Creating a new BS Program in Building Automation Technology at the Pennsylvania College of Technology: An Industry and Academic Cooperative Effort.

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Summary.

The Pennsylvania College of Technology is located in Williamsport, PA in the USA. The new program was created as a result of extensive consultations with building automation industry representatives. The first class of twelve students are in the second semester of their Junior year of the program. This paper describes the activities and philosophy that led to the creation of the program. These included multiple focus groups with industry representatives, an extensive survey sent to control companies and individual visits and consultations with building automation industry representatives. The process has resulted in an innovative program that accepts students with two year degrees in electrical, HVAC, or electronics technology for study in this four year BS two plus two program. The program includes a summer internship, extensive lab work with DDC, pneumatics, BACnet, Ethernet, and LonTalk, a senior seminar and a senior project.

1.0 Introduction

The design and implementation of a new BS program such as the new Building Automation Technology program at the Pennsylvania College of Technology is a complex endeavor that is dependent on successfully completing critical tasks on a time line that extended over two and one half year from April 2000 to program start up in August 2002.

Feedback from industry and from existing faculty and administrators provided major input to the process and resulted in modifications of the program design that we feel has produced a robust curriculum that is positioned to grow and change with the industry.

The successful establishment of this new two plus two BS program in Building Automation required a communication process that occurred across a number of occupational cultures. These cultural groups or communities of practice [1] included faculty, administrators, consulting engineers, controls technicians, managers in controls companies, technical and trade journalists, association representatives and prospective students. Communication tools that were used to bridge these cultures and to foster mutual leaning and the successful design included focus groups, surveys, email discussion lists, individual visits from industry representatives to the college and a web site for the program.

In this paper I outline the critical events that led to a successful program implementation. I will also touch on three features of the design of this program that directly resulted from industry input. These are the two plus two format, the summer internship, and the implementation of speaking and writing skills and problem solving in the senior project. The program started up in August of 2002 with a first class of twelve students who entered this upper division program in their third year.

2.0 Critical Events

2.1 April 2000. Industry Requests a Two Year Controls Program.

Penn College has strong two year programming in HVAC, computers, electrical technology, and electronics. It did not come as a complete surprise that the local Johnson Controls branch office asked us to consider starting a two year controls course leading to an associate degree. The proposal was sweetened considerably by a very generous offer of equipment and support from Johnson Controls.

Cultural issues came to the fore soon into the proposal process. Johnson took a very close look at our existing courses and did an admirable job of matching relevant courses to Johnson Controls institute courses. The result was a complete document [2] that was presented in a meeting with the Dean and other administrators. The layout matched the one Penn College uses in our catalog with the appropriate Johnson courses blended into each of the four semesters leading up to an associate degree.

For ill or good, in academia there is a fairly lengthy process used to develop curriculum and central to the process is the involvement of a faculty and administrators from units across the college and not just one department. It appeared to those present at the initial meeting that despite the very laudable intentions of the company, Johnson had approached this process in a much more direct manner than is normally the case in academia. From the perspective of the culture of business, the company had done what was expected and that was to do their homework and come up with a possible "product" that was well on its way into the practical implementation stage, however from the perspective of the culture of academia things were being advanced at an alarming rate.

The result was that the College administrators at the next higher level passed down the word that Penn College did not wish to be tied to one single company in this program and that we should go out on a multi-vendor basis. To Johnson Controls everlasting credit they did not give up on us at this point but have stuck with us over all of the stages of the development of the new program and its implementation.

2.2 May 2000. Establishing Need: an Industry Survey.

The College, having made the decision to broaden the program design to include multiple manufacturers, needed some hard data that would confirm the need for a new program. A new program such as the one proposed involves the investment of many thousands of dollars of time from faculty and administrators, long range space planning, publicity, new staffing needs and many other investments before the first class of students can start their course of study. As with any "product", success lies solely with the user. No students, no program. Our programs are driven by industry need for graduates and a survey sent to industry personnel was a suitable method of documenting the need for a new program in building automation.

A brief, one page survey [3] was prepared and sent out by email to 200 controls companies. The intent of the survey was to ascertain the immediate need and the five year need for graduates with training in commercial HVAC controls. We received 47 returns, a 24 % return rate which is not bad at all for this type of survey. In the report of the survey [4], the results shown indicated an industry need for a new program in control. It seemed at this point, that the need was for a program at the two year level and one that was centered around commercial HVAC control. We do primarily two year associate degree hands on programming and we have a strong HVAC program. The

conclusions were in agreement with the existing cultural view from inside the academic institution including my own.

2.3 October 2000. First Industry Focus Group.

What would happen if, rather than sending out a well-constructed albeit constricted survey via email, industry representatives came together for a one day face-to-face meeting? The focus group format seemed ideal as a loosely coupled regulating structure to enable communication between the cultures of industry, recent student graduates, and academia. We were fortunate to have on our staff a person with considerable experience in leading focus groups. To this end we assembled a diverse group in October 2000. Twelve industry representatives were present including those from Penn State's Office of Physical Plant, Penn College General Services, Trane, Johnson, Automated Logic and faculty and staff. Michael Ivanovich, editor, HPAC Engineering was not able to attend, but provided valuable written input.

The conclusion in the report of the focus group meeting [5] was that there is a critical need for HVAC controls technicians with a solid background in HVAC systems, computers and direct digital controls. These technicians should have a strong electrical background and be able to read diagrams and interpret sequences of operation. Good interpersonal skills, good work habits and time management skills together with strong presentation skills are essential. Math through Algebra 1 is sufficient together with work in English, public speaking, and a non-calculus lab based physics course. It was the consensus of all that the program should include an industry internship. The projected length of that internship ranged from a high of six months to a summer three month experience. One significant outcome of this meeting was that most present felt that there is too much material to present in a two year associate degree program and consideration should be given to a three or four year program.

An important directional change for the design of the new program occurred at this focus group. We were now looking at a longer program with a substantial internship component and a wider scope that went beyond commercial HVAC controls to include building automation. Paul McWhinnie of TAC, during a visit to the school, suggested the term building automation technology for the program title.

2.4 October 2000- August 2001. A New Two Plus Two Program is Designed by Faculty and Administrators.

Over an eleven month period a program proposal was put together using input from the focus group, a listserv with email comments, individual visits to the college by industry representatives and comments from prospective students in our existing two year programs. A group of faculty set to work on individual courses and produced course abstracts. The faculty that participated in this effort were drawn from the areas of HVAC technology and electrical technology. The resultant detailed curriculum was presented to a second focus group consisting of industry representatives that met in September 2001.

2.5 September 2001. Second Industry Focus Group.

This second focus group, meeting as it did the day after the tragic events of September 11, carried on the business of planning for the education of our young people. We had a surprisingly good turnout of industry representatives, faculty and administrators, and consulting engineers. Significant recommendations of this group

included limiting the length of the internship to three months and making the program a standard length of four years with the first two years to be met by work in HVAC technology, electrical technology, electronics or a related field. These recommendations were consonant with the culture of the college in so far as our preferred time format is for two or four year programs with activities over the summer to supplement work during the school year. This format works well for student expectations for a college experience and also matches the time frame use by funding agencies.

2.6 November 2001. Presentation at the curriculum committee meeting.

After much interplay and internal input across the college a proposal was submitted to the college curriculum committee for a vote in November 2001. The proposed new curriculum [6] was approved at this meeting with a projected start up date of August 2002.

The final proposal admits students into the program who have an associate degree in HVAC, electrical technology, electronics or a related field. A three month internship is required between the third and fourth year and a problem based senior project is completed in the fall and spring semesters of the fourth year. An introduction to the building automation industry is included for all third year entering students. Students entering the program with a background in HVAC take an electronics course in their third year and students entering the program with a degree in electronics or electrical technology take work in mechanical systems.

Technical courses include work in legacy systems and transducers, application specific DDC controllers, building automation networks, building automation programming, commissioning, central plant equipment control, electrical systems, energy management and interoperability. The outline of courses is shown in Appendix A. Additional information on the program and courses may be found at the college web site at http://www.pct.edu/degrprog/bbt.shtml and at the Building Automation (BBT) program "Closer Look" site at http://www.pct.edu/schools/cdt/bbt/.

2.7 Input from three years of student trips to Siemens Building Technologies.

Over a three year period Siemens Building Technologies (SBT) has invited students in our local student ASHRAE chapter to visit their facility near Chicago with all expenses paid by Siemens. The visits included a tour of the training center, talks by Siemens executives, a tour of the manufacturing area and group and individual interviews. Over a period of three years 45 students, myself and another faculty member have participated in these visits.

On-site visits such as these have a tremendous impact on the students in opening up a new vista of employment possibilities. The trips also have provided a rich source of contacts at Siemens for myself and our school. The one to one advice and encouragement plus equipment and software support have been an ongoing critical event in the development of this new program.

2.8 Input and scholarship support from the BACnet North America Interest Group (BIG NA) and other associations.

In the fall of 2002 I was able to attend the BIG NA meeting in Columbus Ohio and was pleasantly surprised to find that I was to be appointed as a co-chair of a scholarship committee to support students who are members of student ASHRAE chapters who are studying building automation technology. At this meeting I set up a table with

information on our new program and received much encouragement and good advice from those present.

The impact of informal contacts at ASHRAE winter meetings, student gatherings, and interest group meetings has been a critical event in the development of this new program. A session at the 2002 meeting of the American Society of Engineering Education (ASEE) was also particularly helpful in the design of the summer internship.

3.0 Three important features of the new program

Three important features emerged as core to the design of the new program. These features were produced in the interplay of the industry-academic collaboration from emails, the listserv, the focus groups and individual visits.

3.1 Two plus two format.

This feature emerged from the focus group as we began to realize that the field of building automation is not well known to most high school students. From the point of view of student recruitment it seemed wise to offer the program as an upper division program. A second element that emerged from the discussions with industry was the need for broad training that includes mechanical and electrical systems and experience with computers.

Students entering the program have an associate degree (AAS) in HVAC, electrical or electronics. As mentioned above, students with an hvac background take a "catch up course" in electronics, those with electrical backgrounds take a course in mechanical systems. An interesting blend of craft cultures as occurred in the program as students from these areas work side by side on lab projects and in class. The present class is about equally divided between hvac and electrical students. The interplay of these occupational cultures could easily be a topic for a separate paper. The program has been greatly enriched by having students from diverse backgrounds working together toward one goal of getting their BS in building automation technology.

3.2 Internship.

The summer internship evolved from a realization that while long term work experience is useful, this experience has to fit into the format of the academic year. The internship is paid with the expectation that the rate of pay will reflect the experience and academic backgrounds of the students who all have a two year degree plus additional course work. Internship sites include the Trane Company, controls contractors, a remote monitoring project with a waste water treatment firm, programming work with a manufacturer of industrial washers and work with the office of physical plant at two universities as well as a position in plant maintenance and environmental control at a compact disc manufacturer. Students enroll in a one credit summer internship course, remain in weekly email contact, write a report and host the instructor on site in fulfillment of the internship.

A simple one page form was used to provide the agreement between the student, the company, and the instructor of the summer internship program. Learning objectives are provided on the form by both the company and by the student.

3.3 Problem based senior project that incorporates presentation skills

A consistent concern of industry has been the development of presentation and communication skills. The one credit senior seminar lecture in the fall is intended to assist the students in the identification of a problem from the controls industry and a proposed solution. Ideally, the problem statement and proposed solution will arise from the summer internship experience and will be developed in close cooperation with industry. In the spring, students enroll in a two credit senior seminar lab during which the solution to the problem identified in the fall is worked out in detail. The students present their solution in written and oral form to an audience drawn from industry, fellow students, faculty, and administrators. Critical thinking, evidence based practice and presentation skills are stressed.

4.0 Labs

A key ingredient in our programs at Penn College is the inclusion of hands on lab based education. We are fortunate to have an existing commercial controls lab that has been developed over the past 20 years and includes; a 20 ton water-cooled scroll chiller with variable speed pumping, a 3,000 CFM VAV AHU with variable speed fan, twelve parallel fan powered VAV boxes with reheat coils and DDC controls, twelve two pipe fan coil units with DDC control, three single zone AHU with pneumatic, analog electronic or DDC controls and a building control unit with an Ethernet connection.

We are building a new lab to be ready for the fall of 2003. With the cooperation of two large controls manufacturers we will equip this lab with 6 stations that will include networked floor level and application specific controllers with a hard wired and wireless Ethernet network. We will use wireless laptops to teach networks, interoperability, programming and energy management in this new lab. Other manufacturers of controls products have indicated a desire to participate in the equipping this lab.

5.0 Student recruitment and the program web site

An important tool for student recruitment has been word of mouth as well as visits by faculty to various classes with two year students. We have also sent out letters and emails to faculty and administrators at schools with two year programs in HVAC and electrical technology.

A very helpful tool for recruitment and program publicity has been a program web site that was developed in the Spring of 2003. The site URL is http://www.pct.edu/schools/cdt/bbt/

References:

1. Lave, J. (1991). *Situating learning in communities of practice*. Perspectives on socially shared cognition. L. Resnick and S. Teasley. Washington, DC, APA**:** 63-82.

2. William J. Thompson. *Proposal for the joint development of an associates degree program in HVAC technology with a an emphasis on Johnson Controls, Inc. DDC controls.* April 12, 2000. Johnson Controls Inc.

3. Philip H. Henning. *HVAC Controls Technicians: Needs Assessment Survey*. May 2000. Pennsylvania College of Technology, Williamsport, PA.

4. Philip H. Henning. *Survey Report: Survey to determine employer interest in a new two year commercial HVAC/R Controls Technician program*. May 2000. Pennsylvania College of Technology, Williamsport, PA.

5. Philip H. Henning. *Report on DDC/Electronic Controls focus group discussion of October 4, 2000 at the Pennsylvania College of Technology*. October 2000. Pennsylvania College of Technology, Williamsport, PA.

6. Philip H. Henning et al. Proposed New Curriculum: Building Automation Technology (BBT). A Two-Plus-Two Upper Division BS Program. November 2001. Pennsylvania College of Technology, Williamsport, PA.

Appendix A Major Courses: Building Automation Technology Program

Students enter the third year fifth semester of the program with an associate degree in HVAC, electrical, or electronics technology.

The technical courses taken in the major are as follows. More information can be found on the college web site at http://www.pct.edu/degrprog/bbt.shtml.

Third year, fifth semester

For students entering with an associate degree in electrical or electrical technology:

ACR226
AC/R Systems and Equipment
The primary focus of this course is to develop a common understanding of the basics and functions of applied commercial building and industrial facility AC/R systems. Students from various technical skill area backgrounds will merge common skills and gain exposure to the specifics of identity, application, and operation of central liquid chillers, packaged DX systems, unitary equipment, and rooftop units. Students will be introduced thru both classroom instruction and practical experiences to the following topics: the importance of AC/R systems for comfort and process, types of systems, how systems work, identification of AC/R system components, the properties of air and water vapor, applicable use of psychometric chart for ACR process analysis. ASHRAE ventilation standards, IAQ basics, and introductory control point strategies. 3 Credits (2 Lecture -3 Lab)

PLH226
Fundamentals of Heating Systems
The primary focus of this course is to develop a common knowledge and understanding of the basics and functions of applied commercial building and industrial facility heating systems. Students from various technical skill area backgrounds will merge common and gain exposure to the specifics of identity, application, and operation of steam and hydronic boilers, pumps, warm-air furnace units, and fans/blowers. Students will be introduced through both classroom instruction and practical experiences to the following topics: the importance of heating systems for comfort and process, types of systems, how each system works, identification of heating system components, the principles of

water and air transfer, an overview of applicable ASME and NFPA codes/standards, equipment and operating safety controls and introductory control point strategies. 3 Credits (2 Lecture -3 Lab)

For students entering with an associate degree in HVAC:

ELT239
Fundamentals of Electronics for BBT
This course is designed to meet the needs of HVAC and transfer students that lack the necessary basic electronics needed to complete the Building Automation Technology (BBT) major. Topics include a review of basic electronic test instruments as well as an introduction to semiconductor devices and their use in control systems such as Direct Digital Controls. 5 Credits (4 Lecture -3 Lab) *Prerequisite(s): ELT252.*

All Building Automation Technology Students:

BBT209
Building Automation Industry
This course presents the fundamentals of commercial HVACR systems used to condition buildings and their occupants and equipment. An introduction to control system operation and control system types is covered. Career opportunities and the scope of the building automation industry are also covered. 3 Credits (3 Lecture -0 Lab)

Third year, sixth semester (all students)

BBT304
Direct Digital Control of HVACR Equipment
Students in this course study application specific controllers as well as general-purpose digital controllers. The course also includes material on digital/analog input and output types. Students also study the installation and set-up of the controllers for single zone, variable air volume (VAV), and unitary systems are covered. Topics in digital control system architecture and the fundamentals of control theory as they apply to digital HVACR control are also studied. DDC cycles of operation and control sequences and documentation are also covered. 4 Credits (3 Lecture -3 Lab) *Prerequisite(s): BBT209.*

BBT344
Electric, Pneumatic and Electronic Control Systems
This course covers the basics of commercial HVAC control theory as it applies to electric, pneumatic and electronic controls systems. Students study control sequences, system drawings and specifications. A section on troubleshooting is also included. 4 Credits (3 Lecture -3 Lab) *Prerequisite(s): BBT209.*

Summer Session

BBT310
Building Automation Industry Internship
This course provides a vehicle for a paid internship with a company, association, or institution with direct involvement in HVACR controls and automation design, layout, installation, or troubleshooting. Internships must be approved by BBT faculty prior to the start of the internship. An internship guide provides more information. 1 Credit (0 Lecture -5 Lab) *Prerequisite(s): BBT304 and BBT344.*

Fourth year, seventh semester

BBT406
Building Control Networks
Topics in this course include common building control network implementations and protocol standards including Web based applications, BACnet, Ethernet, Arcnet, LonTalk and various proprietary systems. Additional topics include transmission types such as twisted pair, coax, fiber optic cable, and RF. Students in this course will also study routers and bridges, installation and troubleshooting building controls. 3 Credits (2 Lecture -3 Lab) *Prerequisite(s): BBT304 and BBT344. Corequisite(s): BBT414.*

BBT414
Building Automation Programming
This course provides the student with a introduction to programming HVACR direct digital controllers and building integration panels. Topics include line programming, icon based programming, and template programming. This course stresses good programming practices including complete program documentation. 3 Credits (2 Lecture -3 Lab) *Prerequisite(s): BBT304 and BBT344. Corequisite(s): BBT406.*

BBT495
Senior Seminar-Lecture
This lecture component of the senior capstone course draws on course work in previous semesters, the internship, and current course work. Students develop a problem statement in the form of a proposal with supporting documentation concerning an operating or proposed HVACR control system. This course emphasizes critical thinking, oral and written communication, and engineering visualization presentation methods. 1 Credit (1 Lecture -0 Lab) *Corequisite(s): BBT406 and BBT414.* Fall Only.

Fourth year, eighth semester

BBT412
Building Commissioning and Recommissioning
This course focuses on the building commissioning and recommissioning process and includes topics in air and water balance and control system operation and optimization. Report writing including the use of tables and graphs is stressed. 3 Credits (2 Lecture -3 Lab) *Prerequisite(s): BBT406.*

BBT415
Integrated Building Operation and Energy Management
This course involves the study of interoperability between horizontal systems such as HVACR equipment operation from different manufacturers. Topics in this course also include vertical interoperability between HVACR, security, energy monitoring and control, fire safety and elevator systems. The course provides an opportunity for students to explore topics in energy management strategies for new and existing buildings. 3 Credits (2 Lecture -3 Lab) *Prerequisite(s): BBT406 and BBT414.* (Science, Technology and Society, Writing Enriched)

BBT416
Central Mechanical Equipment Control and Building Electrical Systems
This course includes topics in the operation and control of central mechanical. Students

in this course study air and water-cooled reciprocating, centrifugal, scroll and screw chillers, cooling tower operation and control, and single and two-stage absorption. Topics are also included in commercial steam and hot water boiler control and in chilled water, steam, and hot water distribution systems control. Students study building electrical systems including metering, wye/delta, and part winding starters, soft-start starters and variable speed drives applied to HVAC fans and pumps. The student is also provided with a brief overview of fire and security systems. Electrical codes, standards, isolation transformers will also be covered. 4 Credits (3 Lecture -3 Lab) *Prerequisite(s): BBT406 and BBT414.*

BBT496
Senior Seminar-Lab
Students will work under a faculty mentor to develop and deliver the finished project as proposed by the student in the planning portion of the senior seminar. Successful completion of the project will include an executive summary, a graphical and oral presentation. The senior seminar emphasizes critical thinking, oral and written communication, and engineering visualization presentation methods. 2 Credits (0 Lecture -6 Lab) *Prerequisite(s): BBT495.* Spring Only.