That Classroom “Magic:” What are the characteristics of an effective pre-college teaching practice for broadening participation in computing and how do we know?

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Introduction: That Classroom “Magic”
What creates that classroom magic when all students awaken, including the most disengaged and discouraged, and start actively participating with, creatively and critically engaging with the subject at hand? Specifically, what does this look like in a computer science classroom, a subject that has a long and deep history of only engaging a very narrow strata of our student population, with others off on the margins? What about this “magic” is most effective for broadening participation in computing?

While an engaged classroom may feel “magical,” it really is not. Rather, it is the result of effective and powerful teaching. How can this “magic” be articulated, defined and “quantified”? As more and more initiatives are being launched around computing education and committed to broadening participation in computing, we propose the following research question:

What characteristics of high school CS teaching practices are most effective for broadening engagement and participation in computing for students traditionally underrepresented in the field?

We have conducted research on effective teaching practices within one context---Los Angeles Unified School District (LAUSD) ---a context which has its own particular history and development. As Exploring Computer Science (ECS) and CS Principles (CSP) expands nationwide, we believe that it is important for research to be gathered on this question in other ECS and CSP classrooms. This has important implications for the CS10K campaign and our ability to articulate and define effective teaching practices, especially those practices that particularly support our mutual mission for broadening participation in computing. How do we characterize these practices? And, how do we know that they are effective?

Current and Prior Research
Educational researcher and scholar, Linda Darling-Hammond (2008), in a review of what is known about effective teaching practice, notes that studies across multiple disciplines find these following facets of teaching important for meaningful learning:

- Creating ambitious and meaningful tasks that reflect how knowledge is used in the field;
Engaging students in active learning, so that they apply and test what they know;
Drawing connections to students' prior knowledge and experiences;
Diagnosing student understanding in order to scaffold the learning process step by step;
Assessing student learning continuously and adapting teaching to student needs;
Providing clear standards, constant feedback, and opportunities for work;
Encouraging strategic and metacognitive thinking, so that students can learn to evaluate and guide their own teaching [1, p.5]

Darling-Hammond and colleagues point out that connecting these principles with particular teaching strategies differs depending on a sophisticated understanding of the content, the learner, and the goals of instruction [2]. Pedagogical content knowledge is a term offered to capture the particular pedagogical techniques that are appropriate for designing meaningful tasks, addressing common misconceptions, and engaging in ongoing, formative assessment of student learning within a particular discipline [3]. For our ECS PD model, we have taken this body of knowledge and applied it to CS content learning with our mission of reaching traditionally underrepresented students.

Teachers must also be able to build on students' personal interests and knowledge in the CS classroom and also must be willing to challenge both their own and students' belief systems about who can excel with computers and technology. It is not uncommon for students and teachers alike to enter a computer science classroom with stereotypical notions about who will enjoy and/or do well in the course. The ECS curriculum encourages teachers to challenge these stereotypes and deficit thinking while deconstructing the preparatory privilege impacting opportunities to learn computer science. This goes hand-in-hand with making computer science accessible to diverse learners by building on students' cultural and social capital in the classroom. Research on science learning for traditionally underrepresented students shows how engagement is facilitated and learning is deepened when the practices of the field are recreated in “locally meaningful ways” and the field is presented in a way that “allows youth to express who they are and want to be in ways that meaningfully blends their social worlds with the world of science” [4, pp. 225-6]. Additional research is needed to investigate how this applies for CS as well.

**ECS Current Research**
For the last few years we have conducted research on ECS teaching practices in the classroom and the implications for broadening participation. In 2011-12, in nine ECS LAUSD classroom, we administered pre- and post-course student and teacher surveys, as well as conducted one year of intensive weekly classroom observations. We have also collaborated on creating and field testing new SRI International student learning assessment measures for ECS.
Our guiding research question during our LA classroom observation study was: What do we know about teacher practices in ECS classrooms? From this research, we learned how curriculum is more than “notes on a page” and it is the instructional practices that really make the learning successful or not. The three facets of teaching practice that we have identified to be important for effective ECS teaching resulting are:

- CS content knowledge
- Inquiry-based pedagogy
- Equitable instructional practices

We refer to these as the three pillars of ECS, but really they are interweaving strands, because none of these three stands alone. Instead they are woven together, inseparable every step of the way. And, it is these three practices that we identify as creating active, collaborative, creative, exploratory, problem-solving learning environments, all important for broadening participation in computing.

Further, as we discuss in our paper Beyond Access: Broadening Participation in High School Computer Science, we have shown that “broadening participation goes beyond issues of access to computer science (CS) learning; we also must transform CS classroom culture and teaching in ways that engage and deep how diverse students learn” [6]. Our research has supported other educational research studies about increasing participation of traditionally underrepresented students [12], and in our own research we have seen how important equitable teaching strategies are for the classroom environment [6] [7] [8] [9] [10] [11].

Finally, in addition to more qualitative descriptors, it is critical to demonstrate that ultimately, student participation data must match local student populations demographics to assure that efforts are truly broadening participation in computing and not just “increasing” opportunities for historically represented students. In LAUSD, enrollment data reveals that the 2000 ECS students each year are closely correlated to the ethnic compositions of the district’s student body population. In 2012-13, 75% of ECS students were Latino (72% of district population), 10% of ECS students were African American (10% of district population), 9% of ECS students were Asian (6% of district population), and 5% were White (10% of school population). Girls represented 45% percent of enrolled ECS students. These basic participation rates by ethnicity and gender serve as critical quantitative indicators for all projects working on broadening participation in computing.

Proposed New Research Questions:
Our research to date has been in a specific context: Exploring Computer Science classrooms in Los Angeles public high schools. As we now conclude our analysis (soon to be released), our research is suggesting a set of new questions that we believe are critically important for our CS education community:
• What teaching practices are effective for broadening participation in computing, and how are our findings from LAUSD ECS classrooms different from or similar to ECS teaching practices across other districts?
• What are the conditions that make these practices similar or different?
• How do these findings apply in different courses (such as CS Principles?)
• How can we measure the importance of specific instructional practices in broadening participation in computing?

Further sub-questions are:
• What is the relationship between teachers’ content backgrounds, their prior teaching experiences, and their effective instructional practices and pedagogy for broadening participation?
• How can we use this information to inform teacher preparation and professional development?

What are the Implications for CS Educational Reform?
Recently, our mission of broadening participation in computing has gained a lot of attention and momentum. As we grow, issues facing the CS10K community are no longer a distant dream. CS teachers and professional development (PD) facilitators are needed and professional development must be instituted. And, all of these elemental needs bring up important research questions: When we recruit teachers to teach computer science, what are the qualities we hope to recruit? How important is content and pedagogical knowledge? Likewise, these findings have large implications for PD planning. What should be the focus of the PD? What knowledge and skill sets are needed for facilitators? How do we best support a teacher corps strong in the most effective practices for broadening participation in computing?

Further, as CS policy initiatives around computing in the core and CS teacher certification garner more attention, our research in the classrooms is needed to create an informed decision on programs of courses for a CS certification. What knowledge is considered fundamental? How can we assure that pedagogical instruction is part of CS certification and how is that defined?

What are the larger implications for STEM?
As we all know, our country is experiencing a crisis in education and a shortage of CS professionals. The crisis in CS education maps onto much of the education crisis in many facets of the larger world of education, particularly the fields of math and science and engineering. Debates over what makes effective teaching, how to measure it, how to assess student learning, how to eliminate the achievement gap all sit at the center of our research agenda for computer science. Our work of democratizing computer science knowledge addresses the entire array of factors that deny a quality education to too many of our nation's students.
The most important "broader implications" for our work are for democratizing knowledge critical for 21st century citizens. We believe that making this subject accessible for all students, especially those who have been traditionally underrepresented in the field, can have significant consequences in terms of students’ current and future learning across multiple domains. This is true as all professions and fields are now being transformed by computer science. For students who have this knowledge, more doors of opportunity will be open to them. And, the world desperately needs diverse perspectives to be voiced and at the design tables.

References


