The Impact of the Robot Roadshow Program to Increase Interest of Technical Disciplines in Rural and Under Served Schools

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Abstract

The *Robot Roadshow Program* is designed to interest school children in technical disciplines, specifically targeting math and science. It focuses on schools categorized as rural or underserved which often fall short in providing access to technical resources to further interest in these areas. We have developed a program utilizing robots as the vehicle to excite children about science. The *Robot Roadshow Program* uses a three-step process to accomplish this goal. The initial step is to send pre-visit workbooks tailored for a specific age group, which help to develop an appropriate set of skills and knowledge necessary to get the most from the program upon visitation day. During the visits, robots are used in interactive experiments to reinforce principles of science in a manner appealing to students. The final step is a follow-up session with the faculty to evaluate overall impact. We then determine what improvements need to be made to maximize impact.

A year ago, we presented the initial proposal and pilot program at the 37th ASEE Midwest Section Meeting at the University of Oklahoma. This year, we present the results, progress and further development of our program. More than 1000 school children from rural and under served schools, pre-Kindergarten through high school, have participated in the program. The program has also been delivered, in a pilot format, at a Headstart school and we are currently evaluating how we can use the same techniques with special needs children such as those with Asperger's Syndrome or autism. We have found that the robots are universally captivating for all school age children, but really peak the scientific interest in the K-6 range. Given this is a long range program, to completely measure the overall program impact we intend to follow the participants over a number of years. To reinforce the experience, we are currently adding several new techniques and methods to the program to include links with other robotics programs that participate in the K-12 range.

Introduction

This program was founded on the principle of extending the education of children who attend schools that have a limited exposure to technical programs. Typically, these students live in smaller towns and school districts where shrinking enrollment, less money and strained resources have put a squeeze on all but the most necessary equipment and subjects. With these constraints, the students of rural schools must still compete to find a place in an ever increasing global economy dominated by workers with the ability to apply advanced technologies and solve more complex problems than before[1]. The Robot Roadshow Program is an attempt to provide an example of a creative method to extend the scientific and math education of these students [2]. In the first year of the Robot Roadshow program, we have visited many schools and involved more than 1,100 children in the program.

In this paper, we will review the overall goals of the program. The nature of what a rural and underserved school is not generally accepted, so we will describe our definition. Over the course of the first year, the intricacies of the delivery process have changed, although the general process has remained the same. In this paper we will discuss the general goals of the program and how they extend education opportunities in rural and under served schools. We will review the delivery process and the program impact and results from the past year. We will complete the paper be outlining the planned, future work to support the program.

Program Goals

We have augmented the goals of the program to include new areas and extensions to students that we were not originally set up to serve. The core goals of *Reinforcement, Access, Enjoyment, Linkage (REAL)* still exist. The extended goal is that of service to some specific *Sub-groups*.

Reinforcement
Create process to reinforce the experience, so that after the visit the child's interest doesn't deteriorate. The success of the reinforcement goal is critical to allow a long term residual effect of the program.

Enjoyment
Many students in Pre-Kindergarten through high school don't view math, science and other technical disciplines as fun and subsequently don't pursue them as options into college. Allow the students to enjoy math and science.

Access
This program was created to provide an opportunity for underserved/rural schools to have access to additional learning resources in the areas of math and science. Many schools struggle with budget reductions and lack of overall resources. Our program will fill resource gaps with access to special technology education.

Linkage
The combination of the first two goals, Access and Enjoyment, support the third goal of Linkage. Linkage allows students to build a relationship between the study of math and science and interesting and fun subjects, in our case, robots.

Sub- Groups
Through the execution of the Robot Roadshow program, we have targeted new sub-groups such as females and children with autism [3, 4] or Asperger's Syndrome. In reviewing and targeting these groups, we can increase program impact. For the female sub-group, encourage more young ladies not be "factored out" of technical disciplines simply because they are girls. For autistic children, give them an additional experience to relate in a world where social norms may be challenging.

Rural and Under Served Schools

This program was founded with the idea of extending and augmenting the education provided by rural or underserved K-12 schools in math and science. We are examining the extension of the program to also look at other target groups, such as autistic children. Another area of potential focus is K-6 females to encourage the idea of technical futures.

As the success of the program has elevated this year, we have developed a more complete set of criteria for judging what is considered a rural or under served school. To be classified as a rural school the population area, such as a county or city served, must be less than 8,000 in population. Most of the children served this year reside in towns much less than 8,000. At the inception if the program, it was more difficult to determine what constituted a under served school. The developed criterion now relates to the number children, in that school, that receive free or reduced priced lunches. This measure is used by the Federal Government for similar purposes. An under served school can be either rural or urban in nature.

Process

The Robot Roadshow overall delivery process has remained the same through its initial year as shown in Figure 1. The process has three delivery elements. *Pre-visit workbooks* are sent to the school prior to the program. The *Visit Day* program is the actual program delivery. *Follow-up* involves asking for input and student tracking information.

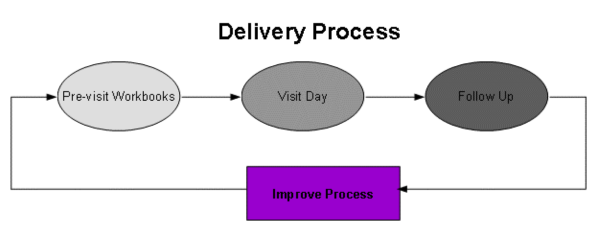

Figure 1: Delivery Process

Pre-visit Exercises

Each child in grades from pre-kindergarten through 8th receives a workbook with exercises to prepare them for the visit day. The exercises are created to be interesting and fun, but also rigorous to prepare the children to maximize the impact of the experience. The exercises range from instructing the students to draw and label their own robot, to word finds, to asking questions on comparative intelligence between humans and robots. These exercises are done in a non-threatening manner and are not scored for accuracy, but used as a tool to create familiarity and comfort with a somewhat technical subject.

Visit Day

The visit day program normally lasts about one hour per group of children. There is a set agenda followed to deliver the program leading the students from an introduction to the robots via a logical progression with the students actually working "virtually hands-on" with the robots conducting experiments. The agenda for a visit day has evolved into a compact program delivering strong tutorial and interactive, experimental content. The visit begins with introductions and explanation of the program agenda. The program is split into three parts. We begin by comparing robots with human intelligence and function through a short lecture period with questions and answers. Then we show a NASA movie with robots venturing to Mars as a way to describe the future and possibilities of robotics. The capstone experience is a set of experiments to allow the children to have a sensory experience with the robots. The agenda is identical for all ages with the exception that the high school students are the only group to participate in the Multi-agent Race experiment.

Lecture and Q/A

In the lecture, we discuss human and robot intelligence, then progress into learning and finish with sensors. In each phase we compare and contrast the way humans use these capabilities to the way a robot is built and how it will use these capabilities.

To begin the lecture, we compare and contrast human versus robotic intelligence. The discussion is initiated by posing a question to all of the children, "Which is smarter, a person in this class or the world's smartest robot?". We ask for a show of hands to gauge the audience's answer. We discuss, in general, the differences in intelligence between humans and robots. We then move to ask for a volunteer and ask the crowd who will win in a foot race between the volunteer and a robot if both were given the direction to run from one side of a room and exit the doorway of the room. We give that direction, velocity and acceleration are the same between the robot and the human. Then we take another poll to see which of the participants, human volunteer or robot will win the race to the door. We ask reasons for belief of why the robot or human will potentially win. We then ask the human volunteer if they know what a "door" is and explain that a robot will not know what a door is and this is why the human will win the race. The human will win not because of functionality, but because of knowledge of the environment.

The next topic of discussion is how we, as humans, generally learn. We talk about how our brain, in conjunction with each of our five sensor types, or senses, allows us to learn almost continuously from our environment. We discuss the nature of each sensor and how our brains can automatically switch from using one sensor as a primary sensory, in one situation, to using another, in a second situation. We use the example of waking up in a dark room in the middle of the night with a goal of making a visit to the bathroom or kitchen. The first task is to locate the light switch. We ask the children what sensor is appropriate for this usage. Most say the sense of touch as they will need to reach out blindly to find the wall, even though they know the mental map of the room. Once the light is switched on the sense of touch is no longer the primary sensor and vision is used to navigate. We then tie this use of sensors into what sensors a robot can potentially possess and describe the AmigoBot robot shown in Figure 2, which is the standard robot used in our program.

Figure 2: AmigoBot Robot

Movie

The movie shown visually describes a potential Mars exploration project using biologically inspired robots, from the field of biomimetics. The *Entomoptor* movie shows a space craft flying through space, moving into Mars orbit and landing on the Mars surface. After a successful landing, a team or robots unfolds and starts to explore the planetary surface. The main idea of the movie is the nature of the robots. There are robot base stations that look like standard Mars rover robots and they are accompanied by robots that appear similar to butterflies or birds with wings that explore the surface with greater speed and ability. The movie is entertaining and builds a linkage to how interesting technology can be and also what is possible.

Experiments

The set of experiments and games executed during the program is meant to engage the students in an active learning engagement instead of a passive lecture. We find the interest is much higher with this format. We have worked through several designs of these experiments to evolve the current set. The experiments and games employed are Robots Roaming, Escape the Circle, Robot Race and the Multi-agent Race.

Robot Roaming

In this experiment, we build a bridge between the discussion of sensors and the image the children see of the robot moving around and not crashing in to any objects. The goal is to show how the robot uses its sensors to navigate and avoid obstacles.

Figure 3: Robot Roaming

Escape the Circle

The goal of the Escape the Circle experiment is to show the student the difficulty an uninformed robot has at doing even the simplest of tasks, in this case, rolling out of a small circle. We can compare the ease a human can escape the circle to draw a comparison between human and robot intelligence.

Figure 4: Escape the Circle

Robot Race

The Robot Race is an extension of the Escape the Circle. In this experiment, the children are split into two teams each having a robot represent them. Both robots are started as far away from the opening in the circle of children as possible. The goal is to see which robot can escape first. That team is declared the winner. Normally this experiment is repeated multiple times to show that there is no advantage from one robot to the next.

Figure 5: Robot Race

Multi-agent Race

The Multi-agent Race is an extension of the Robot Race, except this time we involve students. The goal is for a team, involving a robot and a differing number of students, to work together and escape the circle. In this exercise, the multi-agent team, of humans and robot, works together to supply attributes each possesses to achieve the goal of escape. The strong attributes of the robot as the central device and the humans as navigators and thinkers are employed. The experiment is performed with combinations of the robot and 1 to 4 humans. Each iteration yields a discussion to determine if adding a new person was a help or a hindrance to the team. The performance is evaluated by the length of time it took to exit the circle. The effect of the team's organization and how the team plans are discussed. By conducting this set of experiments, we can also teach a simple example of the scientific process and evaluation.

Post Visit Evaluation and Tracking
The purpose of the Post Visit Evaluation is to record and evaluate the teacher's perspective on ideas to improve the program. We solicit their feedback on appropriateness of the Pre-visit Workbooks and the Visit Day content. We also discuss other extension programs that may be of value to their children.

Impact and Results

In its first year, the Robot Roadshow was delivered to 1,215 rural and underserved children within the state of Kansas. Most of the schools visited were within a 2 hour drive from Manhattan, Kansas. Of the 1,215 students they were split between 243 children from urban schools and 972 children from rural schools as shown in Figure 6. The breakdown by sex for the participants in the program is shown in Figure 7 with females representing 53.8% of the audience and males representing 46.2%, respectively.

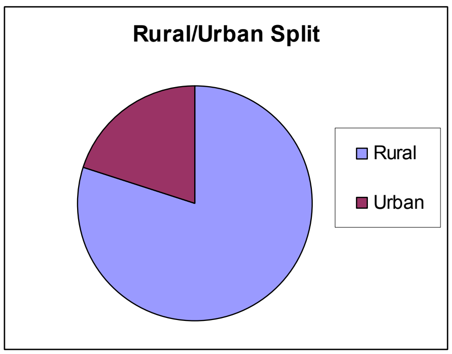

Figure 6: Rural and Urban Distribution

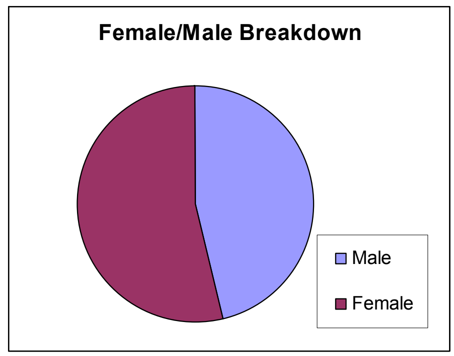

Figure 7: Female and Male Distribution

In Figure 8, we describe the racial origins of the participants. Representatives of five groups participated in the program: African-American (4.7%), American Indian (.5%), Asian (.6%), Caucasian (90.0%) and Hispanic (4.2%). An aim is to provide a program for under served children. The measure of underserved children, by our standards, is from the number of children that participate in a reduced or free meal program through their school. In Figure 9, the percentages of children that receive free/reduced price meals (48.86%) compared to students that don't qualify (51.14%).

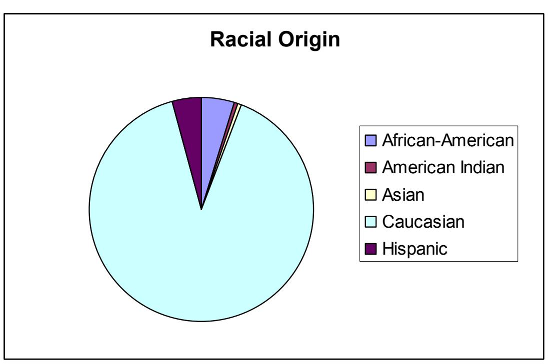

Figure 8: Racial Origin Distribution

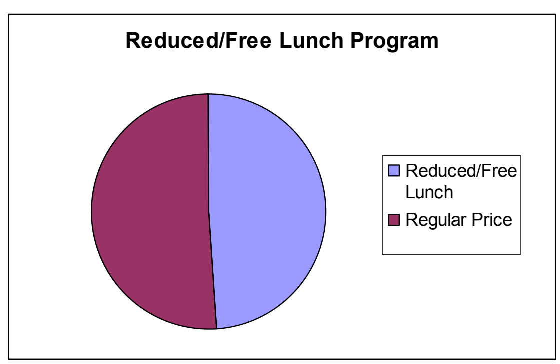

Figure 9: Reduced or Free Lunch Distribution

Based on the mix of students from a racial and socio-economic standpoint, we feel that we have successfully accomplished the goals of serving children in rural and under served schools.

Tracking

An ongoing issue with the Robot Roadshow program is the long term tracking to measure to the effect on the children that participate within the program. To have an effective program, there must be verifiable results. With the number of students covered, it is a difficult and time consuming task to track long term effects and impact.

One of the first schools visited, Ogden (K-5), invited us back to present our robotics program during their first ever school science fair. This event took place approximately 3 months after the our Robot Roadshow presentation. The impact, on the children, was encouraging as we had children presenting and explaining the function of the robots to their parents, in technical detail.

Further Work

After a full year of conducting this program, we have solidified the requirements for long term success, durability and usefulness. The most salient plan element is the gain of funding to provide a permanent base for the program and more staff to conduct and deliver the program. This will allow the resources to extend the program to schools farther in distance from Manhattan, Kansas.

We have developed links to other programs that we can serve via the publicity and general number of students and faculty we are in contact with. These programs are generally other K-12 outreach programs from Kansas State University's School of Engineering that serve small constituent groups during summer.

In reviewing the ability of small children to logically manipulate robots in simple experiments, we have begun another program, described in another ASEE paper [5], to build logic and critical thinking skills in children from kindergarten through the 6^{th} grade. This program will reinforce concepts learned during the Robot Roadshow over a long period of time, accomplishing one of our goals of *Reinforcement.*

Another future project is that of a web presence that will provide information to further the discussions and reinforce the lessons of the Robot Roadshow, over a longer period of time. The idea is to provide a place where all students involved in our program, past and present, can share ideas and designs in a more informal setting.

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Biographical Information

ERIC MATSON is currently a Ph.D. student in the Department of Computing and Information Sciences, College of Engineering at Kansas State University. His current research interests include organizational theory, cooperative robotics, multi-agent systems, and adaptive information systems. Prior to returning to academia full-time, Eric spent 13 years in industry working as a software engineer, project leader, manager and director for companies such as AT&T and Schneider Electric. Eric received his B.S. in Computer Science from Kansas State University in 1988, a M.B.A. in Operations Management from The Ohio State University in 1993, and a M.S.E. in Software Engineering from Kansas State University in 2002.

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SCOTT DELOACH is currently an Assistant Professor in the Department of Computing and Information Sciences at Kansas State University. His current research interests include autonomous cooperative robotics, design and synthesis of multi-agent systems, and knowledge-based software engineering. Prior to coming to KSU, Dr. DeLoach spent 20 years in the US Air Force, with his last assignment being as an Assistant Professor of Computer Science and Engineering at the Air Force Institute of Technology (AFIT). Dr. DeLoach received his BS in Computer Engineering from Iowa State University in 1982 and his MS and PhD in Computer Engineering from the Air Force Institute of Technology in 1987 and 1996.