AC 2009-1758: INTEGRATING ELECTRICAL CONTRACTING INDUSTRY INTO THE ARCHITECTURAL ENGINEERING EDUCATIONAL SETTING TO PROMOTE LEARNING

Mahmoud Alahmad, University of Nebraska, Lincoln
Jamie Tills, University of Nebraska, Lincoln
Steven Swanson, University of Nebraska, Lincoln

© American Society for Engineering Education, 2009
Integrating Electrical Contracting Industry into the Architectural Engineering Educational Setting to Promote Learning

Abstract

Reception and processing of information are the elements of learning. How the information is presented is a critical element in student comprehension. In most engineering institutions, theory and fundamental concepts are taught with passive lectures and “recipe” labs. A balance must be provided between engineering science and engineering practice to prepare students for the real world. This preparation is already underway in the architectural engineering (AE) field at some universities. To build on this foundation, in the electrical and lighting option within AE, developing a relationship between the academic community and the electrical construction industry will help bridge the gap between fundamental engineering principles and practical installation experience. This relationship is currently being implemented between the National Electrical Contractors Association (NECA), its research foundation ELECTRI International (EI), and AE students at the University of Nebraska. Building this alliance will provide an additional element of proficiency that is essential to the students’ practical understanding of systems in the built environment and interaction with industry professionals. The proposed project will develop a series of workshops and seminars consisting of demonstrations, lectures, hands-on activities, and construction site visits conducted and attended by contractors, consultants, faculty, and students. This paper will present background information regarding the different learning styles of engineering students, distribution of learning style surveys to AE students and electrical apprentices, and analysis of those results. Based on the analysis of the learning surveys, a description about how to implement key learning concepts into classroom settings and the workshops will be provided. Expected outcomes and the organization of this project will conclude the presentation of this paper.

1 – Introduction

Learning is considered a two-step process that includes reception and processing of information. Information is first received externally and then immediately interpreted internally. It is interpreted internally by instantly reacting to the information being received and then drawing conclusions based on those reactions. This first step only lasts as long as the material being presented. The information is sorted by material that is retained and material that is not. After information is received and some of it processed, students have different ways of keeping that information stored for later. This may include discussing the material with professors or other students, memorizing the material, or analyzing the material. The second step takes anywhere from a day to an entire semester and occurs when the information is either learned or not learned.

The information may be provided in a number of ways including lectures, demonstrations, hands-on activities, etc. Each student responds differently depending on their innate
abilities and prior preparation as well as the compatibility of their learning style and the 
teaching style of the instructor.

“Professors, confronted by low test grades, unresponsive or hostile classes, 
poor attendance and dropouts, know something is not working; they may 
become overly critical of their students (making things even worse) or 
begin to wonder if they are in the right profession. Most seriously, society 
loses potentially excellent engineers.”

As stated by Dr. Richard M. Felder, this is oftentimes the result of a mismatch between 
learning styles of engineering students and traditional teaching styles of their professors. 
Students may become bored in class, perform poorly on tests, or switch their major. To 
understand the learning styles of students, the Index of Learning Styles was created by Dr. 
Richard M. Felder and Barbara A. Solomon in 1991. This learning instrument was 
adapted from a model created in 1987 by Dr. Felder and Dr. Linda K. Silverman, a 
former educational psychologist at the University of Denver. The Index of Learning 
Styles measures learning style preferences along four dimensions including processing, 
perception, input, and understanding. It is a survey conveniently available online 
consisting of 44 questions that assesses one’s preferences according to these four 
dimensions. Each dimension includes two different learning styles that encompass the 
extremes of each dimension. Results may indicate that one shows a strong preference for 
a particular learning style or they may indicate a balance of the two.

In most engineering institutions, the information, theory, and fundamental concepts are 
taught with passive lectures and “recipe” labs that demand little on the part of the 
student. Students are in need of direct, first-hand experience and practical applications 
rather than “chalk and talk” traditional lectures in an effort to prepare each and every 
student for meaningful problems that they will soon face in the real world. By 
introducing active learning and teamwork to the classroom environment, students will 
have the skills they need to transition from academia to the real world. Tools and 
methods to achieve this transition are being implemented throughout university campuses. 
One such project to bring interaction and firsthand experience into the campus setting, via 
planned workshops, is the subject of this paper as described next.

The goal of the workshops is to bring together AE students, electrical apprentices, and 
industry professionals to facilitate learning based on proven methods supported by 
research. This entails exposing students to careers and practices in the electrical 
construction industry. By doing so, students will be influenced to design electrical 
systems that better meet the needs of electrical contractors. Not only will this project 
benefit students, it will also introduce the electrical construction industry to the 
underlying fundamental design principles used by AE students. This project will 
promote the development of practical and code-related learning modules expected to be 
distributed by NECA and other construction and training organizations.

Section two will provide details and analysis of the learning surveys. Section three will 
provide a discussion on learning styles of engineering students and how this style is
implemented at this institution. Section four will discuss the workshop and its expected outcomes in more details. Finally, section five will summarize the research and implementation involved with this project.

2 – Learning Style Analysis

AE students and electrical apprentices participated in the Index of Learning Styles survey to determine and understand how students at different levels of their educational track learn differently. Specifically, 110 AE students in select classes participated in this learning survey. Eighty-two first-year students taking AE-1010: Introduction to Architectural Engineering and 28 fourth- and fifth-year students taking AE-8030: Building Communication Systems were given the survey. In addition, the learning survey was also given to 57 fourth- and fifth-year apprentice students attending the Omaha Joint Electrical Apprenticeship and Training Center (OJEATC) in an effort to determine and understand the similarities and differences that AE students and apprentices share. The results of the surveys are used to enhance the objectives of the workshop by allowing the workshops to be structured to best fit those results. For example, if the results show that a vast majority of students are active learners, meaning that they learn best by openly discussing course material, then the workshops would include a hands-on approach to learning and possibly group activities.

The results and analysis will be presented by first introducing the dimension being measured followed by analysis of the similarities and differences between AE students and apprentices.

2.1 – Processing

The first dimension is processing and is measured as either being active or reflective. Active learners learn best by doing something active with the information. Discussing, applying, or explaining the material to other students helps active learners grasp the material. They would rather participate in group work than work alone. Reflective learners would prefer to think about the information quietly in their head first than discuss it aloud. They also normally choose to work alone rather than work in groups.

Figure 1 shows the learning style results of AE students as well as apprentices. The distribution shows that both groups of students yielded fairly similar results and both sets of students are slightly biased towards an active learning style over reflective learning.

Figure 1: Processing - Active versus Reflective
2.2 – Perception

The second dimension is perception where most students may be classified as either sensing or intuitive. A sensing learner likes consistency in their coursework and tends to be careful and practical. A surprise on a test such as material that was not covered in class is a particular dislike of this group. They prefer to perform a few standard routine calculations rather than one big complicated problem. A sensing learner tends to be good at learning and memorizing facts. An intuitive learner would rather discover possibilities and relationships than memorize facts. They tend to be innovative in their thinking and can relate better to abstract ideas. They also dislike classes that include routine calculations and a large amount of memorization.

Figure 2 demonstrates the percentage of students that are classified as either sensing or intuitive on the perception dimension. It is apparent from Figure 2 that AE students are sensing learners rather than intuitive learners, which is consistent with other engineering students across the nation. Apprentices appear to be even more sensing learners than AE students.

2.3 – Input

The third dimension is input. Most people labeled either visual or verbal learners. Visual learners tend to learn best by looking at pictures and studying charts, graphs, and diagrams. They are likely to remember information when it is presented as either a film or a demonstration. Verbal learners tend to learn best with traditional learning such as lectures. They are likely to remember information by listening to others discussing the information aloud or hearing their professor answering questions.
Figure 3 illustrates the results for the input dimension. Both AE students and apprentices share very similar results in that the vast majority prefers visual learning as opposed to verbal learning.

**2.4 – Understanding**

The fourth and final dimension is understanding. Students may be classified as exhibiting sequential learning or global learning. Sequential learners tend to easily make linear connections between individual steps that make up the big picture. They prefer to learn in an ordered and logical way. Global learners tend to learn randomly without knowing how each topic relates to another and then suddenly everything clicks for them. They can oftentimes solve complex problems but not be able to explain how they did so.

Figure 4 shows that results from the two groups are fairly similar. A slight majority of both groups of students are considered sequential learners. As a whole, the ability to follow systematic procedures as well as grasping the “big picture” is beneficial to students preparing to enter the electrical design field as well as the electrical construction industry.
3 – Targeting the Learning Styles of Engineering Students

From the preceding section, it is apparent that most engineering students are considered to be active, sensing, visual, and sequential learners. In an effort to appeal to this majority, traditional lectures need to be supplemented with something more. To further support learning, workshops may be introduced to link students directly to industry.

3.1 – Implementation of Learning Concepts in Classroom Settings

In most engineering institutions, theory and fundamental concepts are taught with passive lectures and “recipe” labs that demand little on the part of the student. Students are in need of direct, first-hand experience rather than “chalk and talk” traditional lectures. Universities need to balance both engineering science and engineering practice in an effort to prepare each and every student for meaningful problems that they will soon face in the real world.

There is increasing pressure from industry to provide this balance. They count on hiring fully-prepared graduates who possess a fundamental understanding of key concepts as well as technical and professional skills. According to Bernard Gordon, the founder and CEO of Analogic Corporation, “Engineering is an unforgiving and demanding environment and for students to succeed as engineers, they must go far beyond theories, simulations, and exam-taking.” By introducing active learning and teamwork to the classroom environment, students will have the skills they need to transition from university to the real world.

3.1.1 – Active Learning

Active learning may be defined as any instructional method that engages students in the learning process. Integrating activity and engagement to the traditional lecture allows active students the opportunity to use their unique set of learning skills while still impacting reflective students who typically respond well to passive lectures. A simple way of introducing active learning to the classroom is to set aside a few minutes periodically throughout the lecture and have the instructor pause briefly to allow students to clarify their notes with others. Researchers have proven this method to be highly effective. A study was held in which two 45-minutes classes were interrupted three times to allow for students to confer their notes with others for two minutes. Two separate classes were allowed no such pauses. Each class was tested on their short-term retention by having students write down everything they could remember in three minutes. The classes that allowed breaks averaged 108 correct facts while the classes that were not allowed any breaks averaged 80. All four classes were tested on their long-term retention as well. A 65-question multiple-choice exam was given one and a half weeks after the last of five lectures. The classes that allowed breaks scored 89.4 percent and 80.4 percent compared to 80.9 percent and 72.6 percent respectively.
3.1.2 – Teamwork

There is a great demand for graduate students that have had much team experience. Due to increasing pressure from industry and enrolling a greater than ever amount of students, teamwork is gaining relevance in higher education. Employer surveys have indicated that there is a need for graduates with core or personal transferable skills as well as a current dissatisfaction with skills found in new graduates. A recent proposal by the Organization for Economic Cooperation and Development stated that universities should see themselves as part of the transition to work and should adapt accordingly their teaching, their curriculum, and their research. Due to student enrollment increasing and staff-student ratios decreasing, a new method of teaching must be developed that addresses these issues. Teamwork is a suitable method to meet these issues and still promote independent learning. It requires much communication between all members involved which results in the construction, development, and reconstruction of knowledge.

Teamwork provides many benefits. One of which is that it can provide a powerful context for learning. It is a skill that can transfer readily across a broad range of contexts because it involves good communication and problem-solving skills. The outcomes of teamwork are often superior to individual outcomes. Competition is encouraged between teams, which in turn betters the final outcome. Discussion, explanation, argumentation, and justification of views build upon the knowledge base of individuals and clarify any disconnected information.

3.2 – Implementation of Learning Concepts in Workshops

By following a similar set of guidelines as implementation of learning concepts to classroom settings, a series of workshops will be added to the overall learning environment. The workshops will be held at the University of Nebraska’s Peter Kiewit Institute that houses both University of Nebraska – Lincoln’s College of Engineering and the Durham School of Architectural Engineering and Construction and University of Nebraska at Omaha’s College of Information Science and Technology. The involvement of industry leaders will be a key component of the workshops.

3.2.1 – The Peter Kiewit Institute and Learning

Extensive research has proven that traditional lecturing that takes place in most classrooms is not as effective as other teaching methods. It is not until the classroom is replaced by a laboratory setting that fundamental concepts and theories of science and engineering allow students to apply and reinforce their knowledge.

The Peter Kiewit Institute takes into account various learning styles of students for reinforcing fundamentals and theories learned in class. It does this by displaying hands-on and visual aides throughout the entire building as shown in Figure 5. Students can see
firsthand how all internal aspects of a building (electrical, lighting, mechanical, acoustical, structural, etc.) work and interact together\textsuperscript{13}.

![Figure 5: Exposed Systems Throughout the Peter Kiewit Institute](image1)

Electrical and lighting students have the unique opportunity to take classes in the state-of-the-art electrical and lighting laboratory. It features a replica three-phase electrical distribution system that is exposed at the front of the classroom as shown in Figure 6. Several different lighting systems are incorporated as well to help students see differences in color temperature, lumen output, etc. This allows professors to talk openly and eagerly about their subjects while also encouraging students to interact with the equipment. Faculty is able to easily point out significant topics of their lecture and expand on those same topics. The exposed equipment may be dismantled and put back together again to attain a greater level of understanding.

![Figure 6: Replica Three-Phase Power Distribution System](image2)

3.2.2 – Integrating Industry

Recent graduates of engineering-related programs have adequate knowledge of fundamental engineering science and computer literacy, but they do not know how to transition their skills to fit the industry\textsuperscript{9}. It is clear that a gap exists between engineering education and the industry\textsuperscript{14}. “You can’t get a job without experience, you can’t get
experience without a job,” as stated by William A. McKee of Glasgow Caledonian University. Practical experience must be supplemented by universities.

Each individual workshop will consist of two or three industry professionals including owners, architects, electrical consultants, and contractors. These professionals will share their experiences and knowledge with AE students, apprentices, and university faculty, as well as other consultants and contractors. The aim is to have an open and honest discussion between individuals of all different academic and professional backgrounds about specific topics relevant in the industry today. By integrating the electrical construction industry with electrical designers and the university, students will be able to receive a very well-rounded education and experience.

4 – Workshops

Each workshop will consist of industry professionals presenting various implications of the electrical construction and electrical design industries. Interviews with industry professionals have helped to evolve the framework of the workshops. A different theme will define individual workshops and include both a discussion and a hands-on approach. Expected outcomes of the workshops and learning module development will be discussed in this section as well.

4.1 – Interviews with Industry Professionals

In order to develop focused workshops that will benefit AE and apprenticeship students, contractors, Omaha Joint Electrical Apprenticeship and Training Committee (OJEATC) professionals, and consultants were interviewed. The following is a sample of the results.

By meeting with the training director of the OJEATC, more information was gained about the apprenticeship program in order to invite apprentices to attend the workshops and interact with AE students. This interaction is encouraged as both student groups will be complementing each other in the real world where they will be installing the systems the AE students design. He suggested that apprentices would enjoy seminars about the difficulties of designing electrical systems as well as the overall design process. An electrical contractor was interviewed as a potential presenter and to ultimately help guide the project. He was very enthusiastic about the idea of integrating universities and the electrical construction industry. He suggested that it would be beneficial to the construction industry, designers, apprentices, and students to discuss the differing viewpoints of contractors and engineers that are encountered and overcome. An electrical consultant was interviewed to build upon the workshops. He recommended a hands-on workshop in which apprentices and AE students are given a real-life situational problem and are divided into groups that are assigned a specific job (e.g. one group is the general contractor, another is the architect, another is the engineer, etc.). He also identified a professional, an electrical engineer and a lawyer, who could incorporate liability and its impact on the industry into the workshops.
4.2 – Framework and Themes

Framework for a series of workshops has been developed based on the outcome of interviews with industry professionals and the objective of this project. It is planned as a three-night workshop to be held Tuesday, March 31 through Thursday, April 2 from five to eight in the evening. Each night will cover a specific topic that fits into the overall theme: “QTC (Quality, Time, and Cost): The Dynamics of a Project.” The objectives of the workshop will address the successes and challenges of various projects from design to installation, specifically addressing the main impact issues as they relate to quality, time, and cost. Topics of interest include:

- QTC: The Facets of Successful Project
- QTC: The Forces in Conflict and Resolution
- QTC: BIM and the Electrical Industry

The workshop will be supplemented with hands-on activities to enrich the knowledge of the participants and expand their learning process and impact to the decisions made during each phase of the project. The state-of-the-art lighting and power laboratory in the building will be used to broaden the knowledge and practical implementations of such systems to all participants. Display boards built for active learning purposes (to introduce the how to of electrical systems and power quality issues) will also be available for participant activities.

The preceding themes are discussed in detail below:

4.2.1 – QTC: The Facets of Successful Project

This mini-workshop will discuss the process of a complete project. Interaction between owner, architect, designer, contractor, and commissioning will be identified and a discussion about the successes and challenges throughout this process will be provided. The hands-on activity will include first-hand experience with the state-of-the-art lighting lab. The lab will be available for industry, OJEATC students, and AE students to explore the effect of the lighting systems they specify and install.

4.2.2 – QTC: The Forces in Conflict and Resolution

A successful project starts with the people involved aiming for an outcome that is within their core values and success criteria. This includes clients, architects, engineers, and contractors. This mini-workshop will focus on project successes and challenges and develop team collaboration via exercises simulating real practical experiences. Students will take on the role of owners, architects, design engineers, and contractors. Each group will be led by a practicing industry professional to mentor and guide the group in the process for each of the situations presented during the workshop. In one situation, participants will be presented with a project consisting of realistic changes that will impact the project during the design phase. In a second situation, participants will analyze changes that impact the project during the construction phase.
4.2.3 – QTC: BIM and the Electrical Industry

This session will discuss technology impact on the project process and will specifically focus on the impact of Building Information Modeling (BIM) on the design and construction industry. The adoption of BIM by owners, architects, and general contractors will impact the electrical construction industry and the way that electrical engineers, lighting designers, electrical contractors, electrical distributors, manufacturers, and others do business. Illustrations and hands-on activities that rely on the use of a display board to illustrate electrical system issues such as power quality, energy conservation, and analysis will be provided.

4.3 – Expected Outcomes

By conducting these workshops, expected outcomes include:

- Exposing apprentices to fundamental engineering principles
- Influencing AE students to design electrical systems to more efficiently meet the needs of the project constituents
- Creating a hands-on atmosphere in which apprentices and AE students are encouraged to participate in interactive activities to supplement their knowledge
- Breaking the communication barrier between the electrical construction industry and architectural engineers in an effort to establish an open forum for communication between the two parties
- Distributing learning modules to supplement the NEC Code and aid in knowledge of systems in the built environment for both sets of students

An in-depth analysis of the outcomes will be provided at the ASEE Annual Conference in Austin, Texas pending acceptance of the paper.

4.3.1 – Learning Modules

The project will promote the development of practical and code-related learning modules. The modules are expected to be distributed by NECA and other construction and training organizations as well as other recipients as determined by ELECTRI International and NECA. These learning modules are currently being developed based on the 2008 NEC code books and similar resources. While the NEC Code is essential in understanding electrical system design, it is oftentimes confusing for students. The learning modules will also act as a supplement to the NEC Code to aid in knowledge of systems in the built environment for both students. Learning modules currently completed are:

- Grounding and Bonding
- Grounding Electrode System
- Transformers

Additional topics that will be addressed include motors, emergency systems, and photovoltaics. Each learning module will consist of the following:

- Learning objectives to provide clear outcomes of each module
A description about each completed topic is presented below:

**Grounding and Bonding:** The objective of this learning module is to help clarify Article 250.30 *Grounding Separately Derived Alternating-current Systems* of the 2008 National Electrical Code. This is one of the most commonly misunderstood articles in the NEC. It is very important that apprentices and students have a clear understanding of grounding and bonding to ensure proper electrical installation.

**Grounding Electrode System:** The objective of this learning module is to help clarify *Part III: Grounding Electrode System and Grounding Electrode Conductor* of the 2008 National Electrical Code. A grounding electrode system (GES) is required at each building or structure to comply with Article 250.50.

**Transformers:** The objective of this learning module is to supplement Article 450 *Transformers and Transformer Vaults* of the 2008 National Electrical Code. Transformers are a regular element of electrical distribution systems so it is fundamental to the knowledge of apprentices and students.

**5 – Summary and Conclusions**

This project will develop a relationship between the university and the electrical design and construction industry by holding a series of workshops and seminars consisting of demonstrations, lectures, hands-on activities, and construction site visits conducted and attended by contractors, consultants, faculty, and students. Extensive research about the various ways in which students learn will facilitate the components of the workshops. Learning surveys were given to first- through fifth-year AE students as well as fourth- and fifth-year apprentices, in an effort to understand how students learn differently. In addition, interviews with industry professionals have helped determine the framework and themes of the workshops. Expected outcomes of the workshops include creating a hands-on atmosphere in which apprentices and AE students are encouraged to participate in interactive activities to supplement their knowledge and breaking the communication barrier between the electrical construction industry and architectural engineers in an effort to establish an open forum for communication between the two parties. Finally, the project will promote the development of practical and code-related learning modules to be administered for distribution by NECA and other construction and training organizations and serve as best practices to other institutes of higher education.
Bibliography