Thematic Analysis of Junior-Level Computer Engineering Syllabi

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Work in Progress: Thematic Analysis of Junior-Level Computer Engineering Syllabi

In 2021, the Computer Engineering (CPE) Department at California Polytechnic State University in San Luis Obispo (Cal Poly) underwent a significant transition, moving away from its previous degree-granting program status (managed jointly by two departments) to a full-fledged department of its own. This change prompted re-evaluation of its pedagogical approach, including the content of its syllabi.

This transitionary period presents a unique opportunity for the CPE Department to reassess its commitment to diversity, equity, inclusion, and justice (cornerstones of the new department) in the classroom. As part of this broader assessment, this project examines the language used in course syllabi through thematic analysis, focusing on how these documents reflect or address these values. One key concern for the department is the experience of women, especially women of color, who have historically faced greater challenges in this program compared to their counterparts. We believe that course syllabi may play a positive and/or negative role in shaping the experiences of students in the program. This project is approved by the Cal Poly IRB (2024-120-CP) and does not require anonymization of the department or institution. We intentionally situate this project in the specific context of this work.

This paper examines seven different syllabi in two junior-level courses and highlights similarities and differences in policies, teamwork dynamics, and emphases on ethics and diversity in different sections of these courses via thematic analysis.

- "Computer Architecture" is the second course that students are introduced to in the realm of Computer Architecture and Organization, following one of two introductory Computer Organization courses. The course includes quizzes, labs, and exams focused on a particular ISA (Instruction Set Architecture), and additional emphasis on CPU performance.
- "Microcontrollers & Embedded Applications" is an introductory class in microcontrollers and how they are used in embedded devices. The course includes projects that demonstrate the relationship between hardware and software using the C programming language.

By examining these course syllabi, this paper seeks to uncover differences in pedagogical choices through the lens of an inclusive learning environment.

ASEE reports show that women earned 13.3% of CPE bachelor's degrees in 2018, rising to 14.9% in 2023, compared to 21.9% and 24.6% across all engineering fields, respectively [1, 2]. While CPE has lower representation of women than national averages, the discipline has a greater percentage of graduates from minoritized racial/ethnic groups (19.2% for CPE compared to 17.2% for all engineering fields in 2023) [2].

A premise of this project is that course syllabi should be understood as value-laden rather than as neutral-by-default objects [3] – and that syllabi matter as part of efforts to broaden participation in this field. Syllabi have the opportunity to be innovative, equity-minded and accessible [4] or

to reproduce values of exclusion. We can also consider whether syllabi are "student-centered" or "instructor-centered". As noted in the CUE Syllabus Tool:

> For some faculty members, the syllabus is a guide that outlines what learners should expect in a course and clarifies what is expected of them. For students, the syllabus helps them figure out what they need to do to ensure they will pass the course. However, in many ways the syllabus conveys so much more than rules and course expectations and as such, serves a larger purpose that can shape the students' academic experiences and foster their success. In traditional syllabi that focus on rules and course expectations, instructors outline basic course requirements. However, with well-crafted syllabi, faculty design learning experiences that positively shape and alter how students perceive their instructors and seek assistance for academic challenges.

In addition to attending to "welcoming" or "unwelcoming" language in syllabi [5, 6], it is critical to examine what commitments to and resources related to accessibility and student support are provided. Finally, it is important to situate our project in the context of discipline-specific efforts to transform syllabi, including efforts to increase accessibility in core computer science topics and attention to the question of "designing for whom?" [7] as well as the ways in which attention to ethics is integrated (or not) across syllabi and courses in engineering programs [8-9].

Methods: Via regular departmental communication practices, faculty in the CPE department were invited to participate in this research project by sharing their junior-level syllabi with the research team. Using qualitative methods (including syllabi annotations, memoing), we conducted artifact analysis. In addition, we visualized results using concept-mapping, a way of linking information in an individualized manner to gain a better understanding of the bigger picture [10]. Finally, one member of the research team – a former student in CPE at Cal Poly who transferred out of the major to Computer Science and whom is SWANA-identifying (Southwest Asian & North African) – integrated her experiences as context and lens. We utilize the concept maps below as a way to communicate findings.

Results & Discussion: The results of this study have been split by course. First, results from Computer Architecture will be shown, then the results for Microcontrollers & Embedded Applications. Figure 1 shows similarities and differences between four professors' syllabi in terms of language and policies, particularly in course grading (Figures 1-2):

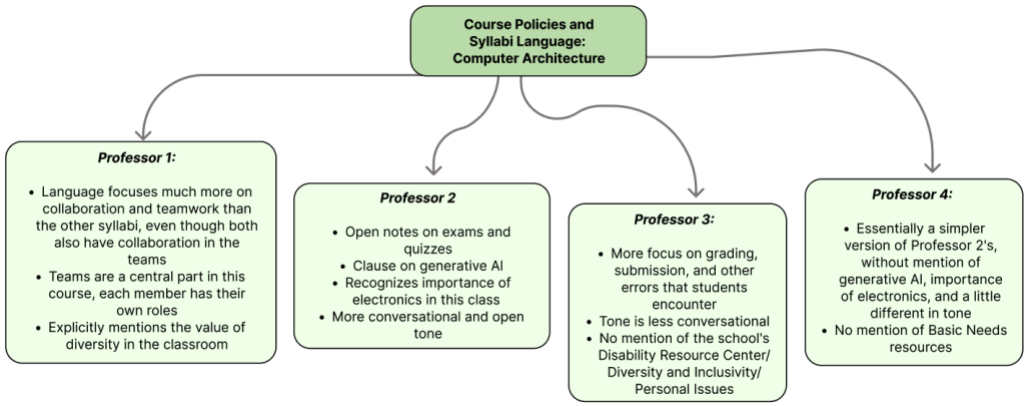

Figure 1 Comparison of Policies and Language for Computer Architecture Syllabi

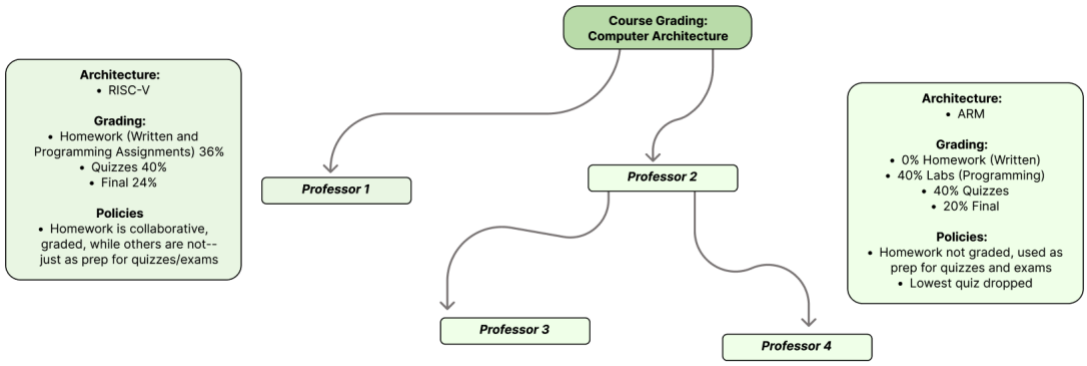

Figure 2 Comparison of Grading Policies for Computer Architecture Syllabi

In addition to differences in language and policies, we note the following:

- Three of these courses inherited syllabi from the same professor, resulting in vastly similar documents.
- Three out of four courses used the ARM computer architecture, while the last used the RISC-V computer architecture
    - RISC-V is utilized in the prior computer architecture course whereas ARM is new content for most students
- Three out of four courses had optional homework assignments, including written assignments and problem sets
- Programming assignments for all courses were approximately 40% of the final grade
- Quizzes for all four courses were worth 40% of the final grade
- Half of courses had open-note policies for quizzes and exams, while the other half did not
- All but one course included information regarding the Disability Resource Center
- Only one course included information regarding the University's Basic Needs Program

Although these syllabi are all for the same course, the variations between them demonstrates that students can have different experiences and potential outcomes. For example, by using an architecture that students might already be familiar with (RISC-V), Professor 1's students could spend less time learning a new architecture and more time using it. Alternatively, the inclusion of ARM Architecture could allow for everyone to start from the same place to better support new community college transfer students who may not have the prior RISC-V experience. Secondly, many students learn about support resources at Cal Poly through their instructors. Having or not having information about the Disability Resource Center and accommodations matters, as does what department/college-specific and university support resources are included, particularly for students from minoritized groups, students who would benefit from enhanced academic support, and students experiencing food or housing insecurity.

Figure 3 demonstrates the similarities and differences between course objectives for the Microcontrollers & Embedded Applications syllabi. The most significant difference in the Microcontroller syllabi is that one utilizes mastery grading [11] and the others do not. Mastery grading is a development-based effort to increase equity and inclusion [12]. In addition, while all syllabi analyzed included emphases on both diversity, equity, inclusion and justice as well as ethics, one course did not include any assignments that integrated or focused on this topic.

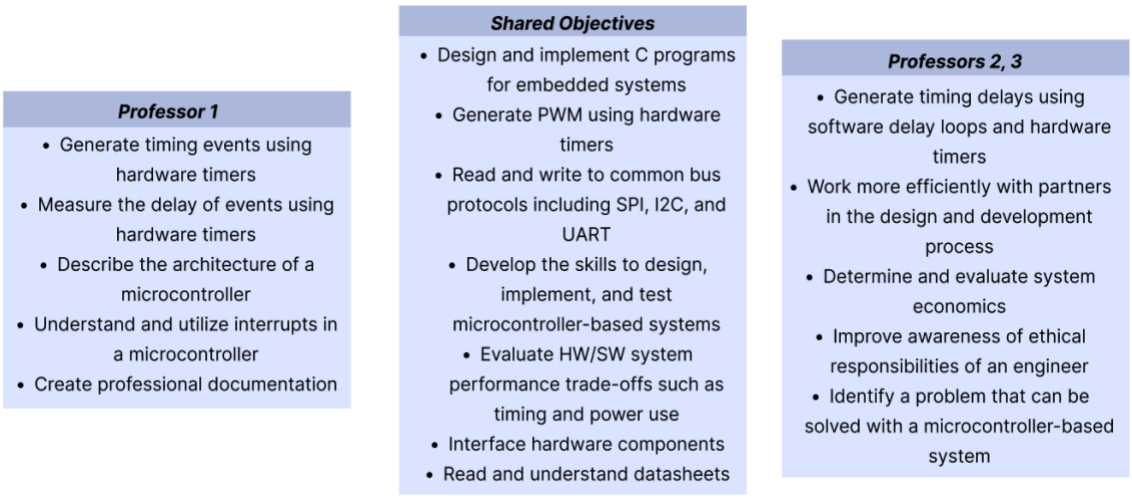

Figure 3 Comparison of Microcontrollers & Embedded Applications Course Objectives

Finally, none of the syllabi analyzed included a Land Acknowledgement, which is a recommended practice on our campus to demonstrate our commitment to Indigenous and Native students and the campus partnership with the yak tityu tityu yak tiłhini Northern Chumash Tribe, the documented descendant Indigenous Tribe of San Luis Obispo.

Conclusion

We wish to acknowledge limitations of this study. First, while we continue to believe that course syllabi do play a positive and/or negative role in shaping the experiences of students in their majors, we also recognize that many other factors shape student trajectories. Second, we recognize that items we identified as "missing" may be communicated by instructors in other ways (e.g., a Land Acknowledgement on the Canvas LMS). Third, our sample was small in terms of syllabi count for these specific courses, and our analysis only focuses on 2 of the 27 CPE-specific required courses in the major (2022-26 catalogue).

That said, this preliminary analysis identified differences in course syllabi that may matter as part of broader efforts to support student success in the CPE major. We are excited to utilize these findings to initiate department discussions about the choices faculty make in syllabus design, the values that these choices communicate, and how syllabi as value-laden objects can play a role in increasing student success and sense of belonging (or unbelonging) in the major.

Acknowledgments

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