

## **DID IT WORK? - ANALYSIS OF WAYS TO MEASURE THE IMPACT OF AN AFTERSCHOOL ROBOTICS OUTREACH PROGRAM**

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### **Abstract**

Nationwide, afterschool programs exist to offer children educational enrichment. Funding organizations, however, want to assure the money invested has the desired impact. This reasonable desire for results leads to the common need for effective and appropriate assessment tools. This paper explores the challenges faced in revising an assessment program for the Austin Children's Museum, which has an afterschool, outreach robotics program for third to fifth grade students from low income schools. This robotics program features LEGO® MINDSTORMS® NXT to facilitate the students' robotics education. The goals of the program include: enhanced academic skills such as computer programming and visual discrimination; increased interest and motivation for future experiences and positive attitudes towards mathematics, science, engineering and technology; and greater awareness of technology/teamwork processes such as brainstorming, planning, teamwork and troubleshooting. This paper presents the challenges and adaptive efforts to effectively assess the program's impact in achieving its goals. The assessment is brief due to the short program (eight sessions), the age of the students, and the voluntary nature of the program. Due to these young students' written comprehension level, traditional assessment techniques were not appropriate. These challenges led to a revision of the assessment at three stages. The resulting assessment program includes short pre- and post-program written quizzes of the students' comprehension of content areas, pre- and post-program verbal interviews of the students, and in-session records of students' abilities to demonstrate understanding of the content discussed. The analysis in this paper focuses on revision of the assessment to adapt it to effectively measure changes in students' skills or attitudes and why the assessment was revised at three stages in the program. The analysis also discusses how each of the assessment techniques impacted the program and provides insight in this area that many programs find challenging.

### **1. Robotic Background**

The materials used for the after-school robotics program were the LEGO® MINDSTORMS® NXT Robotics system. The LEGO® MINDSTORMS® Robotics allows an individual to create autonomous electromechanical inventions that are based on the LEGO building systems. The system features an automatic programmable control unit (NXT brick) that has four inputs and three outputs. Outputs for the NXT brick are motors and lamps (lights). Inputs for the NXT brick are light, sound, rotation, distance, touch and other custom sensors. The robots are built

from LEGO Technic components and other craft materials. Programs to control the robots are written on computers with the NXT software and then transferred to the robots. An example of an NXT robotics project is shown in Figure 1.



Figure 1: LEGO NXT Robotics Example

In the robotics program the students explore concepts about automated devices with active learning principles. The robotics program uses active learning materials that were developed by the Design Technology and Engineering for America's Children (DTEACH) program. The curriculum for the robotics program is based on the DTEACH 5-Step teaching model shown in Figure 2.

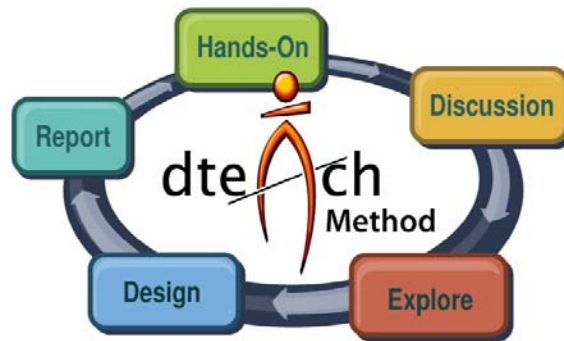


Figure 2: DTEACH 5-Step Visual Representation<sup>1</sup>

The DTEACH 5-step model is influenced by the Kolb's Learning Cycle model and Bloom's Taxonomy<sup>2</sup>. The Kolb Cycle is based on learning experientially through four stages of a learning cycle<sup>3</sup>. Bloom's taxonomy has six levels of cognitive understanding of a subject. Starting with the lowest level, knowledge, each level of the subject must be understood by the individual before moving to the next level of cognitive understanding<sup>4</sup>.

## 2. Brief Introduction to the Austin Children's Museum

The Austin Children's Museum (ACM) is a nonprofit organization whose mission is "to create innovative learning experiences for children and their families that equip and inspire the next generation of creative problem solvers." Through well-crafted exhibits and educational programs, the Museum helps lead young children towards the life-long learning modes of questioning, reflecting, informed decision-making, critical thinking, and multidimensional thinking. There have been significant advancements in the understanding of how young minds develop and are inspired before starting grade school. For the last 25 years, the Austin Children's Museum has been a leader in applying those advancements to help children learn and grow, and has become a vital complement to our public education system. The Museum welcomes more than 200,000 visitors annually and serves a primary audience of children (ages 0 to 11) and the adults in their lives<sup>5</sup>.

## 3. Robotics Program

The Austin Children's Museum has been incorporating LEGO robotics into its program offerings since 2005. Serving an informal audience has several customer-driven challenges: Every child must have a good time and enjoy free choice activities, yet must also stretch his or her capabilities as much as possible. The first robotics summer camps filled to capacity with children from our science/technology-passionate public, and we now offer afterschool programs funded by local foundations at Title One campuses. In this way, the robotics program has served well over 200 children ages 7 to 12 with fun yet challenging activities with programmable LEGOs.

This research focuses on the assessment of the afterschool program. The robotics program is eight two-hour sessions held weekly, depending on the hosting school schedule. The students are voluntarily participating in the program, and are selected by the hosting school. The students vary from second through sixth grade. The sessions are offered on site at host schools to twelve participating students. The students are a mixture of males and females. Figure 3 shows some of the students and instructor of the ACM robotics program.



Figure 3: Students and instructor of the ACM robotics program

#### **4. Assessment Goals and Limitations**

The ACM robotics program's goals are to enhance students' academic skills, increase student motivation towards STEM subjects, and increase the students' conceptual understanding of technology processes. To assess the goals three different methods of assessment were used. The goal of the assessment is twofold: to get a better understanding of the students and to evaluate the assessment approaches.

#### **5. Assessment Tools**

The assessment of the program focused on three methods. The methods are intended to assess the students with minimal impact on the students. The program is a voluntary afterschool program. The program was assessed with a "Pretest" on the first day and a "Post" assessment at the end of the program (a minimum of seven weeks apart). Because the program consists of a total of sixteen hours, a major concern was the minimizing of the time the assessment took during the program. The assessment also needed to evaluate students in a range of grade levels.

##### *5.1 Visual Discrimination and Graphing Skills*

This written assessment instrument focused on academic skills. The first year the program was done the assessment contained four visual discrimination questions asking the student to identify the item on the page that was different from the rest, and two questions about reading graphs. Two versions of the evaluation were created and alternatively used during the assessment. The first page of the written assessment is shown in Figure 4.

In the 2009-2010 school year the assessment was revised to focus on assessing the students visual discrimination skills related to using the NXT programming language. This assessment change was done more close align assessment with the skills being taught.

One of these things is not like the other! Circle the picture that is different in each set.

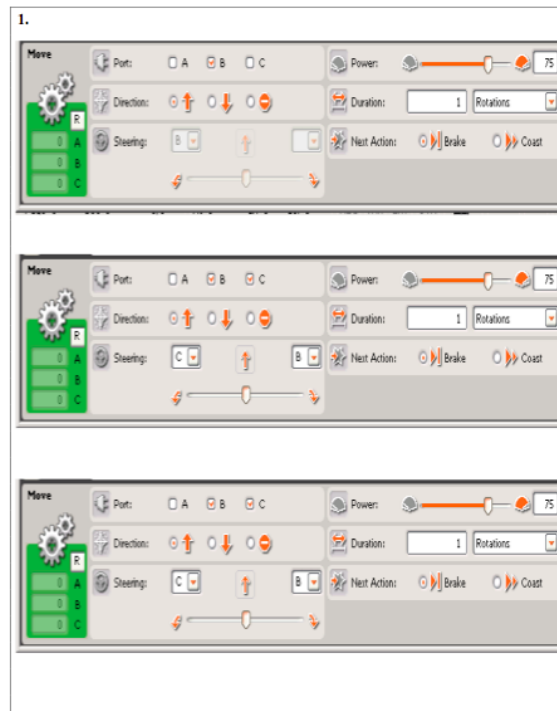
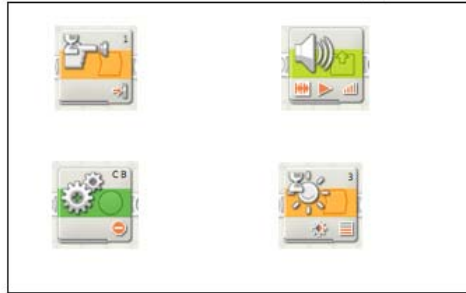


Figure 4: Written Assessment Page One 2008-2009

Circle the icon that will "Wait for Touch" in the NXT program.



Circle the icon that will "Play a Sound" in the NXT program.



Figure 5: show the written assessment page on for the 2009-2010 school year.

Circle the icon that will "Wait for Touch" in the NXT program.



Circle the icon that will "Play a Sound" in the NXT program.



Figure 5: Written Assessment Page One 2009-2010

## 5.2 Interview

To assess the student's interest and motivation, a structured interview of three questions was given to each student at the start of the 2008 school year. After getting feedback on the interview questions a fourth question was added in fall of the 2008 school year. The interview format was used to minimize the effects of the students' reading comprehension and writing skill on the assessment. The interview consisted of three and then four questions as shown in Figure 6 and Figure 7.

Name \_\_\_\_\_ Date \_\_\_\_\_

1. Would you like to do an activity like this again? Why or why not?
2. Would you rather have a video game to play at home or have one of these NXT kits to play with at home? Why?
3. If Dr. Fowler gave you a challenge do you think you could get it right on the first try? Why or why not?

Figure 6: Interview Questions Version One

Name \_\_\_\_\_ Date \_\_\_\_\_

1. Would you like to do an activity like this again? Why or why not?
2. Would you rather have a video game to play at home or have one of these NXT kits to play with at home? Why?
3. If Dr. Fowler gave you a challenge do you think you could get it right on the first try? Why or why not?
4. When you grow up do you think you would like to work on challenges like you did in this class? Why or why not?

Figure 7: Interview Questions Version Two

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### 5.3 Activity - Conceptual Understanding

Assessment of the conceptual understanding technological process focused on the students' understanding of automatic devices. During the first and last days of the program, the students were asked as a group to name automatic devices. The devices were listed on a poster as they are called out. The number of unique devices listed was recorded for each session. An example of a poster list is shown in Figure 8. As the curriculum was revised in the second year the conceptual understanding was revised to assess student understanding of the sensors concept.

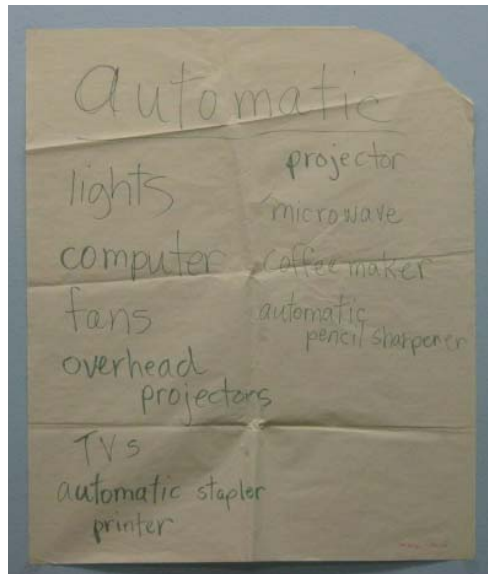


Figure 8: Automatic Devices Poster

## 6. Assessment Results

Overall, the interview demonstrated the students are excited about the program and would like to participate in a future robotics program. At the end of the program, the students stated they would prefer playing with NXT at home over playing with a video game.

The interview was a success in gathering written comments on the program for use with program sponsors and marketing of the project. This form of assessment required an additional individual to perform the interview but was minimally invasive. The first interview question results indicate that all students would like to participate in a similar program in the future but many of the students made the same statements at the start of the program. The second question showed that students overwhelmingly prefer the LEGO NXT Mindstorm Robotics kit over video games as shown in **Figure 9**.



Percent of Children that Want to use the Robotics Kit Over a Video Game

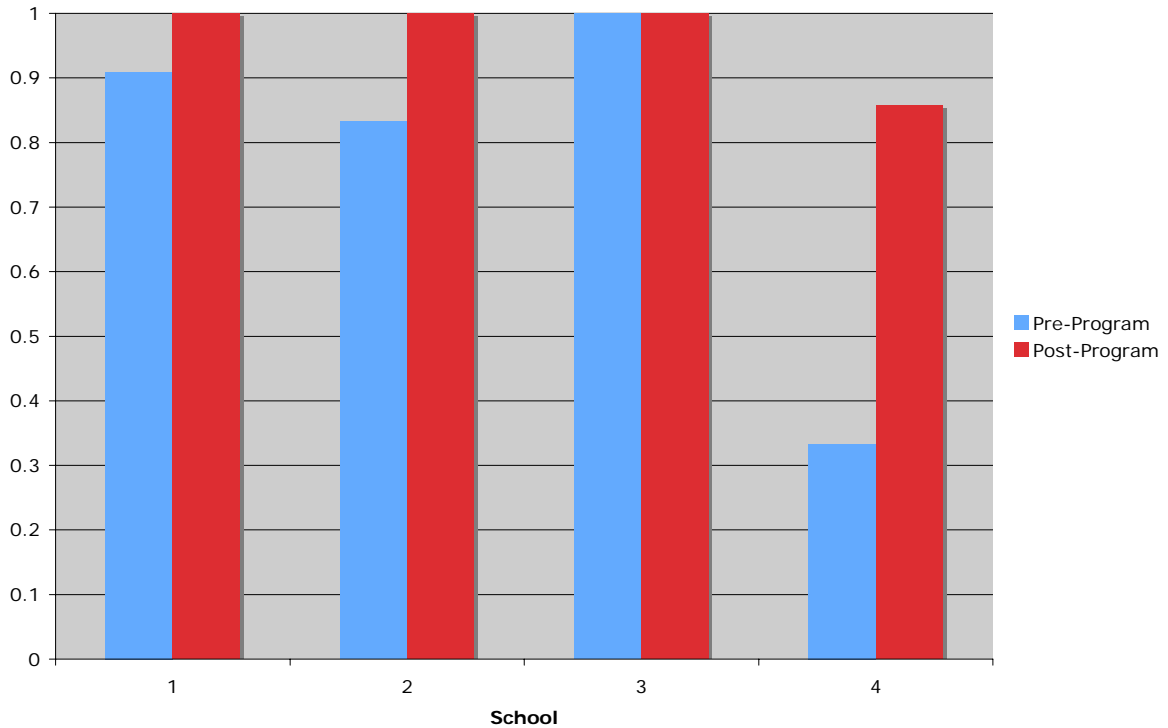


Figure 9: Percent of Children that want to use the Robotics Kit Over a Video Game

Careful analysis of the interview questions is needed. The interview process was conducted while the students were working on building or demonstrating the robots. This method of interviewing allowed the interviewer to interact with the students one on one during the program time. This method appears to be well received by the students and worked well with the program instructor. Due to this interview style a maximum of three to four questions are recommended due to the time it took. After the first sessions the interview was changed to four questions to gain insight into how students viewed future challenges. A representative sample of the interview comments from the students is shown in Table 1.

Table 1: Sample Interview Comments from Students

"I like to make stuff."
"Fun to learn stuff"
"Fun to help people" (challenges)
"You get experience to create something yourself."
"You have to use your imagination and when you finish it and do a contest you feel really proud of yourself."

For the written evaluation, the study had difficulty attempting to assess all students with the same tool due to the students' different ages and abilities. Our research demonstrated that the evaluation could be too simple and or too complex for the students. The visual discrimination test that was given was overall too easy for the students. The majority of the students to correctly answered the questions both before and after the program. The graphing section of the evaluation was based on the program module being implemented in the program. Figure 10 shows how the study was able to demonstrate that the students who could complete the assessment much faster in the post session. For the 2009-2010 school year the evaluation was modified to asses visual discrimination of programming skills the student was taught in the program. This assessment was changed to more closely reflect the curriculum the students were receiving.

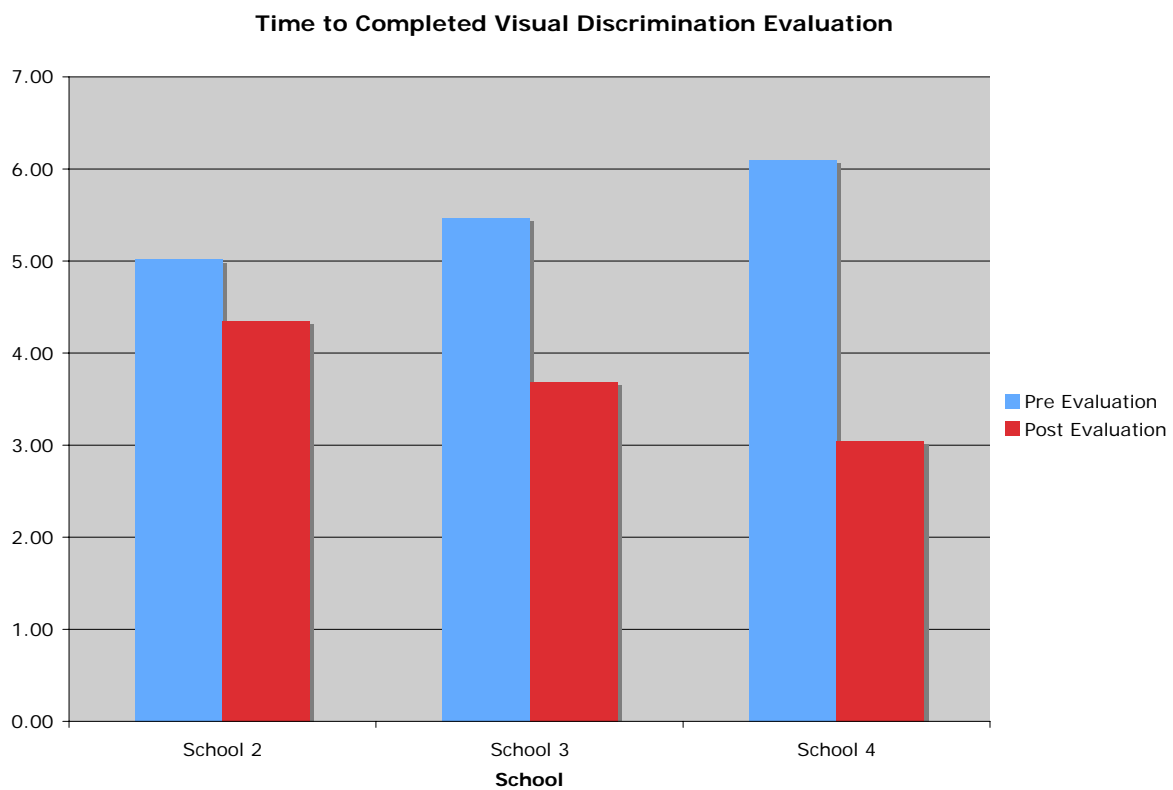


Figure 10: Timed Visual Discrimination Evaluation

The assessment tool for conceptual understanding was successful. The program's instructor felt it was easy to implement the program and the results indicate that students were able to name significantly more items as the end of the program. This lends support to the belief that the students are grasping the conceptual understanding of automatic devices as seen in Figure 11.

## Conceptual Understanding

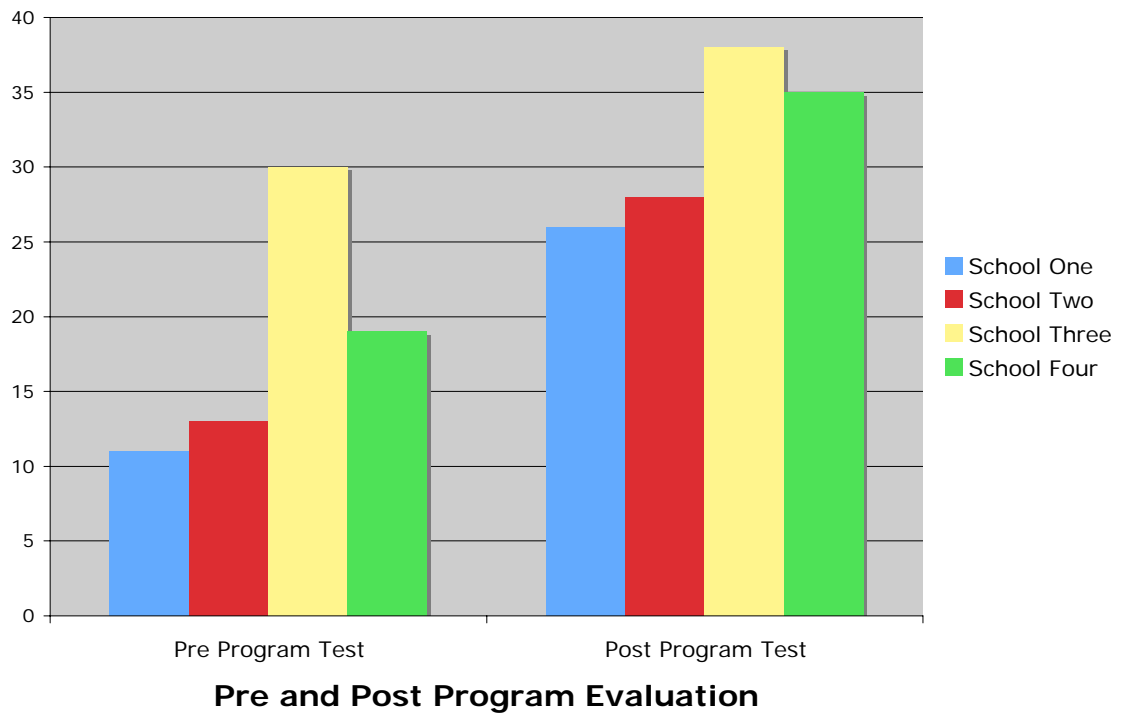


Figure 11: Conceptual Understanding Assessment

## 7. Conclusions

Overall, the three assessment methods allowed the researcher to analyze the students' skill, conceptual understanding of the content, and perception of the program. Conceptual understanding integrated into the program has demonstrated success as an assessment method and appears likely to be integrated into all future ACM robotics programs. The assessment does require that the assessment needs to change as the curriculum is revised. Future use of the conceptual analysis might be directed at using Concept Maps<sup>6</sup>. The written assessment has showed that the students were able to visually discriminate among the concepts presented to them. Careful revision of the assessment to closely mirror the curriculum has shown to be critical. The structured interview takes active involvement for successful implementation but in this study demonstrated some insight into the students' attitudes toward the program. Continued analysis of student assessment methods is needed to refine and maximize the gathering of information with minimal interference in the program.

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