Using Robots to Increase Interest of Technical Disciplines in Rural and Underserved Schools

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Abstract

In Kansas, there are many schools, due to a rural or underserved nature, that fall short in providing access to technical resources to further interest in science education. We have developed a program, using robots, to interest school children in technical disciplines. This program is targeted at schools that do not have people or financial resources to fund a similar program on their own. To make the program interesting, robots are utilized as the vehicle to excite children about science. Our experience indicates that robots are almost universally captivating for children of all ages, in our case, K-12 students.

The Robot Roadshow Program uses a three step process: Pre-visit workbooks, the visit and presentation, and a follow-up session with the faculty to evaluate student impact. The initial step is to send a workbook, consisting of puzzles, short readings, definitions and creative exercises, in advance for each student to complete. There is a different workbook for each of the following age groups: K-3, 4-6, 7-9, 10-12. Tailored by age group, the workbook will develop an appropriate set of skills and knowledge mandatory to get the most from the program upon the visit day. On the visit day, several of our robots will go to the school for interactive experiments with the students. Each experiment injects and reinforces principles of science in an interesting, fun and unique way for the students. The faculty follow-up session reviews and evaluates the impact on individual students and the class as a whole. The follow-up review is used to revise and continually improve the program to maximize the impact of the participant experience.

Introduction

When the Kansas territory was first settled, those who went to school often attended a one room school house. The one room school houses were normally short on supplies though provided a reasonable education considering the resources available to them. Although the students were attentive and worked hard toward their academic goals, they were often lacking resources available in larger cities and metropolitan areas. The actual schools were constructed of whatever materials were available and reasonably inexpensive [1]. With the lack of resources to build the very schools, it is easy to imagine the resource deficits that existed, in small schools, when compared to larger schools and districts. Although the situation has improved somewhat, there is still a resource gap between larger and smaller schools.

While the one room school houses of old have evolved into modern schools with better access to information, the fact still remains in smaller towns and school districts that 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[2]. 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.

Initial Development

This program got its start from Cub Scout troops interested in robots. The results were so positive we decided to try and extend it as an outreach tool for local schools that wouldn't normally have access to these types of expensive and specific teaching and instructional resources. Contact was made with several schools to determine if the proposed program would be a viable and welcome augmentation to the normal science and math cirriculum. The response was positive in all cases. At this point, the program outline was developed and the initial pilot program was tested on two classes of 2nd graders at a small area school in Manhattan, Kansas. After completion of the pilot, a follow up was conducted with the two 2nd grade teachers to determine the program's value and any changes to add additional value or impact.

Program Goals

Our goals for this program are very simple:

1. Create opportunity for underserved/rural schools to have access to additional learning resources.
2. Allow the students to enjoy math and science.
3. Allow students to build a relationship between the study of math and science and interesting subjects (robots).
4. Create process to reinforce the experience, so that after the visit the child's interest doesn't deteriorate.

School Selection Criteria

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. Due to of the sheer number of school districts in the state of Kansas and the limited resources available to execute this program, we developed a criteria to determine if a school is defined as rural or underserved. After a school has been determined as meeting the criteria for one of those categories, we prioritize requests in order of need and economic feasibility. Need is based upon a review of their program application. Economic feasibility consists of the cost to travel to put on the program measured against the number of students and targeted audience. In case there are more requests than we can fulfill, we will use the priority to determine where to present the program.

There are some school districts, with large science and technology budgets, that we will not target with this program. The targeted school districts typically represent a population base of 8,000 or less. This makes up a great percentage of the Kansas school districts. School districts, in this category, normally are rural in scope and typically have less opportunity to go beyond the basic resources provided by the curriculum. A more difficult category to define is that of underserved schools. For our program, we define an underserved school as one that has fallen behind based on math and science scores regardless of the size or population base served.

Process

The approach of our 3 step process is to build a base of knowledge and interest via the Pre-visit Workbooks we provide, then reinforce and strengthen that learning experience with the Visit Day lessons, activities and experiments. These activities are followed up by the review with the sponsoring teacher at the selected school, so that we can continually improve our program and the delivery process, as shown in Figure 1. Due to the short nature of our experience with the program, we anticipate that we will change and improve it continuously, in order to provide the most effective and efficient learning experience possible for the target schools.

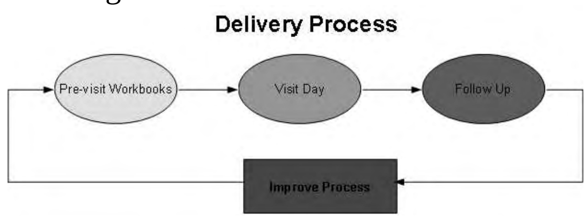

Figure 1: Delivery Process

The key to success for the Robot Roadshow program is to provide reinforcements to learning via a performance-reward linkage. A student will act in a certain way based on the expectation of a certain attractive outcome[3]. The reward or outcome is to see an interesting presentation and set of hands-on, interactive experiments and departure from the normal school day. The performance they have to provide is to complete the Pre-visit Workbook and participate in the interactive experiments. The difficulty of the Pre-visit Workbook and the technical expertise required for the experiments is adjusted for each age group.

Pre-visit Workbooks

The goal of the Pre-visit Workbook is to develop a basic understanding of the program, use games and puzzles to learn about robots, and provide an independent exercise appropriate to prepare for the Visit Day. An example of the pre-visit workbook for elementary school is displayed in Appendix A.

Visit Day

The Kansas State University Robotics Team will travel to the school and take along robots shown in Figure 2. Figure 2 is not to scale as each of the robots is a very different size with different attributes and capabilities. Each is used for a different part of the presentation to the students.

Figure 2: AmigoBot, Pioneer, and Nomad 200

There is a set agenda to be covered, on the day of the visit. The agenda differs based on the age group, but the general topics are based on answering a series of questions:

- What are robots, what are they used for and what can they do?
- What we do with robots at Kansas State University?
- What subjects do you study so that you (the student) can work on robots?
- How are robots made and what scientific principles are used?
- How can robots play interactive games and be part of experiments?

As we progress through answering all of the questions, the emphasis is on involving the students, interactively, by touching and directly taking part in the games and experiments. The games and interactive experiments are adjusted based on the age of the target group.

An example of an interactive game is shown in Figure 3. This was a recent visit to a group of elementary school students. One of the experiments conducted for the younger students is called, "Escape the Circle". The experiment is conducted by having the students sit in a circle and leaving a 6 foot gap in one area. The robot is then placed on the other side of the circle, pointing toward the children, sitting on that side, and started. The goal of the game is to see how long it takes the robot to "escape" the circle via the gap. During the escape the robot will use its sonar to differentiate between the gap and the children. The robot will visit many of the children and bounce sound waves off of them to determine if they are the gap or not. As the robot escapes, the children will count the time, in seconds, in unison. The experiment is repeated several times and the time it takes to escape is measured and compared.

Figure 3: Pioneer Robot playing interactive game, "Escape the Circle".

Post Visit Evaluation

The goal of the Post Visit Evaluation is to benefit from the teacher's perspective on ideas to improve the program. We want their direct input on how helpful and appropriate the Pre-visit Workbooks were, the Visit Day experiments, game and presentation and also any other follow up or customization that may have been developed for their particular visit.

Results

Although results are very preliminary, the interest and existing demand for the program indicate initial success. It is difficult to measure the long-term results for this type of outreach program due to the number of factors and variables. We are researching ways of capturing relevant data to measure, over the program's long term application, the success and impact.

Further Work

As the program gains momentum there are multiple concepts we are investigating to reinforce and maximize the overall learning efficiency. A second goal is to create funding streams to place the program on a sustained and permanent basis. Some ideas currently under review are:

1. Development of a RoboCup Junior League. This would allow the more interested students to develop their skills from a very young age. It would also allow each school to create a more permanent instance of our program in their school. This will create an opportunity for the students to travel to regional and national competitions further broadening their horizons.
2. Funding for Lego Mindstorm Robotic Kits that can be loaned to a school for a specified period of time, such as a semester or 9 week period. This would allow the teacher to use the concepts of robotics to reinforce math and science education and give the students opportunities to work over a longer period of time.
3. 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, designs in a more informal setting.
4. Funding to provide a more permanent base for the program and more in depth programs for the students.

Bibliography

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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 cooperative robotics, multi-agent systems, and Enterprise Information Integration. 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 BS in Computer Science from Kansas State University in 1988, MBA in Operations Management from The Ohio State University in 1993, and MSE in Software Engineering from Kansas State University in 2002.

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.

Appendix A

"Robot Roadshow"

Primary School Workbook

The Department of

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GOAL

Generate interest in math, science, computers and robotics through the use of demonstrations, activities and simple interactive experiments.

ROBOTS

Robots are used in many ways. There are toy robots, robots for science, robots for learning, and robots used in everyday life. Some robots are for indoors, some are for outdoors and others can fly or swim. Robots have even been trained to play soccer!

Robots are built using motors, sensors, wheels, legs, wire, computer chips and many other parts. **Sensors** are the "eyes and ears" of the robots. **Motors** drive the **wheels** or **legs** of a robot to allow it to move. **Wires** inside the robots connect all of the parts together. **Computer chips** are the "brains" of the robot and control the sensors, motors, wheels, legs, and all other parts.

Robots at K-State!

At K-State we have robots with names like Pioneer, Amigobot and Scout. We are interested in making robots work together as a team. We experiment with "Search and Rescue" missions to try and find things that are lost. If you got lost, maybe our robots could help find you! Would you like to be found by a robot?

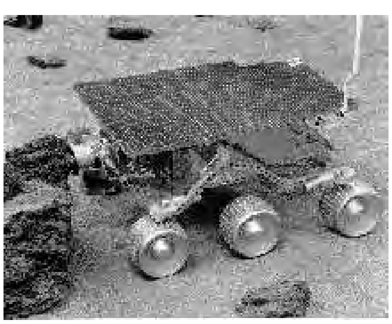
Fun Robot Activities!

Draw your very own robot! Use your imagination to create the robot. Make sure to label all parts of your robot and describe what your robot does.

Word Jumble
Can you unscramble these robot related words: *motor, robot, computer, sonar, brain, arms, wheel, sensor*

- putremoc
- tbroo
- naros
- lewhe
- sornes
- smra
- brina
- omotr

A famous robot: Do you know the name of this famous robot? Why is it famous? (Hint: Look up Mars on the internet?)



Word Find: Find the following robot words:

- sonar, computer, science, brain, wheels, robots, wires, arms, sensor, motor

S	R	U	W	R	A	N	O	S
C	O	M	P	U	T	E	R	E
I	B	K	L	T	M	J	Q	N
E	O	D	N	B	O	M	O	S
N	T	S	S	N	T	P	S	O
C	S	I	M	X	O	E	W	R
E	R	C	R	X	R	Z	Y	B
C	B	R	A	I	N	G	H	F
A	Y	D	W	H	E	E	L	S

Compare: How are these robots different! Write about the differences!

Hexapod Walker II

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