INDUSTRY COLLABORATION FOR TRAINING WORKFORCE

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Abstract—Fast paste changing of technology and global competition bring real challenges to the workforce today. Re-tooling and updating workers is becoming a must for a business competitiveness and survival. The United States has traditionally produced the world’s top research scientists and engineers, leading to breakthrough advances in science and technology. This technological innovation has been a primary driver of U.S. economic growth, with studies showing that half or more of economic growth in the United States over the past fifty years is attributable to improved productivity resulting from innovation. The skills gap surveys consistently underscore how a vast majority of American manufacturers are facing a serious shortage of qualified employees, taking an increasingly negative toll on America’s ability to be innovative and productive. The broadening skills gap is due to several factors, including: the retirement of the baby boomers, advancements in technology that require new skills, increased job competition in the global arena, failure to cultivate a highly skilled workforce, a lack of emphasis on the necessary skill sets for advanced manufacturing and difficulty in retaining skilled talent. Workers with certain skills may require remedial training to become a fit for new jobs. The real challenge is where one course or one subject teaching may require a few weeks of background building. Terminated workers have different backgrounds and having them under one ceiling and one classroom bring new encounters for the instructor. Screening and tests can bring workers with similar and somewhat equal background in one classroom. Unless technician education is designed very carefully so that real needs are determined and addressed, it will be packed with so much science and mathematics that technicians will never learn and obtain the proper skills. These factors explain why so many technicians complain that their academic study was useless for their work.

Majority of industries require workers to have a background in basic electricity, rotating machinery, logics, programmable logic controllers (PLC) and safety. Purdue University Calumet College of Engineering Technology has secured a 2.74 million dollar department of labor (DOL) grant for “Assisting Workforce by Advancing Knowledge for Employment”. The purpose of this grant is to train workers by giving them new skills for new job opportunities. Course topics are broken into several modules. A module concentrates on a subject and usually taught in 16 to 20 hours of classroom. Each module is accompanied with several hands-on experiments for the student to implement the theory and practically observe the result. Several modules are developed and delivered to train such workers. In collaboration with several manufacturers, three laboratories for mechanical, power, and industrial programming are established. Several modules such as mechanical component, basic dc and ac circuits, rotating machinery,
transformers, programmable logic controllers and electrical safety are developed. This paper will describe:

- The development of the modules
- The experiments
- Student performance, assessment and test results
- The industry partnership in the development of the program, and laboratory efforts
- Preparing skilled work force for fast changing industry

1. Introduction

The global competition and fast changing technology requires up-to-date workers with new skills. The workers from old industries such as steel mills lack new skills and if they leave or forced to leave their existing position, they will have tough time finding new jobs. The U.S. workforce is aging. Just over 16% of the labor force is at least age 55, up from nearly 12% in 1995. The Bureau of Labor Statistics projects that this figure will rise to close to 21% in near future. If this projection is realized, more than 34 million persons aged 55 and older will be working or looking for work in next few years, an increase of more than 10 million over the figure for 2005 [1]. The actual number of older labor force participants could be even greater than official projections suggest, if older workers realize their retirement work expectations. Today’s global economy requires a trained and flexible workforce able to adapt quickly to new technology, changing methods of production, and evolving consumer demands. Not all employers, however, are convinced that older workers have what it takes to meet their needs in this new economy. In particular, they have reservations about older workers’ technological competence and ability to learn new technology [1]. Moreover, veterans with specific skillsets might not quite fit into the requirement of new positions in the industries. Most of the machines and operations in the industries require people with background on basic electricity, ac, dc power systems as well as rotating machinery and automation. The workers who are seeking new positions do not have time and may not be able to afford the cost of a four-year college degree. As technology changes, the technicians and workers must be trained and re-tooled. The role of the technology instructors and university professors must be more practical and resourceful to meet the growing teaching demands.

Automation industry is one of the fastest growing industries worldwide. Most industries are trying to automate their production and manufacturing. Advantages commonly attributed to automation include higher production rates and increased productivity, more efficient use of materials, better product quality, improved safety, and reduced factory lead times. Higher output and increased productivity have been two of the biggest reasons in justifying the use of automation. Also, increased process control makes more efficient use of materials, resulting in less scrap. Additionally, workers’ safety is an important reason for automating an industrial operation [2].

Automation systems mostly take advantage of Programmable Logic Controller (PLC). Workers who install, program and maintain PLCs and other equipment employed in automation systems must have working knowledge of electricity, dc and ac power systems, rotating machinery, safety and mechanical systems [3].
To address the increasing demands for teaching technicians, the following three subject areas are selected:

**Mechanical Components**
- Blueprint Reading (Electrical & Mechanical)
- Technical Drawing and CAD
- Mechanics I
- Mechanics II
- Mechanical Drives and Safety
- Power Transmissions and Shafts
- Machine Elements (Belts, Chains, Gears)
- Certification Exam – Mechanical Components 1

**Industrial Electricity 1**
- DC Electrical System
- AC Electrical System
- AC/DC Power System
- AC/DC Rotating Machinery
- Electrical Control System Wiring
- Raceways, Conduits, Conductors and Disconnects
- Safety Related to Industrial Electricity
- Certification Exam – Industrial Electricity 1

**Industrial Electricity 2 & Programmable Logic Controllers 1**
- Programmable Logic Controls Architecture
- PLC Applications
- Basic Process Control Elements & Systems
- Process Control Systems
- Certification Exams – Industrial Electricity 2 & Programmable Logic Controllers 1

At the end of these training sessions several internships from partnering companies are offered to the students. The complete list of these modules is available at [4]. Each module requires students not only to solve engineering problems, but also interpret real technical and experimental data, thereby providing an invaluable hands-on experience. Lectures are accompanied by practical laboratory experiments to reinforce the technical principals, math and formulas. The modular approach not only provides short, intensive sessions on key subjects but also gives students an opportunity to integrate practical hands-on experiments and theoretical principles together. As mentioned in the previous section, each subject area consists of several modules. For example, the *AC Electrical System* is one of the modules in *Industrial Electricity 1* subject. In the following section the day-by-day schedule for AC Electrical System Modules is given.

**AC Electrical Systems Modules**
Purpose of this module is to provide the explanations of fundamental quantities of electrical circuits, including voltage, current, resistance, inductance and capacitance.

**Day #1**

AC Electricity Systems  
1. What is alternating current (AC)?  
2. AC waveforms  
3. Measurements of AC magnitude  
4. Simple AC circuit calculations, frequency and waveform period  
5. AC resistor circuits
6. AC inductor circuits

**Day #2**

AC Electricity Systems  
7. Vectors and AC waveforms  
8. Simple vector addition  
9. Complex vector addition  
10. Polar and rectangular notation  
11. Complex number arithmetic  
12. Series resistor-inductor circuits  
13. Power in resistive and reactive AC circuits  
14. True, Reactive, and Apparent power  
15. Calculating power factor

**Day #3**

AC Electricity Systems  
16. AC resistor circuits  
17. AC capacitor circuits  
18. Series resistor-capacitor circuits  
19. Series R, L, and C  
20. Frequency and phase measurement

**Day #4**

AC Electricity Systems  
21. Topics: Transformers and Review  
22. Book: Lessons in Electrical Circuits, Volume II- AC (full text book can be found in classroom and on flash drive)  
23. Mutual inductance and basic operation  
24. Step-up and step-down transformers  
25. Transformer turns ratio and relation among  
26. Current/Voltage/Impedance  
27. Single-phase power systems

2. Laboratory Equipment and Experiments

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The lectures are accompanied by several hands-on laboratory experiments. New equipment was purchased from Lab-Volt®, and Rockwell Automation®. The purchased equipment along with donated equipment for safety training from local and supporting companies are used to establish three laboratories. Figures 1 through 3 show the trainers and donated equipment.

**Figure-1 Electrical Circuit and Power Test Equipment**

**Figure-2 PLC Test Equipment**

**Figure-3 Donated Safety Gear and GFCI Testing equipment for Teaching**

The purchased equipment provide laboratory experiments as well. However, these experiments are designed for engineering students with adequate math and science background. Requiring technicians and workers to perform such experiments results in frustration and loss of interest. The experiments and tools must be carefully selected and modified to obtain proper and desirable result.

### 3. Assessment

Students with diverse backgrounds attend in each class. Assessing such a group of students and measuring their acquired knowledge is somewhat complicated. In order to overcome this obstacle, several in-class quizzes and small projects on different days of lectures are conducted. Two styles of lecture delivery were examined. In the first style (one-subject-teaching method), a complete topic was delivered and at the end of the lecture a test or quiz was given and the results are tabulated in Table-1. In the second style (step-n-check teaching method), each topic was broken into smaller bits of information. After each piece of lecture topic, an example with a related experiment was performed to make sure the students truly grasp the concept. This method
of delivery was repeated several times and the result of assessment is shown in Table-2. 
Comparison of these two tables clearly indicates better students’ performance was achieved 
utilizing the second method.

Table 1. Student Performance using one subject-teaching and a laboratory experiment method

<table>
<thead>
<tr>
<th>Category</th>
<th>Response before Lecture</th>
<th>Response after Lecture</th>
<th>Response after first example</th>
<th>Response after first Experiment</th>
<th>Response after 2nd Example</th>
<th>Final Test</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series Circuit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Students felt tired and confused</td>
</tr>
<tr>
<td>Resistance calculation</td>
<td>0</td>
<td>2</td>
<td>x</td>
<td>x</td>
<td></td>
<td>5</td>
<td></td>
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<tr>
<td>Parallel Circuit</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Resistance Calculation</td>
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<td>3</td>
<td>x</td>
<td>x</td>
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<tr>
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<td>Voltage divider</td>
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<tr>
<td>Series-Parallel Circuit</td>
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<tr>
<td></td>
<td>0</td>
<td>2</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>3</td>
<td></td>
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</tbody>
</table>

x- Indicates no testing

Table 2. Student Performance after step-n-check teaching and a laboratory experiment method

<table>
<thead>
<tr>
<th>Category</th>
<th>Response before Lecture</th>
<th>Response after Lecture</th>
<th>Response after first example</th>
<th>Response after first Experiment</th>
<th>Response after 2nd Example</th>
<th>Final Test</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series Circuit</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Students felt engaged and involved</td>
</tr>
<tr>
<td>Resistance calculation</td>
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<td>5</td>
<td>8</td>
<td>10</td>
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<tr>
<td>Parallel Circuit</td>
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<td></td>
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<tr>
<td>Resistance Calculation</td>
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<td>4</td>
<td>6</td>
<td>7</td>
<td>9</td>
<td>10</td>
<td></td>
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<tr>
<td>Voltage in Series Circuit</td>
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<td>Voltage divider</td>
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4. National Testing Agencies

There are several national agencies that independently conduct tests for technicians in the area of 
electrical circuit and control systems. Packaging Machinery Manufacturers Institute (PMMI) 
conducts tests through a series of assessments that are based on industry-developed competencies 
[5]. The available PMMI tests are:

- Fluid Power 1
- Industrial Electricity 1
- Industrial Electricity 2
- Mechanical Components 1
- Programmable Logic Controllers (PLCs) 1

These tests allow both entry-level and skilled technicians to assess their skills needed for 
technology intensive manufacturing jobs.

The International Society of Arboriculture (ISA) is another independent agency conducting tests 
for technicians in the area of process control [6]. These tests are as follows:
• Certified Automation Professional (CAP) Program
• ISA Certified Control Systems Technician (CCST) Programs
• Certified Industrial Maintenance Mechanics (CIMM) Program

The above tests are performed by independent agencies and students may register through their websites [5, 6] and schedule their test location and time. The College of Technology at Purdue University Calumet pays the registration fee only for the first time. Students who do not pass after the first try must pay their own registration fee for the next try.

5. Student Recruitment and Internship

Industries in close proximities, local labor organizations, veteran admiration offices and similar offices or agencies are routinely contacted to introduce the availability of these classes. More than 50% of students are employed and looking for new challenges. The remaining students are under-employed or unemployed. The graduates from the program are the best advertising mechanism for our program. Industries hiring these graduates usually provide internship program too.

6. Summary

A training center with a grant from the department of labor is established. With purchased and donated equipment from industry several relevant training modules and laboratory experiments were developed. It was noticed that teaching technicians and factory workers is more successful when a topic delivered in small pieces accompanies with laboratory experiments. These experiments can be used for both engineering technology students as well as industry technician. Assessment is performed through quizzes and short projects. Students can take nationally accepted test to receive the certification.

7. References


Biography
Masoud Fathizadeh – PhD, PE Professor Fathizadeh has been with the Department of Electrical and Computer Engineering Technology Purdue University Calumet since 2001. He has worked over 15 years both for private industries and national research laboratories such as NASA, Argonne and Fermi National Laboratories. Dr. Fathizadeh has established his own consulting and engineering company in 1995 specializing in power system, energy management and automation systems. During last twenty years the company performed many private and government projects. Dr. Fathizadeh has published numerous journal, conference and technical articles. He has been instrumental figure in establishing mechatronic engineering technology at Purdue University Calumet. His areas of interests are, control systems, power systems, power electronics, energy, and system integration.

Dr. Fathizadeh is a registered professional engineer in the State of Illinois.