002) and can be used in education to motivate further study in mathematics and computing (Miller, Stein 2000), demonstrate the interplay between technology and society (Hamner et al. 2008), and broaden participation among underrepresented groups (Williams et al. 2008).

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The intersection of a traditional learning environment with the real world application of newly acquired knowledge makes this program a unique experience for the undergraduate students who serve as mentors. The program provides exceptional opportunities for young students who would likely not otherwise be exposed to the endless possibilities found within robotics. This reciprocal payoff differentiates Duke RoboCupJunior from similar robotics and engineering curricula.

## About RoboCupJunior

RoboCupJunior is an international endeavor aimed at pre-college students that seeks to cultivate interest in science and technology through a multifaceted and unconventional approach to competition (Sklar et al. 2002). Teams of primary and secondary school students participate in one of three competitions: rescue, dance, or soccer. Rescue teams build and program a robot capable of navigating a course while identifying and rescuing victims by following lines and responding to color cues. Dance teams choreograph a dance routine using robots they build and decorate, costumes they prepare, and music they select. Soccer teams build and program two robots, which then face off against other teams' robots in a soccer match. Winners of regional competitions are eligible to attend the annual RoboCup World Finals, held at various locations around the globe.

## Why RoboCupJunior

RoboCup promotes cooperation and the exchange of ideas among researchers from various universities and organizations while encouraging clever and practical solutions to challenging situations (Asada et al. 1999). RCJ can be distinguished from related programs such as FLL and Botball for three main reasons. First, RCJ consists of three standard competitions that remain static or change

only slightly from year to year. This consistency is particularly useful, because it lends itself to familiarity with each task, which in turn encourages students to refine project solutions over time. This standardization of competition topics leads to the second important differentiation: cooperation between teams. This collaboration takes many forms, the most obvious being the common practice of sharing basic code and construction ideas on program run website. For example, RCJ Australia provides code and designs from previous successful teams, so novice teams can start at a competitive level. Finally, students participating in RCJ have the opportunity to work on projects with real-world implications. The junior rescue competition is closely related to the tasks found in the urban rescue scenario posed in RoboCup Senior competition, which takes place in a realistic disaster scene. Similarly, RCJ soccer is based on many of the same principals as the senior competition.

## RoboCupJunior Primer

Research has shown that through preparation for and participation in RoboCupJunior events, students generally self-assess improvement in general science, math, physics, computer programming, engineering concepts, electronics, communication skills, and teamwork (Sklar, Parsons 2002). Preliminary evaluation of the Duke RoboCupJunior Program has shown positive results for students' interest and competence in robotics and science (Osborne et al. 2010). However, the current program and its results are limited to students in Durham Public Schools, where Duke mentors meet with teams of 4 students each week and conduct workshops for local teachers. In order to broaden the reach of the program, the project staff has produced a RoboCupJunior Primer. While there exist many robotics books, tutorials, online guides and the like, this is a unified resource containing all of the information necessary to build and maintain a RoboCupJunior program from start to finish in addition to numerous resources for existing participants. This primer is made up of targeted information that can be broken into three main categories.

First, it enumerates the benefits of educational robotics and provides a list of the requisite materials, software and administrative logistics needed for getting such a program off the ground. One of the biggest goals of the primer is to spread similar robotics programs beyond Durham Public Schools. If effective, the primer will be seminal in the widespread effort to introduce pre-college students to robotics and programming. The primer provides useful information not only about RoboCupJunior, but also educational robotics activities in general (Mataric et al. 2007). For those potential administrators interested in a program similar to Duke RCJ, the primer includes guides on how to recruit and train mentors, foster positive team dynamics, and generally keep a robotics program running smoothly.

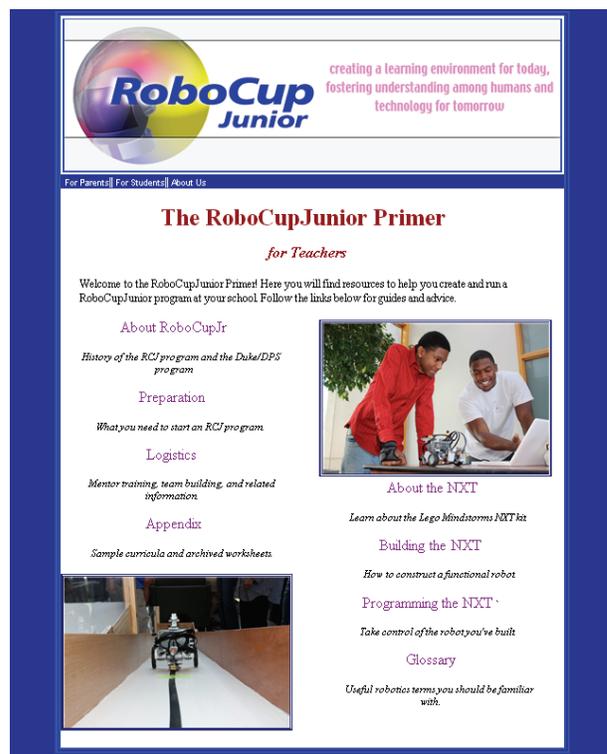


Figure 1: Primer Page for Teachers

Second, the primer has a guide detailing how to produce fun, effective, and challenging curriculum for students. In addition to these guidelines, users can sample curricula for the LEGO Mindstorms NXT. This section of the site is aimed not only at offering ideas for creating original lessons, but also acts as a database for existing plans and building guides written by other site users.

Finally, through use of the gallery feature, the primer acts as a community space for RoboCupJunior participants from around the world. The gallery is a place for students to share robot designs, programs, photos and videos of their handiwork for other students, teachers, and parents to view and comment on. The dynamic, interactive, and community-driven nature of the site sets the RoboCupJunior Primer apart from similar robotics education websites.

## The Primer and the Future

In the five-years since its inception, the Duke RoboCupJunior program has seen a number of iterations and experienced great successes. But these successes come only by learning from mistakes. The primer will afford new program participants the opportunity to capitalize on these lessons and translate the mistakes of past mentors and students into opportunity. For example, through trial and error we have found that groups function best at a 4:1 student to mentor ratio and students typically perform best when some display of progress is expected at the end of

each session. Anecdotal information will no doubt be advantageous for those attempting to start a program.

The primer has additional benefits that extend to current members as well. RoboCupJunior aims not only to foster interest in science and technology, but also open dialogue between competing teams. Students can use the gallery to communicate ideas, display their work and challenge one another to creative exhibitions. This new venue for disseminating information fosters a network of collaboration that mimics a natural research environment. There is no better way to prepare students for a future in science and technology than giving them a taste of what is in store. By creating a welcoming and insightful portal into the world of educational robotics, the primer not only reaches potential mentors, but also encourages students to push the limits of their imagination.

### Conclusion

Through the implementation of an online resource called the RoboCupJunior Primer we hope to foster creativity and imagination while simultaneously creating an environment where cooperation is not only encouraged, but expected. Specifically, the primer serves as a central gateway for parties interested in starting an educational robotics program at their school; as a sounding board for students and mentors to share ideas and seek help; as a place specifically designed to cultivate a community of forward thinking young people to learn from one another and move forward as the next generation of scientists and researchers.

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