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INTERACTIVE CONTROL OF ROBOTIC ARM: AN INSTRUCTIONAL DEVICE

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ABSTRACT

The main purpose of this study was to design, assemble and assess the performance of the Interactive Control of Robotic Arm and find out the effectiveness of the device as tool for instruction. This was conducted in Bohol Island State University – Main Campus, Tagbilaran City in the Academic Year 2020-2021. The study used the experimental method of research in developing the Interactive Control of Robotic Arm. One group of pre skill test and post skill test design was used to test its effectiveness in enhancing student skills. The researcher selected forty (40) respondents for this study. Fifteen (15) are electrical technology and electrical engineering instructors from BISU Main Campus, BISU Balilihan Campus and BISU Calape Campus. Five (5) experts from Coca-Cola Bottlers Incorporated tested and validated the level of performance and assessed the acceptability level of the Interactive Control of Robotic Arm. There was a significant difference in the pre-skill test and post-skill test ratings of the students, the null hypothesis was rejected. The level of acceptability of the Interactive Control of Robotic Arm gained an average weighted mean of 3.84 with the description “very high”. This means that the device was found highly acceptable in terms of performance, convenience, safety and cost. The Interactive Control of Robotic Arm: an Instructional device an effective tool for instruction in BS Electrical Technology. It enhances the skill competency of the students and improves the quality of instruction in the workshop environment hence recommended for utilization.

KEYWORD: Programmable, Robotic Arm, Human Machine Interface, Degrees of Freedom, Instructional device.

INTRODUCTION

Technology has advanced a lot in the last few decades. There have been numerous ground breaking advancements that have revolutionized the way things are done. Rapid developments across science, technology, engineering, and communications have brought about what has been called the new Industrial Revolution, or second machine age, which greatly expands robots' competencies and functions.

Industry 4.0 makes full use of emerging technologies and rapid development of machines and tools to cope with global challenges in order to improve industry levels. The main concept of Industry 4.0 is to utilize the advanced information technology to deploy internet of things (IoT) services. Production can run faster and smoothly with minimum downtime by integrating engineering knowledge. Therefore, the product built will be of better quality, production systems are more efficient, easier to maintain and achieve cost savings. (Wang et al., 2016).

With these changes, industries adopt the new trends in technology and some industries replace human labor with the use of robot. Automation takes place for better and efficient output with the help of new machinery and devices. In relation to this the industry required skilled and knowledgeable worker to operate and manage the advancement of technology in the workplace.

By replacing the routine part of human labor with the use of machines, automation not only increases productivity and the quality of products beyond what can be achieved by humans but also frees up space, time, safety and energy for humans to deal with the new, non-routine challenges of developing innovative and more advanced technologies. This magnificent cycle in which established developments are automated and the free resources achieved by this automation are used to generate newer technologies that are subsequently automated is one of the most successful recipes for the human race towards the goal of sustainable development (Kongoli, 2012).

On the other hand, the university is one of the training grounds of students to acquire the skills and knowledge on the trends in technology. The curriculum must be adapted to the phases of changes of technology in the industry to produce competent graduates. There is a need to embrace the technologies associated with new industrial revolution in order to bridge the gap between the industry standard. It is also the mission of Bohol Island State University to provide quality higher education in the arts and sciences, as well as in the professional and technological fields. The institution focuses on adapting technology to ensure that the knowledge generated is geared towards industry practices. With this goal, course offerings are organized to give attention and training to future human resources of the country to propel economic development (Nacorda, 2003).

Furthermore, teachers and instructors, who are the principal facilitators of learning, should also be constantly trained so that they can develop the skills and competencies required to adapt and apply modern and emerging technologies to an evolving educational environment.

Students were trained to develop competencies to industry standard of success under specified condition through actual practice for clearly defined skill and knowledge. (Nigparanon 2016). However, one of the challenges that the learning institution faces is the shortage of instructional materials specifically in the electrical shops. These instructional materials constitute alternative channels of communication, which a teacher can use to convey more vividly instructional information to learners. It represents a range of materials which can be used to extend the range of vicarious experience of learners in a teaching learning situation.

For this reason, the Interactive Control of Robotic Arm is developed an instructional device to provide students an experience identical to an actual workplace in the industry. Through the use of the Interactive Control of Robotic Arm; the student will gain knowledge and ideas on PLC and HMI programming using two different software to control the robotic arm. The learning competencies of the students will be enhanced. The researcher believes that developing the Interactive Control of Robotic Arm addresses the diverse needs of learning in the field of automation and industrial process control.

METHODOLOGY

The study used the experimental method of research in developing the Interactive Control of Robotic Arm. One group took the pre skill test and post skill test to test its effectiveness in enhancing student skills.

The experimental design was used to assess the outcome changes before and after the implementation of the program. The intention of the pre skill test and post skill test experiment was to see whether an improvement in participants was triggered by the procedure. Since all respondents received same treatment, any improvements that arise through the group of participants were likely result from the treatment.

A pre skill test was given to the students before any discussion and after the assembly of the Interactive Control of Robotic Arm. This evaluated the baseline skills requirement of the study in designing and program construction. This test consists of a set of instructions for installation, interfacing, and programming of the Interactive Control of Robotic Arm. At this point, students were not expected to know all the answers in the skill test situation problems given. However, students were required to use previous knowledge and experience to have sensible answers.

After the pre skill test was completed, a discussion on Interactive Control of Robotic Arm was conducted. Participants were allowed to experience hands-on application by programming the PLC and HMI with a given situation. A post skill test was employed after the discussion. The content of the discussion and the manner of conducting the post skill test were similar to the contents of the pre skill test. Students were expected to answer more problem situations given correctly based on an increase in knowledge and understanding. The students' ratings in the post skill test were the basis in determining the degree of effectiveness of the simulator.

The design weighed the effectiveness and amount of learning a student has acquired through the use of Interactive Control of Robotic Arm. The experimental design was complemented with a descriptive method to find the acceptability of the Interactive Control of Robotic Arm with instructors.

The researcher utilized questionnaire for the experts. To acquire the necessary information on the acceptability level of the Interactive Control of Robotic Arm, the researcher conducted observations for the Interactive Control of Robotic Arm.

RESULTS AND DISCUSSION

This presents the holistic project design of Interactive Control of Robotic Arm: an Instructional Device. It also presents the findings, analysis, and interpretation of the study.

Data were gathered, collated, and tabulated in accordance to the appropriate statistical treatment. The development of the Interactive Control of Robotic arm was based on its specification. This design was the basis of the assembly of the device.

The Interactive Control of Robotic arm was composed of programmable logic controller (PLC) human machine interface (HMI), linear actuator, DC electric motor, push button switches, limit switches, pilot light indicator, sensing devices and a computer set. This device was used in training the students for PLC and HMI programming, motor control analysis, PLC and HMI program interfacing, problem solving, operation of the robotic arm, and robotic arm controls. Block diagram, Pictorial and ladder diagram was created for the wiring installation and programming of the device. The tools were properly identified according to their functions and the materials were canvassed from different electrical and electronic shop to guarantee high quality. The total cost of the Interactive control of the robotic Arm was Php 88,067.00 and the operation of the device was properly tested.

Table 1: Performance Level of Interactive Control of Robotic Arm Interactive Controls.

DOF	Direction	Trials	Control	Operation	Result	Interpretation
1st Panning	Left	1,2,3	PLC	Uploading Program, pressing the manual button and HMI panel	Panned left, indicator energized	Functional
			HMI			Functional
	Right	1,2,3	PLC		Panned Right, indicator energized	Functional
			HMI			Functional
2nd Tilting	Upward	1,2,3	PLC	Uploading Program, pressing the manual button and HMI panel	Tilt up, indicator energized	Functional
			HMI			Functional
	Downward	1,2,3	PLC		Tilt Down, indicator energized	Functional
			HMI			Functional
3rd Pitch	Forward	1,2,3	PLC	Uploading Program, pressing the manual button and HMI panel	Forward position, indicator energized	Functional
			HMI			Functional
	Backward	1,2,3	PLC		Backward position, indicator energized	Functional
			HMI			Functional
4th Linear	Extend	1,2,3	PLC	Uploading Program, pressing the manual button and HMI panel	Extended, indicator energized	Functional
			HMI			Functional
	Retract	1,2,3	PLC		Retracted, indicator energized	Functional
			HMI			Functional

5th Rotary	Clockwise	1,2,3	PLC	Uploading Program, pressing the manual button and HMI panel	Clockwise rotation indicator energized	Functional
			HMI			Functional
	Counter Clockwise	1,2,3	PLC		Counter Clockwise indicator energized	Functional
			HMI			Functional
6th Grip	Hold	1,2,3	PLC	Uploading Program, pressing the manual button and HMI panel	Pick and Hold, indicator energized	Functional
			HMI			Functional
	Release	1,2,3	PLC		Place and Release, indicator energized	Functional
			HMI			Functional

The robotic arm was composed of six degrees of freedom this were the base, lower arm, upper arm, linear wrist, rotational wrist and gripper. Manual and HMI control was the control unit of robotic arm. The base was capable of the panning movement, the lower arm was capable of tilting movement, the upper arm was capable of pitch movement, the linear wrist for linear movement, the rotating wrist for rotational movement and lastly for the gripper which include picking, holding, releasing and placing. The performance of each axis was tested three successive trials and was observed that there were no errors occurred during the test. This means that each axis performed well and described as functional. The pick and place performance of the robotic arm was found to functional. This operation was performed successfully with no errors. It proves that the device was efficient in performing pick and place operation.

Table 2: Performance level of the Interactive Control of Robotic Arm Operation.

Activity	Angle	Horizontal Distance	Width	Weight	Time	Result	Interpretation
pick and place	90 Degree	60cm	4.5 x 4.5cm	54 grams	50s	Object transferred successfully	Functional
			5.5 x 10cm	226 grams	45s	Object transferred successfully	Functional
			6.5 x 8cm	246 grams	43s	Object transferred successfully	Functional
		110cm	4.5 x 4.5cm	54 grams	85s	Object transferred successfully	Functional

			5.5 x 10cm	226 grams	80s	Object transferred successfully	Functional
			6.5 x 8cm	246 grams	78s	Object transferred successfully	Functional
	180 Degree	60cm	4.5 x 4.5cm	54 grams	55s	Object transferred successfully	Functional
			5.5 x 10cm	226 grams	53s	Object transferred successfully	Functional
			6.5 x 8cm	246 grams	50s	Object transferred successfully	Functional
		110cm	4.5 x 4.5cm	54 grams	90s	Object transferred successfully	Functional
			5.5 x 10cm	226 grams	88s	Object transferred successfully	Functional
			6.5 x 8cm	246 grams	85s	Object transferred successfully	Functional
	340 Degree	60cm	4.5 x 4.5cm	54 grams	62s	Object transferred successfully	Functional
			5.5 x 10cm	226 grams	60s	Object transferred successfully	Functional
			6.5 x 8cm	246 grams	58s	Object transferred successfully	Functional
		110cm	4.5 x 4.5cm	54 grams	85s	Object transferred successfully	Functional
			5.5 x 10cm	226 grams	83s	Object transferred successfully	Functional
			6.5 x 8cm	246 grams	81s	Object transferred successfully	Functional

It was observed that when the angles were getting bigger together with the distance it takes longer time to complete the pick and place operation of the robotic arm. It takes longer time rotate in a bigger angle. The object was successfully transferred from one place to another which means that the pick and place operation of the robotic was functional.

In addition to the given statement, Industrial robotic arms are capable of mimicking human motion. With the ability to mimic human motion, they are used and placed in areas that are in need of reducing dangers towards humans, more strength or accuracy than a human, roles that are deemed too dull to human workers or when continuous operation is required. This statement was supported by Automata Theory that proposes that mechanical or computer controlled device can simulate human physical function and behavior (Preston 2013).

To sum up the result, it was found that the performance of interactive control of robotic arm in terms of its operation was interpreted functional. This means that the device performed the operation successfully without any trouble or malfunction.

Table 3: The Level of Effectiveness of the Interactive Control of Robotic Arm.

Score	Description	Pre skill Test			Post Skill Test		
		f	%	Rank	f	%	Rank
3.25-4.00	Excellent	0	00.00%		16	80.00%	1
2.50-3.24	Very Good	0	00.00%		4	20.00%	2
1.75-2.49	Satisfactory	3	15.00%	2	0	00.00%	
1.00-1.74	Needs improvement	17	85.00%	1	0	00.00%	
Average Rating		**1.53 needs improvement**			**3.59 Excellent**		

N=20

Table 3 shows the result of pre skill test and post skill test of the student before and after using the device. It was found out in pre skill test that out of 20 students, only 3 were described as "Satisfactory" with a frequency of 15.00% which ranks 2nd and the remaining 17 students with a percentage of 85.00% described as "Need Improvements" which ranks 1st. No student was described as "Very Good and Excellent". To sum up the result in pre skill test described as it "Needs Improvement" with the average result of 1.53.

On the other hand, the result in post skill test was opposite to the pre skill test. The performance of the students was described as "Excellent" and ranks as the 1st with a percentage of 80.00% or 16 out of 20 respondents. The remaining 4 respondents were described "Very Good". The average result for post skill test was 3.59 which was described as "Excellent". There were no respondents with "Satisfactory "and "Need Improvement" ratings.

The use of Interactive Control of Robotic Arm was found effective in imparting knowledge and skill. "The students were trained to build competencies to industry standard of success under specified conditions through actual practice for clearly defined skill and knowledge" (Nigparanon 2016). Hence, it is effective for improving the learning competencies of students through actual and hands-on demonstration.

Table 4: Difference between the Performance of the students under Pre skill test and Post skill test.

Difference	T computed value	T tabular value	Description	Interpretation
	At 0.05 level of significance, df=19			
Pre skill test and post skill test	-21.689	±2.093	significant	Reject the null hypothesis

N=20

Table 4 presents the difference between the pre-skill test and post-skill test of the students. The computed t-value was -21.689, with absolute tabular value of ± 2.093 at 0.05 level of significance. It shows that there was a significant difference in the performance of the students taking the pre-skill test and post-skill test. Hence, the null hypothesis was rejected. Actual performance was needed to understand the theory; in turn theory serves as guidelines to improve student's application (Kolb, 2014).

The use of the Interactive Control of Robotic Arm as a device for instruction has enhanced the students' retention of knowledge and facilitates effective learning in electrical technology.

CONCLUSION

The Interactive Control of Robotic Arm: an Instructional device is an effective tool for instruction in BS Electrical Technology students. It enhances the skill competency of the students and improves the quality of instruction in the workshop environment. The use of Human Machine Interface as the other means of control gives new ideas and knowledge to student since this was the first of its own in the electrical shop. The device can be used as reference for future researchers who may conduct similar study in the field of robotic and automation.

Recommendations

Based on the data and findings, the researcher offers the following recommendation:

1. That the administration considers the use of the device as instructional tool of in the electrical field, specifically in electrical technology and electrical engineering students who have a prior knowledge in PLC programming.

2. That the researcher may submit the output of the study to Intellectual Property Office – Philippines (IPOPHIL) for patent application and to ensure the protection of the device.
3. The administration may pursue to reproduce using different kinds of PLC and HMI in order expand their knowledge in programming different kind of PLC and HMI.
4. Electrical teachers and instructors have to undergo training in programming different kind of Human Machine Interface devices to broaden their competencies in automation.
5. For electrical technology classes, the instructions have to include subjects such as robotics and technological advancements integrated with the fourth industrial revolution to close the expanding differences between education and industry standards.
6. For the future researchers, instead of using linear actuator in the robotic arm, it is possible to use pneumatic devices for the means of creating the robotic arm.

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