AC 2008-1916: TEACHING TEACHERS BEYOND THE TOOL: INCORPORATING ROBOTICS AND DATA COLLECTION INTO MIDDLE AND HIGH SCHOOLS

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Teaching Teachers Beyond the Tool: Incorporating Robotics and Data Collection into Middle and High Schools

Abstract

There are a variety of technological innovations as well as curriculum materials on the market today to help students become involved in Math, Science, and Engineering in middle and high school levels. Often, the teachers who must use the materials are overwhelmed by the technology as well as how to integrate this into curricula and still meet competencies required by state laws. As a result, many of these tools are left unused or taught in a manner that leaves students unable to connect the technology to higher learning objectives or feel that it is just a "widget" class. In the 2006-2007 school year a collaborative effort between Southwestern Community College (SCC), Western Carolina University (WCU), and several school districts was fostered through the SCC Gear UP program. At a most basic level, a typical robotics competition based on the "First Lego League" was created and executed in the local region with success. This paper discusses the phase after that, where feedback from teachers, parents, and administrators spurred the creation of "Camp Robot" not for students but for the teachers of middle school students. The program incorporated several elements to not only expose the teachers to the technology and its usefulness in robotics and data logging but also, how to put the technology in a background position, to focus on teaching the analytical problem solving, design, and interpersonal skills which are the technology independent goals of the learning environment. Various methods were used including peer learning, multi-age group integration, role reversal, game playing, and both cooperative and competitive learning modalities. The variety of experiences were intended to enhance retention as well as to assist teachers in self discovery of strategies which would be useful for their specific classroom and institutional issues.

Introduction

At this time in history, there is considerable discussion about the development of the next generation of engineers and scientists as well as about the creation of a technically savvy general public. There are several problems with achieving these desired goals. First, as educators and employers, we set our sights on too short-term results. This often precludes the opportunity to reach out into the community and down to the lower grades to begin the process of recruitment, education and engagement at the points where students are forming their interests and decisions. Secondly, and specific to the electrical engineering areas, the pace of technological obsolescence is so swift that educational materials become obsolete as well as the technical training to use them. Third, even if there is outreach, it is focused on short-term vocational training goals and current enrollment issues as opposed to long term (five-ten year) student outcomes. Lastly, an unintended consequence of "excellence in schools" initiatives and standardized testing has been to pack primary and secondary education curricula with so much material that teachers have little maneuvering room to innovate. Along with that, teachers now have huge consequences if their students do not perform as required on standardized tests. So a culture of fear is evolving, restricting teachers' and administrators' desires and resolve to expend time and money on technology based educational "novelties."

It is to address these issues that the “Camp Robot” idea was proposed. This paper outlines the foundational elements which led up to the idea of Camp Robot, the demographics served, and the results observed. Unique elements included non competitive strategies; focus on problem solving, not on the specific technology, role reversal between teacher and student, and service learning for the college student participants.

Geographic and Student Educational Need

The region served by this project included four educational jurisdictions and two post secondary institutions. The region served was Western North Carolina in the counties of Jackson, Macon, Swain, and the Eastern Band of the Cherokee Nation. The post secondary schools involved were the GEAR UP outreach program at Southwestern Community College (SCC) in Sylva, NC and Western Carolina University (WCU) in Cullowhee, NC. The students to be ultimately served included middle school students in the districts, and WCU engineering technology students as well as education students from Southwestern and WCU.

It should be noted here that nothing has been said about secondary school students or teachers. This is not because they are not important or were excluded from this work by design. Rather, the LEGO® Competition caps at 8th grade and a secondary competition, the First Robotics Competition, is pursued in high school. Because of the added costs of these kits, no high schools in the district were able to participate in this work, however in future years, the desire is to make them an integrated part of the learning-mentoring-learning experience.

The ultimate goals for the students were as follows: For grades six-eighth, increase student exposure to technology and technological careers and raise expectations to these students that such careers are possible and educational resources are available to them at both vocational and university levels. Specifically, use robotics and data logging tools to expose the students to using these tools for competitions, and to solve math, science, and engineering problems. In addition, through the process of working with robots, help students experience and internalize problem solving skills. For the post secondary students, the goals were to incorporate a specific example of service learning for both engineering technology and education students and to expose this group of students to current technologies available. Specifically for the WCU Electrical and Computer Engineering Technology (ECET) students, the goal was to tie their learning from embedded design to an elegant example in the LEGO® Mindstorms® NXT® product, and to experience the differences between being educators and engineers. No specific timeline was set, but rather this project was set up as an exploratory activity to gather information about the needs of the target students and the professionals working with them to achieve the goals above.

Available Technology

At the same time that Southwestern had received funding for the GEAR up program, the LEGO® Corporation had released the next generation of its popular Mindstorms® product. The NXT® provides an easy-to-use robotics package suitable for application to the sixth grade level. As such, an international competition has evolved, called the First LEGO® League, which pits teams of students against the clock and each other and a sequence of themed missions.

Phase 1: Southwestern Community College Gear Up Robot Competitions

A decision was made to fund purchase of the Mindstorms® NXT® kits for selected middle schools in the above districts. Schools had to have a teacher "champion" who was willing to undertake a voluntary "club" group for developing robots for the First LEGO® League Competition. In order to get a feel for the process, an initial competition was held locally at Southwestern Community College in the fall 2006 semester. Teams from the four counties met and a successful competition was held.

In addition to the direct middle school involvement, a team of senior undergraduate ECET majors was tasked to participate in the competition as part of their senior project for the 2006-2007 school year. Again, on a voluntary basis as their project choice, these students first learned the LEGO® system, and then went to the schools to act as resources for the teachers and to observe the student needs and to design the remainder of their senior robotics project-based on feedback from the fall semester. Their results would be incorporated into possible teaching materials for students or teachers and for development of project-based learning tools in the ECET program at Western.

Competition Observations

There were several critical observations made by the educational staff at SCC and at WCU of the process, the failures, the needs, and desires of the target groups as a result of the competition.

For middle school students:

1. At grades six-eight, students do not do well at analyzing a problem and breaking it into its component parts. The tendency is to try and solve the problem all at once. Therefore students need guidance and focus on breaking problems into small pieces and solving the pieces one at a time.
2. When students do break the robotic mission into smaller pieces, they typically do not "get" the idea of modularization. Left to themselves, the typical solution of a problem is a long series of movement commands with little or no feedback from sensors or control elements.
3. Club activities of <30 minutes are ineffective due to set up and take down times. Teachers need allocation of at lest 45 min to one hour a few times a week to have effective progress on problem solving.
4. Family members are strongly supportive of exposing students to the possibility of engineering or technology careers at an early age. One example was at the competition when a grandparent came and expressed his gratitude for allowing his child to work with the technology in middle school. It was the first time the child ever thought they could do anything beyond the local, rural area.

For middle school teachers:

1. Teachers at these grade levels are fearful of the learning curve required for new technologies and are concerned about possible negative consequences in taking time away from more conventional teaching activities.
2. Teachers are concerned that any new technology or project-based learning MUST tie-in to State and Federal mandated grade level competencies.
3. Teachers at these grade levels typically have little or no programming background and so learning when presented in technical jargon alone is of limited effectiveness.

For the college students:

1. Middle School Students enjoy the interaction with college level students. They are receptive to learning from older peers.
2. College students' knowledge is reinforced by teaching at a middle school level in basic, piece by piece terms.
3. College students gain a different perspective on their technical learning upon return from the outreach exercises[5].

Phase 2: Teacher/Learner Education

After reviewing the feedback as outlined above, it was decided that it was the teachers who initially needed to be more comfortable with the technology and how to apply it. Looking at the elementary teachers' normal schedule, it was decided that a voluntary one week workshop on "robotics" would be implemented during the summer. It would be structured to allow continuing education units to be awarded. Beyond that, it was now up to the college staffs and the college students to decide what to be taught and how it was to be taught.

Camp Robot Design

The design of the camp was to be for five full days with no homework assignments required. From other work, it became clear that adult learners would require different strategies than the students themselves[1, 2]. In addition, the camp was required to focus on higher levels of learning, beyond basic technology instruction[3, 4]. The goals would be to:

1, Help teachers learn the features and operation of the LEGO® Mindstorms® and NXT-G programming system
2, Help teachers apply the tool for robotics projects and data logging applications
3, Reflect with teachers daily on the applicability of the technology to specific classroom requirements
4, Reflect with teachers daily on the requirements imposed by the North Carolina (NC) standard course of study
5, Brainstorm with teachers the best practices to integrate the technology with not just robotics competitions, but also in math, science, and other areas and,
6 Have senior undergraduates in engineering technology and education take a significant role in curriculum development and lab assistance as part of their study requirements.

Several strategies were attempted to optimize the learning.

1. Keep technical blocks to one hour with only one major “lecture” period during the day.
2. Provide a directed “hands on” experience to reinforce the lecture concept in the morning period designed to simulate the middle school student experience with the material
3. Provide a challenge task for self direction and group peer learning in the afternoon.
4. Provide two timeouts during the day for reflection and group discussion about integration of the learning concepts to existing curriculum and standard course of study
5. Set a week long goal of having a robot “Fair” to show off to each other the capstone projects, selected by the teachers working in small groups.
6. At the end of the day, hold a brief feedback session including daily +/- feedback to the instructors on weaknesses, frustration, and strengths for quick adjustments to the curriculum.
7. Provide opportunity for role reversal for participants to be “students”, showing off to “teachers” who were real middle school students.

As part of the senior engineering technology students’ project, they were required to prepare a five day curriculum[6] for teaching the elements of robotics, data collection, analysis, and problem solving using the Mindstorms® product. In order to accomplish this, for the six months prior to the camp, the students had to interview middle school students, middle school teachers, and university faculty as well as prototype several projects in order to complete the curriculum. In addition, they had to present a peer reviewed report on the curriculum to members of the local IEEE professional society and provide a sample training module demonstration to that group. During the summer camp, the education students were required to assist in the actual teaching activities of the camp.

Experiences

Thirteen participants arrived from several districts. The demographics included six males and seven females from both faculty and technical support from the school districts in a mixed group. The ages of the students were from the mid 20’s to the mid 50’s. Of these students, only one had had any programming experience which was important in testing the ease with which teachers could become competent with the software and the programming concepts in a short time. Initial student motivation ranged from very high, actually playing with the Mindstorms® product at home, to very resistant, saying that they were unable to learn new “technology.” This information set the stage for the first day.

Problem Solving

The first goal was to clearly indicate to the teachers that the learning was to be beyond technology specifics. The initial exercise was unrelated directly to the LEGO® product and was geared simply to problem solving. Teachers were asked to explain how to make a peanut and butter and jelly sandwich to an alien from outer space.

In a short period of time, the answers evolved from an initial response of "Put peanut butter on the bread," to a complete process flow:

1) Open the bread loaf bag
2) Remove two pieces of bread
3) Open the jar of peanut butter
4) Take a knife and scoop up peanut butter
5) Spread peanut butter on one slice of the bread
6) Place second slice on top of first slice
7) Eat!

This focused the teachers on the concept of breaking a larger problem into smaller tasks. Then the initial discussion of the LEGO® product and the NXT-G program was described. Starting with basic motor commands, and using the graphical programming paradigm, the teachers were asked to create a square with a robot they had built from their kits. Typical answers are shown in Fig 1:

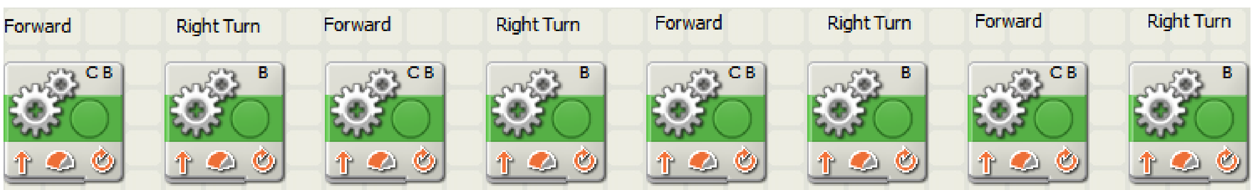

Figure 1: Square Sequence

This is where the typical middle school students stop in their program proficiency. It was very important to also introduce to the teachers the concept of grouping repeated actions together and how to relay that to their students. After discussion, Figure 2 shows a typical response for the same behavior.

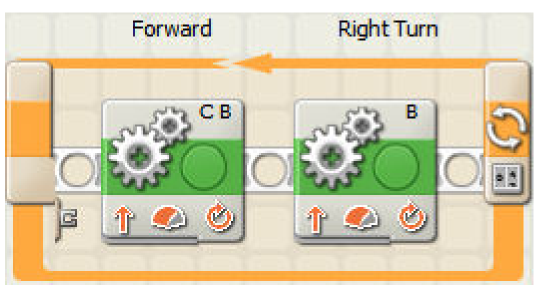

Figure 2: Square with Looping Construct.

At this point, the teachers were made aware that in addition to daily activities, a final day robot "Festival" would be held where they would show off all their weeklong projects. Time was given each afternoon for them to work on these self directed projects.

For the remainder of the week, the skill set was expanded to all the Mindstorms® features including sensors, file handling, Bluetooth® communication and swarm robotics. As the teams began to form, group dynamics similar to what the middle school students experienced during competitions evolved. There were several friendly rivalries as well as complaints when the play mat was unavailable.

One of the most unique aspects of the camp was the incorporation of students as reviewers from a middle school learning camp on campus. It was decided that on the last day, the middle school students would come in and the teachers would present their creations to the students in a classic role reversal situation. When this was announced and when one of the students demonstrated a relatively advanced project, the focus of the camp moved to project completion and performance. As a matter of fact, the pressure of having to present to the students was greater than the previous pressure of presenting results to each other.

The concept of the "festival" is important to note here. . As was stated earlier, the demographic was fairly evenly divided between male and female in terms of numbers and while the groups were integrated by gender, having the option of creating a robot or project not tied to a competition of some type reduced the fear factor somewhat and broke the dynamic of the dominant competitors male or female doing all the design and fabrication, planning and direction. As an important part of encouraging young women or other groups into engineering and science, it is important to provide opportunities for all people to create projects tied to cooperative and creative endeavors in addition to the traditional "my bot's better/bigger/faster/stronger/smarter than your bot." In this case, it meant offering project demonstrations of communicating explorer robots, drawing robots, dancing robots, and singing robots. All of these prove to be as technically challenging as the more traditional robot competition tasks. In addition, for more advanced students, the limits of the motion, memory, and sound resources of the NXT became more of a challenge with those types of projects.

Results for Teachers

For the teachers, there was 100% competency developed with the basic tools of the Mindstorms® system. More importantly, the teachers experienced the learning experience from the students' perspective. In this, they recognized the need for sense of play, and of the importance of both team and individual activity. They also learned the value of teacher student role reversal in teaching and team building. But as important, they observed the need for careful time management to achieve a desired goal.

Results for College Students

For the college level students, the project incorporated several important elements. Because of the requirement that the course materials would be used externally, the level of finish of the materials was very high[6]. They were required to interview multiple groups of people to get feedback as well as to be passive observers during student activities. The combination of requirements resulted in a considerable skill development beyond basic hardware or software design and documentation.

Results for Middle School Students

For the end students, the results were dramatic. From a first year of having only one local competition, teams from three of the schools bypassed local competitions and went to the North Carolina State First LEGO® League Competition. All the teacher groups had at least one peer at their site that was also versed in the robotics, so no individual was felt cut off from others. And having demonstrated full competency at the camp, the teachers were able to address not just making the tools work, but also successful application of management strategies for the robotics club activities.

Conclusion

In response to community needs and desires to improve education in the Western North Carolina area, Western Carolina University, Southwestern Community College, and several school districts have undertaken to both incorporate robotics and data logging into the middle school student activities, and provide opportunities for students and teachers to participate in outside competitions. In response to initial use of the LEGO® Mindstorms® technology, a need was discovered to "teach the teachers." A one week camp format was piloted in summer 2007, incorporating the teachers, the WCU faculty and students, and middle school students. The result was a successful camp with several districts sending students to state level robotics competitions. More importantly, the success of the camp came in helping teachers learn how to use the technology tools to teach generic problem solving skills in both analysis and synthesis, and explore with each other strategies for managing activities, optimize learning, and remain in compliance with academic requirements from state and federal mandates.

Plans for the future include making the camp available on a demand basis through the WCU Center for Math and Science Education. The junior level robot work was integrated into the junior level circuits classes and has caused a drive to project based learning in the ECET program at WCU.

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