ECT 21
COURSE

LANEY COLLEGE
ENVIRONMENTAL CONTROL TECHNOLOGY

Commercial HVAC Systems Program

ECT 21 Introduction to Direct Digital Controls Course Development

National Science Foundation - National Center for Building Technician Education

INTRODUCTION TO DIRECT DIGITAL CONTROLS

Course Documentation

This material is based upon work supported by the National Science Foundation under Grant Number (DUE 1204930).

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Environmental Control Technology
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Catalog description

Introduction to direct digital control systems and building automation systems: basic electricity and electronics and overview of the various approaches to system architecture, hardware, software, and system components.

Class hours

Lecture 26.25 hours Lab 26.25 hours

Units

Lecture 1.5 semester units Lab 0.5 semester unit

Entry skills needed

- Reading level: College-level English technical reading. Ability to decode new technical terminology with reference help.
- Writing level: Ability to express complex technical concepts in English.
- Math level: college technical math
    1. Perform mathematical operations using real numbers, fractions, decimals and percentages.
    2. Solve simple linear equations.
    3. Demonstrate knowledge converting fractions to decimals and decimals to fractions.
    4. Solve basic math and geometry problems on area, angles, volume and percentages.
    5. Use algebraic equations to solve heating and cooling load calculation problems.
    6. Solve problems involving ratio and proportions.
    7. Interpret data in graphs in rectangular coordinate systems.
    8. Use and apply Imperial and Metric systems of measurement.
    9. Solve problems involving area and perimeter.

- Mechanical and Electrical Devices skills:
    1. Identify, test, replace, repair and describe the functions of all electrical and electronic components.
    2. Demonstrate safe work practices with high and low voltage.
    3. Demonstrate proper troubleshooting procedures and the use of basic instruments.
    4. Identify the different types of transformers and motors.
    5. Explain the basic concepts of electricity and Ohm's Law.

6. Describe the relevant sequence of operation of the system.
7. Demonstrate the ability to interpret electrical diagrams.
8. Exhibit familiarity with energy management and efficiency.

- Fundamentals of Electricity skills:
    1. Understand and explain basic AC power concepts, such as phase angle and power factor.
    2. Read and explain single line power distribution diagrams.
    3. Wire Y and Delta connections step up and step down applications.
    4. Select and apply the proper instruments for diagnosing electrical problems.
    5. Understand and explain safe wiring practices including the concepts of proper grounding.
    6. Demonstrate electrical safety practices, including the use of personal protective equipment (PPE) and first aid.
    7. Demonstrate proper knowledge of how to read and draw electrical schematic and pictorial diagrams.
    8. Describe the different types of motor starters and over-current protection devices.

Syllabus

See Appendix A for sample Syllabus, course schedule, and policies. For Lesson Topics to include in course, see Exit Skills.

Student learning outcomes

The exit skills listed in the next section support these 4 outcomes:

Fundamentals

Explain the fundamentals of building control systems.

Integration

Describe proper methods for interfacing digital controls with conventional control devices and their integration.

System strategies

Explain the different strategies and terminologies for controls applications and control systems.

Controls maintenance

Demonstrate proper and safe maintenance, troubleshooting, and calibration procedures for working with controls.

Exit skills

Course content to achieve 4 outcomes listed above:

Basic controls concepts

1. Define and understand the purpose of device types, software types, protocols, and diagnostic codes.

   Course Content for this objective:

   a. Fundamentals of pneumatic and direct digital controls

      Lesson Topics:

      - Overview of air conditioning systems
      - HVAC system energy sources
      - Control principles
      - Control systems
      - Air compressor station
      - Pneumatic actuators, dampers, valves
      - Thermostats, humidistats, pressure switches, transmitters, receivers, controllers

2. Diagram simple, common control systems.

Interfacing DDC and pneumatics

3. Select, set up, and describe the inputs and outputs of control devices.
4. Explain what equipment is needed to connect direct digital controls to an existing pneumatic system.
5. Set up and operate a converted pneumatic system.

   Course Content for this objective:

   a. Interfacing digital controls with conventional control devices

      Lesson Topics:

      - Pneumatic to DDC conversion

Applications

6. List and explain common control system applications and terminologies.

   Course Content for this objective:

   a. Strategies for controls applications
   b. Terminologies for control systems

7. Describe the operation and benefits of proportional vs. proportional + integral + derivative (PID) control algorithms.

   Course Content for this objective:

   a. Proportional and PID control loop feedback

8. List and explain strategies to implement for energy conservation.
   Course Content for this objective:
   a. Energy conservation control strategies
      Lesson Topics:
      - Energy management control features and methods

9. Describe building automation systems.
   Course Content for this objective:
   a. Fundamental concepts of building automation systems

Instruments & troubleshooting

10. Select & apply proper instruments for diagnosing electrical and control system problems.
    Course Content for this objective:
    a. Maintaining and troubleshooting direct digital control systems

11. Manipulate control system software and interpret output and error codes.
    Course Content for this objective:
    a. Interpreting control software output.

Wiring & safety

12. Demonstrate safe electrical field work and wiring practices.

Course materials

Principal text

Ronnie J. Auvil, HVAC Control Systems, American Technical Publishers, Inc First Edition 2003.

Lecture materials and handouts

The following internet and proprietary-sourced documents can be used as handouts or referenced for student inspection to support lecture materials and provide resources for lab work.

- Presentation: **Automatic and DDC Control Fundamentals and Energy Conservation for HVAC Equipment**, PNNL, part 1 & 2. 168 slides.
- Presentation**: Introduction to BAS Technology:** Dave Kahn, P.E., 38 slides.
- Presentation: **Proportional Control, PID and Loop Tuning,** Facility Dynamics Engineering. 111 slides.
- Presentation: **WebCTRL** ALC Server platform software. 29 slides.
- Reference: Cutsheets for control system components.
- Reference: **Trend Analysis for Commissioning**: this article shows how using automated analysis on trend data from energy management and control systems (EMCS) can serve as a powerful tool for troubleshooting control systems.
- Reference**: An Overview of Proportional plus Integral plus Derivative Control and Suggestions for Its Successful Application and Implementation:** By: David Sellers, Senior Engineer, Portland Energy Conservation Inc, Portland, Oregon.
- Reference: Resistance-Temperature tables for various thermistors.
- Reference: **UC Berkeley Latimer Hall DDC Retrofit Controls Submittal**: ACCO Direct Digital Controls, 2009. A complete bid document for a real controls implementation job.
- Reference**: Ziegler-Nichols Methods Facilitate Loop Tuning:** Control Engineering Resource Center, 1998

Other reference materials

Honeywell Engineering Manual of Automatic Control for Commercial Buildings, 1997.

HVAC Controls Introduction, © Invensys Building Systems 2001

Software needed

- **ALC Corp** suite**: EIKON LogicBuilder** creates programs to control equipment, from single pieces of equipment to complex energy management functions. **Microblock Reference** describes source code elements for user. **SiteBuilder** creates the database that WebCTRL Server uses to communicate with control modules in the field. **ViewBuilder** creates graphics and interface for hand-held control module programming unit.

Lab materials

- Pencils, colored felt tip pens, graph paper with 1/8" squares, circle template, line paper, safety glasses, medium flat blade and Phillips screwdrivers, combination wire cutter, stripper and crimper, one roll of electrical tape, wire connectors, multi-meter and tool box or pouch

- ECT Commercial HVAC system lab diagrams and drawings from 3 represented controls vendors (ALC, TAC, and Trane)

- User Guides for ALC EIKON suite software: Logic Builder, Microblock Reference, Site Builder, and View Builder

Lab equipment & instruments required

Generally, hands-on implementation of concepts is key to successful learning of equipment function and relationships. Laney ECT department's lab has a fully functional commercial building central plant system for demonstration purposes. All components of the system are accessible to students for operation, measurement, diagnosis, servicing, and commissioning. See Laney College - Commercial HVAC Systems program documentation for lab layout and more detailed information on equipment and instruments.

A connected and functional commercial HVAC system should include a boiler, chiller, water pumps, air handling units, terminal units, cooling towers, control systems(pneumatic and/or DDC), sensors, and actuators. Monitoring access point computers accompanied by one or more control system trainer boards (with equivalent connected controls and actuators) will allow students maximum access.

At the minimum, DDC system trainer boards with computer and graphic user interface (GUI) are necessary.

Samples of weekly assignments

Selected exercises are assigned from the chapters correlating to the Lesson Topics section. The source of exercises is the HVAC Controls text workbook.

Project

"Converting a Pneumatic Control System to a Direct Digital Control System for Monitoring Building Conditions" (see Appendix B)

PROBLEMATIC SITUATION

The Building "B" complex at Laney College was built in the early 1970s as part of original construction of the campus. There have been faculty complaints ranging from uneven and fluctuating temperatures to not enough outside air being circulated within the building. The district office has decided to convert the control system in the "B" building from pneumatics to direct digital controls, but has to stay within a fixed budget of $50,000. Your team has been hired to be the consultants on this project. It is your job to determine a control specification for the problem by upgrading the system and identifying what key points to look at for continuously monitoring the building.

Key Course Concepts:

- Demonstrate the ability to understand what is needed to evaluate building performance.
- Determine control points for continuous monitoring of the performance of a building.
- Demonstrate understanding of basic concepts of building control systems.

Assessment

Methods

1. Problem based learning exercise (see project above)
2. Quizzes
3. Workbook
4. Midterm Exam
5. Final Exam:

See Appendix B – Sample project rubric for project assessment.

Sample test questions

Midterm: 50 True/False, Multiple Choice questions: covering building science, HVAC components/function, control components/function.

1. A self-contained control system is a control system that requires an external power supply.

2. An outside air dry bulb temperature of ___ is common for outside air economizer use.
   a. 33°F to 45°F
   b. 35°F to 55°F
   c. 45°F to 65°F
   d. 60°F to 70°F

3. Electric control systems commonly use a(n) ___ device to control the flow of electricity in a circuit.
   a. mechanical
   b. pneumatic
   c. solid-state
   d. electronic

Final: 100 True/False, Multiple Choice questions, covering control architecture, components, function, programming, and networks.

1. A pulse width modulated device is a digital output used to position a bi-directional electric motor.
2. A central supervisory control system is a control system in which the decision making equipment is located in ___ and the system enables/disables local (primary) controllers.
   a. one place
   b. various locations
   c. the air handling unit
   d. the building space controller

3. Ethernet is a local area network architecture that can connect up to ___ nodes and supports minimum data transfer rates of 10 megabits per second (Mbps).
   a. 256
   b. 512
   c. 1024
   d. 2048

Adaptability to on-line format

Requirements: The lecture portion can be delivered and assessed on-line with traditional methods. The laboratory portion requires hands-on experience with equipment, so on-line delivery needs to be supported by real world access. Adaptation of laboratory equipment for video presentation might support on-line demonstrations.

Appendix A – Sample syllabus

(See Exit Skills section for lesson topics.)

LANEY COLLEGE

Environmental Control Technology

Course: Introduction to Direct Digital Controls
Course Number/code: ECT 021
Time: Mondays and Wednesdays 5:30 PM – 7:00 PM
Instructor:
Office: **Office Hours:**
Phone: **Units:** 2 units.

Course Description: This course will cover the introduction of direct digital control systems and building automation systems. Topics include basic pneumatic, electronics and overview of the various approaches to system architecture, hardware, software, and system components.

Student Outcomes:

1. Explain the fundamentals of building control systems.
2. Describe proper methods for interfacing digital controls with conventional control devices and their integration.
3. Explain the different strategies and terminologies for controls applications and control systems.
4. Demonstrate proper and safe maintenance, troubleshooting and calibration procedures for working with controls.

Recommended preparation: E/ET 202, English, Math and Computer Literacy

Text: Ronnie J. Auvil, HVAC Control Systems, American Technical Publishers, Inc First Edition 2003

Supplies Needed: Pencils, colored felt tip pens, graph paper with 1/8" squares, circle template, line paper, safety glasses, medium flat blade and Phillips screwdrivers, combination wire cutter, stripper and crimper, one roll of electrical tape, wire connectors, multi-meter and tool box or pouch.

Evaluation: The following classroom work and projects will be evaluated and graded.

6.	Problem based learning exercise	100
7.	Quizzes	100
8.	Workbook	300
9.	Mid-Term Exam	250
10.	Final Exam	250
	Total:	**1000 points**

900-1000 points	**A**
800-899	**B**
700-799	**C**
600-699	**D**

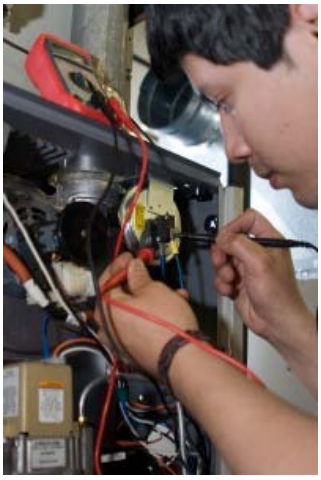
Attendance: Students may be dropped from the course if the number of absences exceeds two days worth of class meetings. However, extenuating circumstances may warrant consideration.

Note: During class please shut off all cell phones, also no eating or drinking. You will be given two breaks of ten minutes each between classes.

Weekly lesson plan

1. Safety
2. Overview of Air Conditioning Systems
3. HVAC System Energy Sources
4. Control principles
5. Control systems
6. Air compressor station
7. Pneumatic actuators, dampers, and valves
8. Thermostats, humidistats, pressure switches, transmitters, receivers controllers
9. Midterm
10. Spring Break
11. Problem based learning exercise
12. Problem based learning exercise
13. Pneumatic to DDC conversion
14. Energy conservation control strategies
15. Building Automation Systems
16. Review and Makeup
17. Final

Appendix B – Sample project scenario with rubric



PROBLEM BASED LEARNING

ECT 21: Introduction to Direct Digital Controls

"Converting a Pneumatic Control System to a Direct Digital Control System for Monitoring Building Conditions"

STUDENT GUIDE

Disclaimer: This material is based upon work supported by the National Science Foundation under Grant No. 0802595. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation

Instructor: Chuck Frost
Course: Introduction to Direct Digital Controls
Course Number/Code: ECT 21

SCENARIO TITLE

"Converting a Pneumatic Control System to a Direct Digital Control System for Monitoring Building Conditions"

Key Course Concepts:

- Demonstrate the ability to understand what is needed to evaluate building performance
- Determine control points for continuous monitoring of the performance of a building
- Demonstrate understanding of basic concepts of building control systems

SCENARIO DURATION

- **4-6 partial class periods**: An introduction to the Problem Based Learning (PBL) process, presentation of sample projects, and class time to work on the project as a group

BUSINESS PARTNER

Laney College, Environmental Control Technology (ECT)

LEARNING OBJECTIVES

By the end of the semester, students will be able to demonstrate the ability to:

- Identify what is needed to monitor the performance of a building
- Develop the design of a control system
- Specify a list of control points for continuous monitoring of a building
- Understand how to convert from a pneumatic system to a DDC control system
- Provide solution(s) and recommendations for upgrading the control system
- Write a control specification for the construction

THE FOCUS OF THE PROBLEM

The focus of this Problem Based Learning (PBL) scenario is based around a real life scenario.

In various settings, the Problem Based Learning (PBL) scenario may be presented as a real time problem, hands-on scenario, or hypothetical problem. Using critical thinking

and investigation, the students go through a process to solve a problem and provide recommendations for a solution.

PROBLEMATIC SITUATION

The Building "B" complex at Laney College was built in the early 1970s as part of original construction of the campus. There have been faculty complaints ranging from uneven and fluctuating temperatures to not enough outside air being circulated within the building. The district office has decided to convert the control system in the "B" building from pneumatics to direct digital controls, but has to stay within a fixed budget of $50,000. Your team has been hired to be the consultants on this project. It is your job to determine a control specification for the problem by upgrading the system and identifying what key points to look at for continuously monitoring the building.

Questions to think about while investigating the Problem Based Learning (PBL) scenario:
***WHO** is involved?*
***WHAT** is not working?*
***WHEN** did the problem start?*
***WHERE** is this scenario taking place?*
***TIME** pressures or deadlines?*

STUDENT MATERIALS

The instructor will provide students with the following information:

- A copy of the Problem Based Learning (PBL) cycle and steps
- An explanation of the Problem Based Learning (PBL) approach
- A copy of the mechanical and electrical drawings to the building
- Tool: "Need to Know" to gather information
- Tool: Scoring rubric for final presentation
- Problem Based Learning (PBL) scenario evaluations: Team evaluation and online survey

Resources and Media:

- The internet
- Educational materials and books
- "Ctrl Spec Builder" software (www.ctrlspecbuilder.com)

INSTRUCTOR ROLE

The instructor will support the Problem Based Learning (PBL) experience by:

- Introducing the scenario and process
- Facilitating reflection and discussion
- Providing applicable resources and materials
- Answering any questions related to the scenario and coursework

- Providing class time to work on the scenario

STUDENT ROLE AND GUIDELINES

Individual

The intended outcome will be measured by having each student:

- Distribute project tasks between the group members
- Perform a specific individual role in their team
- Perform a specific individual role in the final presentation
- Complete a Problem Based Learning (PBL) scenario and team evaluation as a part of the final project

STUDENT ROLE AND GUIDELINES

Group

The intended group outcome will be measured by providing:

- A group presentation where each student will individually present a particular segment (1-2 minutes) of the recommendations to the client
- A class discussion where each student on the team will make an oral presentation of what they learned
- On the day of the final presentation, as a group turn in one copy hard copy of the specification which describes the recommendations on the problem and the solution(s)
- On the day of the final presentation, as a group turn in or email the instructor an electronic version (file folder) of the specification document
- As a group turn in one copy of the "Need to Know Board"

Group Size:

- 4 or 5 groups (Approximately 3-4 students per group)
- The Instructor will participate in the selection of members of each group

STUDENT FEEDBACK

As a team, and individually - students will review, assess and provide feedback regarding the Problem Based Learning (PBL) scenario experience.

Requirements of the final project: Before final presentation

- Completion of team member evaluation and online survey

TEAM LINK

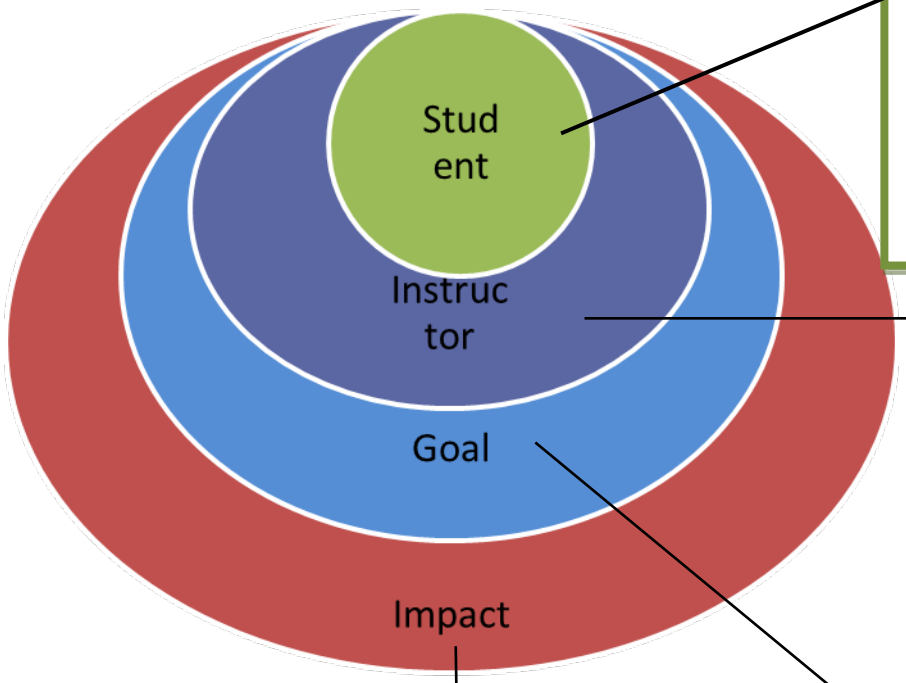
The instructor will support the team learning process by allowing:

- 30-45 minutes approximately every week for three weeks, where students will be able to work on the scenario as a group
- Time to meet during class, outside of class and on the phone to work on the scenario

Problem Based Learning (PBL) Overview

The Problem Based Learning (PBL) approach builds on more than three decades of research by leading experts in learning and cognition. John Bransford, a professor at the University of Washington, is one of the educators whose work underlies the approach. Problem Based Learning requires that students draw from many different sources and disciplines.

Problem Based Learning focuses on creating learning experiences that integrate real world scenarios through which the student investigates, applies skills and knowledge to provide solutions to a unique industry related problem. The learning course objectives are identified, but how the student arrives at the solution(s) is not previously set.



Student's Role

-Critically indentifies problem
-Collects information by asking questions
-Identifies useful resources, integrates information and knowledge needed to determine a solution(s)
-Collaborates in a team environment
-Takes ownership of their project
-Self reflection and evaluation

Instructor's Role

-Creates a learning environment that supports shared responsibility
-Facilitates the curriculum using a hands on approach
-Works with students to achieve goals for a project
-Provides students with opportunities to strengthen professional and critical thinking skills

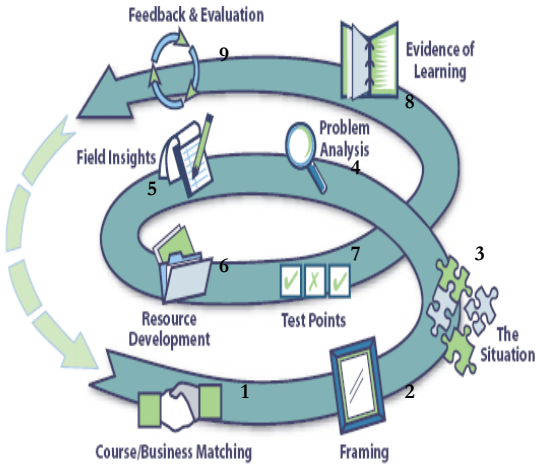
Goal

-A process that involves critical thinking and problem solving skills
-A method that guides students to answer central concepts by asking questions and gathering information
-Creates hands-on learning that are central to the curriculum
-Uses real life examples that are applicable and realistic for the student

Impact

-Supports knowledge retention using real world experiences
-Develops critical thinking skills
-Creates learning connections to industry
-Develops creative problem solving skills
-Increases student's self confidence

Problem Based Learning (PBL) Process



The Problem Based Learning (PBL) cycle is a process that takes the learner through various stages in order to identify real world problems, gather and assess information, and work in a team environment to determine a solution(s).

Problem Based Learning (PBL) Cycle	Description	Laney college How your ECT PBL scenario fits into the Problem Based Learning (PBL) cycle.
1. Course Business Matching	Links real world business and industry problems within curriculum as a way of learning.	Laney college is acting as your business partner.
2. Framing	Set criteria and method for identifying support systems and tools for solving the problem.	
3. The Situation	Begin the process of asking questions, critical thinking and analysis of the problem individually and with the team.	The Problem Based Learning (PBL) scenario is centered around a real world or industry specific scenario.
4. Problem Analysis	In depth question asking, critical thinking and analysis of the problem with the team. Evaluate facts, assumptions and resource options.	As a team, your goal is to focus on gathering and analyzing information in order to determine your solution(s).
5. Field Insights	Gather and organize information, site resources, conduct interviews, and document findings.	
6. Resource Development	As a team, analyze and review data findings. Determine if more research is needed and begin to form theories for a solution.	
7. Test Points	Test theories against facts and assumptions. Develop strategies for selecting, consolidating and presenting information to support the theories for solution to the problem.	As a team, it is your goal to review, evaluate and present your solution(s). In this process, you will also have an opportunity to evaluate your team members and the Problem Based Learning (PBL) experience.
8. Evidence of Learning	Team presentation of identified problem and possible solution(s) with documented support.	
9.Feedback and Evaluation	Evaluate individual and team experience using the Problem Based Learning (PBL) process of learning.	

Laney College

TURN IN TO INSTRUCTOR

TOOL: "NEED TO KNOW" This tool will help you record the facts, questions, resources and knowledge needed to investigate your Problem Based Learning scenario.

FACTS ***"What do I know?"*** List only facts with identified sources or references.	**ASSUMPTIONS** ***"What am I assuming to be true?"*** List assumptions based on unproven information, prior knowledge or experience, and/or beliefs based on intuition, emotion, or opinion.
LIST THE FACTS with sources & references:	LIST THE ASSUMPTIONS:
QUESTIONS ***"What do I need to research?"*** List all of the questions or ideas that you need to find missing information in order to prove or disprove assumptions.	**RESOURCES** ***"Where can I find answers to my questions?"*** List verifiable documents, media, or information; locations or activities to investigate, and /or people with relevant knowledge.
LIST THE QUESTIONS:	LIST THE RESOURCES:

TURN IN TO INSTRUCTOR

EVALUATIONS

Your comments and ideas are important to ECT and will help to improve future classes using Problem Based Learning (PBL) scenarios. This is an opportunity to provide insight on the PBL experience, share your thoughts, and provide feedback to your instructor regarding yourself and your team members.

These two evaluations are a mandatory part of the Problem Based Learning (PBL) scenario. You will be given 15-20 minutes before the final presentation to fill out these evaluations.

[] Team experience: Peer Evaluation
[] Individual feedback: Survey Monkey online survey

PEER EVALUATION

Rate Team Members (write your team member names below)	**Points** Circle points 1(Poor) - 5(Excellent)				
1. Self	**1**	**2**	**3**	**4**	**5**
2.	1	2	3	4	5
3.	1	2	3	4	5
4.	1	2	3	4	5
5.	1	2	3	4	5
6.	1	2	3	4	5

Written Feedback:
Please answer the following questions: All answers will be kept confidential!

Is there a specific team member(s) that over performed or contributed to the team? Explain why?

Is there a specific team member(s) that underperformed or did not equally contribute to the team? Explain why?

TOOL: Scoring Rubric for Final Presentation.

This is a scoring rubric of

SAMPLE: Write each student's name above a score column. For each presentation trait, rate each student using the scale shown.

1	2	3	4	5
Strongly disagree				Strongly agree

Score						Presentation Trait
						⇦ **Quality of information and organization:** Presentation main points are clear and well developed; information is linked to presentation topic; information is organized.
						⇦ **Nonverbal communication:** Speaker appears comfortable and confident; speaker maintains good eye contact and posture; speaker shows engaging and inviting presence; speaker uses body motions and gestures effectively; speaker utilizes room effectively via movement.
						⇦ **Quality of verbal communication:** Speaker's voice is confident, steady, strong and clear; speaker uses inflections to emphasize key points or to create interest.
						⇦ **Visual tools:** Visual aids are creative, clear and easy to read; tools enhance the effectiveness of the presentation.
						⇦ **Appropriate use of terminology:** All terms are included in the presentation; terms are used in unique and creative ways; terms are used in context.
						⇦ **Precision and detail in documents produced:** Documents are clear, well constructed, accurate and show attention to detail; care has been taken in the production.
						⇦ **Overall presentation effectiveness**
						⇦ Total Score

Traits	5 – Excellent	4 – Very Good	3 – Adequate	2 – Limited	1 – Poor

Traits	5 – Excellent	4 – Very Good	3 – Adequate	2 – Limited	1 – Poor
Information Quality and Organization	• Main points are very clear and very detailed • Information is directly linked to presentation topic • Information is very organized	• Main points are clear and detailed • Information is linked to presentation topic • Information is well organized	• Main points are somewhat clear but could use more detail • Most information is linked to the presentation topic • Information is organized	• Main points are not clear and lack significant detail • Some information is linked to the presentation topic • Information is loosely organized	• Presentation lacks main points and related details • Information lacks connection to the presentation topic • Information is not organized
Nonverbal Communication	• Speaker appears very comfortable and confident • Speaker consistently faces the audience and maintains good eye contact • Speaker consistently appears to be engaging with the audience • Speaker uses body motions and gestures very effectively • Speaker utilizes the room very effectively via movement	• Speaker appears fairly comfortable and confident • Speaker generally faces the audience and maintains good eye contact • Speaker generally appears to be engaging with the audience • Speaker uses body motions and gestures well • Speaker utilizes much of the room via movement	• Speaker appears generally at ease and confident • Speaker sometimes faces the audience and maintains eye contact • Speaker sometimes appears to be engaging with the audience • Speaker's body motions and gestures neither support nor detract from presentation • Speaker moves about some of the room	• Speaker appears uneasy and somewhat insecure • Speaker rarely faces the audience or makes eye contact • Speaker rarely appears to be engaging with the audience • Speaker uses few body motions or gestures or has gestures or movements that distract the audience • Speaker is mostly stationary	• Speaker appears very uneasy and insecure • Speaker faces away from the audience or makes no eye contact • Speaker appears disengaged from the audience • Speaker lacks any body motions or gestures or demonstrates consistently distraction body motions or gestures • Speaker is completely stationary
Quality of Verbal Communication	• Speaker's voice is very confident, steady, strong, and clear • Speaker consistently uses inflections to emphasize key points or to create interest • Speaker's talking pace is consistently appropriate	• Speaker's voice is steady, strong and clear • Speaker often uses inflections to emphasize key points and create interest • Speaker's talking pace is mostly appropriate	• Speaker's voice is generally steady, strong and clear • Speaker sometimes uses inflections to emphasize key points and create interest • Speaker's talking pace is appropriate	• Speaker's voice is frequently too weak or too strong • Speaker rarely uses inflections to emphasize key points and create interest or speaker sometimes uses inflections inappropriately • Speaker's talking pace is often too slow or too fast	• Speaker's voice is consistently too weak or too strong • Speaker fails to use inflections to emphasize key points and create interest or speaker often uses inflections inappropriately • Speaker's talking pace is consistently too slow or too fast
Visual Tools	• Visual aids are very creative, clear, and easy to read • Presentation is consistently enhanced by the visual tools	• Visual aids are usually creative, clear, and easy to read • Presentation is often enhanced by the visual tools	• Visual aids are reasonably creative, clear, and easy to read • Presentation is sometimes enhanced by the visual tools	• Visual aids have limited creativity or clarity or are sometimes difficult to read • Presentation is not enhanced by the visual tools	• Visual aids demonstrate no creativity or clarity and are often difficult to read • Presentation is weakened by the visual tools
Appropriate Use of Vocabulary	• All terms are included in the presentation • Used in unique and creative ways • Used in context	• All terms are included in the presentation • Used effectively • Used in context	• Most terms are included in the presentation • Generally used appropriately • Generally used in appropriate context	• Several terms are included in the presentation • May or may not be used appropriately • May lack context	• Few or no terms are included in the presentation • May or may not be used appropriately • Lacks context

Traits	5 – Excellent	4 – Very Good	3 – Adequate	2 – Limited	1 – Poor
Precision and Detail in Documents Produced	• Documents are clear, well constructed, accurate and show attention to detail • Extra care has been taken in the production	• Clearly evident that documents are correct, detailed and accurate • Care has been taken in the production	• Evident that documents are correct and show a general attention to detail and accuracy • General care has been taken in production	• Documents may have some errors and show some detail • Some care has been taken in production	• Documents have numerous errors and lack detail • Little care taken in the production
Overall Presentation Effectiveness	• This was an exceptional presentation and extremely effective • I'd give you a 10	• This was a very good presentation and very effective • I'd give you an 8 or 9	• This presentation was good and effective • I'd give you a 6 or 7	• This presentation was average and somewhat effective • I'd give you a 3, 4 or 5	• This presentation was weak and not effective • I'd give you a 0, 1, or 2

BEST Center Curricula, Resources & Recordings

Academic Programs
Georgia Piedmont Technical College - Building Automation Systems
Milwaukee Area Technical College - Sustainable Facilities Operations
Laney College - Commercial HVAC Systems
City College San Francisco - Commercial Building Energy Analysis & Audits

Professional Development Materials, Presentations & Videos
National Institutes
Building Automation Systems Instructor Workshops
Webinars (e.g., BEST Talks)

Faculty Profile Videos
Reports & Case Studies
Marketing Resources

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