DESIGN AND DEVELOPMENT OF AN INDUSTRIAL CONTROL PANEL AS PEDAGOGICAL TOOL IN MECHATRONICS TECHNOLOGY

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ABSTRACT: *This paper discusses the design and development of a control system to utilize the old mechatronics training equipment located at the College of Technology building University of Science and Technology of Southern Philippines. Since the mechatronics trainer had been bought for quite some time, the computer system used to operate the equipment is already obsolete. Thus, this study designed a system upgrade to operate the unutilized laboratory equipment via hardware switching at the control panel and via the software interface system through an easy-port device controlled by a computer. The performance of the new control system captures the keen interest of the survey participants through their affirmation and approval relative to the test instrument to validate the functionality and acceptability of the device.*

Keywords: Industrial, Control Panel, Pedagogical Tool, Mechatronics, Technology, Easy-port

1. INTRODUCTION

Modern society strives to make it's world smart. The role of education in this process is to meet the challenges of the changing world and prepare learners to become fully integrated members of society. Innovative and effective tools and technologies can transform education by allowing to create an environment where the training is consistent with the needs and characteristics of digital learners and present-day society [1].

While a new learning culture emerges and a new learning model such as an outcome-based education (OBE) learning approach is favored and adopted to reform and renew education policy worldwide. This new learning approach makes teaching and learning more challenging for the academician to administer [2]. Along with this challenge is the inclusion of a comprehensive strategy to teach both knowledge and applied skills—including the "4 Cs" of critical thinking and problem solving, communication, collaboration, and creativity and innovation skills — is one that employers, educators, and the public are ready to support. In addition, employers want prospective workers to acquire at least some level of industry-specific technical skills before they enter the workforce [3]. Thus, for anyone working within the field of instructional technology, this rapid replacement rate of technologies can hold immense implications for both the development and delivery of educational systems [4].

The University of Science and Technology of Southern Philippines (USTP) being one of the leading universities in science and technology in terms of the latest technological edge, has equipped the colleges under her umbrella with modern instructional devices and machinery. The Department of Electromechanical Technology under the College of Technology, in particular, has been equipped with numerous instructional trainers such as Pneumatics and Electro-Pneumatics Trainer, Electro-hydraulics Trainer, SCADA System Trainer, PLC Trainers and the latest state of the art Mechatronics Trainer the Flexible Manufacturing System.

Enhancing students' capability to engage with the utilization of the Flexible Manufacturing System must undergo introductory knowledge in automation through the Mechatronics Standard System and Automation Training Program. However, this equipment had been gradually deteriorated by the following unfavorable circumstances:

a. Manual handling was applied to the component present positions to set up the required position so as to operate the instructional equipment into a specific automation process, by this conventional method it can contribute gradual and unintentional damage to the machine.
b. During the demonstration process, component movements were noticeably fast and students could not have full comprehension of vital positions and movements of each component in the Mechatronics system.
c. Checking of the solenoid, servo motors and other electrically powered components functionality are manually performed through the application of a voltage at the I/O Terminals of the station which could lead to electrical sparks and may cause accidental fires.

The development of the Industrial Control Panel System as a pedagogical tool could not only prevent manual intervention procedures as well as prolong useable life and lessen the effect of wear and tear of the equipment. It can also help train students' competitiveness and awareness in control panels operation as well as a visual indication of components position. Moreover, an interface system via easy port control systems embedded in this learning tool enhances student's technical knowledge and skills as applied to most industrial processes. It could also become baseline research to revise or improve the present control panel set up so as to address some process deficiencies in manufacturing companies.

The main objective of the study is to Design and Development of an Industrial Control Panel as a Pedagogical Tool in Mechatronics Technology. The successful development of this project helps enhance teaching methodology in relation to outcomes-based education where such design could satisfy some specific needs in the theory and application of automation technology and interfacing systems. This could entice student's active participation, interaction as well as develop much-needed competency development in relation to advance industrial control and automation processes in the arena of industrial companies. Moreover, the study could be baseline research for other instructional equipment to improve the present educational set up to a more industrially inclined device in replica with the latest industrial technology.

2. METHODOLOGY

2.1 Design Considerations

The industrial control panel conforms to specific standards under the regulation of PEC (Philippine Electrical Code) and reliable information coming from industrial experts. A focus group discussion of the researchers and invited industrial experts are undertaken to brainstorm on design considerations for improvement of the research project. After thorough

brainstorming and sharing of information the group decided on the possible design of the industrial control panel as follows:

1. Interconnection between the Mechatronics instructional equipment and the industrial control panel should not affect the present setup of the laboratory, but should effectively optimize the learning and skill competency of the students.
2. Controls of each output should be interlocked effectively to avoid collision and incidental movement of the actuators which would cause damage to the mechatronics instructional equipment.
3. Safety gadgets and over current protection should be applied to ensure the safety of the users and the equipment itself.

2.2 Mechanical Design

The industrial control panel as shown in Figure 1 is reinforced with the frame made of 1/8 inch x 1-inch x 1-inch angle bars and 20 mm thick acrylic walls. Roller casters are also be provided for easy mobility.

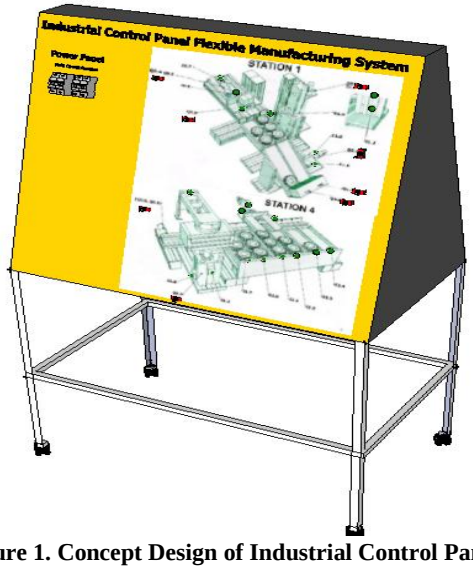

Figure 1. Concept Design of Industrial Control Panel

Figure 2 below shows the control panel and mechatronics instructional system setup. Easy Port Interface system wires are securely fastened in the flexible industrial ducting to ensure the controllability of the industrial panel to the system

2.4 Development

In reference to the predetermined designs, mechanical structures are fabricated through welding of mainframes and rivet binders for fastening securely other structural frames of the control panel. Metal sheets serve as body cover of the industrial panel, while the front panel is covered by acrylic plastic for the prevention of electrical grounding problems on the attached electrical components in the panel.

The wiring of the interface system in both Mechatronics instructional equipment and the industrial control panel is protected via industrial grade busways and shield protection. An appropriate means of support is utilized for the mobility of the device after the wiring interface has been set up.

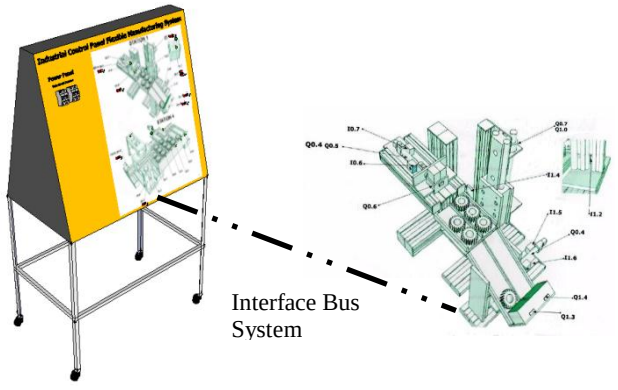

Figure 2. Control Panel and Mechatronics Instructional System Setup

2.3 Electrical Design

The I/O Terminals of the Programmable Logic Controller (PLC) in the existing mechatronics instructional equipment as shown in Figure 3 is interconnected to the industrial control panel stations interface containing Easy Port Device, switches and indicating lamps. This controls the movements and position of components are depicted by means of signals coming from indicating lamps.

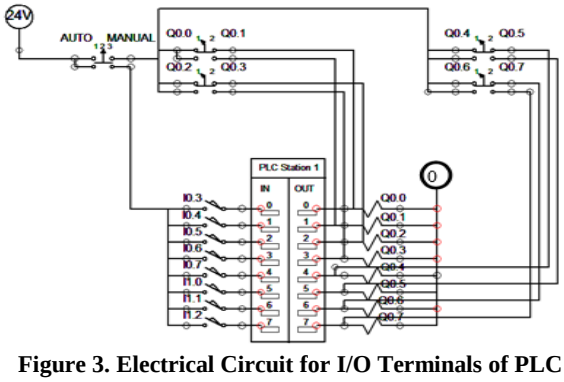

Figure 3. Electrical Circuit for I/O Terminals of PLC

2.3 Testing

After the successful realization of the prototype, the industrial control panel underwent a series of testing to validate its functionality and effectiveness. Simulations shown in Figure 4 are implemented and dry run of the system was done and foregoing events on its functions and troubles are recorded accordingly to implement necessary adjustment to correct occurring troubles in the system.

2.4 Evaluation

The evaluation and validation are the concluding steps by which the performance of its functions, characteristics, and features are assessed purposely by selected evaluation participants. The evaluators are composed of instructors from the College of Technology, industry practitioners and technology students who are knowledgeable about automation technology and controls. Questionnaires are prepared based on the pre-determined criteria on functionality, aesthetics, safety, and reliability using the five-

point rating scale (5 as highest and 1 as lowest). Provisions for comments and suggestions were also provided in the survey instrument.

3. RESULTS AND DISCUSSION

3.1 Development

The Design and Development of an Industrial Control Panel as Pedagogical Tool in Mechatronics Technology were implemented in accordance to the objectives of the study which is to help enhance student's active participation, interaction as well as develop much-needed competency development in relation to advance industrial control and automation processes as shown in Figure 4 below.

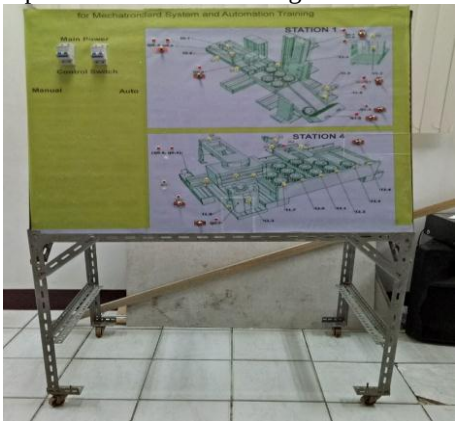

Figure 4. Completed Industrial Control Panel as Pedagogical Tool

The Mechatronics System is interconnected to Industrial control panel through Input-Output (I/O) PLC terminals. Signal wires (highlighted in red) are attached according to I/O address allocations of the PLC to acquire digital signals for interfacing with the Easy-port device and the Industrial Control Panel as shown in Figure 5. The movements and positions of the output of components are visualized via indicating lamps shown in Figure 6, are installed in its appropriate location in the pictorial sketch of the mechatronics system.

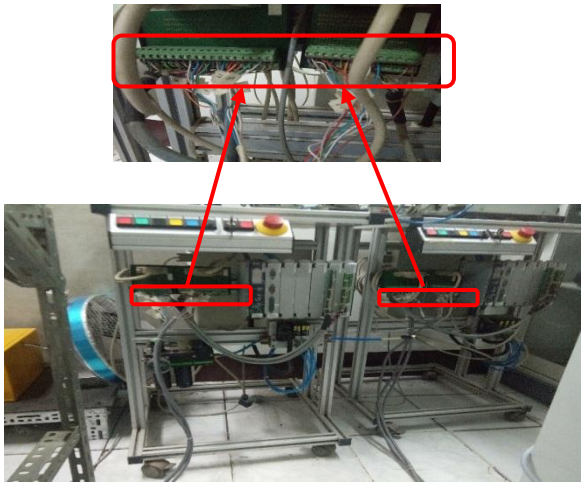

Figure 5. Interfacing of Input-Output (I/O) PLC terminals

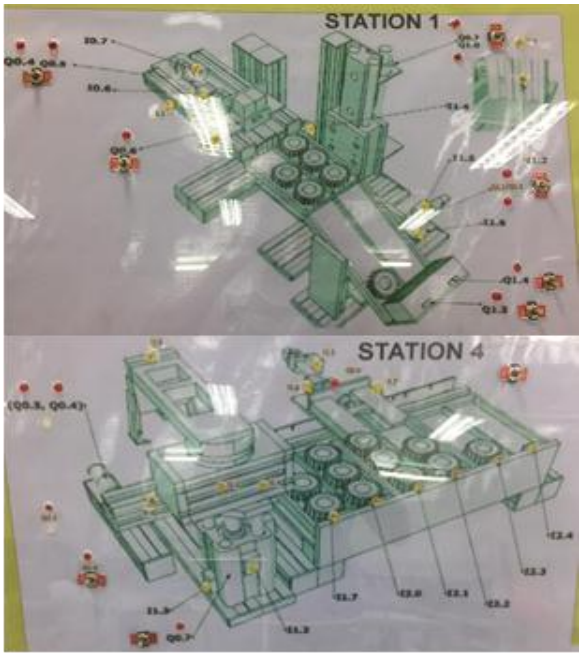

Figure 6. Intdicating Lamps for Signal Activation Operation

3.1 Implementation

After completion of the prototype, rigid testing and troubleshooting had been undertaken to check the functionality of the device interface system both in wired and Easy-port connections. It was observed that the movement and position of each output component, as well as position indicators, had been significantly congruent as per the function of each output and input signal reference. The sample simulation and application of the Easy-port program are shown in Figure 7.

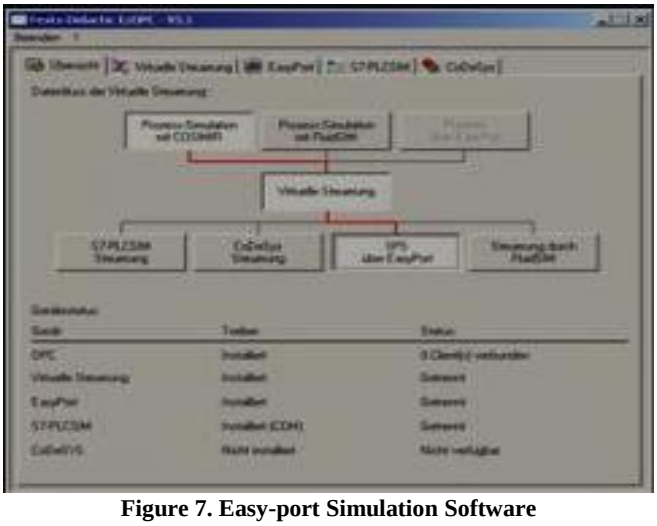

Figure 7. Easy-port Simulation Software

3.2 Evaluation Results

The evaluation results as rated by the respondents of the survey yielded an excellent rating. The following mean response in terms of the criteria specified in Table 1 below proves that the Design and Development of an Industrial Control Panel as Pedagogical Tool in Mechatronics Technology are functional and valuable to the users.

Table 1. Evaluation Results

Project Criteria	Mean	Description
Functionality	4.5	Excellent
Reliability	4.5	Excellent
Aesthetics	4.4	Good
Safety	4.4	Good
Over-All Weighted Mean	4.5	Excellent

Evaluation results above are supported by the following statements:

a. The functionality rating indicated an average mean of 4.5, which means that the survey participants support the functionality.

b.Component's reliability had met the desired output performance indicating an excellent mean rating of 4.5, which means that the survey participants believed that the trainer's reliability is exceptional.

c. An average mean of 4.4 in Aesthetic means the survey participants found that the trainer's physical appearance and structure have yielded a good rating.

d. The overall mean rating in terms of safety indicated a good average mean of 4.4, which means that the trainer is safe to use and applicable for laboratory activities.

4. CONCLUSION

Based on the results and findings of the study, the performance of the device captures the keen interest of the survey participants through their affirmation and approval relative to the test instrument. The survey outcome yielded relatively good ratings in all survey aspects. The outcome is indicative of the survey participant's appreciation of the device as such that some of the survey parameters received excellent ratings.

4.1 Recommendations

The recommendations are anchored on the suggestions and observations of the survey participants on the device. The future works of the study may be directed to the aforementioned argument and maybe given emphasis on the next innovation. The recommendations that may be given worthwhile considerations are:

1. What measure may be incorporated in the device in such a way that advance skill in mechatronics would be readily available?
2. How can we ensure that the electrical and other integral components of the trainer can be safely stored within the device itself?
3. What must be done to improve safety in the use of the circuit breaker to increase safety in the use of the device?

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