Session Title:
Teaching Computational Thinking through Mobilize and the New Big Data Explosion

MSP Project Name:
MOBILIZE: Mobilizing for Innovative Computer Science Teaching and Learning

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Project Session

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Summary:
At the outset of Mobilize, "Big Data" had not yet exploded into the public realm. The new Mathematics Common Core and Next Generation Science Standards did not exist. We have embraced these developments as a key opportunity to introduce Computational Thinking (CT) through participatory sensing to math and science students and teachers. We have developed 1) an Introduction to Data Science curriculum, and 2) CT lessons for mathematics (Algebra I) and science (Biology) instruction. Both are dependent upon teachers engaging their students critically with data. Our biggest challenge is to develop teacher professional development and support systems that deepen content and pedagogy knowledge for inquiry and equitable teaching of these topics.

Section 1: Questions framing the session:
Today, with the rise of personal communication devices like mobile phones, the data we generate are more personal and more detailed than ever before. Much of our lives exist as, or can be rendered in data. Students need to understand the effects that all this measurement has on what it means to be a citizen, to participate in our democracy, to be human. Far from simply accepting digital technologies, students need critical thinking skills to understand how data and computing shape our view of ourselves, of our social conditions, and our history, and how they frame priorities for the future. Students must have the ability to understand what current data technologies offer and the processes that lead to their creation, to identify the perspectives they promote, and to have the imagination and knowledge to suggest alternatives.

The lessons we have designed hinge on effective equitable and inquiry-based instructional strategies for engaging students in purposeful classroom discussions and critical thinking about data. Therefore, some key questions (and the primary focus of the session) will be:

- How de we engage teachers so that they can effectively engage students more critically and deeply in data science, computational thinking, and its application in math and science?
- What are the most effective models of professional development that can introduce both new content and transformative teaching that is focused on facilitating critical thinking?

How can this type of inquiry-based pedagogy take hold with math and science teachers who have been a product of traditional notions of math and science and who may feel they lack the "content" knowledge to facilitate such inquiry?

Section 2: Conceptual framework:

Mobilize is a targeted National Science Foundation Math Science Partnership. The core partners are: UCLA Graduate School of Education and Information Studies (Center X), the Los Angeles Unified School District (LAUSD), the UCLA Center for Embedded Networked Sensing (CENS), and the Computer Science Teachers Association (CSTA).

Mobilize is committed to assuring access for innovative instruction, especially in schools with high numbers of African Americans and Latino/a students. Mobilize was first introduced in 2011 to core teams of math, science, and computer science teachers from 5 LAUSD schools that strongly represent these populations. Our aim is to have school teams of Exploring Computer Science (ECS), mathematics, life and physical science, as well as social science students and teachers working on Mobilize projects by 2015. As computer science is now an integral part of innovation across all fields, a goal of Mobilize is to strengthen computer science instruction throughout our educational system.

Mobilize sits at the crux of several critical issues: How can we foster innovation and inventiveness, improve STEM education for students and teachers, and increase access to quality and rigorous education for more students? The insights we gain from Mobilize about increasing opportunities for inquiry-based, rigorous learning of computer science and about innovative teacher professional development, especially in large urban school districts, will be critically important across multiple disciplines, communities, and institutions. Mobilize addresses the centrality of information technologies in our students' lives, for whom a critical view of computing will be increasingly important as they enter the work force and engage as members and leaders of multiple communities.

Mobilize is imbued with a philosophy of seeking to transform public schooling to create a more just, equitable, and humane society through inquiry and change as community of teachers, students, parents, community members, elected officials, researchers and others engaged in democratic life. Mobilize builds upon Center X research and practice in understanding that the complexity of teaching requires gathering multiple measures to evaluate the effectiveness of that teaching (e.g., through observations, an array of models for measuring student academic growth, surveys to gather information on student perspectives on quality of teaching, rubrics for classroom artifacts and reflections on practice, teacher portfolios, action research, and effective and impactful teacher professional development). However, this evaluative model is effective only within the larger context of a community of learning.

Now in its third year, Mobilize seeks to create hands-on, inquiry-based, curricular units that employ participatory sensing, data analysis, computational thinking, and teacher professional development for computer science, mathematics, and science high school classes. Mobilize projects bring together STEM and computational thinking with students' sense of civic involvement in their own communities.

Section 3: Explanatory framework:
As we begin Year 3 of the project and reflect upon lessons learned in Years 1 and 2 – primarily through the first deployment of participatory sensing in LAUSD classrooms in spring 2012, and the two Mobilize professional development sessions offered to LAUSD mathematics, science, and computer science teachers in July 2011 and June 2012 - Mobilize remains organized around bringing innovative STEM content to the high school classroom. As described in the original grant, this STEM content blends three elements that are at the heart of our work: (1) participatory sensing, through which one utilizes systematic data collection and interpretation to make a case; (2) computational thinking, the conceptual underpinnings of computer science, as well as many modern scientific disciplines; and (3) general data analysis, which requires skills that are increasingly crucial to develop with the rise of "Big Data." This content is delivered using inquiry-based pedagogy, which is not only well matched to these three fields, but is also an established technique for more equitable teaching environments. Mobilize continues its commitment to bring this unique approach to high school mathematics and science in the context of a deepening collaboration with the nation's second-largest school district, the Los Angeles Unified School district (LAUSD).

Based on the experience of implementation in Year 2, in Years 3-5 we plan to enhance our interventions to take fuller advantage of the underlying technology, fill a much needed curricular and instructional gap in LAUSD based on the new Mathematics Common Core State Standards (CCSS) and forthcoming Next Generation Science Standards (NGSS), and directly address the need for increased content knowledge and pedagogical support for teachers – all while keeping the three key elements of Mobilize central to our work.
Specifically, we are pursuing a refined focus on the design, implementation, content and pedagogy of Mobilize as outlined in the following "Three Pillars" for Year 3 of Mobilize:

1. ***Mobilize in Mathematics and Science***: As stated in the original grant, we will pilot newly designed Mobilize lessons in high school mathematics and science classes in Year 3 (the 2012-13 school year). These lessons will engage with issues of data analysis and the skills of computational thinking, broadening the audience for this material to algebra I and biology students, beyond the realm of computer science curriculum. The mathematics and science classrooms will piloting these curricula in spring 2013. To support ongoing learning, teachers will be attending 5 professional development (PD) sessions throughout the school year to prepare and then reflect on their implementation of the lessons and the impact on student engagement and learning.

2. ***Creation of a New Data Science Course***: In light of the new focus on data analysis in the Mathematics CCSS, and in keeping with the goals of bringing computational thinking, participatory sensing, and data science to core mathematics classes as outlined in the original Mobilize proposal, we have begun the process of designing a new yearlong course focused on data science. The design and implementation of this "Introduction to Data Science" course, which is enthusiastically embraced by our LAUSD partners, will fill a current need for a statistics and probability curriculum in LAUSD and will incorporate the CCSS, crucial new technology, participatory sensing, and critical thinking skills. This course will provide a distinct mathematical track within the LAUSD, allowing students to move from algebra to geometry to our data science course, and hopefully on to AP statistics. Because of our close collaboration with LAUSD, we hope to receive a "C" designation from the UC system, which will allow students to use this course as a mathematics credit when applying to college. The design of this course will be a significant national contribution, and could help make statistics and computational thinking part of the mainstream curriculum.

3. ***Mobilize-ECS Collaboration***: We will continue to support our original cohort of computer science teachers in exploring participatory sensing and data analysis through the 6-week Computing & Data Analysis Unit of the Exploring Computer Science curriculum using smart phone technology. In parallel, the Mobilize team has begun the development of the "Mobilize Prime" curriculum, which will facilitate increased student participation by allowing students to collect data around issues of their own choosing. Mobilize Prime will be developed and piloted in Year 3, implemented in LAUSD in Years 4-5 (in conjunction with strengthened teacher support by the Mobilize team), and distributed nationwide in Year 4.

These "3 Pillars" are the key components of our revised Year 3 plan. The creation of the Introduction to Data Science course and Mobilize Prime represent new additions to Mobilize, and have been conceived in response to critical lessons learned in Years 1-2 in the context of "Big Data" and its explosion into the public realm over the past two years.

Significantly, in Year 3 we remain on course toward our goals of A) bringing computational thinking and participatory sensing to mathematics and science teachers; B) providing ongoing support for our original cohort of computer science teachers; and C) expanding computer science teachers' exploration of data science through Mobilize Prime beginning in Years 3 and 4.

All of our work in Year 3 will be framed by a strengthening of the foundation of teacher instructional practices through a deeper focus in content and pedagogy.

Section 4: Discussion:
As described above, based on findings in Years 1 and 2, in Year 3 we are developing two new curricular strands in mathematics and science:

1. Mobilize Introduction to Data Science Course (IDS)

The Mobilize IDS course will emphasize the Mathematics Common Core High School Statistics and Probability Standards that involve the study of data science. Data science is a strong link between mathematics/science content learning and computational thinking. By engaging students in an inquiry-based computational statistics curriculum, we hope they will see computers not simply as machines to memorize the use of, but tools that can be used creatively to achieve their goals.

The main goal of the course is to encourage students to think critically about data. This will be accomplished by focusing on the inquiry-rich practices of participatory sensing and Exploratory Data Analysis (EDA), which allow insights to be gleaned through an iterative process of examining data for trends. EDA encourages students to "get their hands dirty" in data immediately, making many plots to get a visceral sense of the data, then moving on to more rigorous analysis. Data will initially be prescribed in the curriculum, with selections made based on assumptions of what will interest students. However, students will quickly learn how to search for and create data on issues they were concerned about, and the remainder of the course will be focused on these data. As with Mobilize, participatory sensing content will be included to provide deeper connection between modes of data collection and lessons around the important act of transforming objects, patterns, relationships, and ideas into computable data. Through participatory sensing, students will learn firsthand about the incompleteness of data as a representation and their use and reuse in framing how we think about the world. The lessons will emphasize creativity, presenting tools for exploration and inference that are open and constructive. We will rely on directly understandable computational tools rather than analytically derived approximations.

This course will develop the tools, techniques and principles for reasoning about the world with data. We will present a process that is iterative and authentically inquiry-based, comparing multiple "views" of one or more data sets. Inevitably, these views are the result of some kind of computation, producing numerical summaries or graphical displays. Their interpretation relies on a special kind of computation, simulation, to describe the uncertainty in each view. This kind of reasoning is exploratory and investigatory, sometimes framed as hypothesis evaluation and sometimes as hypothesis generation. Exploration and investigation with data, then, necessarily depends on computation. Our course will rely on R, an open source statistical computing environment, and a graphical interface R Studio.

2. Mobilize Math and Science and Computational Thinking Lessons

Our Year 3 plan for integrating data and computational thinking into mathematics and science takes the following national and local shifts into account:

- The emergence of Big Data as a way to bring computational thinking and inquiry practices into mathematics and science classrooms.
- The new educational landscape as a result of the Mathematics Common Core State Standards (CCSS) and the forthcoming Next Generation Science Standards (NGSS).

Math and science lessons to engage students in using Big Data to learn mathematical and science concepts have been drafted and will be piloted this spring. Students will have the opportunity to explore the connections between participatory sensing, data and computational thinking through mathematics and science. They will learn to collect data, analyze big, messy and relevant data sets, and come to use these tools to better understand the world around them and make math and science more relevant and alive.

Mobilize makes authentic, strong connections to the new Mathematics CCSS and NGSS. The authors of the standards have realized that the 21st century world requires everyone - not just statisticians - to be able to decipher patterns in data, and to use these patterns to make decisions. Mobilize students will understand the way participatory sensing data - flowing in real time from social media, blogs, traffic sensors, credit cards, and weather stations - impact their lives. Data are collected in real time and used in decisions made by lawmakers, businesses, scientists and the public. Connections to civic issues become real. For instance, through analysis of their own data and available contextual data sets, students will become aware of the obesity epidemic in young people, how where they live may possibly correlate to obesity, and understand food deserts and why they exist. By allowing students to engage directly with these issues, collect data about themselves and their community, and analyze the data themselves, they will be acting as "doers" of science. Instead of absorbing scientific knowledge, they will be generating it themselves through an inquiry-based practice. To generate a range of social questions that can be further explored using the data, students will apply computational thinking constructs such as data format and representation, modes of data collection, and algorithmic analysis.

The "Big Data in Our Lives" mathematics unit – comprising 5 total lessons that will take 2-3 weeks in total - connects to the CCSS by integrating the insights of Big Data into mathematics through Modeling into three high school conceptual categories: Number and Quantities, Algebra, and Functions.

For science, Mobilize integrates the NGSSS in a number of significant ways, but most specifically in relation to the following three key dimensions:

1. Science and Engineering Practices
2. Crosscutting Concepts
3. Disciplinary Core Ideas

In the Science and Engineering Practices dimension, the Mobilize project enhances and supports science instruction, particularly in the Using Mathematics and Computational Thinking practice. The computational thinking constructs that are at the core of the Mobilize project will allow students to authentically engage in this practice by using "…statistical and mathematical techniques and structure data (e.g., displays, tables, graphs) to find regularities, patterns (e.g., fitting mathematical curves to data), and relationships in data." Additionally, Mobilize will integrate and connect the insights of Big Data through Modeling into four Life Science Core Ideas:

- Structure, Function, and Information Processing
- Interdependent Relationships in Ecosystems
- Natural Selection and Evolution
- Inheritance and Variation of Traits

The "Big Data in Our Lives" science unit – comprising 3 lessons over 2-3 weeks total - is currently being drafted, and will be piloted in 4 science classrooms spring 2013, in parallel with the Mobilize mathematics unit.

Section 5: How will you structure this session? What is your plan for participant interaction?

We are taking a somewhat unorthodox approach to this session. We are going to begin with a short participatory lesson on data analysis and critical thinking. Session attendees will be actively involved in this lesson. The content will be reflective of the type of learning that will occur in our two new educational products. After the brief lesson, we will all then reflect on the learning that occurred. Our ultimate goal is to question and wrestle with our initial question: "How de we engage teachers so that they can, in turn, effectively engage their students more critically and deeply in areas around data science, computational thinking, and its application in math and science?