Student Learning At The University of Dayton Industrial Assessment Center

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Abstract

The U.S. Department of Energy, through its Office of Industrial Technologies, funds twenty-six university-based Industrial Assessment Centers (IACs) to train graduate and undergraduate engineering students to provide medium-sized manufacturers with energy, waste, and productivity assessments (http://www.oit.doe.gov/iac/).[1] Presently, the IAC Program uses a well-established database to track savings resulting from recommendations generated during IAC site assessments (Muller, Barnish, and Kasten, 1998)[2]. However, additional benefits are not quantified by the database. One additional benefit, the subject of this paper, is student learning. The training and experiences that students receive through the IAC Program provides industry with engineers with significant and diverse industrial experiences. Students are introduced to manufacturing environments and must perform their job functions within these environments. When they graduate they have experience in several industries, understand energy efficiency and can implement lean manufacturing techniques. This paper will review the IAC program at The University of Dayton, its learning tools, and the skills that students acquire. Finally, the paper will review the results of follow-up questionnaires from over 130 IAC alumni that discuss the impact of the IAC program on their careers.

I. The Industrial Assessment Centers

The University of Dayton Industrial Assessment Center (UDIAC) is one of 26 IACs funded by the US Department of Energy's Office of Industrial Technologies (OIT) qualified to conduct assessments for mid-sized industries at no charge. Since 1981the UDIAC has been helped over 600 midsize industries reduce their operating costs and remain competitive.[3] The assessments entail a one-day visit to the client's facility where the group identifies and quantifies energy, waste and production cost saving opportunities. The team is led by a faculty member from the School of Engineering and includes a trained group of graduate and undergraduate engineering students. Upon completion of the site visit, the team prepares a complete technical report that presents detailed information regarding the client's utilities, plant description, assessment recommendations and additional comments pertaining to the performance of the facility.

The *Utility Analysis* section of the report reviews the client's electricity, fuel and water billing data and rate schedules. It calculates the avoided costs for energy usage, and discusses all trends associated with individual utility usage.

The P*lant Description* section outlines the process description, shows a plant layout, provides an assessment of current lighting levels and provides a comparison to the Illuminating Engineering Society recommended levels. An analysis of the client's air compressors is provided that details the type, size, configuration, energy utilization and cost of compressed air usage. A list of major-electricity and fuel using equipment and estimated annual energy use is also provided. O

The heart of the report is the A*ssessment Recommendation* section. This section provides the client with specific recommendations to save money by reducing energy waste or production costs. Each recommendation presents the current state a recommendation of the estimated savings, the estimated project cost, and the estimated simple payback. Last year, facilities from The University of Dayton Industrial Assessment Center reported savings on average of $136,000 per year based on an assessment.

II. Student Learning

<u>Communication</u>

A critical element in a successful career is the ability to communicate effectively; transferring information clearly and accurately is important for the students to learn. Through the IAC, students are given the opportunity to become effective communicators by extensive practice conveying written and oral technical information.

Written communication skills are developed throughout the assessment process. Prior to the site visit, students compile data and format it in a usable, understandable executive summary and write specific cost-saving recommendations. After the site visit, students analyze the data they have collected and write specific cost-saving recommendations. Each report is reviewed for content, technical correctness and grammar prior to sending it to the client. Furthermore, program managers at Rutgers University review the report a second time. As a result of this process with its intensive feedback, student-writing skills improve dramatically over the course of a student's tenure at the UDIAC.

Oral communication skills are strengthened during the on-site assessment. Students participate in a briefing meeting to review the agenda for the day, discuss executive summary information, and talk about any special needs the client may have. After the briefing, the team is escorted on a tour of the facility. Often, a representative from production, quality assurance or maintenance conducts the tour, so the students are exposed to many different departments. Because individuals from different parts of the organization lead the students, they quickly learn what elements are important to each organization. During the tour many informal discussions take place. Students formulate questions, ask them efficiently and listen closely for responses. Students learn the art of listening, which is an important part of mastering oral communication skills. Students may find that the company representative cannot answer a question. In this case, the students will ask another person who may be a machine operator, a job setter, a machinist or skilled craftsman/maintenance. The students learn the need to respectfully communicate who they are, why they are in the plant, and what they want to know. Since the IACs assess both union and non-union facilities, environments and protocols may be different; students learn to work with employees so they do not violate company/union bargaining agreements.

Management
Students also develop the ability to become effective managers. Through the UDIAC, students learn self-discipline, since they must manage their time appropriately; assessment schedules and deadline dates for report submissions must be adhered to. Plant visits are often out of town and students may start their day as early as 5:30 am and often do not return until late at night. Students must schedule around their academic classes and labs to ensure their academic commitments are complete and they do not let the IAC team down.

Leadership
The position of "Lead Student" has been developed within each IAC to give experienced students opportunities to function in leadership roles. This position serves many purposes. First, it helps students determine if they want to pursue a career in management by giving them experience serving in this capacity. It also lets less experienced students witness the characteristics of an effective leader. The lead student and rest of the team function as one unit. Their success depends upon their ability to work together. Students learn that the team is only as strong as its weakest member. They quickly pull together and bring less-experienced students up to speed on current systems and technologies.

Industrial Exposure
Industrial Assessment Centers service a wide variety of industries. A brief listing of industries serviced is shown below:

- Paper
- Plastic
- Foundries
- Automotive Assembly
- Glass
- Chemical Processing
- Metal Forging
- Metal Stamping
- Food Industry
- Construction
- Rubber

Because of the wide variety of manufacturing situations, students become familiar with the resources and processes for many types of manufacturing.[4] Thus, students may have some familiarity with the equipment because of previous exposure. In addition, students learn to benchmark critical processes such as productivity, defect, repair, attendance and safety percentages. Team members document exceptional practices and report them to their clients.

Another important facet of the student's education is working safely in the industrial environment. Students are exposed to the dangers such as forklift traffic, electrical panels, hot products and other hazardous conditions. Since the potential for an accident in an industrial environment is high, students are trained about industrial dangers. Each team member is required to complete a formal IAC safety-training program, which reviews safety fundamentals. In addition, the UDIAC conducts formal team safety meetings. These meetings are conducted once a month and review safety concerns.

In addition, safety is also discussed prior to entering a plant on each audit. The team members are aware of any personal protective equipment they may need to wear. Students learn to respect equipment and machinery. Data monitoring equipment such as data loggers must be installed inside electrical panels. Team members have an electrician or maintenance worker install this equipment. Students offer the installers special gloves that guard against electrical shock. If the installer refuses to use the gloves, team members will put them on as a precaution, so they can assist the installer if necessary.

IAC students are also trained to minimize industrial waste streams. Students document the current process and identify each waste stream. Students are trained to use an "inside out" approach that looks at the system from the inside out rather than the outside in. During this part of the process, students ask for information from various members of the plant's management team. They generate ideas through brainstorming and then formulate solutions. Finally they offer recommendations to reduce or eliminate waste streams. If the waste stream cannot be eliminated or reduced, the team attempts to find avenues to recycle, or reuse the material.

Many of the ideas generated are new concepts and require the students to do additional research.[3] For example, students may be required to call vendors and speak directly with salespersons regarding problem-solving solutions. Research can also take on the form of contacting other IAC's that may already have investigated similar problems. Finally, research may be acquired by formulating the problems, applying engineering fundamentals, generating outcomes and building a database to support theories.

Students also learn the importance of economics. Students calculate the cost savings of the proposed changes and the cost of implementing each recommendation. Then the students calculate the simple payback. A recommendation is proposed only if it has an estimated payback of less than 48 months. Ideas that do not meet the 48-month restriction are placed in a separate section of the report. Frequently, this type of recommendation does not payback but is included because it is the right thing to do for the environment or employee working conditions.

Technical and Analytical Skills

Acquiring all the technical theory in the world does not help unless it can be applied. Steve Ray, a Mechanical Engineering graduate student and UDIAC team member agrees. Steve is a mechanical engineering graduate of Kettering University with seven years of practical experience in the design and implementation of mechanical systems. He believes that the program has given him the foundation to apply engineering fundamentals learned as an undergraduate to practical industrial situations.[5] In addition, Wayne Bader, a former graduate from the University of Dayton MSME and IAC program, concurs. Identical to Ray's situation, Bader was a mechanical engineering graduate of the University of Dayton who worked for the utility industry for 12 years before returning to pursue a master's degree. Ray and Bader are only two examples of former IAC students who have had industry experiences prior to working with the IAC. They are not unlike the majority of the students who believe that the IAC has given them the experience to see the basic engineering principles applied to real life situations.

The four analytical and technical skills sets that the UDIAC focuses upon are Lean Manufacturing, Energy Systems, Data Collection Equipment and Computer Software Tools.

Lean Manufacturing is a concept that can be applied to any type of organization, not just manufacturing. Teaching students the principles and tools of these concepts is key. The team focuses on the elimination of waste as explained by John Nicholas in his book, "Competitive Manufacturing Management.

Nicholas breaks the subject of waste into several categories that include; inventory, time, motion, overproduction, waiting, resources etc.[6] Once the team has identified the type of waste, they go to work on the solution. Many solutions stem from the Just- In-Time (J.I.T.) principles. Some examples of implemented productivity recommendation include reducing set-up and changeover times, process simplification, inventory reduction, cleanliness and organization, total productive maintenance, waste reduction, continuous operation and automation.

Identifying the major energy-using equipment and assessing if it is performing efficiently is a primary focus of the team. Students are trained to use the "inside-out approach".[7] This approach teaches students to identify the tasks that equipment must perform and follows it from the inside of the plant to the outside. For example, air compressors are energy intensive equipment. The inside out approach first looks at the uses of compressed air in the plant. Are they appropriate and necessary? Is the pressure appropriate for the equipment being powered by compressed air? Next, the students look at the distribution system. Are there leaks in the piping that cause losses in the system? Only then do students look at the primary energy conversion equipment, the air compressor. Does the system use cooler, outside air for compression? Does it pump the warm air from the compressor back into the plant during winter months to supplement heat? Other energy systems analyzed by IAC students include electrical demand reduction, fluid flow, HVAC, plant lighting, motors, process cooling and process heating.

Software and Equipment

In order to assess the current performance of energy-using equipment, students are trained to use various types of data collection equipment. The UDIAC team is equipped with two laptop computers, two light meters, an amp clamp, infrared thermometer, current transducer data loggers, a combustion analyzer, an ultrasonic flow meter, a vane anemometer and a power meter. Each student acquires the skills necessary to operate key pieces of equipment. In specific cases, some students are responsible for selecting and specifying special energy analysis equipment.

Finally, students are trained to use computer simulation software programs such as CoolSim, HeatSim, LightSim and Esim for quantifying energy savings. CoolSim allows the student to input water temperature and the target water temperatures for a process cooling application. The program calculates how often a cooling tower can meet this demand using TMY2 data.[8]

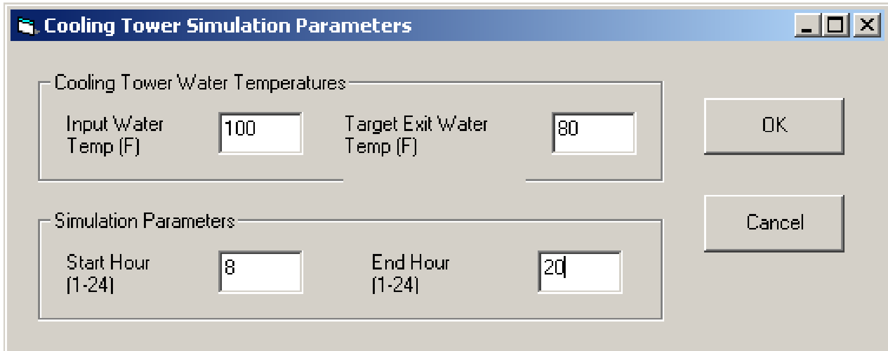

Figure 1 – Input and output display for CoolSim

HeatSim calculates savings from insulating steam and condensate pipes, extruder barrels and hot tanks. HeatSim requires students to enter air temperature, surface temperature, equipment dimensions and insulation information. It calculates the energy savings and the cost to insulate the objects.[9]

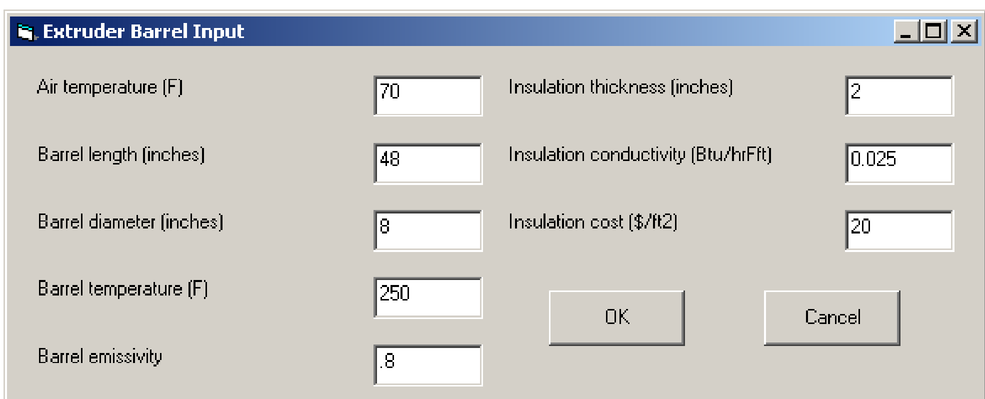

Figure 2 – Input and output display for HeatSim

LightSim is designed to analyze energy savings from replacing electric lights with windows and skylights. The program uses TMY2 data files along with information entered by the student, and calculates how often a desired luminance can be achieved using natural lighting during both summer and winter months.[10]

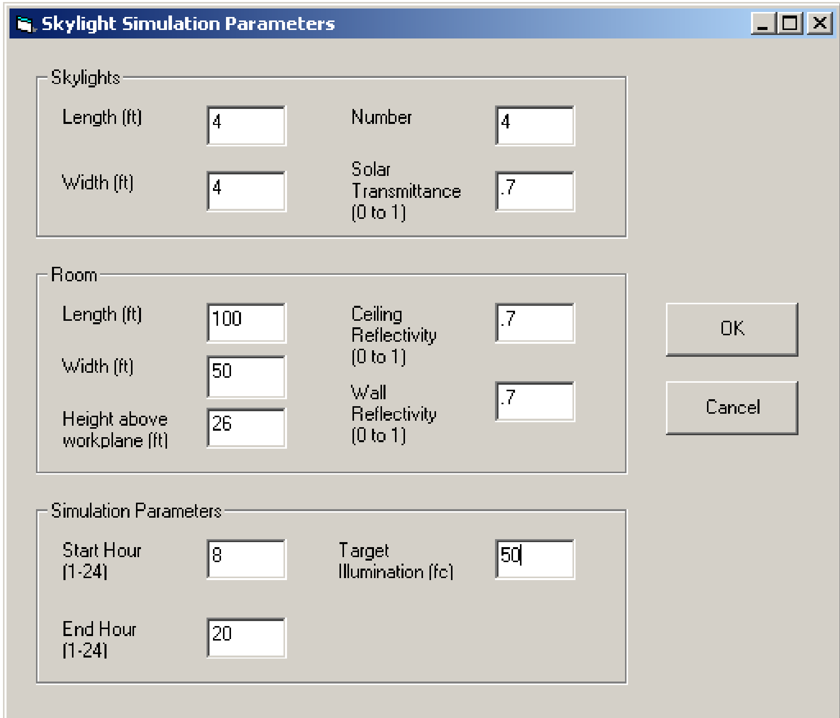

Figure 3 – Input and output display for LightSim

ESim simulates building energy use and correlates it with utility billing data. Among the characteristics considered are heating and cooling set points, building construction and orientation, internal loads and HVAC equipment efficiencies. The software can simulate single zone, multi-zone or passive solar buildings.[11]

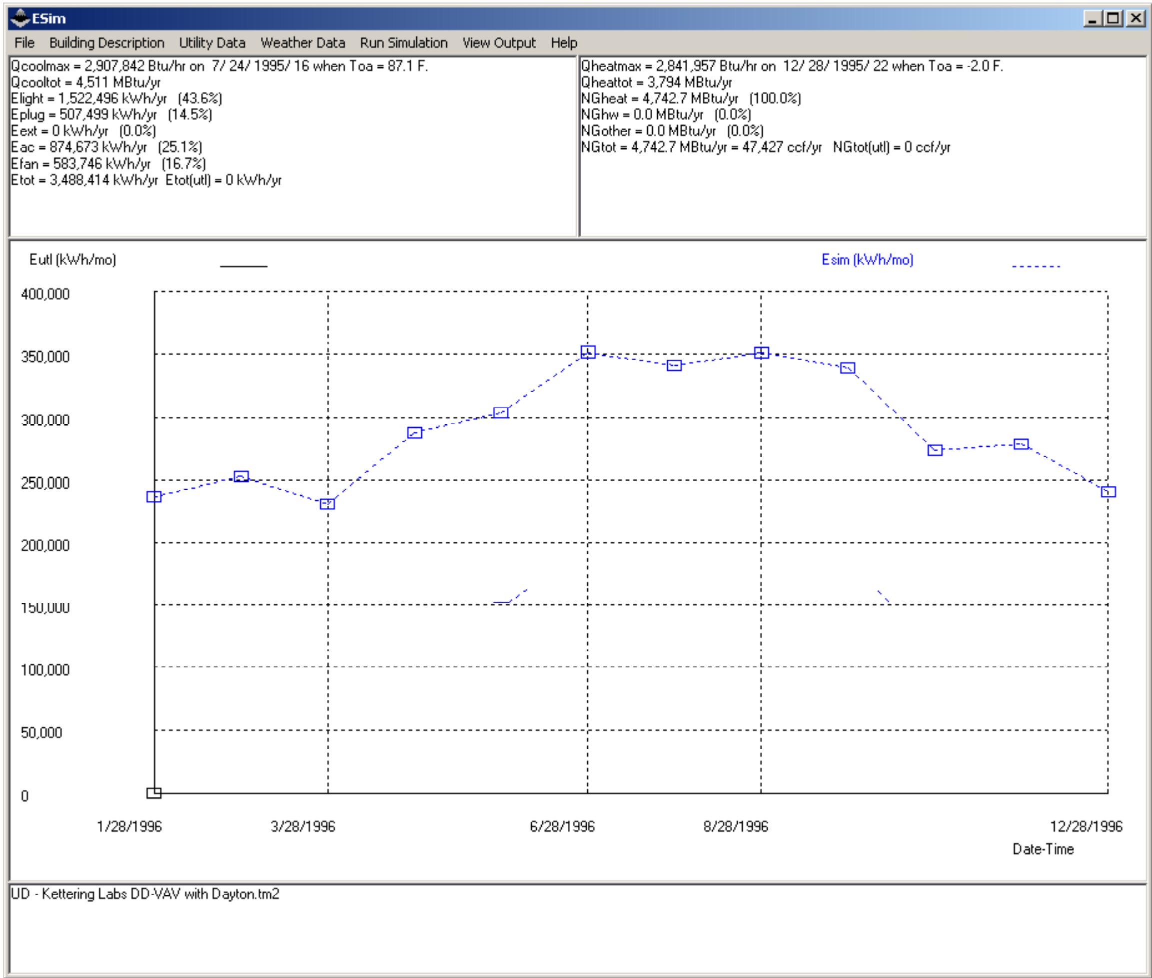

Figure 4 – Display for Esim simulation software

III. Assessment of Student Learning

In order to assess the effectiveness of a system, it must be quantified. Since this program is funded by the Department of Energy, elected officials are concerned with the overall value that the program brings to American industries. Therefore, Oak Ridge National Laboratory conducted a survey in conjunction with the University of Tennessee to learn more about the impacts of IAC student alumni. Students who attain these "alumni pathway benefits" now hold jobs where they are responsible for conducting energy assessments and influencing the manner in which companies manage energy and make energy efficient decisions.

The survey was developed using a database of 656 IAC alumni (out of an estimated 1,420 alumni through 1998). From these 656 alumni, IAC directors identified 77 who were believed to be successful engineers, working in industry in an energy saving capacity. In the spring of 1999, all 656 IAC alumni received a questionnaire in the mail. Alumni responses included 132 completed questionnaires and approximately 150 questionnaire packages were returned as a result of bad addresses. Thus, the overall response rate was just over 26%.[12]

The questionnaire was designed to collect four different types of information; energy and cost savings, changes in energy decision making, contribution of the program to after graduation success and alumni work history. The results of the survey indicate that the IAC program has a significant impact in all four areas and especially in the alumni success category. Within this category, the study confirms that IAC alumni have a strong impact on energy saving decision-making. The study depicts the stages in the lifecycle model as 1-No decision-making, 2-Initial efforts, 3-Program implementation, 4- Program success, 5-Routinization, 6-Inculturalion, 7-Steady state. Responses show a significant shift from 1-No energy decision-making to 7-Steady state, indicating significant impact on how companies make decisions. In addition, energy recommendation projects with paybacks of 2 years or less have significantly increased among companies with IAC alumni. Finally, the report indicates that alumni have made an impact on the financial performance of their company's energy saving decisions.

IV. Summary and Conclusion

In summary, this paper discusses the function of the Industrial Assessment Centers, the diverse skill sets that UDIAC students attain and the measured effectiveness of the program. Those skill sets include:

- Communication
    - Written
    - Oral
- Management
- Leadership
- Industrial Experience
    - Exposure to a Variety of Industries
    - Consulting
    - Industrial Safety
    - Waste Identification
    - Research
    - Economics
- Technical and Analytical Skills
    - Lean Manufacturing Techniques
    - Inside Out Approach to Energy Efficiency
    - Various Types of Simulation Software

In conclusion, the Industrial Assessment Centers effectively promote student learning. The training and experiences that students receive through the IAC Program provide industry with engineers with significant and diverse industrial experience.

Because students are introduced to manufacturing environments, and must perform their job functions within these environments, their experience is like no other. When IAC students graduate they have experience in several industries, understand energy efficiency, and can implement lean manufacturing techniques. The program has made a significant impact in the type of engineers academia supplies to industry.

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