Partnership to Improve Student Achievement in Engineering & Science Education: Lessons Learned in Year 1

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STEVENS Institute of Technology
NJ Math-Science Partnership

- Stevens Institute of Technology
- Montclair State University
- Bank Street College of Education
- Liberty Science Center
- 57 Grade 3-5 teachers in 6 urban school districts in Northern New Jersey
- 555 students of MSP teachers
Challenges & Need

- Technological & scientific literacy for students to compete in the global economy of the 21st century
- Widening gap in math, science, & engineering achievement
- Smaller number students in the STEM pipeline in the U.S. compared to China & India
- Teachers lacking content knowledge in STEM
- Teacher preparation & professional development programs lack in content & coherence
Overarching Goal

- This MSP program was developed to help teachers of Grades 3-5 with little or no science background to gain content knowledge and pedagogy in science & engineering in order to meet the requirements set by the NCLB legislation and to answer the calls of the Rising Above the Gathering Storm report.
Specific Goals

- Improve teachers’ content knowledge in science & engineering
- Improve teachers’ pedagogical knowledge in creating & adopting science inquiry & engineering lessons
- Improve students’ content knowledge in science & engineering (Grades 3-5)
# Focus

<table>
<thead>
<tr>
<th>Year 1:</th>
<th>Life Science</th>
<th>2007-08</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Environmental Science</td>
<td></td>
</tr>
<tr>
<td>Year 2:</td>
<td>Earth Science</td>
<td>2008-09</td>
</tr>
<tr>
<td></td>
<td>Space Science</td>
<td></td>
</tr>
<tr>
<td>Year 3:</td>
<td>Physical Science</td>
<td>2009-10</td>
</tr>
</tbody>
</table>

*Technological literacy throughout*
Program Structure

- Intensive two-week summer institute
- 3 professional development workshops during the school year
- Monthly classroom visits
- Project website and listserv
Summer Institute Content 2007

- Life science lessons with focus on scientific inquiry
- EiE curricula
- CIESE Internet-based real time data and telecollaborative projects
- Faculty presentations, lab tours, workshops & hands-on activities
EiE Modules

- Water, Water, Everywhere: Environmental Engineering
  Designing water filters

- Just Passing Through: Bioengineering
  Designing model membranes

- Best of Bugs: Agricultural Engineering
  Designing hand pollinators
Designing Water Filters
Faculty Presentation in the Environmental Lab
Designing Model Membranes
Teacher Evaluation

- Pre and post tests for treatment and comparison groups (questions taken from NAEP, TIMSS, & MOS)
- Formative assessments for summer institutes (e.g. workshop evaluations, concept maps, etc.)
- Development and implementation of STEM learning module
- Classroom artifacts
Student Evaluation

- Pre and post tests for treatment and comparison groups
- Teacher evaluation of student work
Designing Water Filters
Designing Model Membranes
Results (Teachers)

Impact on Teacher Content Knowledge in Science and Engineering

<table>
<thead>
<tr>
<th>Assessment</th>
<th>N</th>
<th>Minimum Score</th>
<th>Maximum Score</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Test</td>
<td>57</td>
<td>12</td>
<td>24</td>
<td>20.47</td>
<td>2.682</td>
</tr>
<tr>
<td>Post-Test</td>
<td>56</td>
<td>17</td>
<td>25</td>
<td>22.38</td>
<td>1.805</td>
</tr>
</tbody>
</table>

Increase is statistically significant $t(56) = 6.11, p<.001$

The mean score increased by 1.91 points or 7.6 percentage points.
Results (Teachers)

Analysis of Treatment & Comparison Teachers

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Teachers</th>
<th>Mean Pre Test Score</th>
<th>Mean Post Test Score</th>
<th>Mean Score Change Raw Score</th>
<th>Mean Score Change Percentage Points</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>56</td>
<td>20.47</td>
<td>22.38</td>
<td>+1.91</td>
<td>+7.6</td>
<td>.292</td>
</tr>
<tr>
<td>Comparison</td>
<td>33</td>
<td>21.12</td>
<td>21.79</td>
<td>+0.67</td>
<td>+2.7</td>
<td>.330</td>
</tr>
</tbody>
</table>

Difference between the groups is statistically significant $F(1,88) = 5.973, p=.017$

The mean score of the treatment group increased by 7.6 percentage points from pre to post test while the comparison group of teachers gained only 2.7 percentage points on average.
Results (Teachers)

“The inquiry and engineering design process are both eye-openers for me, as far as teaching is concerned.” – Nonpublic School Teacher, Evaluation Report, August 2007.

- Successful transfer of learning from the workshops to the classroom
- Increase in motivation and attitudes toward science and engineering
Results (Students)

Analysis of Student Scores, Composite

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean Score</th>
<th>Mean Score Change</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
<td>Raw Score</td>
</tr>
<tr>
<td>Treatment</td>
<td>555</td>
<td>8.34</td>
<td>11.59</td>
<td>3.25</td>
</tr>
<tr>
<td>Comparison</td>
<td>558</td>
<td>8.39</td>
<td>9.61</td>
<td>1.22</td>
</tr>
</tbody>
</table>

Difference in gains (mean score change) is statistically significant $F(1,1112) = 112.9, p<.001$

Students of teachers in the treatment group had gains more than 2.5 times greater than the students of teachers in the comparison group.
Results (Students)

Analysis of Student Scores, Science

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean Score</th>
<th>Mean Score Change</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
<td>Raw Score</td>
<td>Percentage Points</td>
</tr>
<tr>
<td>Treatment</td>
<td>555</td>
<td>7.11</td>
<td>9.47</td>
<td>2.36</td>
</tr>
<tr>
<td>Comparison</td>
<td>558</td>
<td>7.11</td>
<td>8.11</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Difference in gains (mean score change) is statistically significant $F(1,1112) = 72.80, p<.001$

Students of teachers in the treatment group had science achievement gains almost 2 times greater than the students of teachers in the comparison group.
Lessons Learned in Year 1

- Intensive & ongoing teacher professional development programs & classroom support are needed to foster teacher’s content knowledge.

- Professional development based on collaborative effort, multiple levels of instruction, & different levels of discourse are needed to connect theory into practice.

- More work is needed to foster positive change in content knowledge & attitudes towards science & engineering.
Year 2 Overview

- Earth & Space (Science & Engineering)
- Model-based Inquiry Focus
- Teacher’s notion of inquiry
- Classroom observation protocol- to monitor classroom practices
Naive Model

We believe in that volcano cost near
question.

Revised Model 1

Rocks move side by side.

some rocks
over lapped.

Revised Model 2

Some make too
Plates

Revised Model 3

Plates to the coat over in opposi
tsometimes earthquakes happen in key.
1. When a tree crashes together it causes an earthquake.

2. Rocks crash into each other, the ground shakes, and makes a sound. It causes oil and mud to ooze. All the doors and windows fall down.

3. When a earthquake begins, the waves go up and make it go far.

4. Strike the street then it causes a man to die because an earthquake. It is a big earthquake. Mud and dirt fall like a tornado. A house falls down.

5. The Earth is sinking in water. And when a car is sinking, it makes a boat in the water.
For More Information

www.stevens.edu/ciese/pisa

www.stevens.edu/ciese/eofnj

Overview

A partnership of 59 teachers from 24 schools from the districts of Bayonne, Hoboken, Jersey City, Newark, Pleasantville, Weehawken, and two non-public schools, together with Stevens Institute of Technology, Montclair State University, and Liberty Science Center, will provide teams of teachers with deeper science content knowledge, research-based professional development, and experience with innovative science and engineering curricula and materials for Grades 3-5. The Boston Museum of Science’s National Center for Technological Literacy and Bank Street College of Education are also partners in this collaboration. Teachers participate in a dynamic and online learning community designed to address topics in key content areas in Grades 3-5 science, engineering, and technology education. Year 1 activities will focus on New Jersey Core Curriculum Content Standards 5.5 and 5.10 (life and environmental sciences) and 5.2 (technology education).

An intensive, two-week summer institute will involve teachers in collaborative learning through engagement in science inquiry, engineering design, foundational learning in core science topics, and the development of a Science Technology Engineering Mathematics Learning Module (STEM Learning Module) that introduces topics in science through inquiry-based activities and use of the engineering design process. Teams will work together on developing the module, including identification of student science learning objectives ( tied to the district science curriculum and the NJCCCS), lesson plans, implementation and classroom management plans, and student assessments.

Three professional development days during the school year and monthly classroom visits will support teachers as they implement content and materials during the school year.

Assessment of student and teacher learning will take place within participating classrooms and in comparison classrooms.