

## **AC 2007-2224: MENTORING FIRST LEGO LEAGUE: CHALLENGES AND REWARDS OF WORKING WITH YOUTH**

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# **Mentoring *FIRST* LEGO League: Challenges and Rewards of Working with Youth**

## **Abstract**

The *FIRST* LEGO League (FLL) organizes friendly competitions between students, ages 9- to 14-years-old. The competition focuses on engineering challenges addressing a theme in science and technology. For 2006, FLL chose nanotechnology as the central theme. The youth used a semi-autonomous robot constructed from LEGO® brand building blocks to perform tasks related to current themes in nanotechnology research. In addition to the robot competition, the students researched and presented on a current topic in the field of nanotechnology. To facilitate the project, FLL relies on volunteers from the community including coaches and mentors. This paper explores the experience of two graduate engineering students from Virginia Polytechnic Institute and State University (Virginia Tech) as they mentor the Kipps Elementary School FLL team.

The two graduate students acted as technical mentors to the team. As mentors, the graduate students provided technical direction without suggesting actual design ideas to the team as the youth designed and built the robot for competition. The overall administration of the team was handled by the coach, a volunteer from the community, who managed the assignments, focus, and discipline of the group. To effectively mentor the youth, the graduate students each attended at least one meeting per week and worked closely with the coach to follow appropriate strategies in their mentoring. Since the coach had prior experience with FLL and this team, he was relied upon to make decisions regarding team focus and strategy. The youth worked on specific tasks in smaller subgroups, where the mentors were called upon to help focus the youths' energy to the task given by the coach.

The mentors found working with the FLL to be a fun and rewarding experience. One major reward had been observing the delight of the children when they produced an idea. Another reward was the sense of accomplishment felt by the mentor when one of the children showed understanding of a concept the mentor was describing. This paper also addresses the following challenges experienced by the mentors as they relate to FLL mentoring: communication with children and the language difficulties, the youths' concentration level on a problem and their narrow or wide focus, the difficulty of leading to learning as opposed to giving answers, and the creation of a constructive versus a destructive atmosphere.

## **Background on First LEGO League**

*FIRST* LEGO League (FLL) is a joint effort between *FIRST*, “For Inspiration and Recognition of Science and Technology,” and the LEGO Group created in 1998 for children under fourteen.<sup>1</sup> FLL combines the visions of *FIRST* and the LEGO Group. Dean Kamen, the inventor of the Segway Human Transporter, founded *FIRST* to excite children in the areas of science, technology, engineering, and mathematics (STEM).<sup>2</sup> The LEGO Group motivates children to “playfully [develop] a set of future, highly-relevant capabilities: Creative and structured

problem-solving, curiosity and imagination, interpersonal skills and physical motor skills - building with LEGO bricks is thus about ‘learning through play.’”<sup>3</sup>

The theme of the 2006 competition was nanotechnology. Each mission on the mat incorporated an idea of nanotechnology, mostly areas of current research. Figure 1 illustrates the missions the youth were challenged to overcome. These missions include themes representing atom manipulation, stain resistant fabric, nanotube strength, smart medicine, and atomic force microscopy. These missions were given as a starting point for the research portion of the competition and to encourage the youth to learn more about nanotechnology. Additional emphasis about the nano scale is indicated on the mat.



**Figure 1:** Illustration of the mat including all the missions for the 2006 nanotechnology theme.<sup>1</sup>

### **Graduate Students’ Reasons for Mentoring**

For a graduate level Engineering Education class, all the students were required to choose a LEGO League team to mentor. The graduate students chose the Kipps Elementary School FLL team due to conflicts in scheduling with the others teams.

## **Kipps Elementary School FLL Team**

The Kipps Elementary School FLL team consists of eight children, equally composed of boys and girls. The coach is the father of one of the children and volunteered to work with the team. All of the youth are under the age of eleven, thus the team competed in the Division I category.

### **Team Meetings**

Normally, the team meetings were held twice a week for an hour and a half after school. Closer to the date of the regional competition, meetings were held three times a week, and hours were extended to three and a half hours. The coach was in charge of scheduling meetings and organizing the youth to work on the various tasks for competing. The mentors' main responsibility was to answer technical questions posed by the youth by guiding and teaching, not providing solutions. In addition to the coach and at least one mentor, parents volunteered to help supervise at team meetings, resulting in a different parent coming to every team meeting.

Typical meetings started off with snack time, where the team is given approximately fifteen minutes to unwind from the school day. For every team meeting, the parent volunteer brought snacks and later assisted at the team meeting. During snack time, the coach communicated the plan of action for the day and held discussions about team issues, like the research project and team name.

After snack time, the team moved to the classroom. The coach chose to partner the youth to tackle the problems of the robot performance part of the competition. By partnering the children, the amount of time each student participated on the robot was their own choice. Typically, at least one of the partners could concentrate on the problem designated, giving them a chance to work almost one-on-one on the problem. When neither partner could focus on the problem, little was accomplished, creating a challenge of directing the youth into working. Usually, the coach, one or two mentors, and a parent volunteer were present to supervise and refocus the youth when necessary. The youth could also approach one of the adults with any questions they may have.

By partnering the team to work on individual missions, the final robot had a greater chance of successfully completing multiple missions. The simultaneous design time allowed all eight of the youth to be engaged in the design process of the robot. The subgroups were not assigned specific mission tasks, but were encouraged to choose a mission that no other subgroup was working on to build and design a prototype and any attachments using the RCX model robot. With each group working on all aspects of designing, building, and programming in the early weeks, four simultaneous designs were quickly tested before the team finalized a robot design.

All of the subgroups had time to program in the older RCX model programming language and to experiment with the newer NXT programming language. The NXT programming skills were helpful once a final robot design was decided upon. Each subgroup wrote an individual competition program in the NXT language. The experience of programming in the NXT language in previous weeks sped up the program design process for the subgroups. They became adept enough at programming that edits took a small amount of time; the subgroups spent more

time waiting for other subgroups to test their programs with the NXT before the robot was available to download the updated programs.

Two weeks before the regional competition, the coach decided to lengthen the time of meetings. The longer meetings were a good idea to implement because the team needed that additional time to accomplish a full design and test of the programs. Until this time, the youth had only been able to complete very few missions. Once they had the time to sit down for a couple hours to program, test, and repeat, significant progress was made towards completing missions. During these long meetings, the first challenge to present itself was trying to keep the youth focused for three hours. After some breakthroughs in programming, resulting in completing more missions, the youth settled into a routine. With all the youth wanting to program with one of the two laptops, download to the robot, and test their programs on the mat, the new challenge became one of sharing.



**Figure 2:** The final version of the NXT robot used at both Regional and State competitions. The youth later dubbed the robot “Nanner-Bot Bucky,” incorporating multiple themes of the challenge in its name.

## Regional Competition

The regional competition was held on a Saturday at a local middle school. The day consisted of table performance trials, the research presentation and interview, and design and teamwork interviews. Judging was divided into two divisions based on the age of each youth on a team and the team’s decision to compete in the higher age category. For Division I, every youth was required to be 11 or younger as of January 1, 2006; whereas, any team with a member of 12 or older competed in Division II.

The youth were notably different in their behavior at the regional competition. The general mood of the team was nervous as this was the deciding moment of all their hard work. For the mentors, it was also a nervous time, as “kids say the darndest things.” The interviews were a tense time for the mentors as we were never quite sure what the youth would express next. The rules dictate the coach and mentors are not to speak or otherwise instruct during the team interviews. The challenge was to remain quiet in the back of the room during the interviews when a question was asked that was recently reviewed with a particular person on the team. Recognizing that the youth know but maybe do not have the confidence to speak up is an obstacle that the team needs to address and overcome prior to the state competition.

The officials of the tournament were posting the robot performance scores throughout the day; thus, the team already realized they had the highest robot performance score of all teams competing. By knowing their robot performance score, the team members became extremely excited as the award ceremony progressed. In addition to winning the robot performance, the team earned a position at the state competition.

### **Preparing for the State Competition**

The meetings after the regional competition and prior to the state competition were different. The robot was already assembled, and only minor programming changes occurred. The team spent most of the meetings practicing their subgroup’s placement of the robot in the “base” area, attempting to improve setup time and proper alignment. Since the robot was already proven in competition, the team was calmer about their successes and failures of individual practice runs. What had previously been met with a loud cheer was now just a smile and the nodding of heads.

The team also focused on improving in all areas from the regional competition. The team decided on new missions they believed they could accomplish in the short time before the state competition. Additionally, the comments from the judges of the research presentation were used to focus on using nanotechnology to create a unique solution a human health issue. The team recalled previous research and decided on suggesting improvements of a “nano-nose” to aid asthma sufferers based on information about the duckbilled platypus and its sensory abilities.

Nearing the weekend of the state competition, the coach added an hour to team meetings. This extra hour became useful for many of the youth because of program changes and testing. When a pair had finished their mission(s) successfully and with repeatability, each youth was given the choice to program a new mission or work on new team posters. Given this choice, most of the youth decided to create new team posters, with a few who would help with programming when asked specifically by another team member. At the end of the last meeting, the team practiced the new research presentation and held several timed robot performance trials.

### **State Competition**

The state competition was held on a Sunday at a local high school. The schedule of events started with the teamwork and design interviews early during the day followed by the robot performance and the research presentation. Throughout the day, the team practiced with the robot and discussed how they would handle mishaps when at the performance table. The youth

had a notably different behavior than their first competition. They were significantly more at ease with their surroundings. The coach's mantra was that at states they were there to compete against how the team had previously done, and that no matter the outcome, they were successful if they improved *anything* from the regional competition. The coach and mentors faced the same challenges during the interviews as they had at regional competition.

The team was called back to the teamwork interview to refresh the judges' memory. It was explained to the coach and mentors that this indicates a top five placement in teamwork. After an entire of "hurry up and wait" at the school, the youth's tempers were running short with each other prior to the awards ceremony. As the awards ceremony progressed to the first and second place trophies for both divisions and the team had not won an award, the expression of disappointed was on every face, including the coach and mentors. Upon hearing the team name called for second place of Division I, cheers of excitement shot up from every youth. The youth showed no disappointment that they did not qualify for the international competition; instead, their success of scoring well in each portion of the overall competition after months of hard work had earned the team a LEGO trophy for display in their school.

## **Challenges**

Two major challenges the graduate students encountered were communicating with youth and leading to learning as opposed to giving answers. For example, the youth were finding it difficult to build a drive system for the robot that would travel in a straight line. Concepts of torque and rolling versus slipping needed to be taught rather than telling the youth how to fix the problem. For the youth to understand these concepts, the mentors needed to explain with language everyone could understand. Demonstrations, when applicable, were found to enhance the youths' understanding of what happened and the explanation of the fundamental concept being taught.

During the first few meetings while using the RCX, the youth were having trouble with the robot's driving system. Each driving wheel was attached to independent motors, but the robot was not following a straight path. While the mentors and volunteers were trying to figure out what was going on, one of the youth connected both driving wheels with one long axle and geared them to a motor. Now the robot would track a straight path, but wouldn't turn. Showing the youth how the driving wheels need to be independent reinforced, if not more effective than, verbally communicating the concept.

Another challenge of focusing the youths' concentration on a problem became more prevalent closer to the regional competition. Most of the time, the youth had little problems staying focused, but other times, they would focus on minor details or try to accomplish too much.

Focusing narrowly on following directions perfectly from the LEGO Constructopedia became an issue during prototyping with the RCX system. The youth needed to mount a motor, and wanted to follow all the steps to create a new drive system instead of picking out the directions on how to build a pair of motor mounts. After some guidance to follow just the subset of directions, the youth understood that he would be building a section that could be used anywhere on the robot.

An example of the youth having a wide focus was when they began programming and wanted to complete several missions with one program. The coach intervened and had the youth pick a mission to program; they did not realize the amount of programming and testing involved in completing one mission, let alone numerous missions in one program. The youth learned a lot about reliability through programming. They discovered that a tiny error in placing the robot on the mat could result in some major changes in how the robot performed. Even after the regional competition, the youth wanted to complete all the missions on the mat, but the coach focused them on improving, even if just by a little.

Another major challenge was creating a constructive versus a destructive atmosphere. Any criticism about a design or program needed to be formed in a positive manner to avoid hurt feelings and stifle creative ideas. This challenge was not only about the graduate students forming constructive criticism, but also getting the youth to refrain from putting down ideas different from their own. The youth had the mindset of their idea being the “best” without giving much consent to alternative solutions.

In earlier meeting, the coach would say positive comments, such as “Wow, that’s really cool!” whenever the youth had a good idea. The mentors picked up on these comments and used variations of them. For example, the youth came up with some designs for attachments that *might* work for one mission, but were not easily attachable to the robot. One way to coach the youth was to say, “That’s really neat! Now how can you attach that to the robot?” Another common question was “What other missions can you complete with that attachment?” These questions were meant to engage the youth in decision making without imposing a negative attitude towards creativity.

## **Rewards**

The challenges of mentoring the FLL team have been eclipsed by the fun and rewarding experiences. Several of the rewards can be labeled as “instant gratification” rewards. While working with the youth, observing them come up with ideas for the robot and attachment designs, research presentation, and team posters was rewarding when they showed the “Eureka!” look. Also, seeing a puzzled expression turn into one of understanding was rewarding when trying to teach concepts about force, torque, velocity, etc. Being presented with a team T-shirt was also an instant reward because it really felt like being part of their team. Each time a subgroup completed a mission successfully was also a quick reward, leading to the biggest rewards of winning the table performance at the regional competition and placing second in Division I at the state competition.

Other, more long-term, rewards can be applied to future goals. Knowing that we can teach a concept to youth by analyzing the audience reaffirms the ability to teach anyone about concepts by using appropriate language, visuals, and demonstrations. The experience of leading to learn versus lecturing is also a valuable lesson both graduate students found they can implement in future endeavors.

In retrospect, a greatest reward is the satisfaction of knowing we have positively impacted these youth. The youth overcame uncertainty and anxiety; robot placement on the mat was crucial to

successfully completing a mission and caused much anxiety during the competitions. We also imparted some of our technical knowledge to the youth, which was apparent in latter team meetings when the youth began to troubleshoot robot design and programming in a systematic manner. Lastly, we connected. The youth began to become interested in us, asking us a multitude of questions. We have also heard our names yelled out in random places, such as a grocery store parking lot, causing much confusion until a familiar LEGO League face came bounding towards us with a huge smile on his/her face. This is *the* reward of working with youth.

## **Conclusion**

The *FIRST* Lego League is a robotics competition for children under the age of fourteen. The FLL provides an opportunity for youth to experience design in a competitive, yet fun, environment. The experience requires adult supervision, and the authors chose to pair with the Kipps Elementary School team. The team consisted of eight youth, one coach, and three graduate students. Throughout the mentoring experience, the mentors discussed the challenges and rewards they encountered while interacting with the youth. The challenges of working with the team were many, but the mentors agreed that communicating with youth and leading to learning instead of giving answers were the two greatest challenges faced. The greatest reward of working with the youth of the team was the “Eureka!” moment often experienced when we overcame the leading to learning challenge. The graduate students were able to help the youth connect the dots and arrive at their own answer. Mentoring has been both a challenging and rewarding experience, and one that has led both graduate students to consider mentoring for FLL next year, if their schedules permit.

## **Bibliography**

<sup>1</sup> *FIRST* LEGO League website. [Online] Available: <http://www.firstlegoleague.org/>

<sup>2</sup> *FIRST* website. [Online] Available: <http://www.usfirst.org/>

<sup>3</sup> LEGO website. [Online] Available: <http://www.lego.com/>