AN INNOVATIVE OPPORTUNITY FOR INDUSTRY AND EDUCATION COLLABORATION

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Abstract

Academic institutions are constantly looking for ways to improve the education of their engineering students. Training students to become productive engineers and leaders requires improvements in two fundamental areas: technical proficiency and communication skills. One of the best ways for students to improve both of these areas is to teach someone else a new subject they are trying to learn. This educational axiom is the foundation of a new, ongoing learning program, Bridging Theory into Practice, developed by our two institutions, Valparaiso University's College of Engineering, an exclusively undergraduate professional college, and Infineon Technologies AG, a global, top-twenty semiconductor manufacturer based in Neubiberg, Germany.

Through the Bridging Theory into Practice program, three Valparaiso University students (with the guidance of a faculty mentor and an Infineon peer engineer) were responsible for researching a discipline outside of traditional undergraduate engineering programs. During the self-study, the students were responsible for developing an extended training presentation (150 minutes in length) on the subject with approximately fifty pages of accompanying text. This unique opportunity allowed students to not only develop a technical proficiency in an emerging discipline, it also required them to learn how large technical reports and book chapters are authored.

After twelve months of work, the project was completed. The material has been incorporated into Infineon Technologies AG's formal training materials for internal and external customers. The presentation was the foundation for a webinar viewed internationally. Additionally, the accompanying text will be used in three chapters of a future Bridging Theory into Practice textbook. The Valparaiso University students and faculty mentor were publicly recognized in the webinar for their work and will be listed as co-authors for the chapters in the textbook. From the lessons learned, the Bridging Theory into Practice program has been refined and promises to be an opportunity for additional undergraduate students further develop into young engineers.

Introduction

Undergraduate engineering students are trained in a variety of disciplines. In preparation for their engineering classes, they typically take several semesters of mathematics and physics and a number of humanities and social science classes. During their last two or three years of study,

they often take 50-70 hours dedicated to their specific engineering discipline. However, the skills taught to undergraduate engineering students are only the first steps in the development of a complete engineer. Existing undergraduate engineering education is inconsistent with the skills and practices that practicing engineers require [1]. Valparaiso University (Valparaiso) and Infineon Technologies AG (Infineon) have sought to enhance the undergraduate engineering experience through our on-going educational research grant partnership, Bridging Theory into Practice (BTiP). This partnership helps engineering students by focusing on two areas that will help them transition into competent, practicing engineers. These areas are improving technical proficiency through self-study and communicating effectively. Depending upon their level of participation, students engaged in the Bridging Theory into Practice program can elect to receive wages for their effort or credit in our ECE490 Topics in Electrical and Computer Engineering class.

Infineon required a new training module on the implementation, advantages, and disadvantages of digital control loops for next generation power converters. This is a leading edge innovation, a topic beyond the realm of traditional undergraduate engineering studies. The decision was jointly made by our two institutions to develop the training module via the BTiP program. Through this program, three Valparaiso students (with the guidance of a Faculty Mentor) were responsible for developing a 150 minute presentation and fifty pages of accompanying training material on the digital control of next generation power converters.

This paper is divided into the following sections. We begin with an introduction to the undergraduate engineering skills we focus on developing in the BTiP program. Next, we formally introduce the BTiP program and its implementation at Valparaiso and Infineon. We then discuss the roles played in the development of the digital control module by the undergraduate engineering students, the Infineon Peer Engineer, and the Valparaiso Faculty Mentor. Next, we present the results of the program. Finally, we finish the paper with our lessons learned and conclusions.

Student Skills

While the number of hours engineering students spend in classes has not significantly increased (and in some cases, decreased [2,3]), engineering technology continues to advance at an exponential pace. (The best known example of this exponential technology revolution is "Moore's Law" [4].) Therefore, engineering institutions are looking for ways to further develop their students' technical proficiency within the time constraints of a four year program. Many undergraduate students presently fall into the trap of studying for a test in order to pass a class, continue their academic progression, and finally graduate [5,6]. While this is potentially effective as a solution to an optimization of resources problem, it does little to prepare a student for a career in engineering. One way to better prepare our students is through additional student projects and self-study in topics beyond traditional engineering undergraduate curricula. Students can further improve their technical proficiency by teaching others what they have learned [7].

In addition to improving their technical proficiency in their self-study, the students were also introduced to the concept of Design-Oriented Analysis (D-OA) [8,9]. Many undergraduate

engineering courses focus on analyzing problems to generate a "correct" answer. Such analysis skills are important. However, the skills to create systems from specifications are also important and very useful in the work place. This is the reverse of the analysis problem. Engineers are often asked to design a system that gives a specified result (the answer). They essentially have to determine the problem that generates the final answer. In our project, the students were given an answer (training on the digital control of power converters), but had to synthesize the system to deliver the expected result.

It is also our intention for students to develop the ability to communicate their work clearly and effectively to their peers and business associates. All too often, engineering students and their instructors communicate only through the solution of equations, short answer problems, and brief laboratory reports [10]. We seek to enhance students' oral and written communication skills by first asking them to develop an extended presentation (approximately 150 minutes) to convey the results of their self-study project. Second, we ask students to write an extended text expanding upon the presentation's content and providing additional examples.

Bridging Theory into Practice Program

In 2003, Infineon launched their BTiP program. BTiP seeks to assist engineering graduates as they transition from the often theoretical lessons and concepts learned in the classroom to the "real world" of engineering design in electronic and electromechanical applications [11-13]. The output of the BTiP program is a series of training modules originally intended to train young Infineon engineers. The modules can be followed sequentially to develop a step-by-step approach to electronics design. Additionally, each module can stand alone, so more adept engineers can pick up any module they would like to study. Because of the success Infineon had with the program internally, they decided to make the program available to a broader audience[12,13]. At this time, the BTiP program consists of more than fifty hours of training based upon a textbook (now in its second edition), white papers, and internet webinars. Topics include such far ranging topics such as semiconductor physics, power integrated circuits, dynamic thermal analysis, motor control, and the quality and reliability of semiconductor devices.

In 2006, Infineon and Valparaiso partnered to develop additional training material for the BTiP program. Through the partnership, Infineon awarded a grant to Valparaiso to develop coursework for the mutual benefit and enhancement of the technical proficiency of the Valparaiso undergraduate engineering students and new Infineon engineers. The coursework would be developed using the stand-alone format of earlier BTiP modules by a Valparaiso faculty mentor and undergraduate engineering students.

As the program module is developed, the students' work (and their technical proficiency and communication skills) is evaluated in four ways. First, the faculty mentor must approve the material's technical content, writing, and figures before submitting the module to Infineon. Second, an Infineon Peer Engineer must also approve the module's technical content, writing, and figures. Next, the module is presented to the Infineon BTiP program manager to confirm it is alignment with the BTiP tenets. Finally, the module is released to the Infineon engineering population for self-study, review, and suggestions for improvement. This feedback is reviewed by the Infineon Peer Engineer and included in the project's presentation. This allows the work to

be verified through a final round of peer review and provides the students with additional opportunities to improve their technical proficiency.

Following completion of the new modules, Valparaiso retains the right to use the material for their classes. Infineon retains the right to use the module in support of their ongoing BTiP Program. As such, Infineon assumes all legal responsibility for the presentation and content of the material in their works.

Development of the Digital Control Module

One example of a BTiP program module developed by Infineon and Valparaiso is "Introduction to Digital Control [14]." This is a very timely subject. Within the last five years, several startup companies have developed new technologies for digitally controlled power conversion . Students who understand this technology will find many additional opportunities as they enter the work force. For many years, sophisticated digital controllers were only cost effective for larger static power conversion systems and motor drives. With some of the recent advances in design and technology, these features and performance rich techniques can be applied to more cost sensitive markets. New ideas and innovations are needed from fresh minds to push the frontier in this area further. The real benefits to society are performance and comfort while enjoying energy savings with a more efficient and green conversion technology.

The digital control of power converters is a new topic area, so it is rather challenging for the undergraduate students to find information on the subject. This is exactly the same problem experienced engineers face as they push technology forward. Skills developed tackling these kinds of projects early in our students' careers will indeed help them and all of society. Creating a passion in an area of interest for each student is an important aspect for their development. By providing exposure to one of the electronics industry's most important new areas, we can foster a passion for technology and power electronics that motivate the students to undertake an independent study project and help them launch a successful career.

Before the new digital control power converter module was developed, a Valparaiso BTiP Faculty Mentor worked with an Infineon engineer to develop a one-page proposal describing the self-contained training module for inclusion in the BTiP program. The proposal was submitted to the Infineon BTiP Program Manager. After the proposal was approved, the Infineon BTiP Program Manager officially assigned the Infineon engineer to the module. This Infineon "Peer" Engineer was responsible for providing assistance and direction in the development of the training module and real-time feedback on the industry's current expectations, requirements, and trends. The Faculty Mentor and the Infineon Peer Engineer then developed a detailed outline of the training module. Upon completion of the outline, Valparaiso began developing the training module. The training module was to include:

- A presentation, suitable for training engineers or engineering students, of 150 minutes in duration.
- A text document to accompany the presentation, suitable for use as a stand-alone chapter in a future BTiP textbook.

To support the development of the training modules, the Dean of the Valparaiso College of Engineering and the Faculty Mentor identified students to assist in the development and refinement of the module. These students were named BTiP Scholars. BTiP Scholars were compensated for their work in one of two ways. They could elect to be paid for their efforts or take class credit for their work through enrollment in an independent study project class. The Scholars will be recognized by name in future Infineon BTiP publications containing their work. After the Scholars were assigned to the module, the BTIP Scholars, Faculty Mentor, and the Infineon Peer Engineer established weekly goals for the completion of the module.

Results

There were several physical deliverables submitted at the completion of the training module. Valparaiso successfully delivered a seventy-three slide presentation introducing young engineers to digitally controlled power supplies. The presentation was supplemented with three accompanying texts that will each serve as a stand-alone chapter in a future BTiP textbook. Infineon was able to use the materials to develop an internet webinar [14] on the topic. This webinar has been viewed internationally and continues to be available for the training of young engineers and engineering students alike. Through the four step evaluation process detailed above, the Faculty Mentor and Infineon Peer Engineer were able to directly observe and critique the Scholars' improved technical proficiency and communication skills.

Lessons Learned

Many lessons were learned by the authors in the development of the Introduction to Digital Control training module. While both authors have worked with hundreds of engineers over the last twenty years, this was their first experience developing a full training module in the BTiP program with a team of undergraduate engineering students. Specifically, the authors learned:

- It is important to communicate the outline of the topic clearly and to set expectations for the students so the project gets started with the right focus.
- Undergraduate engineering students have a wide range of extracurricular activities. These activities can place severe restrictions on their time for additional scholastic pursuits and self-study outside of their classes.
- Undergraduate students have problems knowing where to start independent study projects. This was one of the first projects the students had where they given an open-ended assignment.
- Because of their inexperience in open-ended assignments, students have little ability to predict the duration of a work activity. This requires the BTiP Faculty Mentor to closely manage their work and develop a program management schedule for their project.
- Weekly objectives and updates are essential to keep the project on target while maintaining proper focus.
- After the research and self-study were complete, the students had minimal experience in writing the large scale (approximately fifty pages) technical documents that accompanied the training presentation. While students were well-versed in the writing of laboratory reports and short papers, they had never authored manuscripts of this size before.
- After completion of the BTiP training module, the three students conversationally reported improvements in their technical proficiency and communication skills.

- For the development of future BTiP modules, a series of measures need to be established in an attempt to quantify the improvement in the undergraduate students' technical proficiency and communication skills.

Conclusions

To become successful engineers, undergraduate students need to develop their technical proficiency and their communication skills. In an attempt to address both needs, Infineon Technologies AG and Valparaiso University partnered to further develop the Bridging Theory into Practice program. Through this program students can develop their technical proficiency in new areas while practicing their communication skills. Three undergraduate students recently completed a training module using the BTiP program to the mutual benefit of the students, Valparaiso University and Infineon Technologies AG.

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