Abstract - The goal of this work-in-progress is to develop an innovative ECE curriculum that focuses on ECE fundamentals within the context of real-world integrated system design, analysis, and problem solving. The curriculum will be formulated around the theme of Integrated Sensing and Information Processing (ISIP). The foundation of this new curriculum will be a hands-on theme-based introductory course. This course, taken in the freshman year, will introduce students to the major subdisciplines of ECE in the context of real-world applications. In the laboratory, which will be tightly coupled to the lecture, students will apply basic concepts of sensing, information transmission, information analysis, storage and networking to design and implement an ISIP system, such as a health or weather monitoring station. In this way, students will immediately begin to understand the relationships between the major topic areas of ECE as well as be motivated to explore these topics in further depth. Other components of the redesign include the integration of core and upper-level courses into the ISIP theme, the introduction of new ISIP-related design courses, and the integration of MATLAB throughout the curriculum.

Index Terms – electrical and computer engineering, first-year design, theme-based curriculum.

INTRODUCTION

Research into engineering instruction has suggested that a curriculum involving analysis, synthesis, integration, innovation, and an early focus on real-world problems is integral to the successful training of modern engineers [1-10]. In concert with this real-world focus, researchers suggest that laboratory exercises not be formulaic, but involve goal- and design-oriented projects [7]. Most recent studies suggest that with the rapid explosion of content within ECE, optimal curricula should not be designed to cover all possible topics, but rather focus on fundamentals and ensuring that students learn the cognitive skills necessary to solve engineering problems [6-8]. A focus on providing a deep understanding of underlying concepts and design principles, as opposed to simply teaching the mechanics of problem solving, has been shown to be a preferable educational paradigm [1-4,7,8,10,11]. Learning theorists also believe that learning is facilitated when the process is structured around major concepts and principles [1,4-6,8].

Historically, undergraduates in Electrical and Computer Engineering (ECE) at Duke University have had ample exposure to theoretical precepts and design concepts within the construct of a broad curriculum. Despite its strengths, several weaknesses in the curriculum have been identified including 1) No overarching framework is provided that integrates basic principles of ECE; 2) Students must focus their studies before they fully understand the relationship between the various areas of ECE; 3) Concept coverage in the core curriculum is not properly balanced; 4) Design courses are too narrowly focused; and 5) Computational tools are not well-integrated.

In order to develop the best possible undergraduate curriculum for our students, we plan to streamline and update the entire ECE curriculum, with particular focus on the students’ early years in the core curriculum when retention issues are the most critical. Our goals are to revise the overall structure of the curriculum, to provide continuity by emphasizing the interrelatedness of ECE topic areas, and to incorporate innovative pedagogical techniques and hands-on experience throughout the curriculum while maintaining our curricular flexibility. These goals will be achieved through the use of a theme, Integrated Sensing and Information Processing (ISIP), which reflects key concepts governing the future of electrical and computer engineering as well as the active research areas of the majority of the ECE faculty.

COMPONENTS OF PROPOSED CURRICULUM

We have developed a new, innovative curriculum for the ECE department that focuses on ECE fundamentals within the construct of real-world integrated system design, analysis, and problem solving. The five major components of the curriculum are described below.

I. Curricular Theme

The curriculum will be organized around the theme of Integrated Sensing and Information Processing (ISIP). This theme bridges the disciplines of physics, devices, mathematics, electromagnetics, signal processing, computer engineering, communications and controls, with the goal of building systems and networks of systems for specific applications. It not only clearly instantiates ECE focus areas individually, but it also provides a unique and appropriate platform for integration across focus areas. ISIP as a concept considers sensing system design and operation without regard to traditional subsystem boundaries and interconnect structures – and thus it can be used in an educational setting to
teach design and operation with much less regard to traditional course boundaries.

II. Theme-based Introductory Course

In this first-year course, entitled *Fundamentals of ECE*, students will build a prototypic ISIP system, such as a weather-monitoring station. To create this system, students must work with sensors that transduce environmental information, create analog signals that can be transmitted and received wirelessly, use logic to display the results, and interpret and calibrate their results based on subsequent testing. Fundamental concepts of the ECE curriculum, including circuits and devices, systems and systems analysis, logic and computers, and electromagnetics will be introduced. Through this synergistic presentation and organization of topics, students will gain an understanding of each sensor/device at the physical level, then understand the input/output characterization or how the device operates at the system level, and finally gain an understanding of how the device interconnects with other elements as a component of a larger system. By taking this rigorous real-world design course at the outset of their studies, students will gain a much broader picture of ECE. The diverse exposure to ECE topics, combined with the sense of accomplishment associated with completion of a complex project, will serve to energize their progress through the remaining curriculum.

III. Redesign of the Core Curriculum

Another major component of the proposed revision will be to restructure the core curriculum. The core courses will each be linked to the introductory course so that the relevance of their material is more easily understood. There will be four core courses beyond *Fundamentals of ECE*, redesigned and reorganized such that the following goals are met: 1) they must provide a foundation for more in-depth junior and senior level technical electives, 2) they must be integrated into the ISIP theme, and 3) they must be tightly coupled to each other.

IV. Upper-level Electives and Design Courses

The technical elective and design courses will be reformulated such that the ISIP theme is carried throughout the curriculum. This will be accomplished via classroom examples, laboratory experiments, or full-scale design projects relating the current topic to some aspect of ISIP. A new design course will be offered in which students will consider all aspects of a single application, from conceptualization of the basic physical principles involved to marketing a robust and cost-effective device or system. This course, in particular, will provide an opportunity for faculty research to be integrated into the undergraduate experience.

V. Vertical Integration of MATLAB

The final aspect of our reform plan is the vertical integration of MATLAB throughout the curriculum. MATLAB is currently one of the most prevalent software tools used in engineering practice, as well as in academic research, and its popularity continues to grow. The use of MATLAB (following theoretical instruction in basic concepts) facilitates flexible learning, avoids “rote learning” issues resulting from repeated hand solution of similar problems, and encourages exploratory approaches to problems [1-3,6,7].

CONCLUSIONS

In summary, we plan to develop an overarching theme-based curriculum to facilitate student learning and the development of research-oriented design skills. The new curriculum will include an introductory course that integrates all aspects of the ECE curriculum within the construct of this theme, along with a restructured core curriculum to provide better balance and integration with the theme. Additionally, we will modify the structure and content of the upper-level technical and design courses. In concert with all of these efforts, we propose to integrate MATLAB throughout the curriculum.

ACKNOWLEDGMENT

Support for this work has been provided by the National Science Foundation grant EEC-0343168.

REFERENCES


