Introducing Fifth Grade Students to Programming through the Use of Robots

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Abstract

Students use computers all the time. But how do we get these students interested in computers as a career? I attended a conference and observed one method, the use of Lego Mindstorms NXT robots. This paper will explore the use of robots in teaching fifth graders how to program. I will discuss how the students built their robots, the progression through elementary programming features to advanced features and their final projects. I will also discuss how Avila University computer science students helped in this activity and what they learned from the experience.

Introduction

I attended The Consortium for Computing Sciences in Colleges (CCSC) conference in April, 2008. During one of the sessions (1), I learned how robots were used to introduce fifth grade elementary students to programming through the use of Lego robots. I started thinking how this could be implemented and I began working on a program to accomplish this. In April, 2009, I attended another session at The CCSC conference. This session (2), discussed how the program had been expanded to include sixth grade middle school students. That's when I decided to start a program at Avila.

Objectives

There are two objectives for this project. The first is to expose fifth graders to programming and problem solving using a fun and exciting activity, robotics. By working in teams, the students will also be exposed to group process.

The second objective is to give our college students experience in working with elementary age students. Our students will develop team leader skills while working with the fifth graders.

Backgrounds

Fall Semester

The first step was to pick an elementary school. St. Thomas More is a Catholic elementary school located about three blocks from Avila. After contacting the principal, John O'Conner, it was decided that we would start a "Robotics Club" with ten fifth grade students. Since we had five Lego Mindstorms Robotic Kits, this would allow us to set up teams of two.

Mr. O'Connor explained the club to the fifth grade class and asked them to sign-up if they were interested. We had 36 students sign up. Mr. O'Connor made the selection of ten students. We had six boys and four girls.

I asked Avila's Computer Science students if any would be interested in volunteering as team leaders for the Robotics Club. I had four Computer Science students and one Elementary Education student interested.

Spring Semester

St. Thomas More purchased two more robotics kits so we could expand to fourteen fifth graders. That also meant we would need an additional two Avila students. This turned out to be a bigger challenge than I anticipated.

Equipment

We started with five model number 9797 Mindstorms Lego Robotic Kits. During the fall semester four of the five teams used the Mindstorms expansion kits to build more sophisticated robots. During the spring semester, seven 9797 kits were used.

Each 9797 kit consisted of the NXT Intelligent brick, three interactive servo motors, hundreds of Lego pieces and several sensors. The intelligent brick is the brain of the robot. Programs are downloaded onto the brick and are then executed. The servo motors are used for movement – legs, wheels, arms, etc.

The sensors consisted of the following

- Touch sensor – used to detect contact with objects such as running into walls or an appendage making contact
- Sound sensor – detects loud sounds
- Light sensor – detects changes in light intensity
- Ultrasonic sensor – detects when the robot is within a specific distance of an object

The programming software used was Lego Mindstorms NXT 2.0 (3). This software is an intuitive graphical interface. By selecting "blocks" and dropping them on the main screen, the programmer can construct simple to sophisticated programs. Laptops were provided by Avila University for the programming purposes part of the sessions. Laptops were shared by the students to implement the spirit of sharing and cooperation in such projects.

The Project

Fall Semester

The project consisted of ten one-hour sessions, meeting Wednesday afternoons after school. The group consisted of ten fifth graders – six boys and four girls. These students were divided into five groups of two students each. Each team was assigned a college student as team leader.

The students were selected by the grade school principal, Mr. John O'Connor. These students were selected from a list of thirty-six students who signed up for the project. The college team leaders were volunteers from the computer science program and one from the elementary education program.

The students progressed through an agreed upon schedule between the Professor and the student assistants to have each session planned and managed with extra activities for students who are more advanced. Because most of the teams in the class were advancing very quickly throughout the activities, the professor and the student assistants had to come up with more creative and exciting projects for the students. This led to a great presentation for the parents.

The first two sessions were spent building the robots. Each team was given a Lego Mindstorms robot kit. The kit contained all the Lego pieces needed as well as a manual showing how to construct the robot. Figure 1 shows the completed robot. The boys' teams seemed to enjoy the construction more than the girls.

Figure 1

At the beginning of each of the next four weeks, I would demonstrate a feature of the software. The first demonstration was on moving the robot: move forward, move backward and combining these moves. The second demonstration was on turning and combining the turns with moving forward and backward. The third demonstration was on the sound and ultrasonic sensors. The fourth demonstration covered loops and combining all the features shown in the demonstrations.

After each demonstration, the students were asked to program the robots, first with the program demonstrated and then with expanding on what they learned. For example, when turns were demonstrated, the program showed how to have the robot move in a square. The students were asked to repeat this and then write a program to make the robot move in a triangle, pentagon and circle.

At this time, the boys were way ahead of the girls. In order to keep the boys engaged, we changed strategies. I brought in three expansion kits with plans for larger robots. Two of the

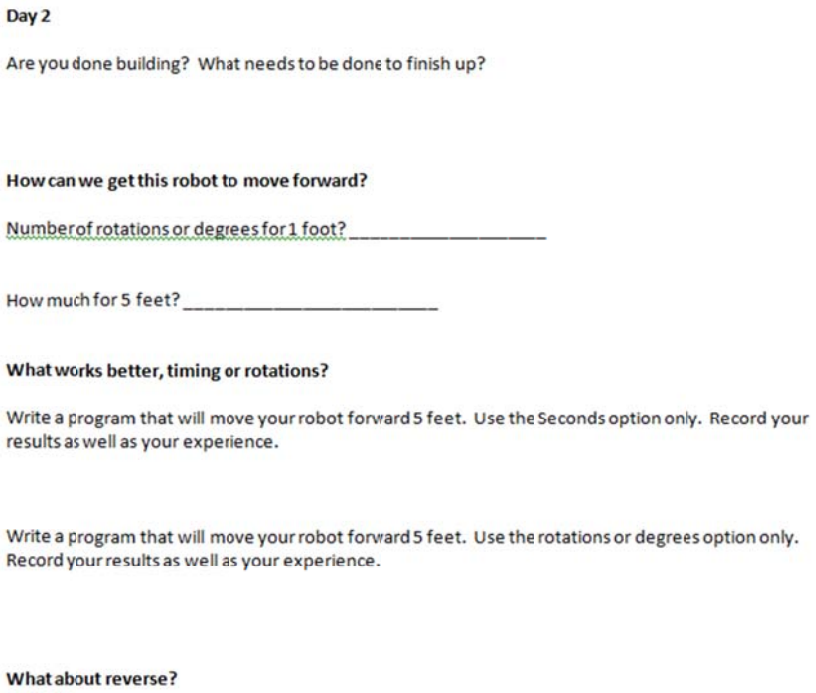
boys' teams decided to build scorpions and the other boy's team built a preying mantis. The girls decided to stay with their original design and spend more time on programming.

The last two weeks were used by each team to develop a presentation. One of the girls' teams designed a dance using the sound sensor to signal each move. The other girl's team programmed the robot to move through a maze. They built the maze and then programmed the robot using the ultrasonic sensor. The boys created a scene from Star Wars and the scorpions and praying mantis were invading monsters.

The parents were invited to the last meeting where the students demonstrated their projects. With a few technical difficulties, the presentations were very good.

Spring Semester

The second semester was slightly different from the first one. There were observations made about the structure of the program. Adjustments were made to accommodate and maintain a timeline that would ensure that students would develop programming skills and have fun at the same time. Also, to keep some order during program development, journals were supplied that asked simple questions about what they were doing. The students were encouraged to write down their observations as they worked. Figure 2 shows an example of the journal. Day one included an introduction section that allowed the students to get acquainted with their team leader and questions pertaining to their construction experience.



Day 2

Are you done building? What needs to be done to finish up?

How can we get this robot to move forward?

Number of rotations or degrees for 1 foot? _____

How much for 5 feet? _____

What works better, timing or rotations?

Write a program that will move your robot forward 5 feet. Use the Seconds option only. Record your results as well as your experience.

Write a program that will move your robot forward 5 feet. Use the rotations or degrees option only. Record your results as well as your experience.

What about reverse?

Figure 2

Days two through seven asked the students to work on programming problems dealing with moving forward and backward, turning, sensors and looping. Each day was designed to build on the previous day's questions. Days seven and eight were for the students to decide on a project

and write the programs for that project. Day nine was parents' day. The parents came to see what the students learned. The students demonstrated their projects.

While writing their programs, the students were encouraged to use trial and error along with their journal entries. The students soon learned that previous programs contained information that could help in writing their next program. For example, the students were asked to write a program that would allow the robot to move forward five feet. Later they were asked to write a program that would allow the robot to move in a square. The students could use the move forward five feet program and incorporate the new commands for turning and repeating.

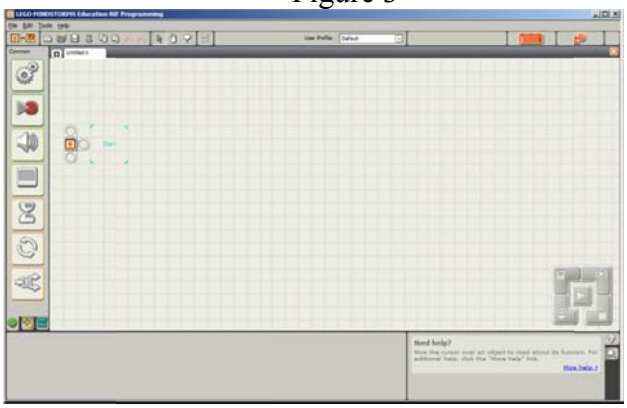
As the sessions continued, the students were challenged with more sophisticated programming. The teams progressed through simple movements forward and backward to making turns to combining moves in order to form shapes. Once all the movements were accomplished, sensors were introduced. The students started with the sound sensor and then worked with the ultrasonic sensor.

Once the students were comfortable with movement and sensors, they started working on their projects. With the problems we had during this session, most of the teams decided to demonstrate programs they designed while learning how to manipulate the robots. One team was more advanced than the others and they built a maze and programmed their robot with three touch sensors. These sensors were used as directional controls. Pressing the right sensor made the robot turn right. Pressing the left sensor made the robot turn left. The center sensor was for moving forward.

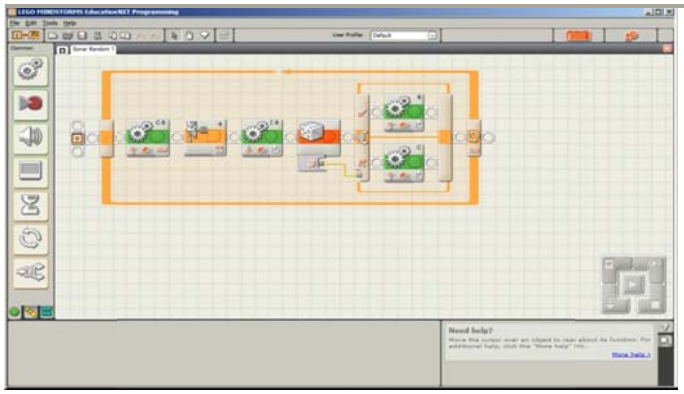
The Programming Software

The Lego NXT v2.0 software was used for this project. This software contains a very insightful graphical user interface. See Figure 3 below. Students can add components just by dragging and dropping. Each individual component has a toolbox which allows students to configure the component. For example, the move component can be configured to move forward or backward, have the speed and distance set as well as which servos are to be activated.

Figure 3



The students can experiment with the components, stringing them together in order to make more complicated programs. See Figure 4 below. Loops are available as well as selection components. The students also discovered that threads can be added so the robots can perform more than one task at a time. For example, the robot could have one thread that is using the ultrasonic sensor to determine if an object is in front of it while using the sound sensor to determine if a sound is loud enough for it to turn.



Once the students have their programs built, the program can be downloaded onto the robot using a USB cable. The robot can store several programs. If modifications need to be made, the students can make the changes, download the program again and then retest.

Figure 4

Project Evaluation

The fall session was the better one, based on how smooth the sessions went and the progress the students made with their projects. These students completed the construction of the robots in one session. The boys then went on to build more sophisticated models. The girls used the extra time on creating more sophisticated programs. Without having a journal though, the boys struggled more with the programming.

The spring session had several problems. The volunteer students were not as committed. While we needed seven volunteers each session, we never had more than six and several times had as few as four. We also had problems with the laptop computers. We had seven computers starting in the fall. This allowed us to have two backup computers. When we expanded to fourteen students in the spring, we were using all seven computers. Two computers crashed so teams had to share when programming. This led to times when a group would be waiting for a free computer.

Conclusion

The first objective, introducing fifth graders to programming and problem solving, was successful. The students enjoyed the experience and worked hard to design and implement some complex programs.

The second objective, to give our college students experience in working with elementary age students, was somewhat successful. During the fall session, all the college students were engaged with the elementary students. The team leaders encouraged the fifth graders and were involved in the development of the projects. During the spring session, only two of the college students were involved with their teams in a productive manner. Many times these team leaders would be talking together rather than working with their team. On several occasions, one or more of the college students would not show up.

Adjustments for Next Year

Based on the two sessions, the following adjustments will be made:

- Establish a training period for the volunteers. This would be two or three meetings about one hour long. These sessions would help the volunteers with building the robots and learning the software. For the past two sessions, the volunteers were given the robot kits and software two weeks prior to the session. They were supposed to build the robots and then learn the software in order to be prepared for the sessions. The fall team did a good job on preparation. The spring team did not.

- Use the journals. The fifth graders need more than just verbal guidance when trying to write the programs. They also need a way to keep track of their accomplishments so new programs can be designed based on previous programs.

- Limit the number of students to ten. When the group was increased to fourteen, it put a strain on resources as well as keeping control of the entire group when one or more volunteers didn't show up.

References

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