2006

Effects of using educational robotics at the elementary school level

Vega Rishelline Anne Flores

EFFECTS OF USING EDUCATIONAL ROBOTICS AT THE ELEMENTARY SCHOOL LEVEL

A Project

Presented to the

Faculty of

California State University,

San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Education:

Instructional Technology

---

by

Rishelline Anna Flores Vega

June 2006

EFFECTS OF USING EDUCATIONAL ROBOTICS AT THE ELEMENTARY SCHOOL LEVEL

A Project

Presented to the

Faculty of

California State University,

San Bernardino

by

Rishelline Anna Flores Vega

June 2006

Approved by:

[redacted]

Eun-Ok Baek, Ph. D., First Reader — Date: June/6/06

[redacted]

Brian Newberry, Ph. D., Second Reader — Date: 6/9/06

ABSTRACT

Through the use of educational robotics, students can learn new technology and at the same time enhance their skills in various everyday subject areas, including computer skills. The purpose of this research was to find out how educational robotics plays a role in elementary school education. The questions that were answered in this research dealt with the impact, implementation, opportunities, challenges, and the nature of learning with educational robotics. The research involved online interviews of elementary school teachers who currently use robotics in their teaching. Seven teachers were selected across the United States to be interviewed using online messaging software. There were eight questions asked of the seven teachers which related to their experiences in using educational robotics. Discovering the positive and negative sides to using robotics in elementary level education is what took place in this research. There were many sides to using robotics for elementary school children, but the overall result of robotics leaned toward a specific side. It appeared to be that the benefits of educational robotics were more numerous than the negative sides of this type of instructional technology in education.

ACKNOWLEDGMENTS

I want to acknowledge two professors in my master's degree program who have shown so much support and devotion to the students in the program. Both Dr. Eun-Ok Baek and Dr. Brian Newberry have guided me through this challenging Instructional Technology program by sharing their experiences and knowledge with the students. I have learned so much more than I expected to in this master's degree program. I compare other Instructional Technology programs of my peers at other universities, and I honestly believe that the program I am a part of at CSUSB is much more rewarding and academically advanced. Dr. Baek and Dr. Newberry have helped me to learn more about Instructional Technology than I expected to learn, especially in the way to conduct thorough research for a thesis paper. I acknowledge the enormous time, teaching, and support from these two professors. Because of them, I am very confident in the future of my career with Instructional Technology.

DEDICATION

This thesis research paper is dedicated to an awesome role model in my life. This person has taught me so much in life and how to live life to its fullest. Most of all, he is a role model in my career and education because he motivates me to accomplish goals that I could not attain if it weren't for his support. This person is also an advisor and role model in my career and in living life without boundaries because of the many goals he has accomplished in his own career and life. I never thought that one person could hold such a large role in my life and in my future. This person is the love of my life and also my idol. Thank you for your love and support K.A.M.!!!

TABLE OF CONTENTS

ABSTRACT iii

ACKNOWLEDGMENTS iv

LIST OF TABLES vii

CHAPTER ONE: BACKGROUND

Introduction 1

Statement of the Problem 2

Purpose of the Project 2

Research Questions 3

Significance of the Project 4

Limitations 4

Definition of Terms 5

CHAPTER TWO: REVIEW OF THE LITERATURE

Introduction 8

Applications of Robotics 9

Benefits of Robotics 17

Negative Views on Robotics 19

Emphasis on Math 20

Growing Software Technology 20

Summary 21

CHAPTER THREE: METHODOLOGY

Introduction 23

Population Served 24

Data Collection 25

Data Analysis 28

Summary 29

CHAPTER FOUR: RESULTS AND DISCUSSSION

Introduction 32

Presentation of the Findings 33

Discussion of the Findings 53

Summary 60

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

Introduction 61

Conclusions 62

Recommendations 67

Summary 70

APPENDIX A: Interview Questions 71

APPENDIX B: Online Interview with Teacher1 73

APPENDIX C: Robot Creations Using Lego Mindstorm . . 79

REFERENCES 82

LIST OF TABLES

Table 1. Experience in Years of Interviewees 25

Table 2. Cost of Each Robotics Package 55

CHAPTER ONE

BACKGROUND

Introduction

Robotics in education is a young field of instructional technology. Because of this, not too many teachers are familiar with using robotics in elementary education. This research thesis is about using robotics education in instructional technology for elementary school curriculums. Elementary schools that use educational robotics have this learning technology in their curriculum because it enhances collaborative learning. Robotics education involves technology integration of math, science, and other subject areas. Students work together when using robotics in the classroom by solving problems or programming a robot to carry out specific commands. Educational robotics is still young in the field of instructional technology, and with more exposure to educators, administrators, and parents it will grow quickly over time.

Statement of the Problem

There are very few teachers, administrators, and parents who know much about educational robotics. If more of them knew what robotics was and how it plays a role in elementary education, there might be more support for implementing this form of instructional technology in elementary schools. Currently, because of the lack of knowledge in educational robotics and understanding its value in education, there is very little support morally and financially for implementing and maintaining robotics programs in elementary schools. Some educators view robotics as playing with toys and that robotics does not teach young learners anything academically rewarding. With further knowledge in robotics and hands on practice, educators and parents can view how educational robotics is a collaboration tool for students and that it involves using skills in everyday subject areas, along with enhancing technical skills and social skills.

Purpose of the Project

The purpose of the research was to learn more about the uses and benefits of educational robotics in an elementary school curriculum. By informing educators, administrators, and parents of this role, they can support

implementation of robotics programs in various elementary schools throughout the nation.

Research Questions

The research study had a goal of answering four research questions, which are as follows:

- How does educational robotics impact students' learning?
- How are educational robotics implemented in the curriculum?
- What are the opportunities and challenges with using educational robotics?
- What is the nature of learning with educational robotics?

These particular research questions were developed because more information was required of professionals who use educational robotics in elementary schools. With information gathered from these specific educators, an analysis of the qualitative data was performed. The answers to these research questions lead to a better understanding of educational robotics at the elementary school level, and also a detailed analysis of the content acquired from research.

Significance of the Project

The use of computers in educational robotics gives students the chance to work with computers in ways that are more advanced than regular daily computer usage in a classroom. By interviewing current users of educational robotics, this study investigated how useful educational robotics was at the elementary school level. If more educators were aware about educational robotics, then they might implement it in their curriculums. Robotics could aid educators in teaching their students math, science, and computers in a collaborative manner. Collaboration among elementary school students is something that should be improved with the aid of research. Educational robotics research can show teachers and administrators how exciting this technology is for young students, therefore they can better enjoy collaboration in the academic environment.

Limitations

During the research, a number of limitations were expected to occur. The primary limitation is that of a small sample size. Robotics use in elementary schools is quite limited and this made it difficult for the researcher to find a significant number of educators who

use educational robotics. Additionally, because the interviews were conducted online, the researcher may not have been able to use non-verbal cues to help understand the participant's responses and/or to probe a topic more deeply. Another limitation in conducting the online interviews was the time difference. Most of the interviewees were located in other states whereas the researcher was located in California. It took careful planning to make sure both researcher and interviewee were available at a specific time considering the different time zones they were in. Another limitation in this research was the possibility of computer hardware/software failure or internet access failure. This could have been an impediment in the online interview session. Regardless of the limitations, the research on educational robotics was very informative and interesting because of the different backgrounds of the interviewees, and because of their input on educational robotics.

Definition of Terms

The following terms have been defined as they apply to the research on educational robotics:

- Educational robotics: Recent robotics research examining robots aimed at teaching children about the

world. This research includes classes and activities focused on teaching children about robots, but also includes some new projects aimed at using robots to engage children in activities while teaching concepts not easily taught with traditional computers (Druin, 2000).

- Robot: A robot is a machine that can be programmed to do a task. Once programmed it can repeat the task without further programming and it can be programmed to do another task without redesigning the robot (Boone, 2001).
- Instructional Technology: The human innovation in action. According to International Technology Education Association (ITEA), technological studies involve:
    - Designing, developing, and utilizing technological systems
    - Open-ended, problem-based design activities
    - Cognitive, manipulative, and effective learning strategies
    - Applying technological knowledge and processes to real world experiences using up-to-date resources

- Working individually as well as in a team to solve problems

- Collaboration: To work jointly with others or together especially in an intellectual endeavor (Merriam-Webster).
- Lego Mindstorms: According to the Lego website http://www.lego.com, the LEGO MINDSTORMS Robotics Invention System is the core set in a line of technology-based products from the LEGO Company. It is the product of a longstanding relationship with the Massachusetts Institute of Technology (MIT). The Robotics Inventions System enables you to design and program real robots that move, act, and think on their own. With the Robotics Invention System, a person can create everything from a light-sensitive intruder alarm to a robotic rover that can follow a trail, move around obstacles, duck into dark corners and a whole lot more.

CHAPTER TWO

REVIEW OF THE LITERATURE

Introduction

Chapter Two consists of a discussion of the relevant literature. Specifically, it is regarding educational robotics at the elementary school level. There were several articles and a few books that were found on educational robotics. These literary pieces discussed robotics education and how they could enhance the learning experience of young students. The literature review first discussed educational robotics in general and the application of it in elementary education curriculum. The second section of literature showed how educational robotics was a collaboration tool in different ways. The next section discussed how math and science played large roles in learning robotics. The fourth section of the literature review showed how educational robotics benefited the educators, not only the young learners. The last section of the literature review discussed how young learners became motivated from competing in robotics competitions. Since educational robotics is still fairly new in the field of instructional technology compared to other technologies, there were not too many pieces of

literature that the researcher found. In respect to educational robotics, there was enough information in various literature items in order to begin this research and make credible conclusions.

Applications of Robotics

Robotics in Elementary Education

There were pieces of literature that gave a large overview of educational robotics in an introductory manner, along with examples of its usage in elementary schools. A book by Pantelidis (1991) contained information on using educational robotics in many grade levels. This book was helpful in the research process because it contained annotations of over a thousand print and non-print items. Pantelidis' book was mostly an information guide on educational robotics. Burke (2004) gave a summary of various ways robotics was used with Gifted And Talented Education (GATE) students at an elementary school. She gave examples of different projects that the students completed during their robotics classes which were held at lunch time and after school. Druin & Hendler (2000) discussed contributions by leaders in the robotics field. Educators in the book discussed the application of robotics in the education environment

and how it should be a central part of young students' learning experiences.

Implementation of a robotics program may be tricky because educators who are new to robotics may not be confident about how successful the students will be at learning robotics. Especially when working with young children like those in elementary school, the confidence of teachers in starting a robotics program may be low. Mock (2003) said that implementing a robotics program with young children was not as difficult as it sounds. Teachers who believe in the natural abilities of the children can create an excellent program where their students can be successful. As long as teachers and administrators stay focused on their goals in implementation of a robotics program at their school, the program should be successful with the teachers and students in that robotics program.

Jones (2004) wrote an article showing teachers how they can integrate instructional technology into everyday learning. She discussed how language arts, math, and science can be used in cooperation with technology. Educational robotics is a field of instructional technology that uses these everyday subjects along with other subjects in order to enhance the skills students

have in these areas. It seemed that a properly implemented, well-planned and funded robotics program can enhance all areas of the curriculum (Firth, 2003). There are many areas of the elementary school curriculum that benefit from robotics because of the use of various subject areas and skills.

Educational robotics enhances computer skills for everyday schooling. Van Horn (2005) stated that a particular robotics product called Rogue Blue would be useful for a class of students interested in computer programming in BASIC. He downloaded the curriculum guide and found it clear, easy to read, and appropriate for a lab-oriented computer class. Paisley (n.d.) discussed how a robot used in an elementary school's science program taught students about computers and software. The specific project that the article discussed involved programming the robot to go through a maze. The students were intrigued on how the robotic technology was able to carry out the programmed commands.

Cutshall (2003) discussed how robotics was beneficial for young learners and educators. She stated that robotics was a fun and engaging activity that appealed to a diverse range of students who wanted to try their hands at creating their own robot devices. Their teachers liked

to see the young people acquiring hands-on experience in design, construction and problem solving. A particular science teacher in the article said that the benefits for her students included improvement in their logical thinking, creativity, math, and problem solving skills. These benefits of educational robotics, according to Cutshall's article showed how students and educators enjoyed robotics because of the wide range of skills that grew by using this technology, along with the fun of using robotics itself. According to Dworetzky (2003), the best thing about teaching robotics was seeing how the students invented ways to solve given problems. Many teachers agreed that problem solving skills were improved when students worked with robotics.

Roles of Math and Science in Robotics

The role of math and science in educational robotics is strong because of the engineering skills required in this type of instructional technology. Turbak & Berg (2002), provided an example of how the Lego Robotics Design Studio introduced engineering to students at a young age. According to Bastoni (2002), building robotics developed technical literacy…required hard thinking, reasoning and the application of basic science and math principles and concepts. Another article by Capstick-Dale

(2004) discussed Lego's robotics products and how they taught young students more about computers and engineering.

Educational robotics could help a student's knowledge in construction and engineering grow. In a research project by Verner (2004), the author stated the following in regards to robotics as follows:

> Educational robotics relies on core concepts of modern engineering education. Seymour Papert and his adherents developed the concept of constructivism to characterize learning processes in which a learner is involved in the creation of external and sharable artifacts. The learner uses artifacts as 'objects to think with' in order to explore, embody, and share ideas related to the topic of enquiry. In a robotics course, a robot was introduced as 'the object to think with' and the project-based curriculum focused on designing, building and operating autonomous robots. (p. 184)

The constructivist view of education could lead one to believe that educational robotics is a way to learn hands-on with technology and by using current skills knowledge.

Young learners who are lucky to be exposed to engineering at a young age could benefit through higher math and science scores. Engineering is a field that requires advanced skills in math and science. Students enhance these math and science skills in robotics which could result in improved test scores in these subject areas. Cobb (2005) explained how a specific teacher appreciates the robotics program because it helped students learn more about many subject areas in addition to presentation skills. Math and science are only a couple of the many skills related to engineering that students enhance when using educational robotics.

There are a group of teachers who have a robotics program that travels to various schools in rural communities. Matson (2004) discussed how the Robot Roadshow Program was designed to increase the interest of elementary school children in technical disciplines, specifically math and science. The program included pre-visit activities to help the students obtain a basic knowledge of robots followed by a multimedia presentation, which included hands-on experiments with real robots. If more schools were aware of this program, they could be encouraged to implement their own robotics programs at their own schools. The Robot RoadShow Program was a great

idea for exposing students to robotics in a low-cost, small-sized robotics program.

Robotics Competitions for Young Students

Many schools allowed their robotics students to compete in various competitions around the nation. Cameron (2005) discussed how immigrant kids from low income families competed in a robotics competition and won first place. The author said that the students had a wide range of abilities which they discovered they can place into extraordinary use. This showed how robotics can boost the students' skills and self-esteem regardless of the type of home life they came from. A robotics competition organized by Harry Roman (2004) brought elementary school students and teachers together to help physically challenged persons. The competition's purpose was to have the elementary school students and teachers compete in teams to design robots that can aid a physically challenged person in various ways. Roman (2004) stated that the students always impressed the teachers with their designs. This was not surprising because young learners tend to be more creative than adults.

Robotics competitions encouraged students to challenge themselves and accomplish difficult goals. There were various goals at robotics competitions, and

this variety within competitions was another reason why students found robotics enjoyable and challenging. In an article by Cutshall (2003), the author states the following:

> Such events are exciting, competitive and engaging. It may be interesting to watch two robots trying to find one another in a maze or push one another out of a circle. It can be intriguing to see how they can be programmed to follow a line, play hide and seek, or find the brightest light. But what is most amazing of all is actually what stands behind all of these small electronic marvels: motivated students who are excited about learning. (p. 49)

The motivation that students gained from robotics in the classroom was great for learning more about everyday subjects and using various skills. The motivation seemed to be more intense when the students competed in robotics competitions because of the challenges from other students of other schools in completing difficult robotics projects.

Benefits of Robotics

How Educators Benefit

Robotics offers many potential benefits to educators. Teachers feel rewarded because of the way students successfully use current knowledge to apply to their robotics assignments and projects. Wendy Wooten (2002) discussed how a good robotics program is rich in the everyday subject areas, encourages problem solving and critical thinking, and develops self-confidence for students. This can bring more motivation for the teachers to continue working everyday as an educator and also enjoy his or her job. Robotics is exciting and intriguing for teachers because of the challenges involved and the goals accomplished with the students.

Collaboration in Educational Robotics

One of the benefits of educational robotics at the elementary school level is improving collaboration. The pieces of literature that best inform on collaboration were reviewed for this research project. Sklar (2000) discussed how robotics was very valuable for children because of the academic and personal development involved in robotics. The students also learn how to work in a team collaboratively. One of the most valuable pieces of literature in this research was an article by Denis &

Hubert (2001) because it detailed collaborative learning using educational robotics. Problem based learning and working collaboratively in an environment of young students was a great way to encourage the students to work together in a team with their peers in order to solve problems. The design and development of projects to solve problems is what the students do when they use robotics in the classroom.

Students can learn collaboratively in a constructive manner when they use robotics at school. Leete (2001) believed that students learn technical reading, writing, collaboration, and problem solving. Collaborative learning involved collaboration of using various subject areas in robotics and working collaboratively in a team with other students. Collaboration of various subjects and skills is a way to use what students are learning everyday for a hands-on technical project. According to Firth (2003), robotics didn't only offer tremendous learning utility in computer science and math...to keep track of their robotics, students kept a detailed research journal…students had a resulting newfound enthusiasm for writing journals. Young learners definitely use the everyday subjects along with other subject areas and

skills in order to successfully participate in a robotics program.

Negative Views on Robotics

Implementing robotics in an elementary school's curriculum could cost a lot of money. Maintaining the robotics program over time is also costly. For some schools who participate in robotics competitions, they incur even more problems with funding the robotics costs. Cobb (2005), stated that most real-world engineering problems were limited by timeliness, a fixed budget, or technology that prohibited us from thinking too big. Since robotics projects, whether used for competitions or not, took a long time to finish, and there is a lot of money required to carry out robotics programs at schools. For elementary schools, young children tend to lose small pieces more often; therefore cost may be high for replacing missing pieces. Students who live in lower income neighborhoods were at an even larger disadvantage when participating in robotics programs. In Matson's article regarding robotics in underserved elementary schools, he discussed that less money and strained resources have placed a squeeze on the most necessary

equipment and subjects. More work would be involved in trying to get funding for low income elementary schools.

Emphasis on Math

Educational robotics requires a lot of math compared to the other subject areas that are used in robotics. It is possible that students may get intimidated or frustrated with the amount of math and complexity of math usage that is integrated into robotics. According to Cutshall (2003), students may not understand all the math concepts, but they can learn how to make their robot do what they want. During the time that the robotics classes meet in the elementary school day, the teacher should place more emphasis on understanding math concepts so that students to not feel confusion when building and programming their robots.

Growing Software Technology

The fast growing technology of computer software makes it difficult for educators and students to keep up with learning the latest and greatest technology within robotics. There is also the question of whether or not computer software is truly educational because of how quickly they are being developed. The software used for robotics should be educational and without software bugs.

Sklar (2000) discussed how educational software exploded too fast, without enough pedagogy behind the software supporting schools' technology integration decisions. Elementary schools should be careful in selecting robotics equipment including software because it should be educational and thoroughly tested for errors. Developers of software for robotics packages should take several years to create and test before presenting the product to educational institutions.

Summary

The literature important to the project was presented in Chapter Two. These articles and books were beneficial to the research because a historical analysis and analysis of current usage of educational robotics was completed thoroughly. This will help those who are new to educational robotics understand the technology better, and they can learn how it aids in teaching various subjects. Learning about educational robotics in general and specific uses of it in elementary schools was also a valuable aid in conducting the research. The researcher was hoping to find literature that placed more emphasis on the negative side of educational robotics, but was unsuccessful. There were only a few items of literature

that discussed negative aspects of using educational robotics. If more literature was found on the drawbacks of using robotics, the researcher might have been able to make a more accurate analysis and understanding of the specific field of educational robotics. The literature review helped to understand the robotics field in a detailed manner because of the information presented regarding the history, current uses, and future of educational robotics.

CHAPTER THREE

METHODOLOGY

Introduction

There were seven teachers chosen to be interviewed for this research. This research sample was comprised of teachers from various locations around the nation, who have all been using educational robotics with elementary school students for various time lengths. Potential participants were found through internet research on educational robotics and recruited through electronic mail. While a number of potential participants were contacted, only the seven included in this study replied with an interest to be interviewed for the research. It was confirmed that they did have the hardware and software technology in order for them to participate in the online interview. Specific appointment times were scheduled for the online interviews. Overall, the online interviews were interesting because it was not a common way to conduct interviews in research. Also, it involved using computer hardware and software which was beneficial considering that this is research regarding instructional technology.

Population Served

This research used the qualitative design method, and consisted of interviews with seven persons in the field of educational robotics. The interview participants were selected using purposeful sampling. The participants were specifically chosen because of their background and experiences in teaching educational robotics at the elementary school level. Because the field of educational robotics is not too popular yet in instructional technology, there were not too many prospective participants. The teachers who were in the sample group were either found on a website regarding educational robotics or they were referred to the researcher by other teachers in the same field. Approximately twenty prospective participants were sent electronic mail messages to see if they were available and willing to participate in an online interview for this research project. The seven interviewees chosen were willing and able to be interviewed, and had sufficient amounts of knowledge on robotics education at the elementary school level. Also, they each currently use robotics education in their daily teaching. The teachers interviewed for this research have had variable years of experience in working with educational robotics for elementary school children.

Only one of the teachers had a small amount of experience, specifically one year. The teachers had various backgrounds and have used robotics in different ways. Some of the teachers participated or organized robotics competitions, which was very impressive. Table 1 shows the different years of experience in educational robotics of the teachers who were interviewed.

Table 1. Experience in Years of Interviewees

Interviewee	Years Using Educational Robotics
Teacher1	10
Teacher2	unknown ("many years")
Teacher3	13
Teacher4	3
Teacher5	1
Teacher6	3
Teacher7	10

Data Collection

The researcher chose to use a qualitative research method because of the need to interview teachers who use educational robotics. Qualitative research was an effective way to conduct research on robotics for an audience who is not familiar with the technology. Hoepfl (1997) stated that qualitative research has an

interpretive character, aimed at discovering the meaning events have for the individuals who experience them and the interpretations of those meanings by the researcher. Finding out the hands-on experience of the robotics teachers was valuable to this particular research in order for the audience of the research paper to learn about real life experiences. The interviews of the educational robotics teachers were conducted over the internet through online messaging software, such as AOL Instant Messenger and MSN Messaging software, with the interviewees' consent. There were eight questions that the researcher asked the interviewees through online messaging. These questions can be viewed in Appendix A. The interview questions were developed based on the analysis of literature on educational robotics, and reviewed by an expert. The purpose of interviewing seven educators was to have more than one type of input for the interview questions. The questions used in the interview consisted of open-ended questions in order to encourage the interviewee to explain his or her views without any limitations. This was compared to if there was a survey involved which would consist of close-ended questions. Open-ended questions were desirable for the interviews because the interviewee could expand on his or her answers

rather than answering questions with one word responses, or close-ended questions. The questions for the interviews were formulated by researching existing literature on educational robotics. Each teacher in the sample was interviewed only once for the purpose of this research. The interviews were a way to find out more on how robotics is used in elementary education, and also to find out the benefits and barriers of using educational robotics from teachers who have had a lot of exposure to this type of technology.

While preparing for data collection, it came to mind that at least one of the interviewees should be an educator who used educational robotics in his or her curriculum, and later discarded it. Being able to interview someone who used educational robotics and decided that it was not a good idea to use at the elementary school level can be beneficial to the research. The researcher could find out more about the limitations and negative aspects of educational robotics. Based on the analysis of literature and interviews, examples of what might cause an educator to stop using educational robotics were cost, complexity for young learners, time constraints, and finding teachers who are able and willing to teach educational robotics.

Data Analysis

The analysis of the qualitative data was completed by content analysis of the interview questions and answers. Each of the interviews were documented and saved as online messaging files. The analysis began by using the three stages of coding. By using software called HyperResearch, the coding was broken down into different parts and analyzed by separating information into categories. The trustworthiness of the qualitative data was tested by using member checking. Lincoln and Guba (1985) stated that member checking was a process through which respondents verify data and the interpretations thereof. This involved sending the interview transcripts to each of the interviewees so they can correct or clarify any text that is incorrect. There was a possibility of recording information incorrectly if there was a problem with the software used for online messaging. Also, if there was an interruption of internet access, the online interview transcript might have been affected. Although, there were no internet interruptions during any of the online interviews. The qualitative data was also reviewed by the researcher's peers. This involved having the peers review the transcripts and also briefly analyzing the data. The two persons selected for assisting in the data analysis

were two graduates of a Master's Degree in Educational Technology from another university in California. By conducting peer reviews, the researcher was able to obtain other analyses of the data in case she inadvertently made a mistake in the initial data analysis. If the content analyses of the two peer reviews had been inconsistent with the original content analysis of the researcher, another peer would have been asked to analyze the qualitative data. A third peer review was not needed for the content analysis of the interviews in this research.

Summary

This research was unique compared to other research projects because of the fact that the interviews were conducted online. In a way, this research involved a miniature research within it to see the effectiveness of online interviewing. The methodology involving online interviewing was exciting because it required the use of computer technology, and not traditional face-to-face interviewing with a tape recorder. There were negative sides to conducting online interviews such as the lack of being able to read someone else's mannerisms or facial expressions as they discussed specific topics regarding educational robotics. Conducting the interviews via

online means made it possible to interview participants in different parts of the country, however the time zone differences were another negative aspect of online interviewing. Another potential problem with using online interviewing was the reliance on text for communication. One person being interviewed said she was not fast at typing, therefore she felt pressured to type fast and with minimum errors. This can cause a feeling of being rushed to answer the interview questions. To help counteract this, the researcher did specify to "take your time answering the questions and with typing your responses". Another interviewee mentioned she could not spell correctly. The researcher found this interesting being that the interviewee was an experienced teacher. But not being able to spell correctly might also cause pressure when answering online interview questions. One of the positive aspects of online interviewing was the convenience of not having to drive to a particular location on the part of the researcher or interviewee. Another positive side to online interviewing was that the researcher could simply save the messaging session in the messaging software, or copy and paste the text to a word processing application. This way, the interview was already documented and transcribed. The method of

conducting online interviews was especially beneficial because of the fact that the educational robotics research is part of a broader field called instructional technology, which has to do with using technology as a learning tool in education.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

The results of the findings from the seven online interviews were similar to what the researcher expected. The findings are discussed according to the research questions introduced earlier. Some interviewees were more detailed than others in answering the questions. The number of years in educational robotics experience and the type of experience each interviewee had were beneficial in analyzing different views on educational robotics. The names of the interviewees have been replaced with pseudonyms for the protection of the teachers interviewed.

The interviewees had similar views regarding the impact of educational robotics on learning. This involves the combination of everyday school subjects and technical skills as a way to enhance learning. There were also a couple of teachers who found improvements in specific types of learners and specific subject areas, and this was how robotics impacted learning in their views. Implementation of educational robotics in the elementary school curriculum was done in various ways for the different teachers. In most schools using robotics, the

class is integrated with various subject areas so that the robotics classes tie into what the students learn in the regular classroom. There were many opportunities of robotics that the teachers felt were great for their young learners. These vary from enthusiasm with school experiences for the students and teachers to increases in skills such as problem solving and cognitive thinking. The challenges of using educational robotics in the elementary school varied from funding requirements and fear of robotics technology. Another challenge that was common in the views of the teachers involved time required to start and continue maintaining a robotics program at a school.

Appendix B is the transcription of the online interview with Teacher1. This interview session was added to the appendix as an example of how the interview session was conducted. Only the specific questions and answers related to the research are included in Appendix B.

Presentation of the Findings

Impact of Educational Robotics on Learning

Teacher1 shared why she decided to implement educational robotics at the elementary school level. She was intrigued by a robotics booth at a conference she went

to, and that's where she got the idea to use robotics in the elementary school as a learning tool. Students could use their technical skills, along with math, science, language arts, and problem solving. Teacher1 saw a future in robotics as a great learning tool for the young learner. She thought it might be difficult and confusing in the introduction of robotics to elementary students, but she was confident that they would be more comfortable with robotics after more practice and hands-on experience.

When asked if Teacher3 would continue to use educational robotics, he responded with "absolutely". Teacher3 works with training other teachers on how to use robotics in their curriculum. He believed that robotics was a great way to collaborate various subjects such as math, science, language arts, computer programming, and problem solving. He felt that both gifted students and students with learning disabilities also benefit from robotics, not just general education students.

Teacher3 realized how excited students were with robotics, and also the benefits of the technology and he continued to explore robotics in more depth. Teacher3 was especially impressed with how the ADHD students responded when using robotics. They were better behaved and interested in academics when it came to using robotics.

He did not have as many problems with ADHD students in a robotics lab as he did when they were in a traditional classroom.

When asked why Teacher4 tried implementing educational robotics in his teaching, Teacher4 said that he felt it was a large motivator in regards to his math curriculum when he was a math teacher. The students were grasping math concepts quicker than other math students who have no exposure to robotics. Teacher4 said the first year he implemented robotics in his math class he had the highest math scores in the entire school.

Teacher5 was asked what caused him to implement educational robotics in his teaching. He responded that having an engineering background, he wanted his peers to see what students could do if they had engineering knowledge also. Robotics seemed like a fun and exciting technology to teach to students, which relates to engineering. After Teacher5 first tried teaching robotics, he realized how popular it was with the students and staff.

Teacher6 believed that there were some skills that students lack and robotics can teach the students those particular skills.

Implementation of Educational Robotics in Curriculum

When asked about how educational robotics uses various subject areas, Teacher1 said that there is a lot of math and language arts usage. She gave an example of how programming a robot to do a particular task could be stated in different math equations and commands. The role science plays in robotics is that students could use Newton's Law for demonstration purposes, and students can learn about simple machines at the same time.

When Teacher2 was asked about what subjects are involved in using robotics, Teacher2 responded by saying that there are too many subjects involved in robotics to go into detail about it. She suggested that the researcher look at her website on robotics for detailed information on its uses in education.

According to Teacher3, with regard to language arts, students have to create technical manuals to accompany their robotics projects. Students use their math and computer skills when doing the programming and diagramming part of the robotics projects. Students sometimes create PowerPoint presentations and animation movies on the computer in order to present their robotics projects to others. Teacher3's experience with robotics was an example of how the technology used various subjects.

Jones (2004) said that language arts, math, and science could all be used with technology in order to enhance students' learning.

Teacher3 was happy to see how robotics integrated various subject areas in the curriculum. However, Teacher3 was still surprised that many of his peers in other school districts did not incorporate robotics more into their curriculums.

According to Teacher4, the various subjects that he used in robotics were language arts, math, and science. Language arts was used in robotics when the students were required to write a proposal to fund the robotics projects. Computer applications skills were used also because the students had to include spreadsheets and diagrams in their proposals. Math was used in robotics when the students had to translate the movement of the robot. Science played a role in robotics because of the use of physics.

According to Teacher5, the everyday subjects that robotics uses was mostly math. They also use language arts when it was time to write the programs. Then, science came into the picture when it was time to work on the design process of making the robot do whatever task the robot should be able to do.

Teacher6 discussed how the everyday subjects that students used when working with robotics were math, language arts, and science. Students used math by measuring how far a certain speed would take them and also the power they set on the robots. In regards to language arts, the students had to make individual and group journals on their progress in their robotics projects. Teacher6 had her students use Blackboard in order to respond to detailed questions regarding their robotics projects. This required good computer application skills also. Science was used in robotics through the inquiry method. When the students had a problem, they discussed what needed to happen and brainstormed ideas. Problem solving skills were also important when using robotics.

Teacher6 thought robotics was fun for both the teacher and the students. Learning is more enjoyable when a teacher uses robotics to teach a curriculum.

Teacher7 was asked about the everyday subjects used in robotics. The everyday subjects at school that have been used when students work with educational robotics were science, math, engineering, technology, data acquisition/analysis, problem solving, logic, algorithmic thinking, teamwork, technical writing/drawing/speaking, building, design, and creativity.

Opportunities for Using Educational Robotics

Teacher1 plans to continue the usage of robotics in her teaching for several reasons. She believed that robotics offered benefits such as teaching the students applied physics skills that were necessary in today's work force, and also programming aids in enhancing logic skills. She believed that every project should be followed through because every project that was started had a result. She thought that students do not get this kind of structure in their home lives or at school.

Teacher1 said that educational robotics provided a better understanding of how the mechanics work. There is also a better understanding of the principles taught when working with robotics. She believed that this learning tool was a hands-on method of instruction that is necessary for many of today's students. Teacher1 said she enjoyed viewing the excitement in the young students when they are working with robotics. One of the interesting things that Teacher1 noticed was that even her female students enjoyed learning with robotics, and they really became involved. This was interesting to the researcher also, being a woman working with technology, because of all the stereotypes that females have little interest in technical areas or that they do not excel in technology.

Teacher1 also believed that students needed the problem solving skills involved in robotics, and this learning tool has proven itself in increasing problem solving skills on students' test scores.

In general, the staff at the school Teacher1 works at was excited about robotics as part of the curriculum. Some of the teachers borrowed Teacher1's Lego equipment for math and science lessons. She has also completed training for the teachers in using the Lego robotics system. The principal at Teacher1's school was so impressed with the success of the robotics classes that the principal sent Teacher1 to other schools and school districts in surrounding cities and states in order to demonstrate how robotics plays a role in elementary education.

According to Teacher2, one of the positive results was learning about the following specific fields: energy, Spanish, math, space, geography, and transportation. The students showed a high interest in the direction of future education, relevance of robotics, and hands-on practice in robotics.

Teacher2's perceptions of how the young learners view robotics were that they think it's great.

Teacher3 believed that the positive result of using robotics was that students got more hands-on experience with technology, and they really enjoyed it. The students were so motivated that they wanted to read more and learn more about robotics.

Many of Teacher3's peers were amazed at what the kids made out of their Lego projects, and they were impressed with how easy it was to learn the programming.

Teacher3 said that the students enjoyed robotics a lot. Because of changes at the school, some classes had reduced time using robotics. Students and parents were disappointed about this because they rather have more robotics time instead of less robotics time. Teacher3 said that most students came in to school to work on their robotics projects outside of the regular school time like after school or on weekends.

Overall, the numerous benefits of educational robotics gave Teacher3 the reason for continuing to implement robotics in his teaching.

The positive result of educational robotics, according to Teacher4, was having a budget to work with. The students used problem solving skills and math skills to stay within their budget, therefore the students were learning how to manage money correctly.

Teacher4 believed that his peers' attitudes on robotics were that they are impressed by it, more than other technology that Teacher4 used at the school. The attitudes of the students toward robotics were that they are anxious to use the technology. They ask their regular classroom teachers if they could work on their robotics projects if they finished their general education work in other subjects.

Teacher5 said that the robotics students felt like they "fit in" to something in the academic environment. The always looked forward to going to the robotics class because they were enthusiastic about robotics.

The attitudes of Teacher5's peers were that they supported the robotics program completely. His peers attended his competitions in order to support him and the robotics students.

One of the positive results of using educational robotics in Teacher6's teaching was that the students gained excellent problem solving skills and higher order thinking skills. Enhancing skills in math, language arts, and science were the other positive results. Teacher6' perception about her peers' attitudes toward educational robotics was that the science teachers specifically supported it.

Teacher7 said that a positive aspect of robotics was that it allowed for multiple solutions and creative solutions to problems. She said that young students needed a teacher that would lead them without knowing where exactly they would end up.

Teacher7 believed that the requirement to work in a team became a positive result of robotics because of the teamwork skills that were learned by the students.

Teacher7's students thought that robotics was very fun. It used a high level of technology, it was interesting, and robotics was also exciting. The students got really excited for the annual robotics summer camp that Teacher7 organized, because they were able to focus on robotics entirely.

When asked about what caused her to try implementing educational robotics in her teaching, Teacher7 said that she could see the educational benefits.

Challenges of Using Educational Robotics

One negative aspect of educational robotics in Teacher1's view was that inventory was difficult because of all the small pieces involved in the robotics kits. The small pieces would get lost or broken, but not too many because she said she was strict about keeping all the robotics pieces where they should be.

There are several barriers with educational robotics that can limit the teachers' usage of robotics in teaching. Teacher1 discussed four particular barriers in robotics. The first one dealt with cost because robotics equipment is somewhat expensive. Because of budget cuts and limits in spending, schools cannot easily afford to implement robotics technology at their schools. A second barrier in educational robotics was that many of the robotics kits have very small parts. These numerous small pieces can easily get lost, misplaced, or stolen by students or staff. A third barrier to robotics was that many teachers were afraid of learning computer programming software. The teachers were intimated by using programming skills in order to be able to successfully use robotics. Computer programming software can be difficult to comprehend and apply, but with a lot of practice it will become easier to use. The fourth barrier in educational robotics was that many elementary level teachers did not have all the background and experience required to teach robotics. This technology involves applied physics, math, robotics technology, computer programming, and being a detailed person. This technology also involves technical literacy, which according to Bastoni (2002), requires hard thinking, reasoning, and

applying science and math. Teacher1 said that she encountered teachers who were very much afraid of learning all of these new areas of study. She believed that often it was the terminology used in robotics that was intimidating. Teacher1 felt that teachers who grew up in a country type of environment, like where Teacher1 works, know the science principles and unfortunately lack the terminology. However, Teacher1 said that after an introductory course in applied physics, many teachers felt comfortable enough to begin teaching the concepts required to do robotics.

Teacher2 said that a minor negative result of educational robotics was that teachers at the schools she worked at believed that there was never enough time to complete robotic projects and lessons. Teachers should not be afraid because according to Mock (2003), implementing a robotics program with young children is not as difficult as it sounds.

Most of her peers were as enthusiastic as herself. Although, some teachers that have been required to do robotics were slow to come around.

There were barriers that Teacher2 felt may keep others from using educational robotics: money, time, patience, and the fear of looking silly.

According to Teacher3, the negative result of robotics was that parents did not understand robotics well, and therefore were not excited about their children using it.

Teacher3 felt that some teachers thought Lego's robotics system was not serious learning material. Also, teachers were intimidated by technology in general such as computers, robotics, and programming languages. They were afraid to learn new technology. The biggest barrier Teacher3 thought was that teachers were afraid of being asked questions regarding robotics by the students, and not being able to answer those questions. Teacher3 stated, "I try to stress with them that with a constructivist method of teaching, that doesn't matter, but still it pushes their comfort level because they don't feel they have enough science training."

The negative side of educational robotics was the amount of money it costs to implement and maintain a robotics program at a school. The initial cost of a robotics program was where a lot of funds are required.

There were a few barriers in educational robotics. Teacher4 said that the main barrier was funding for a robotics program. Managing the students with so many small robotics parts was another barrier. Because of

this, Teacher4 allowed only a few students to work on the robots at a time.

According to Teacher5, there were a few negative sides to using educational robotics. One of the negative aspects was that it was sometimes difficult to keep the students on track because they would get too anxious to get through their robotics assignments and projects. Each student had a specific role in a robotics project, and some students would automatically try to do the other students' roles. This was not fair for all the students in the robotics class. Another negative side was that some students had trouble working in a team because they felt that they work faster individually.

Teacher5 said that there were a few teachers who thought of robotics as playing with toys and not educational. Another challenge to having a robotics program was that there was a waiting list of students who were trying to get into Teacher5's robotics classes. Unfortunately, the budget was not large enough for Teacher5 to have more students in his classes or have more robotics classes available to students.

There are a few barriers that teachers may come across if they want to use robotics at their schools. One of the barriers is that teachers would have to take the

time and money to learn the programming language used in robotics. The teachers would have to teach the students that particular programming language. Another drawback to robotics is the extra time on weekends or after school for competitions and extra work on the robotics projects. A barrier to robotics that is common is money because robotics technology is costly, especially in the startup of it. There should be enough robots for the students to work on their robotics projects in teams. A lot of robots would definitely cost a lot of money.

Teacher6 believed that the negative side of educational robotics was that some students did not work well with other particular students. Teacher6 found this to be a bigger problem among the gifted students.

Teacher6 shared that other teachers thought robotics was a big game, and they did not see how students could learn with robotics technology.

Teacher6 also discussed how the greatest barrier to educational robotics was money. Teacher6 would prefer having more robots in her classes for students to work on. Because of the amount of funding required for a robotics program at a school, the principal and district office did not see how important it was to have more robots for the students to work on. Administration told Teacher6 that

robotics should be more of an after-school program, rather than a regular class during regular school hours. Another barrier to having a robotics program at a school was that some teachers were not aggressive about learning new technology. Some teachers also did not like the feeling of students being more advanced in technology than the teachers themselves. Teacher6 thought that it took a lot of time and dedication to learn robotics thoroughly enough so that she could teach it to young students.

A negative aspect of robotics was that once a young learner has been taught in a constructivist problem or project based manner, it would be difficult for the student to go back to regular read/write/regurgitate methods that teachers usually use with the students.

Teacher7 said another negative side to using robotics was that some students did not like to work in groups with other specific students. The students eventually learned teamwork and that working together was important in lessons in order to accomplish finishing the assignments and projects.

Teacher7's response to the question about the attitudes of her peers in using robotics was that her peers thought it was a "dumb" idea because robots were toys, it did not fit into the curriculum standards,

robotics usage was "playing", and it was also not scholarly. Teacher7 said that these attitudes of teachers who did not use robotics were a major problem because there was very little support from teachers. Teacher7's peers were also against robotics because of the amount of money required to use it in an elementary school.

Teacher7 was asked about the barriers to robotics, and she said that involved time, money, and support. The main barrier to robotics was getting support from administration and other peers. The teachers who did use robotics were receiving less money, less support, and less time. Instead, they were pushed to focus on the everyday subjects such as math, reading, and writing. Performing well on assessments was also an area that the teachers were pushed to focus on, rather than robotics.

Nature of Learning with Educational Robotics

Teacher1 said that her students enjoyed it, especially the students who had trouble with learning in a traditional lecture type classroom environment. Teacher1 said approximately 98% of the students really liked robotics. The students who had problems with using robotics were the ones who had trouble with problem solving. Also, students who had trouble working with a lot of small parts had difficulty with robotics.

Eventually, the students who struggled with robotics in the beginning became used to working with the technology and enjoyed it very much.

Teacher2 was asked about what caused her to start using educational robotics and she said it was the kids she worked with. Having discovered the world of robotics in addition to seeing how young learners enjoyed it was what encouraged her to implement it in her teaching. Seymour Papert is one of Teacher2's idols when it comes to the field of technology in the learning environment. In research done by Verner (2004), there was discussion regarding how Seymour Papert and others developed constructivism to characterize learning processes in which a learner was involved in the creation of external artifacts.

Teacher6's perception about her students' attitudes toward educational robotics was that in the beginning, they did not think they could learn with Lego equipment. At the end of the school year, the students realized they learned a lot about robotics and other subject areas.

Teacher7 believed that educational robotics was a great way to collaborate various subjects and disciplines. She also believed that students showed that they were engaged in learning when it came to using robotics.

Teacher7 thought robotics was a great combination of hardware, software, electronics, problem solving, and teamwork.

Teacher7 said that students were engaged with the problem they were solving because they were designing their own solutions along with building and constructing working models. They were creating their own solutions. There was room for flexibility and creativity in robotics. The robotics models that the students made involved many different levels of thinking because they were touching and manipulating. Teacher7 believed that these solutions would stay in the students' minds and make higher level connections than only pencil and paper or by reading a book. She said that the connections between the computer programs and the actual actions of the robot were similar to the same thinking that it took to learn a second language, or read and play music. Teacher7 wanted her students to grow and experience engineering because using robotics would expand their minds and prepare them for the future.

Teacher7 also thought that project based, problem based lessons with real world applications were most meaningful. Teacher7 believed that performance assessments were as important as, if not more than,

written assessments. With performance assessments, problems can have multiple solutions. Teacher7 did not believe that students should be taught there is only one right answer, and students should be taught what they need to know in order to pass assessments.

Discussion of the Findings

The findings of the online interviews will be discussed in this section of Chapter 4. The teachers all plan on continuing to use robotics in their teaching because of the benefits involved for the young learners. These teachers found teaching robotics fun and enjoyable for themselves also. Part of this is because of the challenges involved, and accomplishing those challenges with the students has been a great feeling for them. The teachers seemed to hope educational robotics will continue to grow at a faster rate so that many more students can learn in a collaborative and constructive manner using robotics in everyday learning.

The collaboration of students and of various subjects is expected when using robotics. The teachers believed that many everyday school subjects are used in educational robotics. These subjects include math, language arts, and science. The other subject areas that were enhanced when

learning with robotics were engineering, computer skills, typing, presentation skills, working in a team, and problem solving. Integrating educational robotics into the curriculum created a more exciting learning environment that involved various experiences and levels of knowledge. Druin & Hendler (2000) discussed that the richer the curriculum, the more points of intersection, the more connections constructed, the deeper the meaning. Intertwining various subject areas from a classroom and a computer lab create a learning experience for young students that increases their knowledge and understanding of subject areas that are state mandated for them to learn. Because robotics involves using various subject areas, the students benefit greatly from working on robotics assignments and projects.

There were several positive and negative results of using educational robotics. The teachers discussed a wide range of positive and negative results, and it appeared to be that the positive results were more abundant than the negative results. A common negative result that teachers stressed was the amount of money required to implement and maintain a robotics program at a school. A comparison of costs for robotics packages are shown in Table 2.

Table 2. Cost of Each Robotics Package

Source	Cost
Orchard Elementary School	$240
ORTOP	$350
Lego Mindstorms	$250
CSIRO Education	$145-$195
NexTag	$200

The common positive results of robotics were similar among the interviewees. One of these was being able to use various skills academically and socially in order to work as a team to carry out the robotics assignments and projects. Another positive result that the teachers mentioned was the students' excitement in learning by using robotics. Using robotics in education for elementary school children can benefit those students who have a difficult time in the classroom. Druin & Hendler (2000) believed that building robots was a way to reach out to children who had difficulty learning in traditional ways. The young learners showed so much enthusiasm, dedication, and motivation when they worked on the robots. A negative result of using robotics, which a couple of teachers stated, dealt with the difficulty of keeping control of inventory. With many small pieces in a robotics package, items could get lost or stolen. The

results of using educational robotics leaned toward the idea that robotics was beneficial in the learning environment for elementary school students.

The teachers shared their perspectives on what the attitudes were of their peers when it came to teaching robotics. The teachers who were interviewed perceived that the other teachers and administration felt that robotics was only a toy and had no educational value. They thought that the students did not really learn, and instead they only played with robot toys. Another attitude was that implementing a robotics program was a waste of time and money because so much time and money was required in order to carry out a robotics program at a school. This issue of time and money contributed to the negative assumption that students only played with the robot toys. The teachers that were interviewed felt that the robotics program at their schools did not get the amount of support they would like from the teachers and administration who did not work with educational robotics.

The perspectives of the teachers who were interviewed on the students' attitudes of robotics were very positive. The students enjoyed working with the robotics technology, and they looked forward to their robotics classes. The students were able to use many other skills

besides skills in everyday subjects in order to successfully complete robotics assignments and project. Some students found working in a team was fun, and others took a while to become comfortable with working in a team. The collaboration and technology learned in robotics was great for the young learners because of the types of instructional technology involved. Denis & Hubert (2001) stated that instructional design concepts were used in an educational setting based on a collaborative and problem based learning environment. Eventually, the collaborative teamwork and the collaboration of using various skills and knowledge were what made robotics fun for the students.

The barriers that the teachers discussed involved a few things that related to the perspectives of other teachers and administration on robotics. The main barrier was the cost of a robotics program. Implementation of a robotics program was where a large amount of money was needed. Money was still needed in order to maintain a robotics program such as replacement parts or buying additional robots for more students who are added to a robotics class. Money was also needed for those schools that had students competing in robotics competitions. This can possibly be taken care of by having fundraisers geared toward educational robotics programs at the

individual schools. Much of the cost of educational robotics was keeping up to date with the technology involved in the robotics programs. Sklar (2000) stated that computer software and hardware became obsolete every 30 months, too swift a change for most schools to handle economically. It was obvious that money would need to be consistently available to elementary schools in order to maintain their robotics equipment.

Other barriers involved the lack of support from teachers and administrators who did not use robotics. They had a lot of complaints and negative views on robotics programs at the schools. If these specific teachers and administrators took the time to really observe and participate in a robotics class, they would realize the many benefits of robotics in the academic environment. Another barrier to educational robotics was the fear that teachers had of learning advanced technology, and also the fear of students knowing more about technology than the teachers themselves. The teachers who were interviewed felt that these barriers would diminish over time as robotics becomes more popular in school districts around the nation.

The interviewed teachers began implementation of robotics at their schools because of exposure they

received from other teachers and non-teachers. These robotics teachers saw the benefits that young learners had if they used robotics at school. The teachers have had exposure to robotics in general, and realized how fun it would be for students to use various skills, academic and social, in learning robotics. The teachers did not regret anything about implementing robotics at their schools because of the great outcomes on the students that educational robotics had.

The teachers interviewed used a variety of robotics packages. The most common robotics package used among elementary school teachers, according to the interviewees and literature review, was Lego Mindstorms. Appendix C contains pictures of robots that users of Lego Mindstorms can create. These particular pictures in Appendix C were samples of robots that elementary school students created and modified.

Even though the researcher hoped to have one interviewee who used educational robotics and later discarded it, none of the interviewees felt that the robotics program should be removed from the school. The teachers interviewed had mostly positive things to say about robotics, and planned to continue using robotics with hopes that the program would grow within their own

schools and other schools. Since the teachers who were interviewed felt so strongly about the benefits of using educational robotics at the elementary schools they work at, the researcher was unsuccessful in finding a teacher who did not like the robotics program enough to discard it.

Summary

The findings of the online interviews in this research were what the researcher expected them to be. The benefits were more abundant than the barriers and negative sides of robotics. Discovering the various views on educational robotics from teachers of different backgrounds and experiences was intriguing for the researcher. Because of the positive views and input of the teachers who were interviewed, the researcher is anxious to implement a robotics program at the school she works at, and continue future research. There were a few barriers to conducting online interviews with teachers who were out of state. For future online interviews, maybe a video conferencing type of interview would be desirable. Overall, the online interviews were successful in terms of the amount of useful information received from the interviewees.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

Introduction

Included in Chapter Five is a presentation of the conclusions as a result of completing the research of educational robotics. The conclusions made on this research were based on the results of the literature review and interviews with robotics teachers. Thanks to all the teachers interviewed, the researcher learned to have better knowledge and insight into the field of educational robotics for young students. There were different aspects and sides of educational robotics that were both expected and not expected from the research work completed. The time and effort involved in the research on robotics and its role in elementary education taught the researcher a lot of information so that further research into educational robotics could be planned. Further, the recommendations extracted from the research are presented. Lastly, the Chapter concludes with a summary.

Conclusions

The results of the online interviews led to specific conclusions for the research. The conclusions extracted from the research are as follows:

1. Educational robotics is a collaboration tool combining several subject areas, and also a collaboration of young learners working in a team to solve problems.
2. Educational robotics is a fun learning tool to aid the student in absorbing everyday subject areas which are required in nationwide curriculums.
3. Educational robotics has some barriers and negative aspects to it, although the positive aspects of using this type of instructional technology are greater.
4. The research questions presented earlier were clearly answered through the literature review and interviews presented earlier in this paper.

Educational robotics impacts young students' learning by becoming a motivating learning tool. Young learners in elementary school are using many academic and social skills when they work with robotics. These students are improving in test scores because of the fact that they are

applying many skills to their robotics assignments and projects. The teachers who were interviewed believed that confidence and motivation were what aided the students and teachers to start using educational robotics, and continue using that learning tool. The impact of robotics on the various everyday subjects was beneficial to the student because it gave the student different ways to understand and enjoy learning the everyday subjects in school. The collaboration of various subjects had a positive impact on the students' way of learning.

The implementation of educational robotics can be accomplished in different ways. Through the research completed, the researcher discovered that robotics can be part of a school's curriculum as an after-school program, a class offered during regular school hours, a class offered only to gifted and advanced students, or part of computer lab class at elementary schools. Implementing a robotics program at an elementary school requires the staff to have a sufficient understanding of the engineering and time involved in teaching a robotics program. Besides knowing everyday subject areas, teachers who were interviewed stressed the importance of being motivated to learn more technology in order to teach the students what they needed to know in a robotics program.

A drawback to the implementation of a robotics program at a school is the large, initial cost and the cost to maintain a robotics program. Another drawback is the patience of teachers to learn and use different areas of computer technology and science.

The opportunities and challenges with using educational robotics were evident in Chapter 4 of this thesis paper. The teachers who were interviewed shared the many opportunities and challenges they encountered with educational robotics. The teachers also said that robotics helped students understand the everyday subjects more efficiently and in an exciting way. Improvements on test scores was one way the teachers were able to see the benefits of robotics.

Some of the challenges with educational robotics were related to time, money, and fear of technology. According to the teachers interviewed, these three areas of challenges with robotics were common in the teachers' experiences. Robotics programs require a lot of money to implement and maintain. A lot of time was required for teachers to learn robotics in order to be able to teach it. Also, time outside of the classroom would be required in order to work on the robotics projects and to participate in competitions. Some teachers are afraid of

technology and this can lead to not having enough teachers who are willing to teach robotics in the elementary schools. Another challenge with robotics is that some students do not enjoy working in groups with other students because of social issues. Robotics should encourage collaboration among students, not only collaboration of various subject areas. Hopefully, more students will learn to overcome their problems of working with their peers. Because the amount of opportunities is greater than the challenges, educational robotics is beneficial for young learners at the elementary school level. They acquire more knowledge in general, along with enhancing their current knowledge and skills in the academic environment.

The nature of learning with educational robotics is having the teachers and students in a technical lab environment. This is typically a computer lab at the school. The students learn by working in teams to solve problems such as trying to make their robots perform specific tasks. This is aside from trying to build the robot from scratch and programming it. The use of everyday subjects plays a large role in completing robotics assignments and projects. There is a lot of writing or typing when it comes to documenting all your

work when working with robots. Presentation skills are also used, if not developed, when using robotics because the robot assignments and projects have to be presented to others. The teachers who were interviewed believe that robotics in the elementary school was a fun learning tool for the children. Using different disciplines to aid the children in learning was a good motivator. A subject area that elementary school students usually do not use, engineering, was introduced in the schools when they started using robotics. One of the teachers thought it was great that the students learned about project based and problem based lessons because of the robotics projects that the students worked on. The nature of learning with robotics is being able to use knowledge of everyday subjects along with computer technology in order to make learning more enjoyable and effective for young learners.

Through this research, learning more about the importance of educational robotics in a learning environment for young children has increased for the researcher. Hopefully, others will also learn and discover more about educational robotics as a result of reading this thesis on educational robotics research. The benefits and barriers of educational robotics programs in schools showed how an elementary school administration can

take steps to implementing a robotics program at their schools. The results of the students' motivation and test scores can give administrators, teachers, and parents the proof that educational robotics is a great learning tool for young students.

Recommendations

The following recommendations resulted from the research completed in regards to educational robotics:

1. Research should be continued by the researcher into a hands-on robotics research project for further investigation into educational robotics at the elementary school level.
2. More elementary schools nationwide should implement educational robotics, and plan to get funding for the costly program.
3. There should be more instructional technology conferences offering classes and detailed information on implementing and using educational robotics at the elementary school level.
4. There should be educational robotics classes offered in the education departments of universities and colleges nationwide.

The researcher plans to continue this research by taking part in a hands-on robotics research project, specifically for elementary school students. By doing so, the researcher can gain more proof that educational robotics is beneficial as a learning tool for young students. A problem with conducting this type of research is the money it will cost to carry out the project. Hopefully, the researcher can get research funding from an instructional technology organization or university.

There should be more elementary schools nationwide implementing robotics into their curriculums. Finding the money to implement robotics at a school will be difficult, but if educators can convince administration of the benefits to young learners then funding may be easier to obtain. When teachers, administrators, and parents see the positive outcomes of having their young learners use educational robotics, they can invest more money in the robotics program at the school. In the future, the researcher is confident that the field of educational robotics will continue to grow throughout schools.

The researcher attended a couple of instructional technology conferences recently, and had never seen anything on educational robotics. The organizations that hold annual conferences should encourage educational

robotics by offering seminars and having vendor booths that relate to robotics. If educational robotics was more publicized in the broad field of instructional technology, then more schools would implement a robotics program in their curriculums. The purpose of having instructional technology conferences is to increase growth in the field so that students can learn in an enjoyable and motivating manner. With motivation, young students learn quicker and use their many academic and social skills productively.

Universities and colleges should offer educational robotics classes in their education departments. If college students in education programs have exposure to robotics while completing their teaching credential, then they can learn the benefits of robotics. By being aware of the benefits of robotics and learning how to use it, prospective teachers can utilize this type of instructional technology to teach young students in elementary school. Maybe one day, the researcher of this thesis paper will become a teacher educating other teachers on how to use robotics as a learning tool for students.

Summary

Chapter Five reviewed the conclusions extracted from the thesis research that was completed. The recommendations derived from the project were presented. This research thesis on educational robotics taught the researcher more knowledge about the field. Those who read this research paper will also gain knowledge about how robotics can play a major role in enhancing a young learners skills in academics and socially. The collaboration involved in educational robotics is a highlight of using this type of instructional technology. The students enjoy using robotics most of all, which is important because it shows that they are motivated to learn more and use their numerous skills in order to solve problems in a team environment. Educational robotics is a growing field within instructional technology, and the researcher hopes to play a significant role in the field by conducting future research.

APPENDIX A

Interview Questions

1. How long have you been using educational robotics, and what has your experience with robotics been?

2. Will you continue to use educational robotics in your teaching? Why or why not?

3. What everyday subjects at the school have been used when students work with educational robotics, and in what ways are these particular subjects affected?

4. What are the positive results of using educational robotics with your students? Are there any negative results?

5. What are your perceptions about the attitudes your peers have about using educational robotics?

6. What are your perceptions about the attitudes your students have about learning with educational robotics?

7. What are the barriers that you are aware of that might keep others from using educational robotics in their teaching?

8. What caused you to try implementing educational robotics in your teaching?

APPENDIX B

Online Interview with Teacher1

Researcher: How long have you been using educational robotics, and what has your experience with robotics been?

Teacher1: I have been using educational robotics for approximately 10 years. We did not have any kind of simple machines/applied physics programs in our school years ago. I found that Lego Dacta had a kit that I could use to teach simple machines, add a motor and simulate a machine - robotics. I still use Lego in my classroom in 6th grade, 7th grade, and 8th grade at different levels. I'll give you more information about that if you want. I also have two different robotic arms in my classroom in a module. Students learn the various parts of a robotic arm and then program these to do different operations.

Researcher: Will you continue to use educational robotics in your teaching? Why or why not?

Teacher1: Yes I will continue to use robotics in my teaching. I think teaching robotics not only teaches the simple machine/applied physics skills so necessary in today's manufacturing work force, but the programming and logic is so necessary for our students. For every beginning there is an end and a result for every action. Mr. Rogers' neighborhood was the only television show produced in which he had follow-through with everything he

did. Most students don't have this kind of structure in their home lives or at school.

Researcher: What everyday subjects at the school have been used when students work with educational robotics, and in what ways are these particular subjects affected?

Teacher1: We often use the robotics in math to teach math concepts. For example - 1st class lever. Load x distance of the load arm = resistance x distance to the resistance. (That can be stated many different ways.) After teaching this with robotics, students can be taken to the playground where they calculate where they might sit on a teeter-totter in relation to another student. In science, students can use robotics to demonstrate Newton's laws and learn simple machines.

Researcher: What are the positive results of using educational robotics with your students? Are there any negative results?

Teacher1: It provides a better understanding of how the mechanics work - a better understanding of the principles taught. It is a hands-on method of instruction that is so necessary for many of today's students. Students are excited to learn in such a manner. Even my female students enjoy learning this way and really get involved. Students need the problem solving involved with robotics. We have

seen an increase with our problem-solving scores on tests. Negative - with the kits that have small pieces, inventory is sometimes a hassle. Pieces get broken or lost. Not many, though. I run a pretty tight ship.

Researcher: What are your perceptions about the attitudes your peers have about using educational robotics?

Teacher1: Many of my peers actually borrow my equipment. The 6th grade math and science teachers use the Legos often for instruction. Some of the teachers have actually asked for individualized instruction themselves. My teachers were so excited when I began using robotics that my principal sent me to other schools to demonstrate how they were used. I then began going to various school districts across Kansas, Nebraska, Oklahoma, and Missouri giving instruction.

Researcher: What are your perceptions about the attitudes your students have about learning with educational robotics?

Teacher1: Most of them love it…especially those who struggle with lecture-type instruction. Those who struggle with problem-solving or have never "played" with very small parts often frown upon it at first. I'd guess 98% of all students like the approach.

Researcher: What are the barriers that you are aware of

that might keep others from using educational robotics in their teaching?

Teacher1: 1) Many robotic kits are expensive. 2) Many kits have very small pieces. 3) Many teachers are not familiar with robotic / applied physics principles and therefore, lack the instruction themselves that is necessary to provide even adequate instruction. Many I have encountered are actually scared to tackle it. I have found that often it is terminology that is the problem. Teachers who were raised in the country, especially, often know the principles but lack the terminology and therefore don't think they understand it. However, after a small introductory course, many teachers feel comfortable enough to begin teaching these concepts. 4) Many teachers are scared of programming (when it is involved).

Researcher: What caused you to try implementing educational robotics in your teaching?

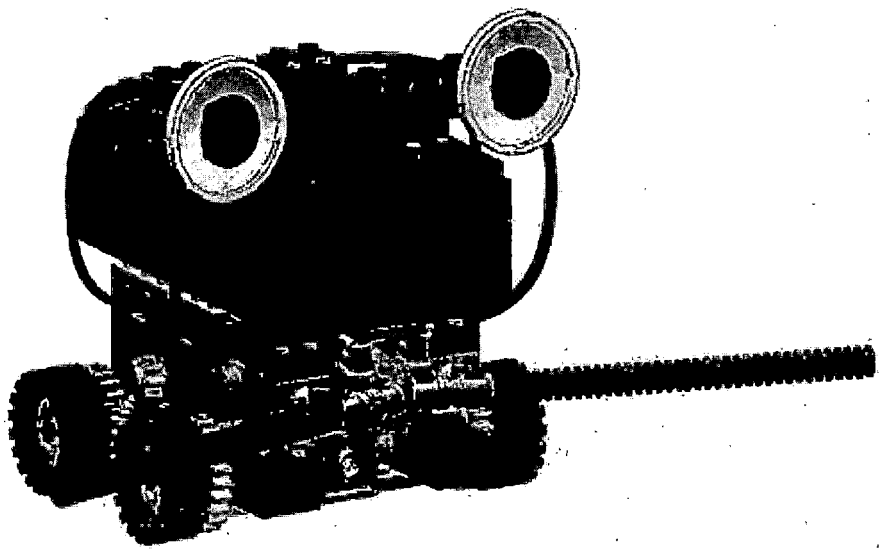
Teacher1: After receiving a small packet of gears and axles as a sample at a booth at a conference, I knew that I didn't know much about gearing ratios, etc. and knew that in my school's curriculum it was not being taught anywhere. I realized that using even this small packet I could teach ratios, gearing up and down, etc. Coming from a computer programming background I then saw that after

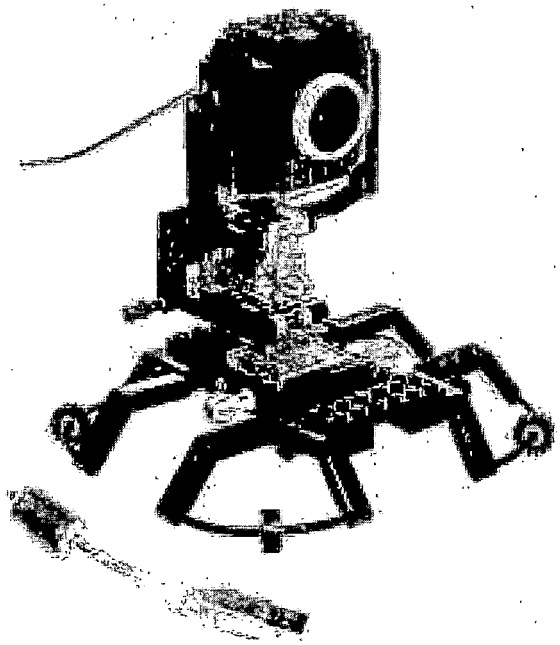
building a simulation of a machine, with the right software, students could put their machines in action. I know that a logical order of steps in crucial for a program and many students struggle with sequence, order, and problem solving. Robotics teaches so much!

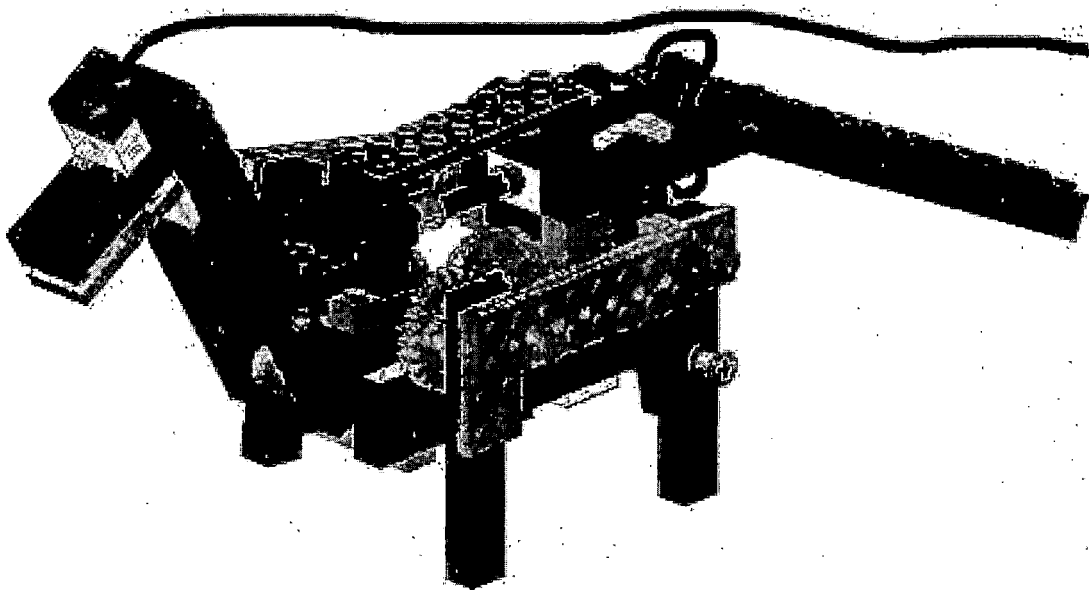
APPENDIX C

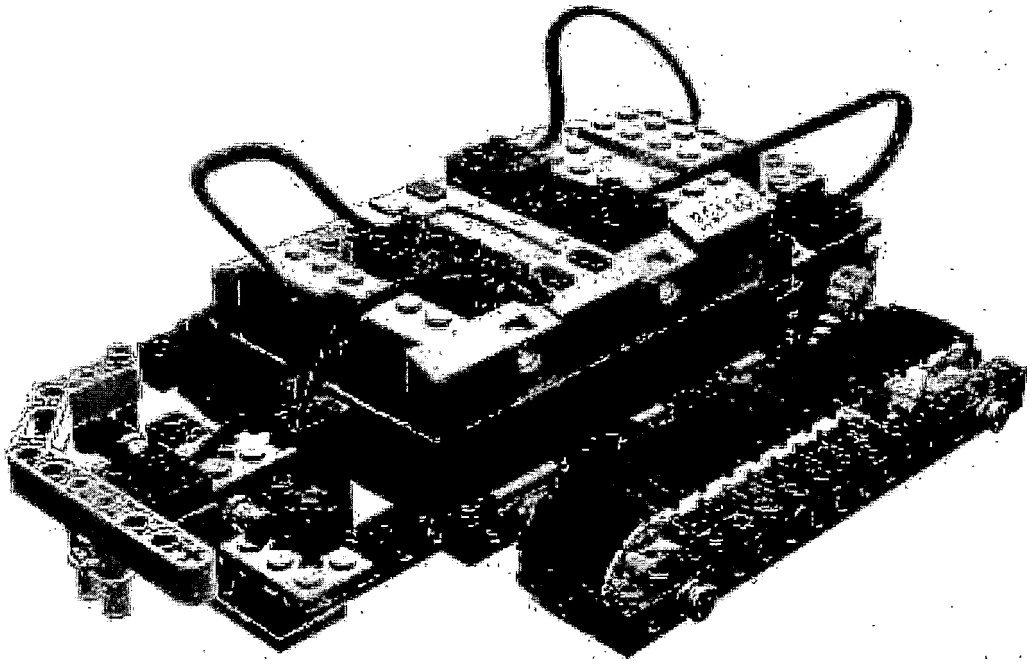
Robot Creations Using Lego Mindstorms

These are pictures of robots that are used as robotics projects for elementary school students. These images were retrieved from http://www.roboticslearning.com/examples/robots.html









REFERENCES

Bastoni, M. (2002). *An interview with Michael Bastoni.* Retrieved September 17, 2005, from http://www.imagiverse.org/interviews/michaelbastoni/michael bastoni 06 08 02.htm

Boone, K. (March 2001). The organic robot. *Circuit Cellar.* Retrieved February 16, 2005, from http://users.aol.com/TheOrganicRobot/Organic.pdf

Burke, K. (2004, September 3). Reading, writing and robots: What we did at school today. *Sydney Morning Herald.* Retrieved January 20, 2005, from http://www.smh.com.au

Cameron, A. (2005). Robots rule. *NEA Today, 24*(2), 64.

Capstick-Dale, S. (2004). *Children learn how to program robots using Lego pieces.* Retrieved January 20, 2005, from http://www.capetimes.co.za

Cobb, C. (2005). Robots recruit tomorrow's engineers. *The Technology Teacher, 64*(4), 19-21.

CSIRO Education. (n.d.). Retrieved August 30, 2005, from http://www.csiro.au/melbcsirosec/programs/robotics.html

Cutshall, S. (2003). Why go robo? *Techniques, 78*(8), 34-49.

Denis, B. & Hubert, S. (2001). Collaborative learning in an educational robotics environment. *Computer in Human Behavior,* 17, 465-480.

Druin, A. & Hendler, J. (2000). *Robots for kids: Exploring new technologies for learning.* San Francisco, CA: Morgan Kaufmann Publishers.

Dworetezky, S. (2003). *An interview with Steven Dworetzky.* Retrieved September 17, 2005, from http://www.imagiverse.org/interviews/stevendworetzky/steven dworetzky 19 08 03.htm

Firth, J. (2003). *Elizabeth Rummel brings robotics lab to life!* Retrieved March 3, 2005, from http://www.schoolnet.ca/nis-rei/e/enews/2003-09/integration.asp

Hoepfl, M. (1997). *Choosing qualitative research: A primer for technology education researchers.* Retrieved March 29, 2006, from http://scholar.lib.vt.edu/ejournals/JTE/v9n1/hoepfl.html

International Technology Education Association (ITEA). (n.d.). Retrieved February 16, 2005, from http://www.iteaconnect.org/A1.html

Jones, K. (2004). Ideas for integrating technology education into everyday learning. *Technology and Children, 9*(1), 19-20.

Leete, B. (2001). *Hands-on applied physics along with computer-controlled robotics.* Retrieved June 3, 2005, from http://www.4teachers.org/testimony/bleete/index.shtml

Lego. (n.d.). Retrieved January 30, 2005, from http://www.lego.com/eng/service/faqs.asp?section=ConsumerService-FAQ-Products&catid=E8D0CD47-16B8-4B2F-900C-8FC40C163598&faqid=1528

Lego Education. (n.d.). Retrieved January 21, 2005, from http://www.legoeducation.com/sharedimages/resources/Mindstorms Quickstart.pdf

Lego Shop at Home. (n.d.). Retrieved August 30, 2005, from http://shop.lego.com/product.asp?p=8527&cn=55&d=11&t=5

Lincoln, Y. & Guba, E. (1985). *Naturalistic inquiry.* Thousand Oaks, CA: Sage Publications.

Matson, E. & DeLoach, S. (2004). Building interest in math and science for rural and underserved elementary school children using robots. *Journal of STEM Education, 5*(3 & 4), 35-46.

Merriam-Webster Online. (n.d.). Retrieved February 16, 2005, from http://www.m-w.com/dictionary

Mock, M. (2003). *Robotics in the elementary and preschool classroom.* Retrieved July 20, 2005, from http://www.imagiverse.org/activities/robotics/mer/elem/

NexTag. (n.d.). Retrieved August 30, 2005, from http://www.nextag.com/lego-robotics/search-html

Orchard Schools PTO Minutes. (2002). Retrieved August 30, 2005, from http://orchard.sbschools.net/pto/minutes11-11-02.htm

Oregon Robotics Tournament and Outreach Program. (n.d.). Retrieved August 30, 2005, from http://www.ortop.org/FAQ.html

Paisley, J. (n.d.). *Reading, writing and robots?* Retrieved January 20, 2005, from http://www.Researchert.com/news/news_02.html

Pantelidis, V. S. (1991). *Robotics in education: An information guide*. Lanham, MD: Scarecrow Press.

Putz, S. (2004). *Robotics learning - sample robot models*. Retrieved March 4, 2005, from http://www.roboticslearning.com/examples/robots.html

Roman, H. (2004). Robot design challenge. *The Technology Teacher, 64*(1), 9-10.

Sklar, E. I. (2000). *Children learning from team robotics - RoboCup Junior 2000 educational report*. Retrieved January 20, 2005, from http://demo.cs.brandeis.edu/papers/rcj2000.pdf

Turbak, F. & Berg, R. (2002). Robotic design studio: Exploring the big ideas of engineering in a liberal arts environment. *Journal of Science Education and Technology, 11*(3), 237-253. Retrieved January 22, 2005, from ERIC database.

Van Horn, R. (2005). Marvelous toys and educational robots. *Phi Delta Kappan, 86*(5), 408-409.

Verner, I. & Ahlgren, D. (2004). Conceptualising educational approaches in introductory robotics. *International Journal of Electrical Engineering Education, 41*(3), 183-201.

Wooten W. (2002). An interview with Wendy Wooten. Retrieved Septebmer 17, 2005, from http://www.imagiverse.org/interviews/wendywooten/wendy_wooten_02_09_02.htm