Research Statement

As a Lecturer with Security of Employment, and a tenured professor at Cal Poly, San Luis Obispo before that, Dr. Franklin’s primary mission has been to provide high-quality teaching, facilitate research opportunities, and improve the environment for undergraduates. Her teaching load has always been two courses per quarter, while research faculty teach one course per quarter. In addition, she has always had a higher service requirement than research faculty.

Despite this commitment to undergraduate education, Dr. Franklin has maintained a targeted research program resulting in top-tier publications in two research areas, over $2M in NSF funding as lead PI (a funding rate of 67% - 4 out of 6), and the first CAREER award ever awarded to Cal Poly State University, San Luis Obispo. Selected publications include 3 papers in the International Symposium on Computer Architecture, 2 papers in the International Symposium on Microarchitecture, 3 papers in SIGCSE, contributions to two editions of Hennessy & Patterson’s graduate textbook, and a book, “Practical Guide to Gender Diversity for Computer Science Faculty.”

As recognition for the contributions she has made to undergraduate research for minority students, she was an inaugural recipient of the NCWIT Faculty Mentor Award. Four awards are given nationally, one in each category of junior/senior faculty and doctoral/non-doctoral emphasis. This year’s awardees include Margaret Martonosi of Princeton.

Parallel Microarchitecture – Dr. Franklin’s core architecture research area is parallel microarchitecture, with an emphasis in caching and multi-threading. Her current project aims to reduce redundant execution and data in parallel systems. Parallel systems are being shrunk more and more, scaling down from a large-scale parallel processor to a parallel computer on a single chip. The tighter coupling reduces the communication time between threads and allows for more intricate sharing of compute and memory resources. Unfortunately, legacy code does not take advantage of such couplings (especially multi-execution and MPI programs), and it is preferable to abstract such details away from the programmer. Within an SMT machine, she detected and dynamically compressed redundant parallel execution in her MMT (Minimal Multithreaded Processor), which appeared in Micro 2010[37]. In addition, in collaboration with Dr. Tim Sherwood and LLNL, she compressed memory in on-chip caches and DRAM pages, resulting in an ISCA 2009 publication (among others)[29, 32, 41]. Dr. Franklin’s CAREER award focused on approximate computing, finding opportunities when programs are more tolerant to errors, and exploiting those opportunities to save power[22]. Finally, earlier work, with Dr. Fred Chong on the Synchroscalar project, culminated in an ISCA publication and journal publications.[17, 19, 21, 24] This project exploited the statically-scheduled DSP applications, scaling clock frequencies and voltages both spatially and temporally depending on application needs.
**Future Technologies** – Dr. Franklin has begun recent work on future technologies, specifically memristors and quantum computing. The unique characteristics that these technologies bring to computing provide opportunities to trade off computation and memory storage. In collaboration with Dr. Sherwood, Dr. Dmitri Strukov, and Dr. Chong, Dr. Franklin explored the use of memristors in neural-network-based branch predictors. While this has been touted by some as a promising use of memristors, we found mixed results. The limited write durability made a cache useful to capture many consecutive writes, but making the implementation depend on digital data failed to capture the most useful memristor properties – taking advantage of the analog properties of memristors. With the addition of novel load-balancing techniques, our design was competitive with state-of-the-art predictors, depending on the projections for the area and density of future memristors. This resulted in a best paper award in Computing Frontiers[50]. In the area of quantum computation, Dr. Chong and Dr. Franklin explored the tradeoff between time and space for sequences of quantum operations that are only known at run-time. They optimized the state-of-the-art sequence generation algorithm and developed new algorithms that represented a trade-off between compilation time, run time, and space. They found that new algorithms, with precompiled partial sequences, can be used to generate sequences very quickly (orders of magnitude faster than prior work), and with only a small run-time penalty. This resulted in an ISCA13 publication[53].

**Textbooks** – Dr. Franklin has contributed to two editions of Hennessy & Patterson’s Computer Architecture: A Quantitative Approach. She contributed the case studies for the 1st chapter in the 4th edition[20], and she contributed two chapters of problems for the 5th edition[39, 40].

**Upper Elementary Computer Science Education** - Dr. Franklin’s current primary research focus, begun four years ago, is on computer science education with an emphasis on diversity. Her target in computer science education is at the middle school and upper elementary school level. She is particularly interested in designing curricula that develop both thinking skills and programming skills, with examples that appeal to a diverse population. Therefore, there are two separate goals: create a curriculum that attracts diverse populations, and teach them computational thinking. Because computer science has not been a part of core standards for schools, most schools have not taught it, and most education researchers have not studied it. So, unlike mathematics and science, we have very little research on how students learn computer science. Dr. Franklin’s work fills this void.

Drs. Franklin and Phillip Conrad started with a middle school program targeting females and minorities. Dr. Franklin was the lead PI on an NSF BPC grant which, over three summers, developed and refined a curriculum designed to achieve specific student outcomes. Unlike most similar programs, 90% of the participants were under-represented minorities. Over 50% entered the program with no interest in computer science. When students completed the camp, there was a
significant interest in computer science, and there was no statistical difference between interest of those who had prior interest in computer science and those who didn’t. In addition, our students demonstrated competence in several key computer science concepts, including sequential execution, event-driven programming, and message passing. This work resulted in three SIGCSE publications\[38, 47, 48\].

Dr. Franklin is building upon the BPC work with a new project with Dr. Danielle Harlow in Education. Dr. Franklin is the lead PI on a new NSF CE21 grant to develop a curriculum for 4th-6th grade that combines computational thinking (problem solving techniques useful for working with software) as well as programming. This will be used to observe how students learn computational thinking concepts, not just whether they learn. This research will develop the first comprehensive computer science curriculum that combines thinking skills with programming skills for this age group, and it will be specially designed for diverse audiences.

**Diversity**

Dr. Franklin has recently begun a research program in diversity. In her educational research, tailoring the curriculum to diverse populations is a first-order constraint. The entire camp was designed around themes that we hoped would attract females and Latina/os – animal conservation and Mayan culture. The curriculum was designed based on these themes. The lessons learned from that project are being applied to their more mainstream elementary school curriculum. In addition, they are interviewing students at a wide variety of schools in order to take examples from diverse students’ daily lives for use in our curriculum.

Dr. Franklin’s commitment to diversity goes beyond UCSB. She goes to the NCWIT (National Consortium for Women in Technology) Summit as the UCSB representative to the Academic Alliance. Here, the latest sociology, psychology, and education research that relates to gender equity in the field are presented. Through these talks and additional research, Dr. Franklin has published a book: “The Practical Guide to Gender Equity for CS Faculty”\[49\].

Finally, Dr. Franklin has begun a research project with Dr. Karen Myers exploring the messages females receive about different fields, and whether their belief in a growth mindset versus a fixed mindset is correlated with what career they choose.

**Funding**

Dr. Franklin has a phenomenal NSF funding success rate of 67%. Cal Poly, SLO does not have Ph.D. students, and advising graduate students is not her primary mission at UCSB. Despite this, she has been the lead PI on over $2M in funding. Specifically:

- **2012**: PI for NSF CE21: DEPICT: Developing Elementary (Learning) Progressions to Integrate Computational Thinking. Dr. Franklin’s most competitive grant is her latest – the $600K CE21 educational research grant awarded to her and Dr. Danielle Harlow last fall. This was one of only three awarded in the CER track in 2012.
• 2010: NSF BPC: Animal Tlatoque: A Synergy between Mesoamerican Cultural History and Endangered Species to attract and retain Latina/os and Females in Computer Science. This was UCSB’s third attempt at the grant, but Dr. Franklin’s first as lead PI. Dr. Franklin teamed up with Dr. Phill Conrad and Dr. Gerardo Aldana to create an interdisciplinary summer camp to attract and educate students in elementary computer science concepts.

• 2007: Dr. Franklin’s NSF CAREER award was the first awarded to Cal Poly, San Luis Obispo. It explored the possibilities in exploiting error tolerance in applications.

• 2006: NSF MRI: Awarded to provide parallel computing facilities to Cal Poly, SLO researchers and educators.

• 2003: Co-PI (subcontract) for NSF-ITR, Synchroscalar: Exploiting synchronized clock domains for energy-efficient multicore embedded systems.