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Development of a Building Electrical Power Systems Design Specialty

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Abstract

Enrollment in Electrical Power Engineering courses has been in a steady decline, and many institutions have dropped power and energy conversion courses. At the same time, the demand for engineers in the field has remained constant, and in some cases has increased significantly. To meet the demand for engineers in the electrical construction sector, the Milwaukee School of Engineering and local industry have worked together to develop a sequence of courses for a Building Electrical Power Systems Design Specialty in the Architectural Engineering program. This sequence includes four courses from the Electrical Engineering and Computer Science Department: Electrical Systems, and three courses on Electrical Power Distribution Systems (system basics, small systems, and large systems). The Architectural Engineering and Building Construction Department offers five courses: Illumination for Buildings, Communication Systems, National Electrical Code, Electrical System Cost Estimating and Specifications, and Electrical Power Quality for Buildings. This paper describes the development of these courses, along with feedback from the first graduating class, current students, and industry.

Introduction

The decline in enrolments in power engineering courses is well documented. Even among universities with well-established electrical power engineering programs, the percentage of curricula requiring a course in energy conversion has declined[1]. At the Milwaukee School of Engineering (MSOE), elective courses in power systems did not run last year due to a lack of student interest.

The demand for students with an interest in power systems has been strong as of late. In the building electrical arena, this need was apparent when a group of 25 local design firms and contractors approached MSOE and requested a design sequence to address a chronic shortage of engineers. Additionally, other programs have been developed recently to address this shortage[2].

Table I. Building Electrical Systems Design Specialty Coursework

		Lecture Hours Per Week	Lab Hours Per Week	Credit in Quarter Hours
AE-357	Illumination for Buildings	3	0	3
AE-358	Communication Systems	4	0	4
AE-359	National Electrical Code	2	0	2
AE-472	Electrical Power Quality for Buildings	3	2	4
AE-476	Electrical System Cost Estimating and Specifications	3	0	3
EE-351	Electrical Power Distribution Systems I	4	0	4
EE-353	Electrical Power Distribution Systems II	3	2	4
EE-355	Electrical Power Distribution Systems III	3	2	4
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Table II. Other Salient Engineering/Science Coursework

AE-100	Introduction to Architectural Engineering & Construction Management	2	2	3
AE-103	Introduction to CAD	1	1	1
AE-123	Building Construction Materials & Methods I	4	0	4
AE-130	Architectural Engineering Graphics	2	2	3
AE-200	Statics	4	0	4
AE-201	Strength of Materials	4	0	4
AE-213	Introduction to Fluid Mechanics	4	0	4
AE-220	Building Construction Materials & Methods II	3	2	4
AE-222	Construction Materials Laboratory	1	2	1
AE-225	Specifications and Contracts	3	0	3
AE-3001	Dynamics	3	0	3
AE-310	Basic Conditioning of Air	3	0	3
AE-342	Architectural History	3	0	3
AE-345	Integrated Engineering Concepts	1	1	1
AE-431	Architectural Design	2	4	4
AE-432	Working Drawings	2	2	3
AE-440	Office Management	3	0	3
AE-441	Building Investment Economics	3	0	3
AE-450	Architectural Engineering Design I	1	3	3
AE-451	Architectural Engineering Design II	1	3	4
CH-350	Chemistry of Building Materials	3	0	3
CM-212	Surveying	2	3	3
CM-224	Construction Estimating I	3	0	3
CM-323	Construction Practices & Management	3	0	3
EE-250	Electrical Systems	4	0	4
IE-423	Engineering Economy	3	0	3
ME-252	Fundamentals of Thermodynamics	4	0	4

Overview of Specialty

The Building Electrical Power Systems (BEPS) design specialty is part of the Architectural Engineering (AE) program. The coursework for the BEPS specialty is shown in Table I. Other salient coursework required for all AE students is shown in Table II.

As seen in the tables, the students receive significant instruction in the fields of architecture engineering and construction management. The coursework in the BEPS design specialty augments this learning with very specific topics from the field of electrical engineering. However, this design specialty is not intended replace the traditional electrical engineering program. On the contrary, the students in this program develop an appreciation for the wide array of topics that now constitute an electrical engineering degree. The main focus of the specialty is for the student to learn how to utilize and design systems of electrical apparatus employed in modern buildings.

Electrical Engineering and Computer Science Department Courses

Four courses are offered in the Electrical Engineering and Computer Science (EECS) Department. The first course is required for all AE students. Only AE students in the BEPS program take the remaining three courses. Students in the Electrical Engineering (EE) and Electrical Engineering Technology (EET) programs can also take the last two distribution system courses. Course descriptions and more information on the EE and EET programs are available via the web[3].

EE-250 Electrical Systems

This course is required for all Architectural Engineering students. Because of its introductory nature, Electrical Engineering students cannot take this course for credit. This course is not a typical electrical circuits course for non-electrical engineering majors. The focus of the course is on specifying electrical wiring and apparatus used in building electrical power systems.

EE-351 Electrical Power Distribution Systems I

This is the first course in the electrical distribution sequence. Since the electrical systems course does not cover many of the traditional circuit analysis techniques, e.g., mesh and nodal analysis, those topics are presented in this course. In fact, this course is typical of most circuit analysis courses for non-majors. The main difference is that most of the examples are drawn from building electrical design problems. These examples must be drawn from outside the text, because, as with other texts, the text used for the course has eliminated many of the electrical power system type of examples and replaced them with automotive examples.

EE-353 Electrical Power Distribution Systems II

This is the second course in the electrical distribution systems sequence. This course focuses on the electrical design of a small commercial or industrial building. The building used as a design problem in AE-357, Illumination for Buildings, is also used in this course. As a term-long project, the students add all the necessary electrical equipment and design the electrical

distribution system for the building. They work in teams of two and develop a set of design documents for the building. At the end of the term, the team presents their design to the rest of the class. The building for the 2000-2001 school year was a print shop. As part of the course, the class toured a local print shop. A digital photo taken by one of the students during the tour is shown in Figure 1. The class also toured local transformer and switchgear manufacturers.

Figure 1. Printing press seen on class tour

This course also includes several laboratory assignments involving three-phase transformers, dc machines, ac machines and drives, and programmable logic controllers. These assignments are also worked on in teams, but each team member must individually submit at least one formal report.

EE-355 Electrical Power Distribution Systems III

This is the last course in the electrical distribution systems sequence. This course focuses on the electrical design of a large commercial building or industrial complex. The students choose between a 20-story building and a four building campus. As with the EE-353, the project is done by a team of two students and presented to the rest of the class at the end of the term.

These last two courses, EE-353 and EE-355, can be taken for credit by EE and EET students, provided they have taken courses that cover the prerequisite material. Since they do not fit directly into either curriculum, they must be taken as free electives.

Architectural Engineering and Building Construction Department Courses

Five of the core courses are offered in the Architectural Engineering and Building Construction (AE&BC) Department. Course descriptions and more information on the AE&BC Department and the AE Program are available via the web[4].

AE-357 Illumination for Buildings

This course focuses on the design and specification of interior and exterior building illumination systems, including lighting loads, branch circuits and switching. Design work includes the study of applicable NFPA 70 (NEC) and related building codes.

AE-358 Communication Systems

This course focuses on the design and specification of communication systems in buildings, including fire alarm, security, sound, telephone, cable, clock and program, television, data and nurse call. Students study applicable sections of National Electrical Code®. In addition, acoustics, as it applies to communication systems and noise, is also covered.

AE-359 National Electrical Code

As the course title implies, this course focuses on the National Electrical Code® and the Wisconsin addendums/amendments. This course was offered in the past in the Electrical Engineering Technology program at MSOE, but was discontinued in the 1980s along with the rest of the Electrical Construction Specialty. A lead design electrical engineer teaches this course. Since the code nuances and interpretations change over time and from jurisdiction to jurisdiction, it is significant that an engineer from a local firm gives his insights. While most of the student have taken positions outside of the southwestern Wisconsin area, the concept that code interpretations change is vital to a successful working engineer.

AE-472 Electrical Power Quality for Buildings

This course covers topics involving typical equipment utilizing solid-state devices for power quality, such as uninterruptible power supplies, transient voltage suppressors, power line conditioners, and voltage regulators. Grounding and neutral systems are also studied. The student is exposed to basic electronic concepts, monitoring devices, and the analysis associated with identifying and mitigating power quality problems.

Although taught in the past by EECS faculty, EE or EET students have not taken this course. Since this is an area of concern for anyone using electrical energy, exposing EET and EE students to this topic is vital. Educators in both EET and EE have developed laboratory experiments[5] and classroom demonstrations[6] to illustrate power quality problems. Power quality

can be discussed in many courses, for example in a Power Electronics course, but a entire course devoted to identifying and mitigating power quality problems would be beneficial to anyone entering the electrical power field. Therefore, work is underway to also offer this course to EE and EET students.

AE-476 Electrical System Cost Estimating and Specifications

This course focuses on cost estimating and specifications. In particular, cost estimating software and systems, case studies, and value engineering are discussed. Typical electrical specifications for general conditions, equipment, and the installation of equipment are explained in detail. This course is in addition to general specification and construction estimating courses taken by all AE students.

Student Response

The student response has been very positive. The average of the overall scores on the class evaluations for four of the courses, EE-351, EE-353, EE-355, and AE-472, for the first three years was 3.86 out of 4.0. The first class (Fall 1998) petitioned MSOE's administration to have the courses run one year earlier than originally planned. The enrollment for the first course in the Electrical Power Distribution Systems sequence (EE-351) is shown in the chart below. Based on an informal survey by the AE&BC Department chair, the decrease in enrollment in Fall 2000 was due to unenthusiastic teaching of the introductory course in Spring 2000. In an informal survey of this year's incoming AE students (students in the Spring 2001 EE-250 classes), over 20 students stated that they would be entering the program next year. This shows that since EE-250 is the only exposure AE students have to the program before deciding on a design specialty, it is imperative that someone interested in the long-term success of the program teaches the course.

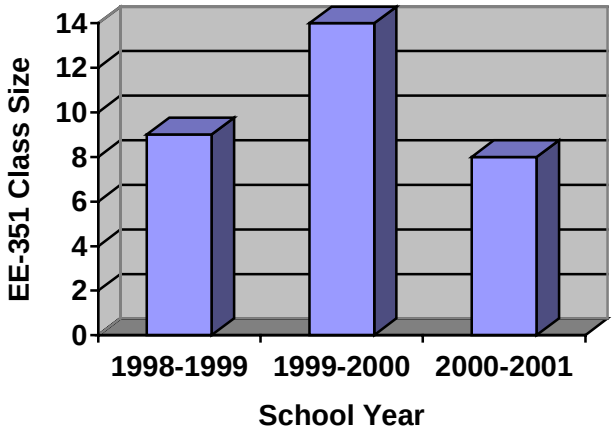

Figure 2. Class Sizes

Industrial Response

The industrial response has also been very positive. Students from the first two classes are now working for design firms and contractors in Alaska, Florida, and throughout the mid-west. One of the first-year students came back to speak to this year's class with a principal from his firm. The principal offered employment to everyone who made it through the design specialty! Other firms have also made very positive comments. The only problem has been that demand has been so great that some of the local firms were not able to hire the interns that worked for them. This caused some of the local firms to cut back on the number of intern positions offered to the current students. Since that time, other firms, both locally and regionally, have increased their number of intern positions, so that almost all of the current students work during the summers in their chosen career field.

Summary

The design sequence seems to fill a niche that has been ignored for some time. The strong demand for students in the design sequence is testimony to that proposition. Since some of the courses offered can also be taken by EE and EET students, the critical mass necessary to sustain the courses seems to have been obtained. Several EE program graduates have obtained their desired positions as a direct result of the courses they took in the AE specialty. In a time of shrinking enrollments in most electrical power programs, offering this sequence of courses to other congruent programs makes sense.

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