Title: **Computer Supported Collaborative Science (CSCS): AN Instructional Model for Teaching the NGSS**

Program Abstract

Computer Supported Collaborative Science (CSCS) is a 4 year effort to train science teachers to use online collaboration tools (e.g. Google Docs) with their students to support science inquiry. We discuss our professional development methods and the impact on teacher practice and student learning the need for collaboration described in the NGSS.

Proceedings Abstract

Computer Supported Collaborative Science (CSCS) is an ongoing research project designed to train science teachers in how to use online collaboration tools with their students. For the past four years, faculty from the Colleges of Education and Science and Math at Cal State Northridge (CSUN) have worked with pre-service and in-service science teachers on how to use tools such as Google Docs to enable students to share data and ideas online. As more and more schools invest in technology for classroom use, teachers need to learn how to take advantage of these tools. Instead of using technology to have students watch videos or read websites, CSCS teaching methods engage students in hands-on science, pooling data, analysis and interpretation. CSCS provides teachers with techniques to help meet the demands of the Next Generation Science Standards (NGSS) through the use of collaborative inquiry and formative assessment. Online tools support English Language learners and promote science literacy skills by engaging students in writing and giving feedback to their peers.

This paper set will discuss the CSCS pedagogy and teacher professional development methods and subsequent science teaching practices as seen in the findings from the project so far. We present four papers discussing: (a) CSCS pedagogy designed to address the NGSS, (b) how collaboration and data pooling promote student's metacognition, (c) the evolution of the preservice science methods course and (d) the use of clinical teaching experiences for professional development method to help teachers learn both the technology and pedagogy of CSCS. These papers stem from our experiences teachers in the urban schools of North Los Angeles including dozens of pre-service teachers and over 70 in-service science teachers who have participated in CSCS summer workshops. We have collected data on their participation in the workshop as well as their teaching practice back in the classroom. The analysis of this data has led us to explore new professional development methods from clinical teaching to MOOCs.

Proposal

Both the Common Core State Standards (CCSS) and the Next Generation Science Standards (NGSS) place substantially more emphasis on science process skills and scientific explanations than exist in the current state standards. Many teachers are not yet ready for this shift. Less experienced teachers tend to rely on didactic techniques such as reading textbooks rather than experiential learning or inquiry instruction that promote higher order thinking skills (e.g., Newton, 2002). Both in-service and pre-service teachers will need to develop new teaching skills to meet the demands of NGSS. At the same time, technology is slowly becoming available in classrooms but instruction lags even this slow adoption. We surveyed local teachers and found almost a third (31%) have reliable access to computers for the students. But of those teachers, less than half (44%) actually use the computers at least once a week. Instead we hear of laptops collecting dust in closets. Technology can support the changes in teaching that we need, but teachers need support to make this a reality in the classroom.

Computer Supported Collaborative Science (CSCS) is an ongoing research project to train science teachers in how to use online collaboration tools with their students to support inquiry and meet the demands of the NGSS. For the past four years faculty from the California State University Northridge (CSUN) College of Education and College of Math and Science have collaborated on an effort to improve science instruction through the use of online collaboration tools such as Google Docs in science classrooms. Collaboration tools enable students to share data and ideas online and get feedback on their thinking (Herr & Rivas, 2009). As more and more schools invest in technology for classroom use, teachers need to learn how to take advantage of these tools. Instead of using technology to have students watch videos or read websites, CSCS teaching methods engage students in hands-on science, pooling data, analysis and interpretation. CSCS provides teachers with techniques for formative assessment in the classroom and give students a better understanding of scientific research and how scientists collaborate and share results. Online tools also support English Language learners and science literacy skills by engaging students in writing and giving feedback to their peers.

This paper set will discuss the CSCS pedagogy and teacher professional development methods and subsequent science teaching practices as seen in the findings from the project so far. We present four papers discussing: (a) CSCS pedagogy designed to address the NGSS, (b) how collaboration and data pooling promote student's metacognition, (c) the evolution of the preservice science methods course and (d) the use of clinical teaching experiences for professional development method to help teachers learn both the technology and pedagogy of CSCS. These papers are born of our experiences with science teachers in the urban schools of North Los Angeles. Our pre-service science teacher preparation has adopted this approach and produced dozens of young teachers

ready to utilize CSCS in the classroom. Additionally over seventy in-service science teachers have participated in CSCS summer workshops over the past four years. We have collected data on their participation in the workshop as well as their teaching practice back in the classroom. The analysis of this data has led us to explore new professional development methods including clinical teaching.

The Pedagogy of Collaboration: NGSS and the Connected Classroom
Brian Foley & John M. Reveles

The Next Generation Science Standards (NGSS) provide an opportunity to make significant changes in how we teach science including bringing instructional methods into the 21st Century. Computer Supported Collaborative Science (CSCS) is an instructional model that utilizes a collection of technology teaching tools that directly address these NGSS goals. This paper provides the conceptual basis for the pedagogical approach underlying CSCS and discusses the ways that this instructional model directly addresses the NGSS in the classroom. The core idea of CSCS is to utilize the connectivity of the internet to enable students to share information and collaborate with students in their classroom and beyond. Collaborative documents like Google Spreadsheet allow students to simultaneously answer questions and give ideas creating new forms of collaboration. We utilize these tools to create a student-centered science class that engages students in inquiry and the eight Science & Engineering Practices identified by the NGSS. We use the practices as a structure for describing the pedagogy of collaboration.

1. Asking questions (for science) and defining problems (for engineering)
Collaborative documents allow students to submit ideas questions to the group to get feedback and to allow the group to reach consensus on research procedures.
2. Developing and using models
Online documents allow students to articulate models via writing, drawing and diagraming. Because documents are stored in the cloud, students can link models to the data collected from experiments to see how well their models match.
3. Planning and carrying out investigations
Like questions, research procedures can be constructed collaboratively, allowing the teacher to engage students is designing research while still ensuring they develop effective plans. Data can be entered online and pooled with other students to create more powerful data sets and allow students to compare data with others (see d'Alessio, Lundquist & Reveles ibid).
4. Analyzing and interpreting data
Data entered online can be easily shared or pooled with other students and the teacher to help scaffold the analysis.
5. Using mathematics and computational thinking
Spreadsheets with graphs or scatter plots allow students to explore data in different ways and create images to illustrate their findings.
6. Constructing explanations (for science) and designing solutions (for engineering)

Results bring together data and analysis (including visualizations) and are easily shared and compared to help the class reach consensus.

7. Engaging in argument from evidence

8. Obtaining, evaluating, and communicating information

Ways that CSCS Engages Students in N GSS Practices

The CSCS model provides a pedagogical approach that draws upon collaborative teaching tools for engaging students in the scientific and engineering practices that are linked to the NGSS by facilitating student development of such practices. For example—using CSCS pedagogy—a teacher can solicit research questions surrounding a particular scientific phenomenon being investigated. Students then enter their own research questions into a blog and simultaneously see the ideas of their classmates. Afterwards, the teacher highlights specific questions and illustrates how they may be refined into researchable questions. Next, students are required to post suggestions for their peers. Throughout this iterative process, students learn to ask scientifically researchable questions by seeing numerous examples edited and refined in the collaborative environment of the blog. In this way, CSCS supports students developing metacognitive skills by utilizing near-instantaneous peer feedback during every part of the inquiry process. Moreover, CSCS pedagogy provides tools for teachers to assess student thinking to identify misconceptions and check understanding. It does so by providing immediate identification of student misconceptions by pooling whole-group data sets into a classroom corpus of data. Thus, students are able to see where they might be off the mark in their analysis during the actual investigative process itself instead of after the fact. This type of immediate misconception identification "in vivo" allows for real-time student cognitive correction before the misconception is able to become deeply ingrained into student thinking. Thus, creating opportunities for students to engage in the enterprise of science in ways that are more akin to those that actual practicing scientists do within their respective science disciplines.

If science teachers at all levels are going to be expected to engage their students in the Next Generation Science Standards (NGSS), it then becomes necessary to provide them with the tools needed to facilitate the engagement of authentic science learning. CSCS provides a pedagogical model that does so by creating a culture of collaboration in today's connected classrooms.

A Case Study of how CSCS has Transformed Instructional Practices

Norman Herr and Marty Tippens

This paper presents a case study analysis regarding the evolution of teaching practices of two instructors (professors at California State University, Northridge and Woodbury University). Each of these instructors has gradually adopted a teaching approach that utilizes the principles of Computer Supported Collaborative Science (CSCS) in order to deliver science and math content to their students.

The investigation uses a case study approach to document the changing practices as they have occurred over time from a teaching pedagogy dominated by lecture-based instruction to a collaborative whole-class approach that engages all learners in the collection, analysis, and interpretation of individual data in the context of whole-class data. Class sessions have been recorded using Elluminate/Collaborate, and student contributions have been recorded using collaborative online documents. An analysis of these artifacts indicates an increasing involvement of students in asking questions and defining problems. In addition, the professors spend significantly more time guiding students in the analysis and interpretation of data and encouraging them to construct explanations from evidence. Records indicate a significant change in teaching style, away from pre-digested explanations towards argument from evidence. This study documents how classroom activities model the science and engineering practices specified in Dimension-1 of the Next Generation Science Standards (NGSS).

Using Computer Supported Collaborative Science CSCS: The Impact on Teacher Practice and Student Metacognition
Matthew A. d'Alessio, Loraine Lundquist, and John M. Reveles

This paper presents a theoretical perspective on the impact of a Computer Supported Collaborative Science (CSCS) teaching methodology on teachers' teaching practices and students' metacognitive functioning. We focus our theoretical argument on the notion that the use of a CSCS teaching method provides teachers with the opportunity to change their current science teaching practices to engage students in 21st century skills by using collaborative tools to promote student metacognition. The paper provides a conceptual basis for understanding how CSCS is utilized by drawing on data collected during university course instruction. Our theoretical supposition uses data excerpts—drawn from university instruction—showing how the public comparison of student artifacts (ideas or data) provides a forum that encourages metacognition. Specifically, these data support our theoretical position by exemplifying two related ways that CSCS supports student metacognition. First, utilizing a CSCS teaching approach supports student metacognition by allowing students to see the difference between their own scientific thinking (individually) and the thinking of the rest of their collaborators (collective). Second, using a CSCS teaching approach supports student metacognition during science investigations by allowing students to identify patterns and outliers in data in real-time instead of after the fact.

Seeing the Difference Between Individual and Collective Cognition
Research about the differences between novice and expert thinking in a given field indicates that experts constantly monitor and evaluate their progress, a category of metacognition. Experts maintain a vast library of background knowledge and cognitive models that they use as a basis for comparison for new information, but novices lack this library. Without such a basis for

comparison, novices are less able to engage in meaningful "self-checking." While it is not possible to instantly impart an expert's vast background knowledge on a novice, CSCS methods of instruction provide a comparison by making an entire classroom's ideas public. A student can therefore see his or her ideas beside the ideas of peers and the comparison automatically prompts students to self-check. Unlike revealing a correct answer after students submit responses (allowing the student to passively accept the correct response without evaluation), students must contemplate which elements of their classmates' answers are valuable.

Identifying Real-Time Patterns and Outliers
The theoretical position taken in this paper posits the notion that using a CSCS teaching approach can help science teachers support student metacognition during science investigations by allowing students to identify patterns and outliers in data in real-time. Many novice students have no experience at distinguishing high quality, precise data from inaccurate, "bad" data. Researchers in geoscience education have shown that training novices to recognize complex patterns in visual data (such as quantitative graphs) works best when students are simultaneously shown an example of the pattern and a related counter-example that does not match the pattern (Ormand et al., 2009). The comparison calibrates the novice into all the nuances of the pattern. CSCS accomplishes this goal by showing students their own (individual) data in the context of everybody else's (collective) data in the class. Outliers with errors in data or calculation are much easier to spot when seen in comparison with collective data ranging from low level poor quality data or calculations high quality data and/or calculations. Repeated exposure to this process over time (e.g., during several weeks, over the course of a semester, or across an entire school year) helps students develop the internal mental models needed to ask and answer the fundamental question, "Do these data look reasonable?" We provide examples from our classrooms showing how students spontaneously self-monitor their data, notice errors, and fix them when they see their data beside other students' data.

Our thesis in this paper is that the Computer Supported Collaborative Science (CSCS) teaching method provides teachers with 21st century teaching tools necessary to engage students in individual and collective metacognitive thinking.

Clinical Teaching as In-Service Professional Development for CSCS
Kelly Castillo & Virginia O Vandergon

This study follows a cohort of in-service secondary science teachers as they participate in a summer professional development program based on the Responsive Teaching Cycle (RTC) intended to promote the use of Computer Supported Collaborative Science (CSCS). As opposed to traditional professional development, which is typically delivered in the form of a workshop, the RTC model consists of clinical teaching followed by collaborative daily reflection (Cheng, 2010). Clinical teaching, a model typically utilized during the student teaching experience, also has implications as a professional development tool for in-service teachers. When introducing a

specific pedagogy, clinical teaching provides teachers with the structured hands-on experience, as well as the support and guidance to practice implementation before bringing the pedagogy back to their school year classrooms (Grossman, 2010). Additionally, the collaborative planning time built into the model allows teachers to develop and foster Professional Learning Communities (PLCs), support structures intended to further aid participants in implementation (Musanti & Pence, 2010; Richmond & Manokore, 2011).

Preliminary findings from the first year of implementation suggest that the RTC model leads to increased teacher confidence when implementing CSCS in the summer classes as well as a greater understanding of the pedagogical benefits of the CSCS model (Foley, Castillo, & Kelly, 2013). Additionally, teachers report that the RTC model has been helpful in assisting in their understanding of the various CSCS tools. Following the first summer, almost all (7/8) teachers reported that they were "Highly Satisfied" with the collaborative planning aspect of program and all teachers were either "Confident" or "Highly Confident" that they would be able to successfully implement CSCS during the coming school year. Continued research will investigate the impact of this form of professional development, now in its second year, on both new and returning teachers as well as investigate the impact of the program on school year implementation of CSCS.

Conclusion
We see this as a time of dramatic changes in science education. Not only new standards, but new tools as well. The Los Angeles Unified School District just announced plans to provide tablets to all students in the district - in part to meet the needs of Common Core assessments. Other districts will likely follow suit. These changes provide an opportunity to shift the way science is taught. The findings from the CSCS project show how to combine technology and pedagogy to help teachers meet the challenges of the new era. Science teacher educators can learn about the challenges of this approach and how we have adapted to meet them. At previous ASTE meetings we have conducted workshops on CSCS techniques. This paper set provides a chance to describe the methodology and findings in more detail.

References:

Cheng, I. (2010, May). Using collaborative inquiry with student teachers to support teacher professional development. Paper presented at the American Educational Research Association Annual Meeting, Denver, Colorado

Foley, B., Castillo, K. & Kelly, K. (April 27, 2013) Clinical Teaching as Professional Development for Educational Technology: Thrown Into the Digital Deep End. Paper

presented at the American Educational Research Association Meeting 2013, San Francisco, CA

Grossman, P. (2010). Learning to Practice: The Design of Clinical Experience in Teacher Preparation. National Education Association Policy Brief. May 2010. Retrieved online http://www.nea.org/assets/docs/Clinical_Experience_-_Pam_Grossman.pdf

Herr, N. & Rivas M. (2010) The use of collaborative web-based documents and websites to build scientific research communities in science classrooms. Proceedings of the AERA 2013 Digital Deep End 8th Annual Hawaii International Conference on Education, January 7-10, Honolulu, Hawaii.

Musanti, S. I., & Pence, L. (2010). Collaboration and teacher development: Unpacking resistance, constructing knowledge, and navigating identities. Teacher Education Quarterly, 37(1), 73-89.

Ormand,C. J., Gentner, D., Jee, B., Shipley, T. F., Tikoff, B., Uttal,D. and Manduca, C. (2009) Finding Fault: Laboratory Experiments and Classroom Studies on Identifying Faults in Images, *Geol. Soc. Amer. Abstr. Prog.* 41, 196 .

Richmond, G., & Manokore,V. (2011). Identifying elements critical for functional and sustainable professional learning communities. Science Education, 95(3), 543-570.