Wireless Robot

Dr. Asad Yousuf, Savannah State University
Mr. Jarvis Brewer T, Savannah State University
Dr. Mohamad A. Mustafa, Savannah State University

Mohamad Mustafa is a professor of Civil Engineering Technology at Savannah State University (SSU). He has six years of industrial experience prior to teaching at SSU. He received his B.S., M.S., and Ph.D. in Civil Engineering from Wayne State University in Detroit, Michigan.

Mr. Alberto G De La Cruz, Savannah State University
Faraz Muhammad Yousuf, 3D Imaging Developer

Yousuf is a graduate of Savannah Christian High School and will be attending the Georgia Institute of Technology (Georgia Tech) this fall as an Electrical and Computer Engineering major. Yousuf specializes in basic computer programming, website design, computer graphics design, file mapping, and various other basic component of computers. Yousuf has attended various engineering seminars at Georgia Tech. and NASA, received the ”Best in Festival” award at the International Student Media Festival for website design, and was an intern at the local IT company Speros. During this wireless robot project, Yousuf was asked to create a 3D drawing of the with approximate dimensions. Using Solidworks, the 3D CAD drawing was completed in the duration of two days.

Engaging High School and Engineering Technology Students: An Outreach Program Based on a Wireless Robot Platform

Abstract

If we aim to enhance the interest of students in Electrical Engineering Technology and therefore produce the best engineers, it is essential to strengthen the pipeline to high school education. This paper discusses Wireless Robot activity undertaken by three college students and a high school student, to help the transition between high school and Electrical Engineering Technology education and to make students aware of the Electrical Engineering Technology/ Electrical Engineering profession. The wireless robot activity demands an interdisciplinary approach, connects to hands-on concepts, and promotes collaborative project-based learning (PBL). This paper will discuss Project Based Learning which includes creation of Embedded System based on Basic Stamp2 Parallax Microcontroller to wirelessly control the BOE-BOT'S movements through PC using the Easy Bluetooth Module and the design/development of the base model for the wireless robot using the 3D simulation software called Solid Works. Electrical Engineering Technology students connect with high school student through the sharing of designing and building of wireless robot project. This activity enables the high school student to promote students' awareness of Electrical Engineering Technology and how the concepts learned in this project can relate to the engineering concepts. For the Electrical Engineering Technology students, they are provided with a meaningful context within which to share their projects and explain their own understanding of Electrical Engineering Technology principles

Introduction

Electrical Engineering Technology/Electrical Engineering is one of the few disciplines that high school students are unlikely to have exposure with, whether in school or through their own experiences. If our objective is to enhance the interest of students in Electrical Engineering Technology/Electrical Engineering then it is essential to strengthen the pipeline to high school education. Strengthening the engineering career decision-making can happen in several ways through high school Science, Technology, Engineering and Mathematics (STEM) courses, by providing career counseling, and through the guidance of parents [1]. It is important to reach out to high school students to inform them about engineering concepts and how they connect to the math and science they are learning in high school. Career talks that guide high school students through the career path of an engineer, including the skills, education, and motivations involved are another facet of the outreach process. In addition, it is vital to provide a Project Based Learning in Electrical Engineering Technology/Electrical Engineering that builds on high school math and science and provides students with a strong view of the nature of engineering[2]. This paper builds on this knowledge and presents a Project Based Learning which includes creation of Embedded System based on Basic Stamp2 Parallax Microcontroller to wirelessly control the BOE-BOT'S movements through PC using the Easy Bluetooth Module and the design/development of the base model for the wireless robot using the 3D simulation software called Solid Works. The outreach program promotes electrical engineering technology concepts through a high school student. Furthermore, the student from high school disseminate the information to a wide range of high school students, increasing the pool of students who will be both prepared for and interested in an electrical engineering technology/electrical engineering career. Furthermore, the program both draws on and builds on the expertise of current Electrical Engineering Technology students at the university as an aspect of their project-based learning (PBL) program.

This paper will present design of embedded system based on Basic Stamp2 Parallax Microcontroller to wirelessly control the movement of the Robot. Wireless robot will be housed in a case. The case is designed using 3D modeling software, SolidWorks. The wireless robot can be used to automate the process of performing tasks in unsafe environment where human presence is risky. Through this automation it is hoped we perform task in robust manner which will be harmless to the humans. The paper describes the following:

- Physical Overview
- Hardware and Software Design
- Student Outreach
- Conclusion

Physical Overview

Over the past few years, we have seen numerous changes in the microprocessor and microcontroller market. Motorola stopped the development of its popular 8-bit 68HC11 microcontroller for approximately 10 years. With these advancements in technology, modern system design requires the use of advanced microcontroller chips and tools. Several new companies have emerged in the microcontroller market to meet the complex design requirements. A PIC microcontroller is a single chip computer that is commonly found in everyday products such as microwave ovens, cell phones, alarm clocks, etc. If the device consists of push buttons and displays, chances are it also contains a programmable microcontroller[3]. The PIC is a popular, inexpensive single chip microcontroller for a low powered, complex embedded system. A design project by enlarge is focused on developing a product that is robust, reliable, and economical. Keeping this in mind, our project team decided to incorporate Parallax Inc.'s BASIC Stamp2 module, in the wireless robot project. This compact BASIC Stamp2 module plugs into Parallax Inc.'s board of education carrier board[4]. The basic BOE-BOT was used as a base model for the wireless robot. The Boe-Bot robot is a Basic Stamp 2 microcontroller integrated with a circuit board (board of education) which allow for multiple functions to be performed using the PBASIC (parallax beginners all-purpose instruction code) programing language. The components that are needed for the Boe-Bot to function are held together by the chassis, which is the aluminum frame of the Boe-Bot[5]. The board of education, servo motors, wheels, and tail wheel ball are all connected to the chassis. The chassis could be considered as the body of the robot that supports the brain (microcontroller) and the legs (wheels). The board of education is the hub for technical and electrical components, such as the microcontroller and built in bread board. The bread board is where circuits can be integrated and used to increase the Boe-Bot's functions. The board also contained two servo headers which are connectors that bring power, ground and I/O (input/output) pin access together and servos can be easily plugged in while housed underneath the chassis. The visible physical features of the Boe-Bot are the Board of education, which sits above the chassis connected to four standoffs. The chassis itself which includes two plastic machined wheels, one on each side, on the front end, and a tail wheel ball attached to the rear end using a cotter pin.Figure1 (a) shows the Boe-Bot robot. Figure 1(b) shows the non-visible features of the Boe-Bot which includes the servo motors as well as the battery pack.

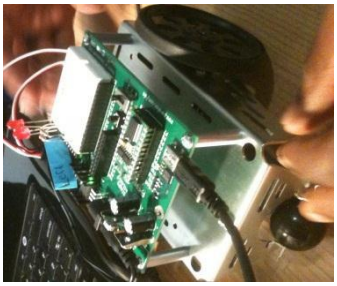

Figure 1(a)

Figure 1(b)

Hardware and Software Design

Typically, development tools needed for the microcontroller can be divided into two different groups: software and hardware. Software tools include assemblers, compilers, program editors, debuggers, simulators, communication programs, and systems integration environments to implement solutions. In the wireless robot project, the BASIC Stamp2 microcontroller is interfaced to the BASIC Stamp2 Editor software, which is used to write programs that the BASIC Stamp2 module will run. The software is also used to communicate with Easy Bluetooth Module. The BASIC Stamp2 Editor is free software, and the two easiest ways to get it are:

• Download from the Internet. Search for "BASIC Stamp2 Windows Editor Version 2.0" on www.parallax.com, the Parallax Web site.
• Included on the Parallax CD.

Hardware and software control architectures were designed to control the wireless robot. Assigned by the faculty, the project team was composed of three electronics engineering technology students and a high school student. College students were responsible for the hardware and software design/development of the embedded system. The high school student was assigned the task of case design using 3D Solid Works software. During the early execution stage, the students handled the mechanical design portion of the project. The electronic concepts, which included interfacing and programming of the microcontroller, were followed and the students programmed the wireless robot in BASIC Stamp2 programming language. Students also kept a record of their progress in their individual notebooks, including design ideas and sketches, along with issues faced and their solutions. The hardware section of the wireless robot uses the PIC16C57 microcontroller. The microcontroller is programmed in BASIC Stamp2 programming language to control the wireless robot system. The case for the wireless robot system was designed by the high school student using the 3D modeling software called solid works[6].

The role of control electronics was to create a clean interface between the wireless robot and the BASIC Stamp2 programming language to wirelessly control the BOE-BOT'S movements through PC using the Easy Bluetooth Module[7]. The block diagram of the hardware and software interface is shown in Figure 2.0.

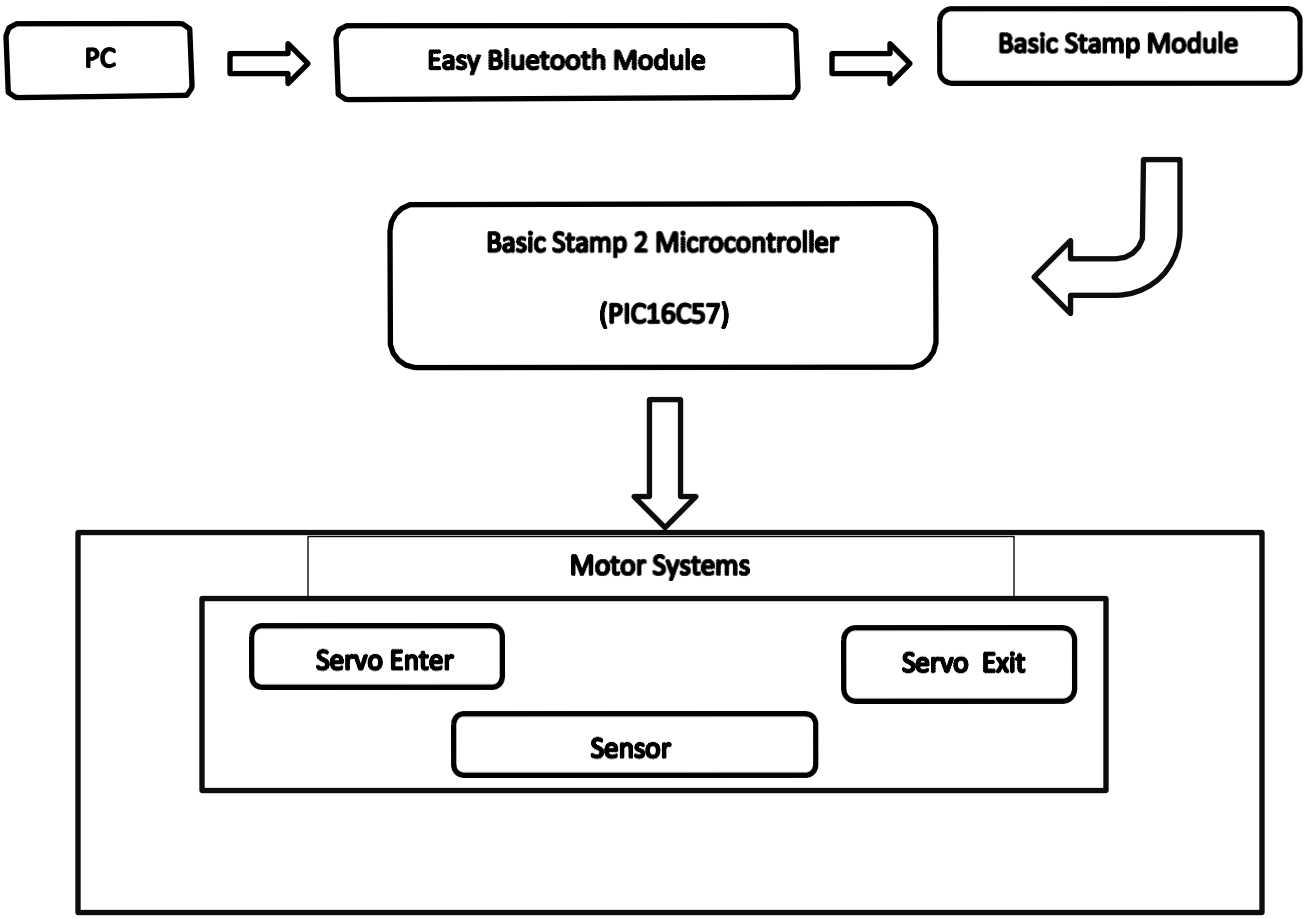

Figure 2.0: Block Diagram of the Hardware and Software Interface

The wireless robot circuit is built by plugging the components into small holes called sockets on the prototyping area. This prototyping area has black sockets along the top left. The black sockets along the top have these labels above them: Vdd, Vin, and Vss. These are called power terminals, and they are used to supply power to the parking garage circuits. The black sockets on the left have labels like P0, P1, up through P15. These sockets are connected to the BASIC Stamp2 module's input and output pins. The software developed is downloaded to the board of education via a serial or USB cable. The integration of the hardware and the software produces an integrated embedded system, which controls the wireless robot.

The challenge of this project was to take those signal transmitted through the USB cable and send them instead wirelessly using Bluetooth technology. Figure 2 illustrates how signal are sent to and from the microcontroller and what they are used for. To replace the USB cable as the medium of communications students designed a program that utilizes the SERIN and SEROUT commands of the PBASIC language. These commands take the role of sending and receiving the serial data. To establish connection wirelessly, the Easy Bluetooth Module must be inserted into the Board of Education. Using the wireless adapter (external component) the Boe-Bot was paired to the laptop entering the predetermined pairing code. Developing a program that utilizes this connection can be done with multiple methods; one way is to declare PULSOUT durations as constants at the start of the program and incorporate them using subroutines and mapping them to the keypad using the Else…If command. This method can be used not only to control the basic Boe-Bot movements but also other components connected to the Board of Education including the LEDs and the Piezospeaker. Student explored the program designed by Jessica Uelmen, which was designed to control the four basic maneuvers of the Boe-Bot.

Project team had to declare more PULSOUT duration constants for the program as the ones included were only used for full speed motion. Upgrading the program required creating new subroutines for the added maneuvers and mapping them to different buttons and entering values that adjust the diagram to display the new directions that are entered. The newly develop program also implemented a circuit which caused the LEDs to emit light and for the speaker to play a high or low pitch. The custom program contained nine additional buttons:

Input	Output
Q	Veer Left
E	Veer Right
Z	Pivot Back Left
C	Pivot Back Right
T	Left LED emit light for ½ second
I	Right LED emit light for ½ second
B	Both LEDs emit light for ½ second
H	Speaker plays High pitch
L	Speaker plays Low pitch

Design of the Wireless Robot Case

The electronic equipment is housed in a case. The case is designed using 3D modeling software, SolidWorks. After the design is complete, the manufacturing process (rapid prototyping) came next. Files must be formatted in sterolithography (STL) to be compatible with the printer software (Catalyst EX) for rapid prototyping. The Dimension SST 1200es (3D printer) was used to create the three dimensional physical model to test the design of the case. The case is made from a durable acrylonitrile butadiene styrene (ABS) plastic. Following is the focus of design:

1. Develop the embedded System:
    Program the parallax BS2 Rev J microcontroller
    Interface the parallax Easy Bluetooth Module to the microcontroller
2. Designing and manufacture (Rapid Prototyping) a model (Figure 3) of the wireless robot using 3D Solid Modeling software package.
3. Assemble parts

The 3D modeling software called SolidWorks was used to design and assemble the cover case for the electronic assembly of the wireless robot. SolidWorks is 3D parametric solid modeling design software. Its purpose is to create 3D mechanical design, simulation, tooling creation, and design communication that help the designer cost-effectively take advantage of a Digital Prototyping workflow to design and build better products in less time.

In this Stage five task were identified. Figure 4.0 shows the 3D-Solid Modeling Design and Manufacturing Process.

1. Learn SolidWorks Software and in particular parametric design.
2. Determine dimensions of discovery board and robot frame to constrain the parametric design of the case.
3. Design locking mechanism of the case.
4. Manufacture a sample of the constrained parametric design for testing purpose.
5. If unsatisfactory results are obtained go back to step 2

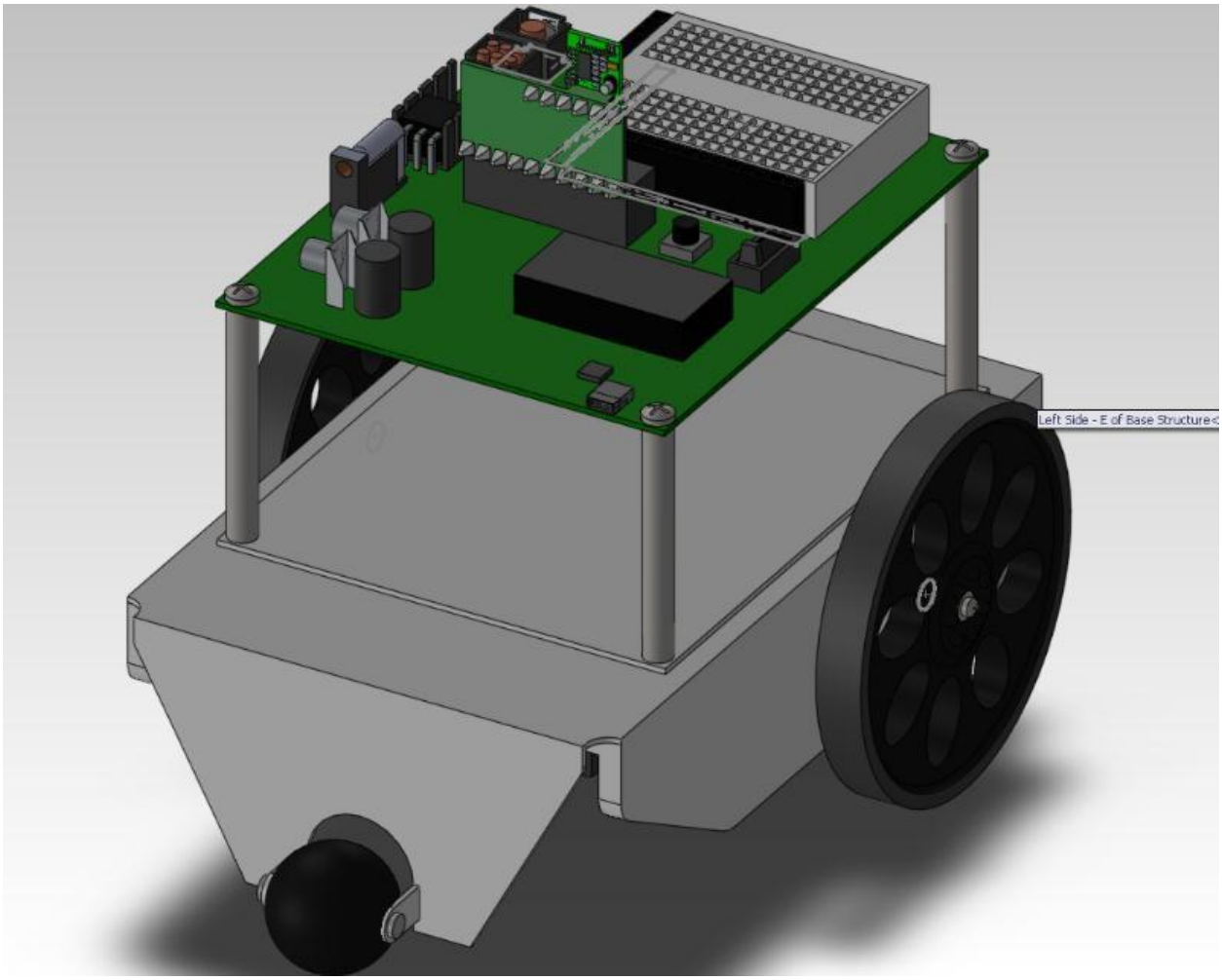

Figure 3.0 3D Model of the Wireless Robot

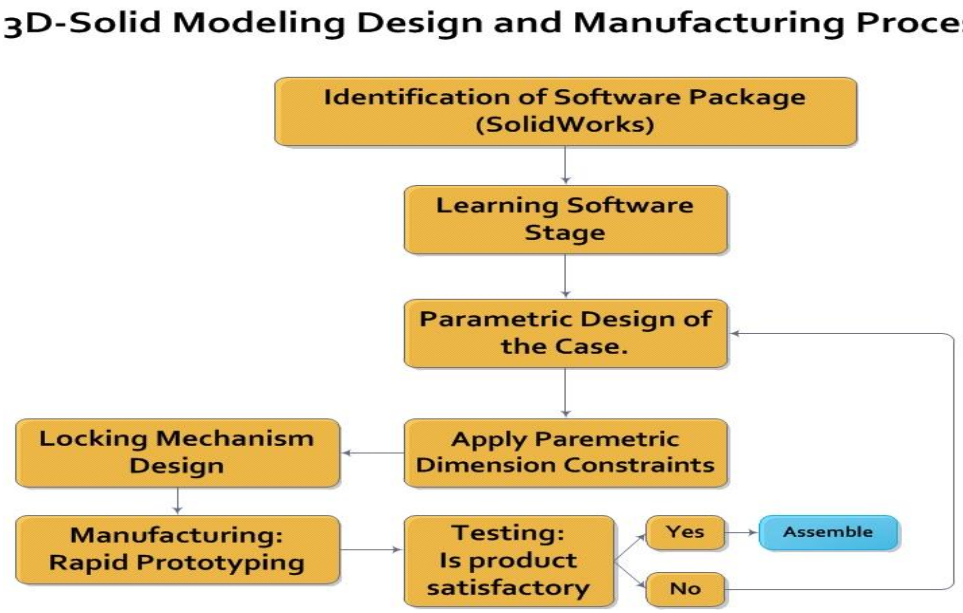

Figure 4.0: 3D-Solid Modeling Design and Manufacturing Process

The integration of the hardware and the software produces an integrated embedded system, which controls the wireless robot. The wireless robot focused on important learning concepts such as physical layout, electronics, programming, and cross disciplinary interaction. The physical layout symbolizes the interrelationship between various substructures of the wireless robot. This includes an understanding of components and the manner in which all these components function together as a deterministic whole system. Basic components, such as 3D modeling with SolidWorks and electronics, which include microcontrollers, and Easy Bluetooth Module, are the major components of the wireless robot system. Integrating these components offered an opportunity for the student to understand the design/development of wireless robot system.

The goal of this project based learning program was to exemplify the impact of hardware and software design in embedded system products. Significant trends were measured from the wireless robot system, which included 3D modeling, electronics, programming, and student interaction with the faculty. The results show that the student learned tangible lessons from each topic.

Student Outreach

The wireless robot offered an opportunity for students to work with others in their class whom they had never worked with. Wireless robot focused on important learning concepts such as Mechanics, Electronics, Programming, Teamwork, and cross disciplinary interaction. Mechanics symbolize the interrelationship between various substructures of the robot. This includes an understanding of mechanical components and the manner in which all these components function together as a deterministic whole system. Basic mechanisms such as servos motors, chassis and electronics which include microcontrollers, sensors and Easy Bluetooth module for wireless control. Integrating these components offered an opportunity for the students to understand the design/development of the wireless robot.

Wireless robot carried out the concept of teamwork in all phases of design and implementation. The goal of linking the students into a learning community is to give the student a peer group in

which they feel comfortable[8]. The team work prepares the students to solve technical problems in a group environment in addition to meet new challenges encountered in the work place. Students gain experience being on successful teams to understand and appreciate the values of good team work. Wireless robot emphasizes on the word team because team is not same a group. The term group implies a somewhat more than a collection of individuals but the team implies much more.

College students in conjunction with the high school student delivered a series of enrichment presentation to the area high school to promote interest not only in Electrical Engineering Technology/Electrical Engineering but also in STEM disciplines. . The main objective of the enrichment presentations was to provide education to early high school students about engineering and to show them that it may be a feasible career choice. The presentation has been of particular interest to 9-12th grade students. The presentations included discussion, hands-on practical activities, instruction by undergraduate engineering students, high school student and faculty. Presentation mainly focused on robotics and was titled "Wireless Robots". The main objective of the presentation was to highlight Project Based Learning activities that are used in system design. The planned activities allowed the students to focus on learning about sensors, motors, controllers and Easy Bluetooth module to wirelessly control the movements of the robot.

The area high school teaches a course in Computer Aided Design (CAD) in which the students use the 3D modeling software solid works. During the high school presentation of wireless robot students are given assignments to design the 3D model of sensors, motors, controllers, chassis of the robot, breadboard and Easy Bluetooth module.

Program assessment was essentially based on perceived attitude changes, such as whether or not the students developed an interest in STEM disciplines by scheduling for advanced STEM based courses in high school and applying to the university in a STEM related field. All of the high school students participating in the PBL were given a survey at the end of the project and were asked to rate their experience with the PBL. The survey was based on four of the Accreditation Board for Engineering and Technology (ABET) a–k skills[9]. Table 1.0 shows the results of the survey, which rated project activities based on ABET student performance levels and expected outcomes. ABET a–k skills were redefined in terms of student perception of the PBL. Activities were rated on a Likert scale from 1(least-liked) to 5 (most-liked).

Table 1.0: Survey Results of PBL

How do you rate the…	On a scale of 1 to 5
Project helped you to apply current knowledge and adapt to emerging applications of mathematics, science, engineering, and technology.	2.35 (need more project activities)
Project helped to identify, analyze, and solve technical problems.	3.7 (best activity of the PBL)
Project helped to function effectively in teams.	3.2 (working in teams was cool)
Project helped to conduct, analyze, and interpret experiments and apply experimental results to improve processes.	2.26 (more activities are needed)

Conclusion

This paper described the design and implementation of a wireless robot. This activity has served as a reference for providing students with challenging and exciting hardware and software design experiences that involved various fields of mechanical, electrical, and physical layout design concepts. The wireless robot provided an excellent opportunity for both the faculty and students to work in an application-oriented environment. It was not trivial to simplify the project so that high school students could benefit from the work of the college students, and it was a positive experience at the high school level, as well as a great motivator for the high school students. Our overall message was to take an application perspective in considering ways to improve STEM education and to create interest in STEM disciplines.

Future Plans

The future plans of the project are to recognize, assess, classify, and distribute resources (via a Web site) for STEM educators (grades 9–12) wishing to incorporate hands-on learning into their curriculum to encourage students to pursue careers in these fields. By helping students make connections between STEM subjects and real-world issues, these strategies are likely to enhance student interest in STEM disciplines, improve learning experiences for students, and enhance the skills of STEM educators on the content and application of STEM subjects. A collaborative team of university and high school students will be responsible for design/development of the Web site.

Bibliography

1. C. M. Jagacinski, W. K. Lebold, K. W. Linden, and K. D. Shell, "Factors influencing the choice of an engineering career," *IEEE Trans. Educ.*, vol. E-28, no. 1, pp. 36–42, Feb. 1985.
2. L. Jackson, "Applying virtual technology: A joint project between the University of Queensland and Townsville State High School," Australian Sci. Teachers, vol. J.46, no. 2, pp. 19–22, 2000.
3. Myke Predko, "Programmin and Customizing PICmicro Microcontrollers", McGraw Hill 2000.
4. Lindsay, A., "What's a Microcontroller?" Parallax Inc., 2005. [10] Microchip PIC Microcontrollers, http://www.microchip.com/1010/pline/picmicro/index.htm, accessed Dec 2012.
5. Robotics with BOE-BOT, Parallax, Inc.
6. http://www.solidworks.com/ accessed Dec 2012.
7. http://www.parallax.com/StoreSearchResults/tabid/768/List/0/SortField/4/ProductID/550/Default.aspx?txtSearch=Easy+Blue+tooth+module accessed Dec 2012.
8. "AC 2007-919: Stem-Related K–12 Outreach through High-altitude Balloon Program Collaborations," Claude Kansaku, Oregon Institute of Technology, and Linda Kehr, Klamath County School District Catherine Lanier, Oregon NASA Space Grant Consortium. © American Society for Engineering Education, 2007.
9. http://www.abet.org accessed Dec 2012.
10. Dana Britt Lundell, Jeanne L. Higbee, and Susan Hipp, editors; Robert Copeland, "Building Bridges for Access and Success from High School to College: Proceedings of the Metropolitan Higher Education Consortium's Developmental Education Initiative," Associate Editor, Co-sponsored by General College and the Center for Research on Developmental Education and Urban Literacy, http://www.gen.umn.edu/research/crdeu, accessed Dec 2012.