What do Gumball Machines, Pencil Counters and Dung Beetles have in common?
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The Answer: an XBC

After six years of being an Adult team leader for botball, I had amassed an impressive collection of robotics equipment. I had been using it with great success at the end of the school year after exams as well as during summer robotics camps, but there was this nagging desire to employ it throughout the school year. This year, three projects presented themselves as opportunities to use an XBC. These projects ultimately exposed more students to programming, served as a recruiting tool for my botball team, and impressed upon me the versatility of the robotics equipment that are part of the botball experience.

Rube Goldberg Gumball Machine

The first challenge was to design and build a working Rube Goldberg gumball machine. At the beginning of the school year, I was approached by our county supervisor of technology education to test a new curriculum project. We were given a budget and a deadline to complete the project and prepare a presentation for a national audience at the 2007 ITEA conference in San Antonio, Texas.

I assembled a team of interested students, one of which was part of the botball team. The team decided to purchase a used Wowie Zowie© brand gumball machine. They proceeded to strip it down and begin the design process. However, they realized early on that coordinating all of the parts of the gumball machine would be critical. This is usually done with factory stamped electronic circuit boards that are not programmable. In addition, the team would need servos and motors to move parts of the machine and sensors to be able to tell when the gumball had passed through different components. Finally, the machine had to be programmed for reliable and repeated performances. It was clear that this project was tailor-made for the XBC.

The team got a crash course in programming using Interactive C. They also learned about the XBC and the kinds of available sensors. While they still used the original circuit board for the sound card that it contained, the XBC did all the work. In fact, the team used the 6V power output from one of the motor ports, to control the original circuit board. See Figure 1 below.

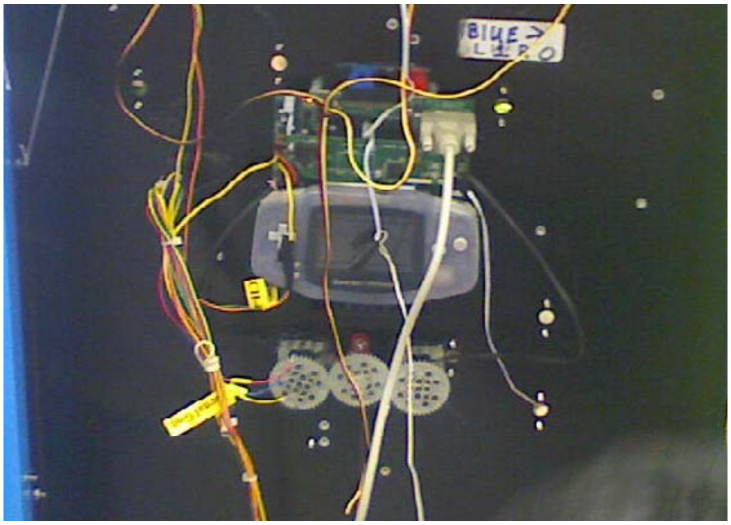

Figure 1: The XBC in the rear of the Gumball machine

The team chose an ambitious amusement park theme that took the gumball through a series of rides that are typically found at amusement parks. The gumball first takes a ride on a set of swings, then a roller coaster, into a Ferris wheel, down a spiral drop, into a swinging ship, and finally retrieved. See figure 2 below for the concept drawing.

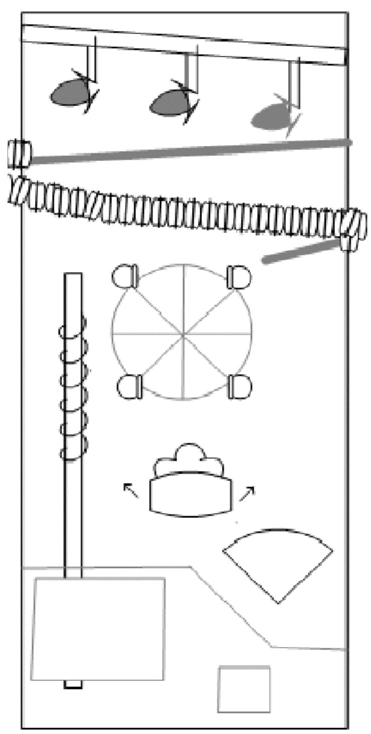

Figure 2: Concept Drawing

Getting from concept drawing to reality proved difficult and involved solving a series of problems. The first problem to be solved was starting the machine. The original machine came with a standard coin turning mechanism that would close a switch when rotated. But how do you signal your XBC to begin? The solution was to hook up a lantern battery to a solenoid that would pull on a plunger attached to a spring when engaged, but would pull the plunger out when disengaged. The team then slid a bump sensor into the mechanism, so that it would be depressed when the solenoid was engaged. See Figure 3 below.

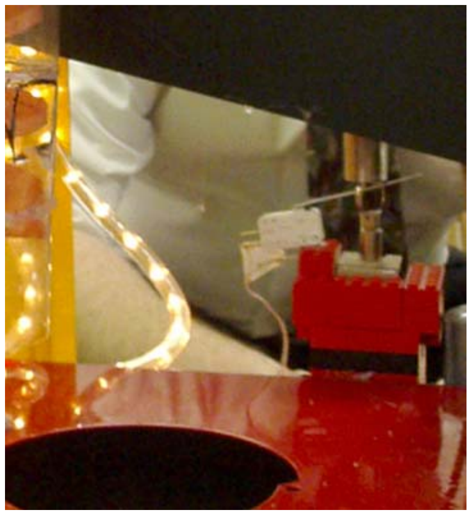

Figure 3: Start Mechanism

The next problem, was to release a single gumball. This problem was also solved by a solenoid triggered by the XBC. This time the solenoid contained a permanent magnet that was propelled upward when engaged to hit a gumball and begin its journey. The magnet fell back down under the influence of gravity when the solenoid was disengaged.

The first part of the ride, contains 3 swings that are powered by servos. The servos are programmed to catch the gumball and transport it to the next swing until it is released onto the roller coaster. Then the swings return to starting position. See Figure 4 below:

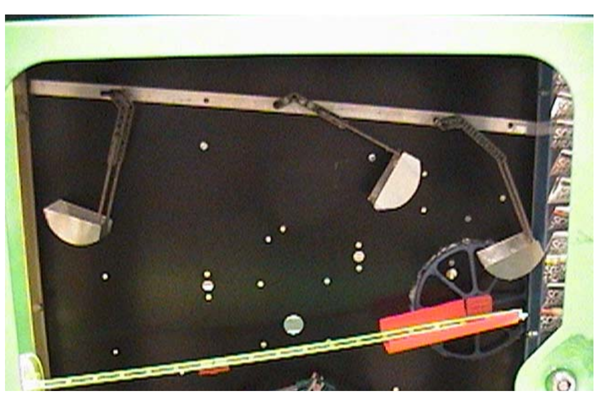

Figure 4: Swings

The Roller coaster carries the gumball outside the machine, through hamster tubing, and into the Ferris Wheel. The Ferris wheel is powered by two lego motors and is programmed to turn 2 ½ revolutions to be in the right place to be ejected by an arm that tilts the chair of the basket. The Ferris Wheel then is turned back to its starting position. The gumball falls down a spiral drop and into a waiting boat that is rocked back and forth by a fourth servo, until the gumball falls out into a funnel and out the exit door. The gumball hits a last bump sensor on its way out to stop the music. The final product is shown in figure 5.

Figure 5: A completed gumball machine

The project was ambitious and there is something deeply gratifying to see it in action. I mentioned that only one of the students had programming experience, so this project was a great way to expose several other students. I was able to recruit three of these students to join our botball team and they will be attending the 2007 NCER in Honolulu. In addition, we were able to set up the gumball machine in school and use it as a fundraising tool. At a quarter a pop, it can really add up!

<u>Dung Beetle</u>

A student, who was not a member of the botball team, but was aware of it, approached me with an assignment from his technology class. The assignment was to design and build a working model of a dung beetle. The model had to walk and also had to push a piece of "dung."   Most of his classmates were completing this project by creating a rolling beetle. However, this student wanted to make his model as authentic as possible by trying to give the beetle four legs, whose movements could be individually coordinated. This seemed like another perfect opportunity to break out an XBC.

The student did not have any programming experience, so he was given a crash course in programming the XBC and using servos. He was able to build a model that coordinated the movement of the front two legs of the beetle with the back two legs of the beetle to have the beetle move forward. See Figure 6 below.

Figure 6: An XBC powered dung beetle

We then discussed how the camera on the XBC could be used to locate the dung. The student learned how to use the camera, but due to time constraints and limited motion of his beetle, was unable to program a find and recover routine. This student and his project would later be recognized and showcased at the school's end of the year expo.

Pencil Counter

Two students, who also were not members of the botball team, had a different assignment from their technology class. The assignment was to design and build an automated pencil counting machine. The machine had to count out ten pencils at a time from a storage bin and be able to do this through several iterations.

The students were given the same crash course in programming and XBC use. They used a light sensor to count pencils as they dropped from a mechanical waterwheel that was turned by a motor controlled by the XBC. They used sound to notify the user when the box was full and a bump sensor to notify the XBC when the box had been emptied and replaced. See Figure 7 below:

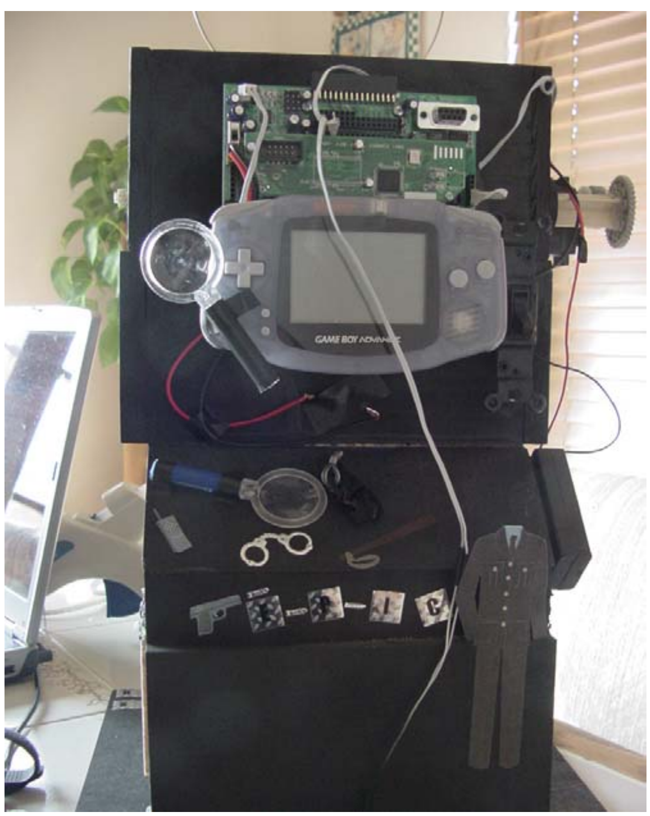

Figure 7: An XBC powered pencil counter

The students did not have any prior programming experience, and I was able to recruit one of the students to join our botball team and he is attending the 2007 NCER in Honolulu.

Conclusion

I have outlined three projects that students were able to complete and tuly excel at because I had received the hardware, software and training from my participation in botball. Six years ago, I would not have been much help to these students. There are several important nuggets that I have gleaned from these experiences.

First, students can become proficient programmers in a fairly short amount of time. In each of the cases that I have outlined, students had little or no programming experience. Yet, in an intense and intimate atmosphere, students quickly picked up the expertise needed to successfully write and debug code. I was at first hesitant about introducing programming, thinking that the learning curve would be very steep. However, in every case, I was impressed by student ability to grasp the subtleties of programming.

Second, these projects proved to be very efficient ways to recruit members for our botball team. Four new members for this season's botball team were recruited from their involvement in these projects. In my experience, it is not difficult to get large numbers of students to come to the first couple of meetings in a botball season. However, the number of students quickly dwindles to a core group of dedicated students. I do not really have a problem with this, but have often wondered why students decide that botball is not for them. It may be that it takes too long to see the fruits of their labor as they have to learn programming and have to design a robot from scratch. They don't see a working robot for weeks. In these projects, students had smaller, more clearly defined tasks and often fit the XBC into their already existing mechanical designs.

Finally student motivation for these projects was very high. Students often spent hours and hours outside of class time working on these projects. I think this kind of dedication can be attributed to two things: One, the inherent coolness of using an XBC and the motors, servos, and sensors; Two, the challenging, open-ended nature of the tasks. Given opportunity and support, I have repeatedly seen students respond to authentic, complex problems. In addition, students take ownership when the solutions to the problems are their own. One of the common threads between the projects that I have presented and in botball, is that there is no one right solution. The solutions are unique to the students and that is something that we don't often make time or room for in the traditional classroom.