University of Memphis Efforts Assisting US First® Teams in Memphis City Schools

A Year in Review

***Daniel Kohn*[1]**

Abstract – Back in 2008-09, Memphis City Schools (MCS) started a FIRST® Robotics Competition (FRC) Team in one of their high schools as part of an initiative to help increase interest in Science, Technology, Engineering and Math (STEM). This spread to six schools over the next two years, with further growth expected.

To help expand the program and to give students an opportunity to learn more about mobile robotics and engineering fields, MCS approached the Department of Engineering Technology at the University of Memphis to create a program to help further develop US First Robotics Teams within their high schools.

Along with providing technical support and helping find mentors from the University and Engineering community, The University of Memphis ran two programs for the MCS FRC Teams.

The first was a "Quick Build" to help the teams quickly assemble the "Basic Robot Base", the control system and driver station. This enabled the teams to have an early success and to ensure the teams could at least field a robot at the competition.

The second was a FRC Robotics Summer Camp, where students on various FRC teams learned more about FRC robotics for the 2011-12 robot build season.

This paper will cover the Quick Build and FRC Robotics Summer Camp, organization of the events, topics covered, lessons learned and how we hope to expand and to improve these events in the future.

Keywords: STEM, US First, First Robotics Competition (FRC), Robotics, Summer Camp

FIRST ROBOTICS COMPETITION

For those unfamiliar with FIRST®, it is an organization started by Dean Kamen, the inventor of the Segway, to inspire students to pursue careers in the Science, Technology, Engineering and Math (STEM) fields. Started in 1989, it has now grown to four competitions, Jr First Lego League (K-3), First Lego League (4-8), First Tech Challenge (9-12) and First Robotics Competition (9-12). For more information please refer to the FIRST® website [1].

The First Robotics Competition (FRC), which this paper is focused on, has high school students learn about mobile robotics from Aug to Dec, then, in January at "kick off" they announce the game to be played for the year and the teams receive their Kit of Parts (KOP) from which to build their robot. For the next six weeks they, alongside teachers and engineering mentors, will design, prototype, build, program and test their robots, before they are shipped to the competition site, where they will compete.

FRC has been the subject of many papers and studies and has been shown to increase awareness and interest in STEM fields. It has also proven to be an effective way to encourage students to pursue university degrees in those fields.[2]

[1] Engineering Technology Department, University of Memphis, dekohn@memphis.edu

In Memphis City Schools (MCS) there was a dire need to improve interest and test scores in STEM fields [3]. In 2008, the first FRC team was created in MCS to try to address this issue. Thanks to grants from Medtronic and NASA, Team #2817, the Bluff City Bots, was formed from students and teachers from three schools: Booker T Washington High School, Hamilton High School and Fraser High School. Over the next 3 years, the FRC program in MCS grew and was instrumental in MCS receiving the "Race to the Top" Grant from the US Department of Education, as well as being included in the winning submission by Brooker T Washington High School for the "Win a commencement address from President Obama" contest in the spring of 2011.

As the program grew, it was obvious that the support for the teams needed to grow as well. In the summer of 2010, MCS approached the author and the Department of Engineering Technology at the University of Memphis to set up a more comprehensive program for the FRC teams in MCS.

THE MCS AND UOFM COLLABORATION

MCS and the University of Memphis (UofM) entered into an agreement in which UofM would support the FRC teams in the following ways:

- Offer five pre-season (Nov 2010-Jan 2011) workshops for teachers and students in topics relating to Robotics, Engineering and Technology as they pertain to the First Robotics Competition (FRC)
- Provide two "Quick Build" half day Sessions (Jan 15, 2011 and Jan 22, 2011) to assist MCS teams in getting the basic robot built quickly at the start of the build season.
- Provide a week long daytime summer camp program (Summer 2011) for up to 30 students to help generate interest in STEM and Robotics Programs within MCS students.
- Provide technical expertise to assist teams participating in the US FIRST Robotics program during the pre-season, build and competition periods (Oct 2010 to April 30, 2011).
- Create and maintain a webpage to support FRC teams within MCS.
- Use University of Memphis Engineering Technology Department contacts within professional and student organizations to help recruit mentors, both from the University of Memphis and industry, to work with teams.
- Provide technical expertise to MCS teachers interested in participating in US FIRST Programs.

Unfortunately, by the time the contract was signed for the 2010-11 season, it was impossible to do the preseason sessions described above. These were held for the current 2011-12 FRC season. Many of the other points (the Memphis First Teams Website [4], recruiting mentors and providing technical expertise) are self-explanatory and beyond the scope of this paper but were accomplished or part of the ongoing effort for the 2nd year of the collaboration.

QUICK BUILD

During the first season for the Bluff City Bots, the Team was saved by Team #2775, Jackson Area Robotics when they came and did a "Quick Build". This was the first time the author was exposed to this idea. A "Quick Build" is when more experienced teams come and help rookie teams get the basic robot (base, drive train and control system) up and running in an intensive and compressed time period. Without this help, and with no individuals with FRC experience in the area, it would have been doubtful if the robot would have moved by the end of the six week build period (especially when you take into account a three week delay in getting the kit of parts to the team).

That experience the first year with the "Quick Build" was so successful that it was decided that one way UofM could help all the teams in Memphis was to host a "Quick Build."

Thanks to US First, Andy Mark and Teams #476 and 1750, instructions were available for most of the "Quick Build" either by kick off or shortly after. We had decided to do the quick build in three stages, Kit of Parts (KOP) sorting, gearbox / control board and lastly the drive train / control board II and test program.

KOP Sorting

At the Memphis "Kick Off" event, a special session was held for teams that were attending the “Quick Build” the following weekend. They were told how to sort their KOP into sub-kits (Gearbox Kit, Frame Kit, Wheel Kit, Pneumatics Kit, Manipulator Kit, Control System and Misc). Returning teams were told what parts would be needed from last year's robot since some parts are reused to reduce cost. Along with the instructions on sorting the KOP, each team was given a list of tools required for both the mechanical and control system groups to have and what tools would be made available at the event.

Quick Build Session I

At the first session, the teams were broken into two sub teams. The mechanical group worked on assembling the gearboxes. Since Andy Mark, the main supplier for US First, did wonderful instructions for this step, the teams were shown how to use an arbor press and with minimal instruction and help, were able to complete this task.

Meanwhile, the control system group was first instructed on the various connectors used for the wiring (ie wago connectors, crimp connectors and RC/servo extension cables) . Then they were instructed on the basic robot wiring and on how to use heat shrink to insulate electrical connections. While Andy Mark did a wonderful job with the instructions for the mechanical systems, the electrical instructions supplied by US First needed work and were, at times, out of date. Mounting all the various components of the control board (main breaker, power distribution board, digital side car(s), cRIO, and Jaguar motor controllers) took more time than expected and were hindered by a mounting hardware change from the previous year, forcing a quick trip to the nearest hardware store. Each team needed a lot of assistance while wiring the robot. Luckily, there were a lot of people there to assist teams including students from the Institute of Electronics Engineers (IEEE), members of the MidSouth Makers and team mentors.

At the end of this half day session, the mechanical group got though the gear box construction and even started the frame of the robot, ahead of schedule. The control system group did not get as far as expected, but most were far enough along that they could complete the control system wiring on their own during the week.

In Between Session

In between sessions, stations were set up to perform various tasks. Two computers were needed to configure the "radios" (internet router/bridge), one configured to work with the default IP address (this also was used to configure the camera) and one after the “radio” was configured to it’s final IP. A third computer was set up to re-image the cRIO control system with the new base code. We also configured a computer to act as a driver station and LabVIEW programming station in case the software installation (see below) for the netbook computers took longer than expected.

We also prepared USB thumb-drives with the installation software for the robot programming languages since the software came on DVDs and the netbooks (provided with the KOP) did not have DVD drives.

In addition, the procedures for setting up the various components (netbook, radio and cRIO) were tested, errors were found and noted and more detailed instructions were written (when necessary) to help teams avoid these problems at the next "quick build" session.

We also built a power supply to enable the cRIO to be powered without the robot control system, so the cRIO could be updated while the control system was still being wired.

Finally, training of the volunteers took place to assist the teams in all these areas.

Quick Build Session II

The second session had the goal of teams driving away the basic robot. To accomplish this, the mechanical team would have to complete the drive train and frame. In the meantime, the control system would have to be completed and programmed with test code. Then the two systems would be integrated for the final test.

The mechanical team once again had wonderful instructions from Andy Mark and were able to complete their task without much difficulty.

The control systems group was split into wiring, configuration, and programming. The wiring group completed the wiring of the robot and, when the drive train was delivered, temporarily mounted the control board on the frame for testing, In the meantime, the configuration group configured the "radio", webcam, and reflashed the image for the

cRIO. Concurrently the programming group reimaged their netbooks, installed LabVIEW and created the default robot code for testing. Since National Instruments, the maker of LabVIEW and the cRIO, creates base code for the robots each year, the last step was not as difficult as expected.

Although only half of the teams met the goal of being able to drive their robot out of the building, all the teams were able to complete their basic robot and test it back at their schools with only minor additional support.

SUMMER CAMP PLANNING

At the end of the FRC season, a meeting was held to evaluate needs of the MCS teams. Although the next game is not released until the following January, there were curtain deficiencies that were quite obvious, regardless of the competition:

One of the first was the lack of teams prototyping their designs for the manipulators that would lift, kick or in some way move the game pieces. This has been an issue for the last three years.

Another major observation was that most teams failed to modify the robot code from the base code supplied by National Instruments. Most of the time mentors took the modification of code upon themselves even though sample code and tutorials were available to the students.

Many of the drivers on the team showed great interest when they discovered they could use other joysticks or devices to control their robot, but most MCS teams did not know how to do this.

Many of the MCS teams were avoiding using the pneumatic system. This was partly due to inexperience, difficulty in selecting and ordering cylinders (FRC teams get to order a set number of cylinders from Bimba, but have to use a complicated part number chart which to non-technical people is quite intimidating) and lack of a technically appropriate manual for the teams.

Lastly, many of the teams failed to allow time during the build season for the students who were going to drive the robot during the “teleop” portion of the competition.

Goals and Objectives

From the above list we decided to create a mini competition concentrating on a pneumatic system that would have to manipulate simple game pieces. We would use a pre-existing basic robot base but add a manipulator using both electric and pneumatic components to play a simple game where the robot would be driven over to a stand, pick up a pool noodle cut in half (commonly used for bumpers of the robots), drive it across the room and hang it on a board on one of three levels, or put the pool noodle though a hole in the board for additional points.

To meet these goals, the following skills would be taught:

For prototyping designs, CAD software, which is made available to all teams for free from AutoDesk, was discussed, but it was decided that scale models done with wood, cardboard and other readily available materials would be less intimidating to the teams and would be more interactive with a much shorter learning curve given the five day length of the camp.

For the control and programming side, we would hold one session on wiring the robot, but would spend most of the time on LabVIEW programming. We would stress how to take the sample code and insert it into the existing robot base code, using the pneumatic control system and valve controls as our primary examples. We would also show the participants how to test new input devices (ie a PS3 controller) and how to modify the existing software to use that controller for part or all of their robot.

As for the pneumatics system, both the mechanical side and control side would be covered in multiple sessions: an overview of what pneumatics are and how the various components (valves, cylinders and regulators) work, a more detailed session on mechanical systems that use cylinders (lifts, booms, etc) and, as mentioned above, how the control system is programmed to control the compressor and control valves.

Lastly a portion of the week would be a simple driving competition to give each participant the chance to practice driving a robot. This would include a timed obstacle course as well as a precision driving task.

SUMMER CAMP

Monday

The day started with an introduction to US First and the First Robotics Competition (FRC). Since many of the students were recruited the waning days of the school year to be on next year's FRC team, it was felt that this introduction, as well as a timeline of a typical FRC season would help the students think ahead. We described the season, what they would do and when. We also discussed the dangers of working with power tools and the dangers associated with FRC robots. We then discussed how the summer camp related to the typical build season (its similarities and differences).

We then announced the competitions to be held during the week. The driving competition would be a simple zig-zag course that would be timed, followed by a task of driving as close to a wall as possible without touching (not as easy as it sounds when you are driving the robot from across the room).

The second competition was the one on which the rest of the week's work would revolve. The students were presented the challenge as follows:

Arm Design Challenge

- Two teams will be selected composed of Mechanical and Controls Design students
- An existing FRC robot base already programmed to operate the drive wheels will be used.
- The Mechanical team members will design an arm using a limited KOP to accomplish the Noodle Competition.
- The arm will then be attached to the robot base.
- The Controls team members will do additional programming to control the arm.
- The Control team members will then wire the attached arm to the control system.

The game rules were then discussed in a similar way to the kick off, FRC teams would see in January. The game was to simply drive the robot over to a feeder that would hold pool noodles. Pick up the noodle and then drive it across the room and place it on a board with three sets of brackets place on the top, middle and bottom of the board. The highest level scored three points, the middle two points and the bottom one point. A ten point bonus would be awarded if all three levels contained a noodle at the end of the round. In addition, there was a hole in the board and if a noodle was placed though it, that scored five points (see figures 1-3).

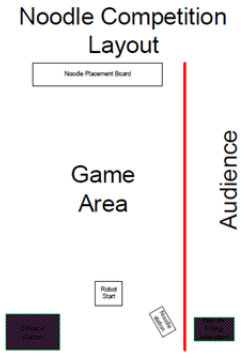

Figure 1 - Game Field

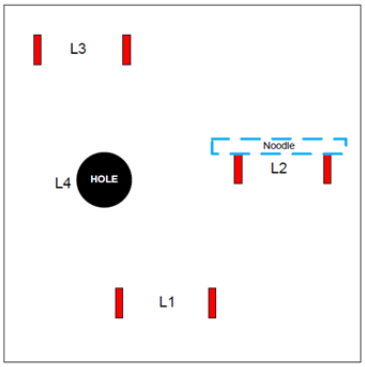

Figure 2 - Game Board

Figure 3 - Actual Board

After lunch we had discussions on Mechanical Systems, Basic Pneumatics and then showed the students the Kit of Parts they would be given to build the manipulator for the previously announced game.

The day ended with the students being broken into teams (making sure to balance the teams so that each team had those interested in working on the mechanical design / build and the control wiring / programming). We then allowed the teams to do some brainstorming on how they will build their arm to pick up and place the pool noodles.

Tuesday

The day started off with a little more time for the teams to brainstorm but then the teams were broken up into sub-teams for mechanical and control.

The mechanical team was given instructions on how to produce scale drawings of their design. They then proceeded to build moveable scale models of their design first in cardboard then in wood.

In the meantime, the controls group was given instruction on the basic control components of the robot, instruction on how to make good electrical connections and how to insulate those connections using heat shrink tubing.

At the end of the day, the two sub groups were brought back together to discuss how the design was progressing and to determine the requirements of the control software to be started the following day.

It should be noted that during the day, individual students also competed in the driving competition as time permitted.

Wednesday - Thursday

While the mechanical group started to build their design, the software group started in on the LabVIEW programming to control the compressor and pneumatic control valves necessary for the mechanical system being constructed by the mechanical group. They also worked on how to integrate a PS3 joystick to control the robot.

By Thursday afternoon, the teams were doing preliminary testing of their arms (using manual pneumatic valves and switches to control the mechanics).

Each day at lunch and again at the end of the day, the teams came back together to discuss their design, review any changes and to discuss how they would operate the robot/mechanical system.

Friday

The teams completed the integration of the mechanical and software and both teams had a working manipulator by the time the main competition took place in the afternoon.

The final designs were quite different, one team going with a completely pneumatic scissor lift design, while the other team built a more conventional arm.

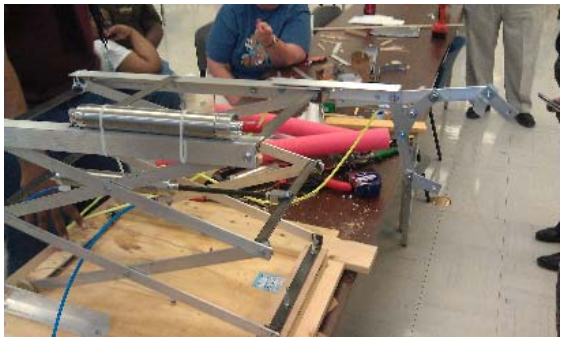

Figure 4 - Scissor Lift Design

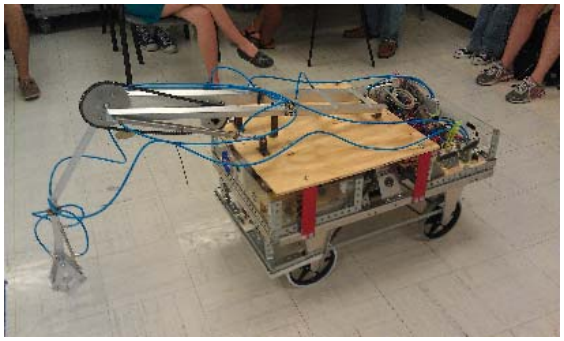

Figure 5 - Conventional Arm Design

After the competition we did a brief evaluation of the designs of both manipulators. It was unfortunate that, right at the end of the competition, the arm design got caught on the game board and this broke the mount for the electric motor used for the elbow joint. This was used as an opportunity to discuss the pros and cons of both designs.

We then held a brief award ceremony and concluded the camp and a high note with everyone walking away with more confidence for the upcoming FRC season.

Summer Camp Evaluation

The camp had fifteen students and three teachers participate. This represented six teams in the Memphis area, five MCS teams and one local private school. We also had one student whose school did not have an FRC team but was interested in robotics.

The camp was originally planned for thirty participants, but we underestimated the issues with students getting transportation to the event. According to feedback from the teams, this was the biggest attendance issue.

Since, at the time of writing the paper, the FRC season has yet to begin, it is unclear how much of the information was retained or how it will impact the team's performance this year. Initial feedback from teachers indicates that the students are more familiar with FRC and the basics of mechanics and software, but time will tell if this translate into improved performance of the teams and an increase interest in STEM fields.

Future Plans

With the continuation of the collaboration between UofM and MCS, a second summer camp will be held in 2012. We plan to use a very similar procedure to determine what will be covered during the week long camp. The teams in the MCS system are becoming more diverse, transitioning from a majority of high schools seniors to a mix of all grades. Hopefully this will allow us to move to new areas of weaknesses amongst the teams while still having team members knowledgeable in the skills taught the previous year.

ACKNOWLEDGEMENTS

The camp and quick build would not have been the success it was without the help of:

Dr. Jada Askew, Academic Coordinator for Memphis City Schools and the coordinator for the US First efforts within the school system.

Associate Professor Robert Hewitt, who served as the lead for the Mechanical portion of the summer camp.

Assistant Professor Tom Banning, who created and executed the competitions that took place during the summer camp as well as acted as the event coordinator.

US First employees: Nancy Skerry, FRC Project Coordinator for providing the Quick Build information and LaJean Robinson, Regional Director US First Tennessee.

The teachers who took their time over summer break to get their students to the camp and who participated in the camp.

Lastly the University of Memphis Engineering and Engineering Technology students, UofM IEEE Student Chapter, the Midsouth Makers, and all the other who assisted during the Quick Build and Summer Camp.

REFERENCES

[1] US FIRST, "US FIRST Homepage", http://www.usfirst.org, (November 2011)

[2] Melchior, Allen, Cohen, Faye, Cutter, Tracy and Leavitt Thomas, "An Evaluation of the FIRST Robotics Competition Participates and Institutional Impact", April 2005

[3] TN Department of Education, "Report Card Archives", http://www.tn.gov/education/reportcard/ (November 2011)

[4] Kohn, Daniel, "Memphis First Teams – News and Info for the Memphis US FIRST Community", http://memphisfirstteams.org/ (November 2011)

Daniel Kohn

Daniel Kohn is an Assistant Professor of Engineering Technology at the University of Memphis. He has been teaching for eleven years and has over thirteen years of industrial experience in the area of computer control and measurement system. He also has an extensive background in Mobile Robotics and K-12 STEM Outreach.