Teaching Logic Using Lego's

Kami Vaniea

Overview

Students today are growing up in an increasingly technological world. They must learn more, faster compared to their parents, just to survive in today's world. Unfortunately, most classrooms don't reflect this change. Math and science courses are still taught in the traditional manner. Basic problem solving techniques are still taught using story problems. There is very little hands on learning that makes use of technology. The problem is how to bring technology into the classroom in a meaningful manner which is interesting to students. Our proposed solution is to use Lego Robots to teach basic problem solving.

Our research goal was to determine the effectiveness of using Robots as a method to bring technology into the class room to teach good problem solving skills. As a secondary goal, we would be creating an effective lesson plan and set of materials for teaching with Robots.

Background Research

The first step was doing background reading. Our reading supported our original theory that through a hands on environment, students better understand fundamental science, math and technology related concepts. We also did research on different ways technology had been integrated into the classroom in the past.

Why Lego

We needed a medium that would allow us to teach problem solving and logic without being intimidating or boring. Legos offered us the perfect solution. Legos have a very simple and intuitive interface that is easy to interact with. Also, since the majority of children have played with Legos before, they view them as toys instead of work.

Legos are nice toys but we needed something more interactive on the programming level. Thankfully Lego had the answer for us with their Mindstorm series of Lego Robots. The Mindstorms consisted of a programmable "brick", sensors, motors and other assorted pieces. They also had a simple graphical interface, RoboLab, which was designed for use by young children. During our background research we discovered several examples of successful integration of Lego Mindstorm robots into classrooms.

Familiarization

After we chose our tools, we set about familiarizing ourselves with them. This is a very important step that is often ignored. However, in retrospect, it was invaluable. By testing the limits of the Robots and their programming environment we were able to identify potential problems and solve them in advance. This allowed for a much smoother classroom environment. We were also able to identify fundamental concepts that were necessary to implement the curriculum in the classroom.

A specific example of how helpful this familiarization was made clear to us in a testing phase. Another undergraduate tried to teach our material without familiarizing herself with the tools first. Since she didn't know the quirks of the program she was unable to help students with their problems as efficiently as she could have. This was a very important lesson to us. After the incident we added a 'Quick Tips' section to our webpage listing the quirks of the system and how to best avoid them. Unlike our group, many teachers don't have the time to familiarize themselves with the Robots. Often teachers learn the material one step ahead of their students.

Design Process

After we had a good feel for the capabilities of our tools we laid out a preliminary plan for designing and testing a curriculum that would teach students good problem solving skills. Our first major problem was that no one in our group had prior experience designing lesson plans or serious teaching experience. To fix this problem we brought in a graduate student from Columbia Universities Teachers College. The graduate student was part of the GK12 program (described later) designed to assist teachers in bringing technology into their classrooms. With her assistance we were able to design a preliminary lesson plans and materials.

We arranged to teach in three different classrooms/programs. Each group of students was different in race, gender and background. This allowed for three testing iterations of our curriculum. During each iteration we tested and evaluated the lesson plans and resources in a classroom environment. Then based on our experiences we modified the materials to accommodate what we learned.

First Iteration

The first iteration was a 6th grade classroom in Washington Heights, New York. It consisted of two classrooms of about 30 students each and one teacher. The teacher had had minimal experience with the Lego Robots. The students came from mainly Hispanic families and consisted of both male and female students.

We chose this classroom as a first iteration due to the existence of the teacher and the age of the students. The presence of the teacher gave us an opportunity to experience teaching in a classroom environment under controlled conditions.

This iteration was extremely valuable. We acquired new teaching techniques. Specifically; behavior management and how to abstract complex ideas. The teacher was very helpful and gave us several pointers. For example when the students were having trouble understanding how to get their robots to rotate. The teacher explained the concept by using the example of a wheel chair. You turn a wheel chair by moving one wheel forward and the other backward. He then demonstrated this by using an imaginary wheel chair.

We were also able to observe the students in their natural setting and how they interacted with the robots. Quite often the students would try and do the tasks in ways we never anticipated. Sixth graders view a Robot in a different manner than a Computer Science College student.

To evaluate the effectiveness of our curricula we administered a pre and post test. This allowed us to see what problem solving skills the students had learned.

Second Iteration

The second iteration was done with an older group of students in a college prep program. (Science and Technology Entrance Program) The program was intended to increase the number of students that attend college and pursue science and technology related fields.
The students ranged from 9th to 12th grade. The classes were approximately 75% female, hailing from broad socio-economic backgrounds.

In the second iteration we modified the materials to reflect the change in age group. We also made adjustments based on our experiences in the first iteration. The major differences between the second and first iterations were the absence of a teacher and the attitude of the students. The first iteration was in a public school and the students had some behavioral issues. The second iteration was in a voluntary program, so even with the absence of a teacher the students were much easier to manage.

Third Iteration

In the third iteration, we wanted to see how our curriculum would function if taught by someone else. So the third iteration was taught by other undergraduates that had minimal training in Robotics. We gave them the curriculum and materials we had developed and had them teach a class at a community center in Harlem, New York. We would then meet with them after each class and discuss how the classes went.

The students at the community center ranged in age from 9th – 12th grade and had an even

male/female mix. There were major behavior issues and willful disinterest. Some students would spend all of class doing nothing but disrupting other students. Despite all the behavior problems the director of the community center was very impressed with our program. He remarked that students "responded better in Robotics Class than any other." The other teachers shared his opinion and assured us that the students behaved far worse in other classes.

We gained valuable feedback by having teachers external to our research group use the material to teach. They discovered problems that we had not previously considered. One such problem is that teachers normally teach a class by staying one step ahead of the students. They learn the material the day or even the morning before they teach it. That is enough to get the basic concepts but there are plenty of quirks in the system that the teachers miss this way. Then when a student's program isn't functioning the teacher doesn't have the experience necessary to debug it. To help fix this problem we added a 'Tips and Tricks' section to the curriculum. We also added "Common Student Problems" to all the lesson plans.

Final Presentation

The final part of the project was to present it to a group of teachers as part of the GK12 program. GK12 is funded by the National Science Foundation. It is designed to assist teachers to integrate technology into the classroom in meaningful ways.

The majority of teachers at the workshop had never worked with Lego Robots previously. We taught the workshop using the lesson plans and materials developed in the previous iterations. The curriculum was heavily supplemented with our own experiences. Emphasis was placed on how to troubleshoot mistakes most often made by students.

We had a very positive response from teachers. Most refused to use the workbooks we provided them because they wanted to take the workbook back and copy it for use in their own classrooms. The teachers had lots of implementation questions, and were impressed with the amount of practical experience we had. They were very glad to discover that we had tested this material outside of the lab in "real" classrooms.

Conclusion

Using Lego Robots we were able to successfully bring technology into different classrooms. Through three iterations we were able to improve upon the lesson plan and materials based on experience. The material was presented and warmly received by a group of K-12 teachers who plan on implementing it in their own classrooms.