FITC Institute Final Report

Appendix G

Curriculum Analysis Report:
Florida Agricultural and Mechanical University
Computer Engineering Program

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1. Introduction

This curriculum analysis report, as a part of the Florida IT Career Alliance (FITC) Assessment project, presents the curriculum analysis findings of the Computer Engineering (CE) program at the Florida Agricultural and Mechanical University (FAMU). This analysis answers a specific research question: To what extent are the learning outcomes specified in the FAMU CE program syllabi similar to the Association for Computing Machinery and the Institute of Electrical and Electronics Engineers (hereafter ACM/IEEE) 2004 CE curriculum guidelines?

Computer engineering is defined as "the discipline that embodies the science and technology of design, construction, implementation, and maintenance of software and hardware components of modern computing systems and computer-controlled equipment" (The Joint Task Force on Computing Curricula: ACM/IEEE Computer Society, 2004, p. 4). CE has traditionally been viewed as a combination of computer science (CS) and electrical engineering (EE). It has evolved over the past three decades as a separate, although intimately related, discipline. CE is grounded in the theories and principles of computing, mathematics, science, and engineering, and it applies these theories and principles to solve technical problems through the design of computing hardware, software, networks, and processes (The Joint Task Force on Computing Curricula: ACM/IEEE Computer Society, 2004).

Curriculum models for the computing fields began in 1965 when the ACM first published a set of recommendations (Pasha & Pasha, 2012). Every decade since then, the ACM and the IEEE (hereafter ACM/IEEE) jointly sponsor a curriculum framework, which mainly aims at providing modern curricular guidance for undergraduate computing related programs internationally. Starting from the year 2001, this volume was fragmented into 5 disciplines: Computer Science (CS), Computer Engineering (CE), Information Systems (IS), Information Technology (IT), and Software Engineering (SE). The effort behind publishing curriculum guidelines is to help train future generations of computing professionals ("ACM/IEEE-CS Jointly Published Curricula," 2015). The ACM/IEEE CE curriculum guidelines were last revised in 2004, and they aim to offer direction and curriculum coherence in what is a generally expansive and varied field (Ricks et al., 2008).

The ACM/IEEE curriculum guidelines for all computing disciplines are organized in a specific format, constituting an overall *Body of Knowledge*. The *Body of Knowledge* hierarchical organization comprises three levels:

- The highest level of the hierarchy is the *Knowledge Area*, which represents a particular disciplinary sub-field. A three-letter abbreviated tag identifies each area, such as DIG for "Digital Logic" and CAO for "Computer Architecture and Organization."
- Each *Knowledge Area* is broken down into smaller divisions called *Knowledge Units*, which represent individual thematic modules within an area. A numeric suffix added to the area name identifies each knowledge unit. For example, CAO3 is a *Knowledge Unit* on "Memory System Organization and Architecture" within the CAO *Knowledge Area*.
- A set of topics, which are the lowest level of the hierarchy, further subdivides each *Knowledge Unit.* A group of *learning outcomes* addresses the related technical skills associated with each Knowledge Unit. The concept of learning outcomes is a mechanism for describing not just knowledge and relevant practical skills, but also personal and transferable skills, which include skills such as communication skills, the ability to work in a group, presentation skills, etc. A skill is considered transferable according to the ACM/ IEEE CE curriculum guidelines if it can be used in any occupation, and the individual can transmit the skill from one job to another without having to be retrained (The Joint Task Force on Computing Curricula: ACM/IEEE Computer Society, 2004).

The CE Task Force sought to assemble a modern curriculum by first defining the primary disciplines that make up the *Body of Knowledge* for CE. The CE *Body of Knowledge* comprises 18 *Knowledge Areas*, including two related to mathematics topics.

The Department of Electrical & Computer Engineering (ECE) at the FAMU-FSU College of Engineering is a joint program between FAMU and Florida State University (FSU).

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The Department of Electrical and Computer Engineering is accredited by the Engineering Accreditation Commission (EAC) of the Accreditation Board for Engineering and Technology (ABET), Inc. As required by ABET accreditation criteria, the ECE Department has developed program educational objectives and student outcomes (The Accreditation Board for Engineering and Technology, 2013).

Table 1: FAMU-FSU CE program educational objectives and student outcomes as required by ABET[1]

Program Educational Objectives	Student Outcomes
1. Have a successful career in computer engineering. 2. Be enrolled in or have completed a MS or PhD program 3. Have a career in digital systems, digital signal processing, computer networks, or VLSI 4. Participate in either the research, development, or application of engineering solutions that have had a positive impact on society. 5. Have made contributions to workforce diversity. 6. Have shown a commitment to life-long learning and continuous self-improvement. 7. Have become proficient in the oral and written communication of their work and ideas.	A. An ability to apply knowledge of mathematics, science, and engineering. B. An ability to design and conduct experiments, as well as to analyze and interpret data. C. An ability to design a system, component, or process to meet desired needs. D. An ability to function on multi-disciplinary teams. E. An ability to identify, formulate, and solve engineering problems. F. An understanding of professional and ethical responsibility; G. An ability to communicate effectively. H. The broad education necessary to understand the impact of engineering solutions in a global and societal context. I. A recognition of the need for, and an ability to engage in life-long learning J. A knowledge of contemporary issues. K. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Beginning in 2000, ABET has required qualifying engineering programs to convey certain specified learning outcomes and competencies to students (Passow, 2012). ABET requires universities to include both technical and professional competencies, but since ABET is largely concerned with program-level concerns, the relative emphasis placed on competencies is left to the judgment of the individual university program (Mohan et al., 2009; Passow, 2012). According to the ABET "Program Criteria for Electrical, Computer, Communications, and Similarly Named Engineering Programs 2014-2015," a CE program that qualifies for accreditation must include, "probability and statistics, including applications appropriate to the program name; mathematics through differential and integral calculus; sciences (defined as

[1] Retrieved from https://www.eng.fsu.edu/about/accreditation/program_outcome.html?ID=203&agency=ABET

biological, chemical, or physical science); and engineering topics (including computing science) necessary to analyze and design complex electrical and electronic devices, software, and systems containing hardware and software components," as well as discrete mathematics (The Accreditation Board for Engineering and Technology, 2013).

Because ABET offers no course-specific standards and is focused on program-level outcomes, this curriculum analysis only employs ACM/IEEE CE curriculum guidelines as a standard to assess the learning outcomes specified in an individual CE course syllabus.

2. Method

2.1 Data Collection

The unit of analysis for this portion of the assessment project was an individual course syllabus. The FAMU Bachelor of Science in CE degree program gives a list of courses a student is supposed to take in his 4 year degree program. The FAMU CE program is comprised of 128 semester hours of credits including 24 semester hours of general studies courses; 43 hours of engineering core courses; 42 semester hours of required CE courses; 13 semester hours of computer science core and six semester hours of technical electives. Forty-two semester hours of required CE courses and 13 semester hours of computer science core courses are included in this curriculum analysis. The 42 semester hours of required CE courses can be obtained from 16 courses, and 13 semester hours of computer science core coursework can be obtained from five courses, which resulted in the total number of syllabi analyzed (N=21).

2.2 Data Analysis

The FAMU-FSU CE program's syllabi analysis was conducted using the Python programming language to implement text preprocessing and keyword extraction. Python is a programming language used in many parts of the analysis. It was utilized for automating tedious tasks such as extracting relevant sections from the syllabus, tokenizing the text, extracting key words, and identifying these key words and patterns in the ACM/IEEE undergraduate curriculum guidelines. The extracted learning outcomes were listed in various syllabus sections, including *Course Description, Course Objectives*, and *Course Contents/Schedule* from each syllabus.

All of the extracted keywords from each syllabus (N=21) were automatically compared to the corresponding *Knowledge Units* in the ACM/IEEE CE curriculum guidelines to determine the ACM/IEEE *Knowledge Areas* that were not being covered in the syllabi, as well as the percentage of coverage for *Knowledge Areas* that were present in the syllabi. In order for a *Knowledge Area* to be considered 100% covered, all *Knowledge Units* in that *Knowledge Area* must be covered in the course syllabi. However, it is not necessary for all learning outcomes under each *Knowledge Unit* to be covered. At least one instance of a matching learning outcome is sufficient for the *Knowledge Unit* to be considered covered in the course syllabi.

3. Findings

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A CE program is administered by an Electrical and Computer Engineering Department (ECE).[2] According to one of the syllabi in the sample, foundation courses in computer science are typically offered by a computer science department; the remaining courses are taught by the ECE department. This program has a smaller general education component, with more hours devoted to CE topics. This program is characterized by a greater prominence of some of the traditional electrical engineering topics (circuits, signals, and electronics).

The 2004 ACM/IEEE CE curriculum guidelines specify 18 distinct *Knowledge Areas* for the Computer Engineering discipline including:

- ALG-Algorithms
- CAO-Computer Architecture and Organization
- CSE-Computer Systems Engineering
- CSG-Circuits and Signals
- DBS-Database Systems
- DIG-Digital Logic
- DSC-Discrete Structures
- DSP-Digital Signal Processing
- ELE-Electronics
- ESY-Embedded Systems
- HCI-Human-Computer Interaction
- NWK-Computer Networks
- OPS-Operating Systems
- PRF-Programming Fundamentals
- PRS-Probability and Statistics
- SPR-Social and Professional Issues
- SWE-Software Engineering
- VLS-VLSI Design and Fabrication

Based on the analysis of course syllabi (N=21) from FAMU's CE program, 15 of the18 *Knowledge Areas* are covered, though 11 (83%) are partially covered, meaning that although they demonstrate some similarity to the ACM/IEEE curriculum guidelines, not all of the ACM/IEEE *Knowledge Units* are present in the course syllabi.

According to ACM/IEEE curriculum guidelines, it is possible for course content to cover multiple *Knowledge Areas* (one course can contain learning outcomes from multiple *Knowledge Areas*). Therefore, it is not possible to determine the specific *Knowledge Areas* or *Knowledge Units* not being covered by a certain course. However, it is possible to determine which *Knowledge Areas* are not covered in the entire sample, which was done in this analysis.

It has been observed that out of the 18 *Knowledge Areas* detailed in ACM/IEEE Computing Curricula –CE 2004 report, the 21 courses analyzed from FAMU-FSU CE program

[2] http://www.eng.fsu.edu/ece/undergrad/

cover all of the core *Knowledge Units* in respective *Knowledge Areas*. Since the program is focused mainly on electrical engineering topics, and foundation courses in computer science are limited to four, the *Knowledge Areas* that are not addressed in course syllabi are *Database Systems*, *Human-Computer Interaction,* and *Computer Networks*. It is important to note that it is possible that learning outcomes related to these *Knowledge Areas* is conveyed in other aspects of the curriculum besides the syllabus such as lectures, assignments, textbooks, etc.

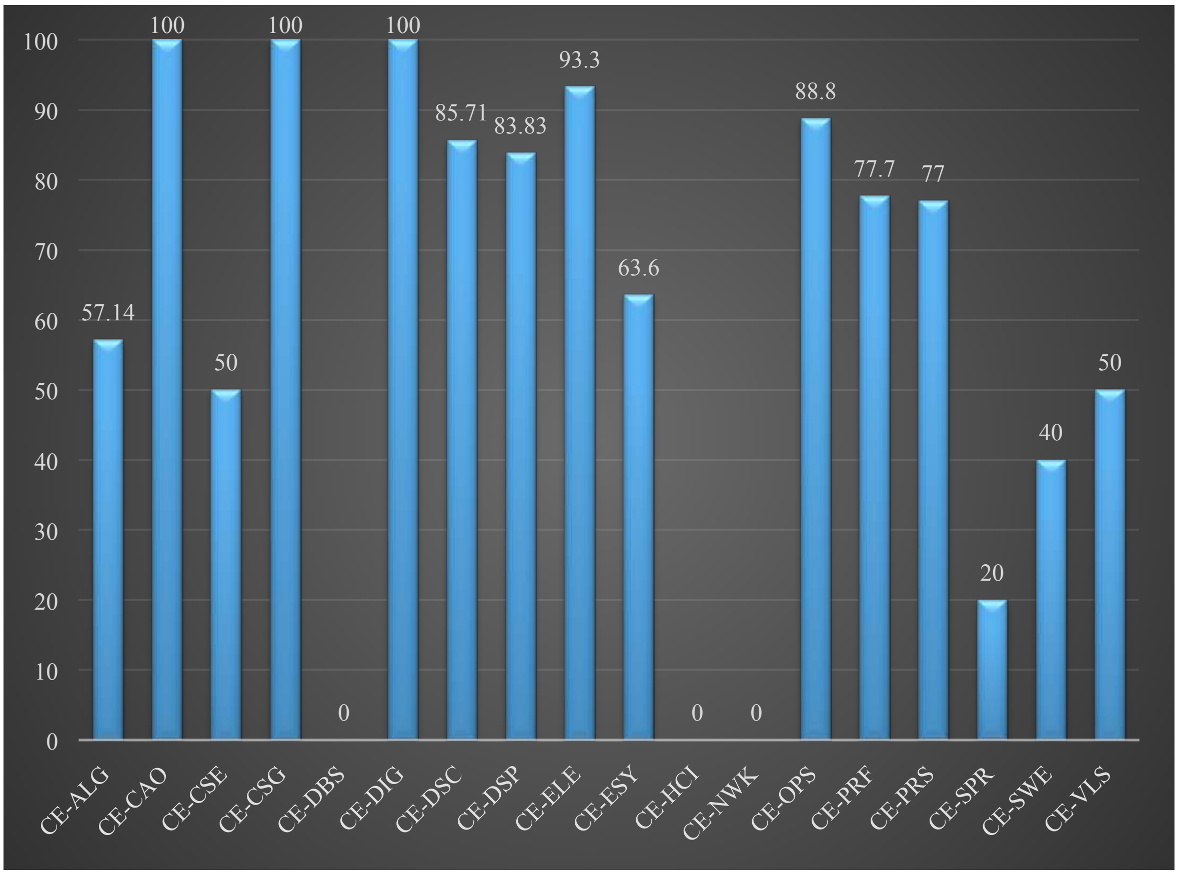

Figure 1: Percentage of Knowledge Unit coverage in each Knowledge Area

Figure 1 presents each *Knowledge Area* as specified by the ACM/IEEE. For each *Knowledge Area*, a percentage of the total *Knowledge Unit* coverage is provided. For instance, in the *Knowledge Area* Circuits and Signals (CSG), 100% of the *Knowledge Units* were present in the syllabi sample (N=21).

The *Knowledge Areas* that had more than 60% *Knowledge Unit* coverage in the FAMU course syllabi are: Computer Architecture and Organization (CAO) with 100%, Circuits and Signals (CSG) with 100%, Digital Logic (DIG) with 100%, Discrete Structures (DSC) with 85.71%, Digital Signal Processing (DSP) with 83.3%, Electronics (ELE) with 93.3%, Embedded Systems (ESY) with 63.6%, Operating Systems (OPS) with 88.8%, Programming Fundamentals (PRF) with 77.7%, and Probability and Statistics (PRS) with 77% *Knowledge Unit* coverage in the syllabi.

4. Discussion

4.1 Findings Discussion

This analysis sought to answer one research question: What is the extent of similarity between the FAMU CE undergraduate program and the ACM/IEEE CE curriculum guidelines? To answer this question, 21 (N=21) course syllabi from the FAMU core CE courses were analyzed and compared to the *Knowledge Areas* and *Knowledge Units* in the ACM/IEEE curriculum guidelines. Based on the analysis, it was determined that the FAMU CE program is similar to the ACM/IEEE curriculum guidelines. The syllabi analyzed contained *Knowledge Units* from 15 out of 18 (over 80%) ACM and IEEE CE *Knowledge Areas*. Some possible areas to further examine include Database Systems, Human-Computer Interaction, and Computer Networks.The ACM/IEEE provide comments on each of the 18 *Knowledge Areas* for CE. By referring to the curriculum framework, it may be possible to gain a deeper understanding of the *Knowledge Areas*' significance to the overall curriculum.

For instance, the ACM/IEEE guidelines remark on the importance of Human-Computer Interaction, given the need for technological advances concerning "human diversity including matters such as color-blindness and deafness" (The Joint Task Force on Computing Curricula: ACM/IEEE Computer Society, 2004, p. A8). The Human-Computer Interaction *Knowledge Area* prepares students to meet challenges in the design process for devices and interfaces.

4.2 Limitations

Due to the scope of this study, only syllabi were considered in the curriculum analysis. Certain learning outcomes not listed in the syllabi may be conveyed through other course materials or course instruction. The most recent ACM/IEEE CE curriculum guidelines available for this analysis was the 2004 version. An updated version of the framework would perhaps offer *Knowledge Areas* and competencies that are more relevant to today's students and new professionals in the CE industry.

5. Conclusion

This phase of the FITC Assessment project was conducted in order to examine the extent of similarity between the FAMU CE curriculum and the ACM/IEEE CE curriculum guidelines were published in 2004. A syllabus analysis of CE program course syllabi found that there was similarity between the curriculum and the ACM/IEEE guidelines. *Knowledge Areas* with decreased similarity were *Database Systems*, *Human-Computer Interaction,* and *Computer Networks.* As a syllabus analysis alone cannot provide a comprehensive view of a program's curriculum, further research may be conducted to determine if these *Knowledge Areas* are included in other aspects of the course such as lecture, assignments, textbooks, etc.

Future study could include triangulation of these results with job posting analysis results and employer interviews which would enhance an understanding of knowledge areas that may benefit from greater focus in computing curricula.

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