Work in Progress: Certification and Training for Robot and PLC Integration

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WIP- Certification and Training for Robot and PLC Integration

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Introduction

The Engineering Technology (ETEC) department at Sam Houston State University (SHSU) provides students with cutting-edge education in various disciplines. Under our umbrella, we currently offer programs in Electronics and Computer Engineering Technology (ECET) and Mechanical Engineering Technology (MET), with both programs emphasizing automation and control as key focus areas. To address the growing skills gap in the industry, our curriculum includes courses such as Industrial Robotics for both ECET and MET students, Computerized Numerical Controls (CNC) for MET students, and Programmable Logic Control (PLC) for ECET students. These courses have been developed based on feedback from our Industry Advisory Board (IAB) and are designed to equip students with the necessary expertise to excel in the rapidly evolving manufacturing landscape.

As the demand for automation in assembly lines and manufacturing processes continues to rise, we recognize the importance of providing our students with relevant certifications [1, 2]. Our goal is to train and certify our faculty in the latest technologies, enabling them to guide students in developing integrated smart manufacturing systems that utilize industrial robots and PLCs for tasks like material handling, painting, assembly, and CNC machining. According to studies by Deloitte and The Manufacturing Institute, the skills gap in manufacturing may leave an estimated 2.4 million positions unfilled over the next decade [3]. As the US manufacturing industry embraces Industry 4.0 [4] and digital transformation, there is a growing mismatch between available workers and the skills required for open positions. Among the most critical skills needed for future manufacturing job markets are programming skills for industrial robots and automation systems. By incorporating these skills into our ECET and MET programs, we aim to prepare our students for successful careers in the manufacturing industry, ensuring they are equipped with the knowledge and expertise to meet the challenges of an increasingly automated world.

Exploring Certification Options for Engineering Technology Programs

In the pursuit of providing our Engineering Technology students with relevant certifications, we have explored several options and compiled a comparison in Table 1. This Work in Progress (WIP) paper presents the professional development efforts associated with the "Industrial Robotics" and "Automation & PLC" courses within the Electronics and Computer Engineering Technology (ECET) curriculum at SHSU. These courses will also be required for Mechanical Engineering Technology (MET) students pursuing Manufacturing and Mechatronics concentrations.

One of the primary certification options considered is the Fiji Automatic Numerical Control (FANUC) certification. Established in 1956, FANUC has installed approximately 4.2 million CNCs and 600,000 robots worldwide. The primary author underwent a week-long training with FANUC America in Michigan in October 2022 to acquire hands-on skills for a fully automated environment. This training is intended to prepare the authors to teach interdisciplinary courses on Industrial Robotics, PLC, Manufacturing, and Automation. Since obtaining FANUC certification, SHSU has been officially recognized as a FANUC training site. The primary author is also working

Table 1: A comparison of different certification [5]

NAME	DIFFICULTY	COST	ACCREDITATIONS	QUESTIONS	DURATION	PASS
SPS	Expert	$250	+4,700	40	60 mins	85%
SAFe Agile	Expert	$3000	N/A	45	90 mins	77%
AWS	Beginner	$100	+400,000	60	90 mins	70%
NCCER	Beginner	$100	+400,000	40	240 mins	70%
PE	Expert	$350	32,000/year	80	480 mins	64%
FE	Intermediate	$175	80,000/year	110	360 mins	75%
PMP	Difficult	$575	N/A	180	230 mins	50%
NOCTI/FANUC	Intermediate	$150	N/A	153	180 mins	70%

to administer the National Occupational Competency Testing Institute (NOCTI) credential exam for students, adult learners, and industry professionals at SHSU and has recently been acknowledged as the Site Administrator for NOCTI, a third party for FANUC robot operator licensing.

The ROBOT and PLC integration training focuses on preparing operators, technicians, engineers, or programmers to set up, record, and troubleshoot programs on a FANUC LR Mate robot integrated with an Allen Bradley Control Logix PLC through Ethernet/IP. The main objective is to train participants in setting up, creating I/O, programming, and using an Allen Bradley ControlLogix PLC controller to direct a FANUC robot application. Ladder Logic is used to coordinate automation in production states. The training also covers User Input/Output (UI/UO) details, the correlation between each bit and the I/O module, and the design, creation, and configuration of Bit Maps. A detailed step-by-step process for configuring each module using Ethernet IP is also explained during the training. By integrating these certifications into our curriculum, we aim to provide our undergraduate students with a multi-disciplinary, hands-on learning experience that equips them with the skills needed for the evolving demands of the manufacturing industry.

The Robot and PLC Integration Training towards Industry 4.0

Following the primary author's FANUC certification in 2018, the ETEC department at SHSU has been officially recognized as a FANUC training site. Additionally, the author completed an extensive hands-on training at the Amatrol facility, focusing on various components of PLC in Allan-Bradley logic. The paper on these faculty development trainings was published in ASEE [6]. However, with the advent of Industry 4.0, an integrated system where robots, PLCs, and manufacturing equipment work together to maximize product throughput is essential. In the Fall of 2022, the primary author attended a 40-hour long training at FANUC America's headquarters in Rochester Hills, MI, from 10/03/2022 to 10/07/2022. The registration fee and total expenses, including accommodation, airfare, and meals, were funded by the Fred Pirkle Endowment Fund for faculty professional development. The training manual, provided by FANUC America, includes 26 modules, a pre-test, and a post-test. The pre-test is administered on the first day of training, while the post-test is taken on the last day to evaluate trainees' progress. Modules 4-11 cover material handling with FANUC R-i30B and R-i30B plus controllers, modules 12-15 focus

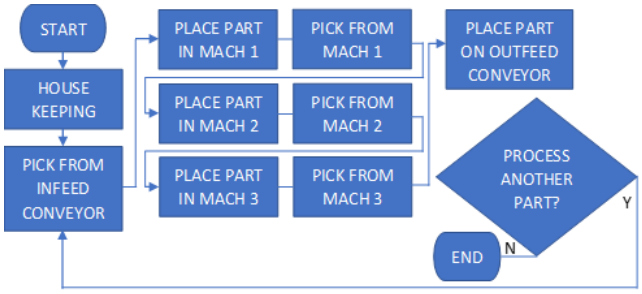

Figure 1: The flowchart of manufacturing process for pick& place part

on the basics of PLC with Allan-Bradley logic, and the remaining modules deal with bit maps and network communication setup between PLC and the robot. Each module includes hands-on tasks using Studio 5000, FactoryTalk View Studio for the PLC portion, and robot programming with a teach pendant. Bit mapping is a critical aspect of the training, as it ensures proper communication between the PLC and the robot. The training emphasizes the importance of understanding project I/O requirements and determining the appropriate module and rack for those I/O. Two tables are used to track I/O and sizes, with one table aligning robot input to PLC output and the other table listing corresponding robot output to PLC inputs. Figure 1 shows the flowchart of the process. The training's goal is to design a fully automated manufacturing pick-and-place project controlled solely from HMI inputs via PLC into the robots. The primary author scored 60% on the pre-test and 96% on the post-test, indicating significant improvement after completing the training. By investing in faculty development, we are better equipped to provide our students with hands-on experience and knowledge of integrated systems, ensuring they are prepared for the challenges and opportunities of Industry 4.0.

Importance of Such Trainings and Student Success

To address the skill challenges of the cutting-edge industry, it is essential for higher educational institutions like ours to reflect these needs in our course curriculum, especially for Engineering Technology departments that emphasize applied engineering and hands-on learning. To achieve this, faculty members participate in professional development trainings to enhance their knowledge and skills, which they can then pass on to students. The primary author's training in automated manufacturing and assembly lines, where PLCs and robots work together, is a prime example of this approach. In Spring 2023, the primary author will teach the "Automation & PLC" course and follow it with the "Industrial Robotics" course in Fall 2023. The goal is to integrate the class projects from both courses, allowing students to automate specific tasks through programming robots and PLCs. This integration will enhance students' understanding of communication between the systems, including bit mapping and networking. At the end of the Spring and Fall semesters, the primary author will conduct a survey to assess the impact of these integrated courses on student learning. Students have been receiving FANUC certificates for material handling and operation through the Industrial Robotics class. Now, they have the additional option of obtaining FANUC Robot Operator licensing I and II through NOCTI, which will serve as an added certification beyond the standard course completion certificate. If this integration is successful, the future goal is to include MET students and develop an automated assembly system with vision capability for CNC parts and manufacturing.

Research Question and Assessment Plan

The main research question that we are planning to address is “How does the integration of "Automation & PLC" and "Industrial Robotics" courses, combined with faculty professional development, impact students' knowledge and skills in the field of automated manufacturing and

assembly lines?" The objective of this research is to investigate the effectiveness of integrating the above-mentioned courses in addressing the skill challenges of the cutting-edge industry.

Pre-assessment:

a. Evaluate students' knowledge and skills in automation, PLC, and industrial robotics before taking the integrated courses.
b. Gather data on students' career goals and expectations from the courses.

Course integration:

a. Implement the integration of "Automation & PLC" and "Industrial Robotics" courses through class projects focused on programming robots and PLCs for specific tasks.
b. Encourage interdisciplinary collaboration between ECET and MET students for real-time applications and prototyping.

Faculty professional development:

a. Train faculty members in FANUC certification and other relevant certifications for automation and robotics.
b. Encourage faculty members to share their experiences and knowledge gained through professional development with their students.

Post-assessment:

a. Assess students' knowledge and skills in automation, PLC, and industrial robotics after completing the integrated courses.
b. Gather data on students' satisfaction with the courses and the impact on their career readiness.

Certification:

a. Offer students the opportunity to obtain FANUC Robot Operator licensing I and II through NOCTI, in addition to the FANUC certificates for material handling and operation.
b. Assess the impact of certification on students' employability and career success.

Data analysis and evaluation:

a. Analyze pre- and post-assessment data to determine the effectiveness of the integrated courses and faculty professional development on students' knowledge and skills.
b. Evaluate the impact of certification on students' employability and career success.

Future improvement and expansion:

a. Based on the findings, refine, and improve the integrated curriculum to better address industry skill challenges and meet students' needs.
b. Expand the scope of the integration to include additional courses and interdisciplinary projects, such as automated assembly systems with vision capabilities for CNC parts and manufacturing.

By implementing this research question and assessment plan, we aim to understand the effectiveness of the integrated curriculum and faculty professional development in preparing students for careers in the rapidly evolving field of automated manufacturing and assembly lines.

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