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Research Article

LOW COST ROBOTIC ARM TRAINER FOR K-12, CIT AND IT STUDENTS

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ABSTRACT

The study aimed to design and build a low-cost robotic arm trainer and learning platform for Senior High School (K-12), Industrial Technology, and Information Technology students of Bulacan State University. The project will help private schools that are catering K-12 program. The survey method of research was used in the study. Comparative market research and survey was also conducted in designing and building the low-cost robotic trainer. The respondents were teachers and instructors of Electronics, Embedded Systems and Information Technology in different private high Schools, Colleges, and Universities. It is a finding that most academic institution has no robotic trainer for their electronics subjects and not ready for the vocational readiness with respect on robotics and automation. The trainer aid students in the various course subjects like Embedded Systems, Capstone, Industrial Electronics, Digital Logic Design, PLC Programming, Basic Automation, Microprocessor Interfacing Techniques, and can even be the platform of Voc-Tech and STEM strands of Senior High School of Department of Education. The factors that constitute the design are its low-cost price, platform adaptation to Outcome-Based Education, ability to learn hardware programming by the students in a not so intricate programming language, adaptation to the open systems of different hardware modules like sensors and actuators, and ability to prepare high school students for robotics engineering course.

KEY WORDS: Microcontroller, Arduino, Actuators, Automation, Atmel, Bootloaders, Embedded Systems, Hardware Interfacing, Programmable Logic Controller, Open Systems Software and Open Systems Hardware.

INTRODUCTION

"Robots excite people of all ages. Their physical behavior often inspires primary and secondary students' interest in computers, science, math, and engineering more broadly." (G. Ayorkor Korsah, Ken Goldberg, March 2013). Currently, robotics even penetrates the Secondary and Tertiary academe in many parts of the world and even in the Philippines. Around the world, nowadays robots are very popular and have entered new and many fields of applications. Robots are not limited anymore to simple toys, but it reaches its simple applications from home to larger and sophisticated industries. It helps people to do many tasks accurately, fast, and easily in the area of various house activities, educational communities, medical institutions, military, commercial and educational entertainment, personal assistance, manufacturing industries, and etcetera.

In recent years, robotics has attracted considerable attention by the academic and the research communities in the Philippines especially the Department of Science and Technology. Robots have also become of greater interest to people with minimal technical skills, hobbyists, young inventors, so there are great need for easier to use, low-cost, and more flexible robot training and building kits systems.

It is not only the primary and secondary schools who has adapted robotics learning but also college students, especially in the Philippines. Few starter kits are commercially available to assist robots' college students, hobbyists, and enthusiasts in designing, building, and programming working robots. Also, current platforms are too expensive and too complicated for students, and only able universities can afford sophisticated high-cost robotics trainer systems. Examples are LEGO, Kinex, Parallax, OWI, NXT, Fanuc, and etcetera. These are all expensive robot brands and imported from other countries and mostly are not user-friendly that the students need to learn a sophisticated programming language to manipulate the robots. Some local brands (e. g. Genesis Robotics, INEX Robotics, RQ Robots) are in the Philippine market, and the price ranges from Php 20,000 to Php 40,000 which is still costly for the average student of a private or a government university.

The main campus of BulSU has expensive robotic arm trainer that can be used in time of their designated laboratory classes. Students' research and experimentation were hindered due to the fear of destroying those high-cost robotic arm trainers. The other existing satellite campuses have no trainers that can enhance the skills of their students. Lack of robotics laboratory facilities also limits the advancement of their learning. Because of both lacking and limited facilities, students' skills are limited to one application only, often neglecting the various and many promising applications in the world of robotics and automation.

Other large universities are offering robotics classes but those are also very costly, and after the sessions, there are no platforms to continue the study, and enhancing more what have learned. Also, only the students from the middle class background can afford the costly projects leaving the unable ones dreaming to have one.

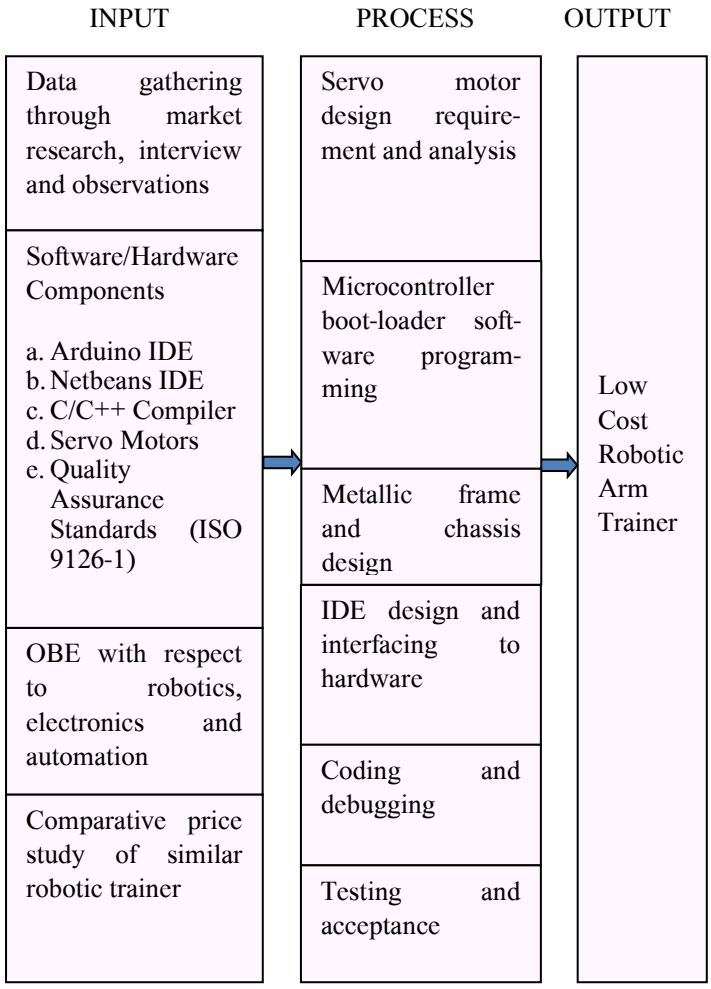
OBJECTIVES OF THE STUDY

The main concern of the project was to provide students a low-cost robotic arm trainer that to be used as a platform in a laboratory that matches their outcome-based syllabus. Lacking robotic platforms that are used by the schools to facilitate robotics learning, the researcher came up with an idea of creating a low-cost robotic arm trainer system that can be afforded even by the poor students individually and can help students to pursue more research and applications development. The researcher will develop free customizable Integrated Development Environment and will use free and open software applications and low-cost affordable microcontroller chips. The robot arm trainer will also be a laboratory platform for students to develop different robotics, automation projects, and microcontroller-based applications. It will also help the students explore their skills in the world of entrepreneurship like building prototypes applications of educational toys and home appliances, and furthermore, students can create prototypes for advanced applications in the field of manufacturing industries, medicine and environment control.

FRAMEWORK

Figure 1 shows the conceptual model of the study. Presented in three separate frames are the input, process and output variables of the study. Frame 1, included in the input variables are data gathering through market research, interview, and observations. Market price comparison of similar works was also done. Outcome-Based Education is the determining factor wherein the research's whole framework was patterned to OBE syllabus of the related subjects. Software and hardware components with free open systems and specifications were also considered. Frame 2 presents the process variables wherein the construction of the robotic arm with standard specification and programming of the microcontroller from embedded points to final debugging of the IDE and microchip boot-loaders. Carefully considering the overall design of Frame one and two, will result in Frame 3 as the Low-Cost Robotic Arm Trainer.

Figure 1: Conceptual Model of the Study



MATERIALS AND METHODS

Method and Techniques

The progress of developing the project will be smooth and easier with a well-defined survey, proper planning, design, and management. Basically, crucial consideration of DEPED K-12 curriculum, resources, and surveys have carried out and considered at the initial stage of the project

conception. The main concerns of the planning of the project are as below:

i. Knowing the period of time provided for completing the project;
ii. OBE survey and analysis with respect on the target curriculum subjects;
iii. Market research procedure;
iv. Defining the amount of resources that are available (economic selection were planned);
v. Determining the hardware and software materials to be used;
vi. Identifying the level and industry standards of building the robotic trainer;
vii. Maintenance process and project testing;
viii. Engineering project standard confinement (in case of any modification)

Respondents of the Study

The respondents included in the study were the heads and members of the Faculty of Electronics, Information Technology, and High School Principals of different Bulacan Private Schools. Hobbyist and Engineers were also selected especially of those with circuit design capabilities. As shown in Table 1, the researcher involved 100% of the respondents to have a valid investigation. Bulacan State University, Living Angels College, Grace Christian Academy of Baliuag, and Baliuag University, each has five member respondents. St. Mary High School of Baliuag, Collegio De Sto. Nico of Bustos, Holy Child Academy, and Notre Christi Academy have individually had four member respondents.

Table 1: Respondents of the Study

Teachers/Faculty/Engineers	Population	Samples	%
1. BulSU	5	5	100
2. St. Mary HS of Baliuag	4	4	100
3. Collegio De Sto. Nico	4	4	100
4. Living Angels College	5	5	100
5. Baliuag University	5	5	100
6. Holy Child Academy	4	4	100
7. Notre Christi Academy	4	4	100
8. Grace Christian Academy	5	5	100
Total	36	36	100

Instrument of the Study

A locally constructed questionnaire used in the project. Before its construction, the researcher made intensive readings of electronic books, hardware and software magazines, educational robotics manufacturers, robotics web forums and related studies to come up with a useful instrument. CHED's STEM and VOC-TECH modules were also considered to cater its learning outcome requirement. The first draft of the instrument presented to three experts and highly qualified engineers in the academe. Their valuable comments and suggestions are useful in improving the draft.

Data Gathering Procedures

Letters requesting the permission to conduct the survey was given to the principals and administrators of different High Schools in Bustos and Baliuag. The respondents provided ample time to accomplish the questionnaires. Close supervision was extended by the researcher in the retrieval of the instruments to obtain one hundred percent return of the questionnaire. Robot Trainer prices, capabilities, and functionalities were also researched and compared through local robots distributors and in the internet.

Data Analysis and Statistical Treatment

Collected data were tallied, tabulated, and organized according to the following headings:

a. Manufacturers, Local and International;
b. Microcontroller Specifications;
c. Functionality;
d. Assembly Features;
e. Compatibility with OBE Syllabus of DepEd and CHED;
f. Availability of Spare Parts;
g. Sensors Inclusion;
h. Accessories;
i. Modularity;
j. Price Range;
k. Audience Target;
l. Software Category

In the survey questionnaires variables, valuable factors were categorized according to the data above. The questions below lead the researcher to design a multifunction robotic arm trainer:

i. What category of characteristics do they want in an educational robotics trainer? (Industrial robot kits, Mobile robot, biologically inspired robots, social interaction, competition based robot kits).
ii. Is it DepEd/CHED recommended? Yes or No
iii. Is it multifunction? (ability to transform and perform many jobs)
iv. Is it easy to be assembled even by a primary schooler? (Assembly level depends on target applications vs. age)
v. Do the spare parts is abundantly ready and available in the local market?
vi. Is the trainer can be extended its application through the sensors? (Sensors adaptability and modular compatibility to real world)
vii. What is the price compare to overall capability of the trainer? (Economy vs. Functionality)
viii. Does it fits the required student's learning outcomes, and able to expand beyond that learning?
ix. Is it programmable or one-time assembly only?
x. Do the hardware and software are supported by large technical and engineering pool? (Software and Hardware Open Systems).
xi. What is the target programming age of the software and hardware? (Audience Range)
xii. What is the price range?

Table 2: Data Analysis and Comparison of Different Robotics Trainer

Factors/Company	**My Study**	**LEGO**	**RQ**	**Kinex/Inex**	**OWI**	**Genesis**	**Parallax**	**VEX**
Company	L	D	L	L	D	L	D	D
Microcontroller	A	RCX	C	BS	BS	C	BS	BS
Software Target	C++	VB	VB	PB	PB	C	PB	PB
Functionality	√	√	X	X	X	X	√	√
Category	Robot Arm/ Modular	Multiblocks	Sumobot	Multiblock	Sumobot	Sumobot	Robot Arm	Robot Arm
CHED/DepEd Recommended	√	√	X	X	X	X	√	√
Availability of SP	L	D	L	L	D	L	D	D
Sensors Included	√	√*	√*	√*	√*	√*	√*	√*
Accessories	√	√*	√*	√*	√*	√*	√*	√*
Modularity	√	√*	√*	√*	√*	√*	√*	√*
Price Range	8K+	25K+	18K	20K	22K	17K	20K	22K
Audience Target (Age)	8↑	10↑	12↑	10↑	10↑	10↑	10↑	10↑

Legend:

A – Arduino Open Hardware System
RCX – Lego proprietary hardware
C – Customized, one time pre-programmed according to customers
BS –Basic Stamp, Software with a price
L – Locally manufactured
D – Distributed, imported by local dealers
C++ - Open system programming language
VB – Visual Basic
PB – PBASIC programming language (with a price)
√* - Sensors/accessories included with additional charge
√ - With 20 accessories/sensor modules included

RESULTS AND DATA ANALYSIS

Most of the respondents agreed and recommended the project due to the major edge of factors in the above survey.

As shown in Table 2 the respondents agreed that the first thing they require in a trainer is its ability to support the Outcome Based Education especially in the STEM and VOC-Tech strand. Learning modules of the trainer system can be modified in accordance to the lectures required in the syllabus. Other brands are able also but with matching price and services fee. The functionality and modularity of the robotic arm do not limit to robot arm only but can be expanded to any microcontroller based applications using the different included sensors. The system design was compliant to Quality Assurance Standards (ISO 9126-1), an international standard that governs the software and hardware system design of a product especially of robotics.

Price is the greatest strength of the system, and everything is locally available in the market. Sensors included are:

i. Joystick
ii. Relay
iii. Sound sensor
iv. Small microphone
v. Tracking Avoidance Sensor
vi. Flame
vii. Linear
viii. Hall
ix. Touch
x. Digital temperature
xi. Buzzer
xii. Passive buzzer
xiii. RGB LED
xiv. SMD RGB
xv. 2-color LED
xvi. Reed switch
xvii. Mini Reed
xviii. Heartbeat
xix. 7-color flash Laser emit
xx. Button
xxi. Shock
xxii. Rotary encoder
xxiii. Magic light cups
xxiv. Tilt switch
xxv. Ball switch
xxvi. Photo-resistor
xxvii. Temp and humidity
xxviii. Analog Hall
xxix. Hall magnetic
xxx. TEMP Analog temp
xxxi. IR emission IR receiver
xxxii. Module Light blocking

Figure 2: The prototype using scrap materials

CONCLUSIONS AND RECOMMENDATIONS

Because of the lack of readily available low-cost robotics trainer in the Philippine market and an increasing population of the K-12 Senior High Schoolers, Engineering, and IT students, the system can help not only the BulSUans, but this project is recommended to be of significance to the following:

K-12, BulSu Engineering and IT Students: The robotic arm trainer is significant to the engineering and IT students since the system will provide a low-cost, flexible, and explorable robotic trainer platform in the applications of robotics and automation.

Academic Institution: The project will be significant to the Bulacan State University and other schools in bringing about the strengths and weaknesses of the technical status of the existing curriculum. This will produce changes, innovation, and inventions of more applications in the field of robotics and automation. They can also incorporate the trainer in their respective subjects that concern the input/output data manipulations.

Researcher: The researcher would also benefit in this project because this will enhance the skills in the area of technical research applications and work performance while inheriting knowledge throughout the development of the system. Some applications of concerns are Animatronics, Environment Monitoring and Control Systems, Embedded Systems, Automated Pick and Place Systems, Mini PLC-like functions, etcetera.

Future Researcher: The system will serve as an inspiration to those who wanted to develop and improve the existing system. The system also aids as a first step in developing different robotics and automation systems using various approach. They can also use this research as a reference for whatever study they will be venturing in the area of robotics. Further revision of this proposal to improve the system will be promoted for the betterment of the BulSU and academic community.

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