Control Systems Technology

Preliminary Course Specification

Background

This specification will inform development of a Control Systems Technology course at Chaffey College under the leadership of Professor Steve Siedschlag.

Eight representatives from the manufacturing and commercial building management industry segments collaborated on development of this specification on December 16, 2014. They were supported by administrators from Chaffey College, the San Bernardino Office of the Superintendent of Schools, and members of the *Doing What MATTERS for Jobs and the Economy* sector teams in Energy Efficiency and Utilities, Advanced Manufacturing, and ICT/Digital Media.

The meeting was preceded by several months of planning as outlined in the attached:

- Control Systems Technology – A Proposed Course for Chaffey College
- Faculty on Special Assignment – Course Development Facilitator 2014-15

Acknowledgements

Contributions to this specification were made by:

Chaffey College Representatives

Steve Siedschlag, Professor
Joy Haerens, Dean
Alisha Serrano, Interim Director
Kathy Dutton, Director
Laura Myers, Administrative Assistant
Alisa Vaughn, Administrative Assistant

Industry Representatives

Rick Pettit, California Steel Industries
Trina Tran, California Steel industries
Juan Ortega, Cushman & Wakefield
Alex Caraveo, Cushman & Wakefield
Ron Rector, County of San Bernardino
Corey Lee Wilson, IFMA IE Chapter
Carlos Santamaria, Executive Institute for Energy Efficiency

San Bernardino County Superintendent of Schools

Debra Mustain, Interim Director

California Community Colleges Doing What Matters Initiative

Bruce Noble, DSN – Energy & Utilities
Jim Caldwell, Director – Energy & Utilities
Ken Eaves, DSN – Advanced Manufacturing
Alan Braggins, DSN – ICT/Digital Media

Preliminary Specification

Course Objectives

1. Train incumbent workers in the advanced manufacturing and commercial building management industry segments in technologies that control manufacturing systems and building environments.
2. Re-purpose incumbent worker training to develop a course for community college career and technical education students in preparation for entering the workforce.
3. Develop model curriculum and course delivery system that can be adopted for use by community colleges and apprenticeship programs statewide.

The remainder of this specification relates to incumbent worker training.

Target Audience

Manufacturing Control Technicians
Manufacturing Systems Operators
Building Operators / Stationary Engineers
HVAC Service Technicians
Facilities Managers
Building Automation Systems Specialists

Proposed Student Learning Outcomes

Two levels of definition are proposed:

- As required for curriculum approval (Chaffey and Chancellor's Office templates)
- As required to get industry buy-in for a detailed response to the workforce need

Recommendation for detailed industry review: Initial research via O*Net Online for each of the above occupations, capturing information that can be validated by the industry advisory council.

Sample Occupation: Manufacturing Control Technicians
Translates to O*Net Manufacturing Production Technicians
http://www.onetonline.org/link/summary/17-3029.09

Format used in the US Department of Energy Job Task Analysis:

Student Learning Outcomes	Specialized Knowledge	Skills & Abilities	Tools, Technologies, and Resources

Final student learning outcomes – for both levels of definition - will be determined through dialog with the industry advisory council.

Overview of Priority Skill Sets

Priority 1.	Fault Detection and Troubleshooting
Priority 2.	Programmable Logic Controllers Control Theory
Priority 3.	Process Control Systems Sensor Technology
Priority 4.	Networking Theory and Applications Drive Control/Process Applications Database Applications Data Analytics Computerized Management and Maintenance Industrial Network Security Safety and Risk Management Stationary Engineering Fundamentals Manufacturing Systems Operations Manufacturing Process Fundamentals

Please see the attached detailed definition of priority skill sets.

Course Delivery Planning

Hours of Instruction:	The course was initially planned for 72 instructional hours, but the industry representatives felt that more instruction time would be required to cover all the priority skill sets in sufficient depth.
Meeting Times:	A concentrated learning experience is preferred in relatively short blocks of time multiple times per week. For example, classes could meet twice a week at 4 hours per session. Alternatively, significant portions of the course could be delivered online in a "flipped classroom" format, with a lower frequency of classroom instruction or lab time. Completion of the course should take six months or less. Industry representatives at the meeting cited that their employers usually prefer that training occur during normal working hours, an approach that would need to be vetted with other employers.
Delivery Format:	Interactive learning is preferred, using an appropriate mix of classroom instruction, online learning, lab time, project-based learning, and work experience. The industry group discussed various approaches and is willing to continue discussion on format, but left the final decision to the instructor.
Class Size:	Typical class size is 20 to 30 students.

Venue: The main options are Chaffey Rancho campus or the California Steel Industries Training Room A, although others may be considered. It's possible that project-based learning will occur at actual manufacturing and/or commercial building operations.

Enrollment Cost: To be determined. Multiple options exist for funding the cost of instruction, which will be evaluated. There is precedent for certain employers to cover wages of their employees while attending class, but more research is needed to determine applicability of this practice across the full range of target employers.

Industry Engagement

Curriculum development will be guided through periodic meetings with the industry advisory council. Special consultation may occur with key industry advisors to inform various phases of development and to address specific topics which need more analysis than would be appropriate with the full council.

Advisory Council Leader: Carlos Santamaria, Managing Partner
Executive Institute for Energy Efficiency

Advisory Council Support: Jim Caldwell, Sector Navigator
Energy Efficiency and Utilities

Ken Eaves, Deputy Sector Navigator
Advanced Manufacturing

Alan Braggins, Deputy Sector Navigator
ICT/Digital Media

Council Configuration: Attendees of the December 16, 2014 meeting plus additional members as determined by the Council leadership and support team. It is expected that the Council will grow to as many as 20 members in order to more fully engage industry stakeholders.

Enrollment Strategy: Council members agreed to assist in developing and executing a strategy to engage a broad cross-section of employers that can assure robust enrollment in the course.

In-Kind Services: In order to make the course fully relevant to industry needs, Council members may provide in-kind contributions along the following lines:

- Course content and training materials
- Guest lecturers
- Case studies
- Data for simulation and project-based learning

- Work experience related to student learning outcomes
- Specialized training sites for project-based learning
- Site visits
- Software, tools, instrumentation, and technology

Additional Resources

As the curriculum developer, Professor Steve Siedschlag will access Chaffey College course content and instructor expertise as required.

Carlos Santamaria, Jim Caldwell, Ken Eaves, and Alan Braggins will facilitate access to additional resources as required.

Proposed Timeline

Timeline	Approximate Date
Initial Advisory Council Meeting	December 16, 2014
Draft outline of Student Learning Outcomes and course topics	Mid-January, 2015
Second Advisory Council Meeting	Early February 2015
Draft detailed curriculum	Late March 2015
Third Advisory Council Meeting	Early April 2015
Final Detailed curriculum	Early June 2015
Delivery of Pilot Training Course	Fall Semester 2015
Fourth Advisory Council Meeting	November 2015
Finalized for-credit course definition and materials	November 2015
For-credit course availability at Chaffey College	Spring Semester 2016
Model Curriculum available for statewide adoption	June 2016

Contact:
Jim Caldwell, Sector Navigator – Energy Efficiency & Utilities
jcaldwell@workforceincubator.org
(925) 899-2665

Control Systems Technology
Skill Set Prioritization

Fault Detection & Troubleshooting				
Priority 1				
Building Operator	3 votes		Manufacturing	3 votes
Immediately identifying what control or controls failed			Identify faults inserted in various equipment	
Use EMS to get HVAC systems up and running with minimal down time			Know how to use the system to diagnose faults	
Ability to read, understand, and plan sequence of operations				
Functional knowledge of control logic				
Awareness and knowledge of electrical circuitry, DDC control, and motor control				

Programmable Logic Controllers				
Priority 2				
Building Operator	1 vote		Manufacturing	3 votes
			PLC Programming	
			PLC Logic	
			Common applications for efficient operations	

Control Theory				
Priority 2				
Building Operator	3 votes		Manufacturing	1 vote
Understand how HVAC equipment and EMS controls go hand in hand			AC Motor theory	
Understand control applications within various building types			DC Motor Theory	
Understand how controls apply to various building components			Motor controls including DC variable speed and AC variable speed	
Graphic design (JC interpretation: ability to interpret graphical representations			Basic automation principles	
			Math and physics (JC interpretation: understanding of the math and physics behind control functions	
			Analytical (JC interpretation: ability to effectively analyze controls as applied to various functions)	

Process Control Systems				
Priority 3				
Building Operator	0 votes		Manufacturing	3 votes
			How the process is being controlled	
			Input/output functions	
			Programming	
			Networking	
			Database	
			PLC functions	
			Drive functions	
			Feedback	
			Closed loop	
			Testing and troubleshooting	
			Design parameters	
			Communications (protocols?)	

Sensor Technology				
Priority 3				
Building Operator	1 vote		Manufacturing	2 votes
Pneumatics			Theory of operation	
Digital functions			Sensor types	
Analog functions			Calibration	
Types: Humidity, temperature, flow, chemical				
Process functions monitored by sensors and performance indicators				

Networking Theory and Applications				
Priority 4				
Building Operator	1 vote		Manufacturing	1 vote
Protocols			Application-specific theory (e.g. BACNET vs. MODBUS	
Network platforms				
Understand sequence of operations and process flow				

Drive Control / Process Applications				
Priority 4				
Building Operator	1 vote		Manufacturing	0 votes
CMMS			Electricity	
BAS			Motor theory	

Building Components			Math	
Smoke controllers			Communications	
Access controllers			Network	
Fire/life safety controls			Electronic design	
HVAC/R			Troubleshooting	
Database Applications				
Priority 4				
Building Operator	0 votes		Manufacturing	1 vote
Communication			Signals	
			Where data comes from	
			How to obtain	
			Software writing	
			Web applications	

Data Analytics				
Priority 4				
Building Operator	1 vote		Manufacturing	0 votes
Predictive/preventive/proactive				
Data reduction and interpretation				
Strategic planning based on analytics				

Computerized Maintenance & Management				
Priority 4				
Building Operator	1 vote		Manufacturing	0 vote
Energy Management System training				

Industrial Network Security				
Priority 4				
Building Operator	0 votes		Manufacturing	1 vote
			Security of: PLCs Communications Network Drive control	

Safety & Risk Management				
Priority 4				
Building Operator	1 vote		Manufacturing	0 vote
OSHA Training				
Load share and system re-start sequence				

Stationary Engineers

Priority 4				
Building Operator	1 vote		Manufacturing	0 votes
Key is hands-on experience			PLC Programming	
Internships			PLC Logic	
			Common applications for efficient operations	

Manufacturing Systems Operators				
Priority 4				
Building Operator	1 vote		Manufacturing	0 votes

Manufacturing Control Technicians				
Priority 4				
Building Operator	0 votes		Manufacturing	1 vote
Quality control				
BAS				

Topics Receiving Zero Votes		
Major Topics (Large Index Cards)		Subtopics (Small Index Cards)
Data Analytics		
Process Optimization		Statistics Quality Control Design
System Optimization and Sustainability		
Numerical Control Systems		
New technology integration		
System modeling and configuration		
Life cycle cost analysis		
Information Security		Emergency preparedness Back-up systems
Green building & sustainability		
CAFM		
HVAC service technicians		
Facilities Managers		Project management

Control Systems Technology

A Proposed Course for Chaffey College

Background

Control systems are embedded in complex processes across a wide range of industries. Most obvious is Information and Communications Technology, which includes real-time management of the internet, wireless and wireline telecommunications, computer networks, etc. Other examples are:

- Industrial process controls for manufacturing
- Medical records systems management for health care providers
- Transportation systems controls for scheduling and traffic management
- Monitoring and dispatch controls for emergency services and public safety

While these types of control systems are relatively mature, emergence of new technologies in the Energy Efficiency and Utilities Sector is driving new applications:

- Smart Grid utility controls for energy generation, transmission, and distribution
- Building automation and environmental control systems for commercial buildings

All of the above applications adhere to principles with common elements, suggesting that control systems technology can be viewed as a set of fundamental disciplines that can be learned and applied across many occupations.

Applications can vary widely by industry and by individual company, but typically some or all of the following disciplines are required:

Control theory
Process control systems
Process optimization
Networking theory and application
Database applications
Data analytics
Numerical control systems
Programmable logic controllers
Sensor technology

The Workforce Challenge

Increasingly, the technical services workforce will need to install, operate, and maintain systems that involve advanced control systems technology.

The challenge for some industry segments is very large, as is the case for Heating, Ventilation, and Air Conditioning (HVAC). Approximately 58,000 HVAC workers are employed in California, having received training in various types of mechanical systems. Very few of these workers have had significant training in control systems technology, and even fewer have learned the basic energy efficiency measures that these technologies enable. An additional 2,000 HVAC workers are needed in California annually through 2017, the vast majority of whom will enter the workforce without significant training in control systems technology.

Identifying the combined workforce skills requirements across all industries is beyond the scope of this brief document. But on the basis of HVAC alone, the workforce challenge is compelling, especially considering California's energy efficiency mandates arising from AB 32, the California Global Warming Solutions Act.

Proposed Solution

A new course at Chaffey College is proposed to add new knowledge, skills, and abilities (KSAs) for multiple occupations, delivering control systems technology fundamentals that can be applied across multiple industry segments.

Existing workers are by far the largest population for which these new KSAs are needed. At the same time, this population offers the greatest opportunity to engage employers in identifying priority occupations and defining specific KSAs. Further, incumbent worker training can be funded outside the college apportionment process, providing a cost-effective low-risk approach for innovation in courses serving mainstream community college students.

So, the proposed solution has two phases:

1. Develop and deliver incumbent worker training to meet immediate industry needs
2. Re-purpose incumbent worker training to create a new credit course for mainstream college students

As related to Chaffey certificates and degrees, a control systems technology course potentially can be integrated into Industrial Electrical Technology, CIS-Networking, Engineering Technology, and perhaps other programs.

Next Steps

Faculty consideration of the workforce challenge and proposed solution is the first and most essential step. Assuming that faculty is supportive and engaged, the next step is to develop a hypothetical course description that leverages current Chaffey offerings and other available resources (e.g. US Department of Energy, Department of Labor, and National Science Foundation) and offerings at other community colleges. Skills Panels or DACUMs with employer groups will add depth to the course description and identify gaps. Funding for course development and incumbent worker training can be facilitated in parallel with these activities.

Contact

Jim Caldwell, Sector Navigator – Energy Efficiency & Utilities
jcaldwell@workforceincubator.org
(925) 899-2665