AC 2011-2751: TEACHER TRAINING AND STEM STUDENT OUTCOME: LINKING TEACHER INTERVENTION TO STUDENTS' SUCCESS IN STEM MIDDLE AND HIGH SCHOOL CLASSES

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Abstract

Engineers and scientist utilize the principles and theories of science and mathematics to design, test, and manufacture products that are important to the future of a nation's citizenry. With the exception of biological sciences, however, the percentage of college students seeking degrees in math, science and engineering disciplines has been declining for the past two decades. Furthermore, fewer potential engineering majors are completing rigorous college preparatory programs and graduating in the top quarter of their high schools. This shortfall has raised concerns among leaders in science, technology, engineering, mathematics, (STEM) fields.

To meet the changing demands of the nation's science and engineering labor force, recognition of the importance of pre-college education intervention and implementation of challenging curricula that captures and sustains middle and high school students' achievement and interest in science and "pre-engineering" content is critical.

Current research reveals that one of the most important determinants of what students learn is the expertise and pedagogy of the teacher. Accordingly, our research is focused on improving teacher quality and resulting middle and high school student learning in STEM via formation, nurturance and sustaining an important targeted school-university urban educational partnership. Our university has partnered with large urban school districts to plan, deliver and sustain a targeted inservice teacher professional development and a middle and high school STEM curriculum intervention. The partnership goals are to assist inservice middle and high school science teachers in: (1) designing and implementing integrated science and engineering curricula and (2) development of instructional methods and strategies that enable teachers to effectively (a) teach challenging content and research skills in middle and high school as demanded by state/national science standards; (b) generate knowledge and transform practice in high school STEM education, (c) cultivate a world-class STEM workforce, (d) expand students' scientific literacy, and (e) promote research that advances the frontiers of knowledge in STEM middle and high school education.

Introduction

Engineers and scientist utilize the principles and theories of science and mathematics to design, test, and manufacture products that are important to the future of a nation's citizenry. With the exception of biological sciences, however, the percentage of college students seeking degrees in math, science and engineering disciplines has been declining for the past two decades. Furthermore, fewer potential engineering majors are completing rigorous college preparatory programs and graduating in the top quarter of their high schools. This shortfall has raised concerns among leaders in STEM fields. To meet the changing demands of the nation's science and engineering labor force, recognition of the importance of pre-college education intervention and implementation of challenging curricula that captures and sustains middle and high school students' achievement and interest in science and "pre-engineering" is critical.

Current research reveals that one of the most important determinants of what students learn is the expertise and pedagogical approach of their teacher. Accordingly, our research is focused on improving teacher quality and resulting middle and high school student learning in STEM via formation, nurturance and sustaining an important targeted school-university urban educational partnership. Our university has partnered with a large urban school district to plan, deliver and sustain a targeted inservice teacher professional development and a middle and high school STEM curriculum intervention.

Teacher Intervention

Through our university partnership with local urban public middle and high schools, we engaged in a targeted recruitment of mid career teachers in the sciences. The project's leadership team has worked with teams of two teachers who were placed, based on research interest, in an engineering laboratory that is conducting research using societally relevant engineering technologies. The teacher intervention was intense in that it included a five week program of lab experience and pedagogical practices. Accordingly, due to the nature and intensity of the teacher intervention and follow-up with their students a small group of teachers was targeted for this intervention. Organizationally, each two-teacher teams were matched with a Ph.D. student in university engineering laboratory, for direct daily interaction, and for facilitating bi-directional expertise transfer between the teachers and the Ph.D. student mentors.

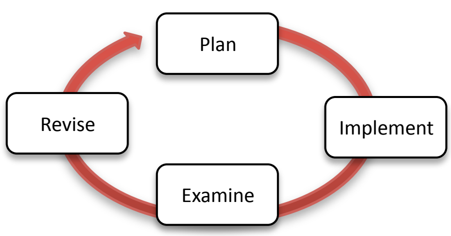


Figure 1: Lesson Study Cycle

To facilitate this teacher-lab matching process, the teachers participating in the program were sent pointers to web sites summarizing the participating research projects one month before the start of the program. The 5-week summer program commenced with a 2-day teacher orientation. Besides working together in the labs, the teachers and Ph.D. students mentors met weekly to review, network, compare experiences, address issues, and to engage in collaborative lesson study and curriculum planning. Weekly time was allotted for helping the teachers to develop best practice pedagogy towards teaching science in their respective schools, under the supervision of a curriculum team from the University's school of education. The teachers had weekly meetings for planning how their research experiences was translated into curriculum modules which introduce their students to societally relevant engineering and relate lesson plans and activities to state and national science and math standards using a lesson study approach. *Lesson study*, according to James Stigler (2005), refers to a professional development process whereby teachers closely examine their lessons with a focus on addressing student need via data-driven decision making, creating powerful and relevant curricula and reformed designed lesson creation. Lesson study goes beyond collaboration to co-planning and observing actual lessons with a focus on student thinking. In the lesson study model, teachers learn together. Participants plan, observe, and refine "research lessons" designed to make real their long-term goals for student learning and development. A key, concrete component of lesson study is the observing and teaching of lessons, which are improved collaboratively. This compels teachers to examine their own practice in depth in the context of student learning, connects them with their students and their professional community, and inspires them to improve continually. This model of *teacher professional development* has been applied widely and successfully in Japan and has recently been initiated by teachers at many sites across the U.S. For the purpose of the summer experience, participant teachers "studied" videotaped lesson exemplars using the lesson study cycle. Figure 1 illustrates the lesson study cycle (Stigler, 2006).

Two major lesson structures were utilized for the curriculum planning, pedagogical practice, and lesson study. These are the *learning cycles approach* and *inquiry based learning*, both approaches that are powerful pedagogical structures in teaching (Stigler, 2006). Anderson and Krathwohl's (2001) learning taxonomy was used to guide instructional objective creation and pedagogy development. The teachers also utilized principles from Bransford's (1999) *How People Learn* to develop scientific curricula that are theoretically aligned to learning principles. As a follow-up structure, the team developed and permanently maintains a *comprehensive web portal* where participating teachers engage in "virtual" lesson study and post their research activities, summaries of their experiences, and implementation plans for translation to the middle and high school classroom. The web portal includes instructional materials where K-12 teachers nation-wide can engage in interaction related to the research that the teachers participated in directly during their summer experience. Continued lesson study occurred via this web portal as teacher participants were required to "attend" on line at least four times monthly to discuss their school site lesson study. In the fall and spring follow-up, the teachers videotaped their own lessons using the research knowledge they have gained and implement the lesson study cycle virtually via the web portal interface with fellow teachers and the research team. Additionally, teachers met for a face-to-face after school seminar to further discuss curriculum implementation and to engage in additional lesson study. This follow-up structure was designed to create a sustained community of practice with participant teachers (Wenger, 1999).

Instrumentation

In an effort to measure the success and challenges of this teacher training effort, we wanted to measure both student and teacher performance that may result from an intensive professional development effort. Four assessment metrics were used to judge the success of this intensive teacher training project (two teacher and two student):

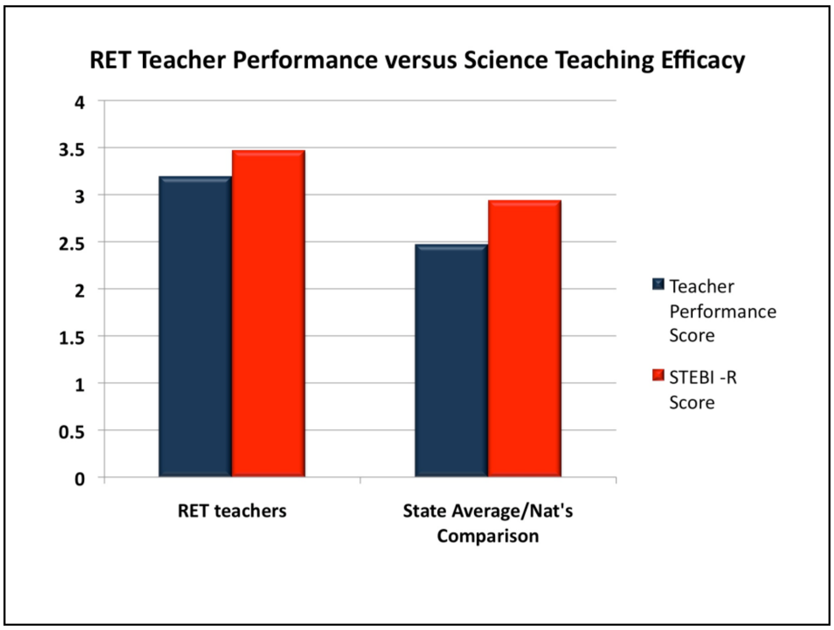
Teacher Metrics:

- Teacher Instructional Performance Metric: A rubric scored observational assessment of science teacher instructional performance aligned to California's teacher performance assessment entitled Performance Assessment of California's Teachers (PACT).
- Science Teaching Efficacy Beliefs Instrument Revised (STEBI-R): This instrument is a teacher metric and is a measure that assesses the teacher's efficacy in teaching science to middle school and high schoolers. It includes personal science teaching efficacy and science teaching outcome expectation, delivered post-test to all teacher participants and compared to non-participant science teachers that match the participant teachers demographically.

The STEBI-R measures teacher personal and professional teaching efficacy in science. Using three years of efficacy data, we compared the science teaching efficacy of the participants to demographically matched non-participants at the school sites of the participants and to other national studies using z score adjusted data for multi-measure comparative accuracy. Mean scores were compared to non participant groups (see figure 2 below).

We also compared teacher instructional performance using a standardized teacher observational metric, the PACT, to the STEBI-R results. The PACT is used to measure instructional performance in preservice and inservice teachers across California. Figure 2 illustrates the comparison of the two teacher measures. Descriptive statistical analyses were performed due to the relatively small teacher sample size. The mean score on our teacher performance rating (PACT) for participants after our lesson study focused teacher professional development and associated targeted lab research experience is 3.19. The Statewide average in single subject science PACT rating is 2.47. Our mean STEBI R rating when z scores (adjusted for standardized comparisons) are utilized is 3.47. While we recognize that many factors go in to improving teacher performance, and that without controlled comparison predictions of performance indicators are difficult, however our statistical comparisons to state and national averages reveal promising teacher results.

Additionally, we wanted to measure changes in student performance of the teachers who participated in the project. Specifically, because our research program is designed to intervene on science literacy, we used this metric as a student comparison measure. As such, we designed and validated a qualitative reading measure for science literacy at both the high school and middle school levels. We have tracked one year of science literacy gains in the past year per student. Our results of these intervention relate assessments in science literacy reveal that students had statistically significant increases in vocabulary and reading comprehension specific to science content (mean gain = 1.8 grade points on 9 months – grade range gain is .8 to 2.7).



Discussion, Limitations and Future work

This project has great promise as both a student and teach STEM intervention. We intend to increase sample size and look at additional student and teacher variables in the near future. Due to the nature of the teacher intervention it is difficult to include a large sample size in the project each year. Recognizing that teachers receive many interventions and professional trainings, we are not assuming that our teacher intervention "caused" changes in student or teacher performance, however in particular, our comparisons to national results in teacher performance and efficacy indicate that the intervention is a promising practice that extends far beyond typical teacher "workshops."

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