



Minnesota Science Teachers Education Project (MnSTEP) Final Report – 2007-2009

Overview

The Minnesota Science Teachers Education Project (MnSTEP) is a series of rigorous, content-focused, summer science institutes offered regionally throughout Minnesota for K-12 teachers of science. Institutes are provided in the areas of biology, chemistry, physics, earth science and scientific inquiry – addressing the Minnesota Science Standards in each area – with at least one K-5 and one 6-12 institute offered in each of five regions each summer. MnSTEP also includes one-year licensure programs in high school chemistry and physics. The goal is to provide statewide, inclusive, convenient, reliable, high-quality science professional development for teachers. This \$2.3 million Math and Science Partnership grant over three years was the largest MSP award in Minnesota and the largest single grant received by Hamline University.

The project involved one project director (Lee Schmitt), one fulltime project administrator (Shawn Hubert), one independent evaluator (CAREI), 20 MnSTEP partners, 4 advisory groups, 36 different instructors (two per institute), five regional coordinators, a central online registration and marketing system, continual quality control, and a budget that included MnSTA membership, food, materials, stipends, and graduate credit for teachers.

Numbers: MnSTEP totals include providing 47 highly-successful institutes over three summers, serving 919 Minnesota teachers of science, producing 55 licensed physics teachers and 27 new chemistry teachers, 10 teachers earning *Elementary Science Certificates* for completing all five elementary science institutes, 848 inquiry-based science lessons posted on the Science Education Resource Center (SERC) website, between 600 and 960 contact hours of science professional development per summer, averaging 83% capacity over the three summers, and impacting 80,500 Minnesota students.

Institute Design: Most summer institutes were five days long with the exception of the licensure programs PhASE/ChemCAL and the secondary earth science institute (TIMES) which were 10-day programs. All institutes have two instructors with most inviting guest speakers as well. Secondary institutes are taught by an IHE professor paired with a high school master science teacher. For the elementary institutes, a high school master science teacher, or IHE professor, is paired with an elementary science specialist. One facilitator is the content expert, while the other is more responsible for aligning to standards and processing the learning. Content is primary, but this is blended with pedagogical discussions and lesson design. The rule was 80% content, 20% pedagogy.

All institutes use an inquiry-based instructional model. Concepts are introduced through direct interactions with the phenomenon; teachers then develop questions, investigate further, debate, and formulate hypotheses. Instructors are allowed to lecture, but only *after* participants have had evidence-based discussions and formulated questions. Any lecture is required to have discussion breaks every 10 minutes using focus questions. At the end of every lesson cycle, teachers are led in a processing session about what they learned and how it relates to teaching. Journals were provided to every teacher for data collection and reflection. The goal was to provide a completely non-threatening professional environment where, regardless of science background, teachers could engage in scientific inquiry and discussion while constructing a deeper understanding of science concepts.

In this instructional model, answering questions or affirming explanations is not immediate. Teachers construct their own understanding based on their investigations. (Every institute was required to have at least one “research presentation.”) Facilitators reinforce key concepts and correct misconceptions, but the questions come from the participants. By using this instructional model, teachers experience science with the same satisfaction and excitement as their students; they remember more, and are more likely transfer this approach to their own teaching.

Follow-up: Hamline University provided an online fall course available to any MnSTEP participant from that summer. The “MnSTEP Online Learning Community” course included focused content and pedagogical discussions in small and large groups, resource sharing, and a peer review of the teacher’s SERC online lesson. A total of 112 teachers were enrolled over the three years. The PhASE/ChemCAL licensure groups held fall and spring online courses as well as a practicum classroom observation experience in spring. The 60 TIMES participants participated in two full-day follow-up sessions each year. MnSTEP staff offered follow-up sessions at the MnSTA state conferences every spring, attended by a total of 38 teachers.

Evaluation Instruments

Teacher Tests: Instructors for each of the 12 MnSTEP institutes submitted the majority of pre-post content test items to project staff. Test items were conceptual, standards-based, multiple choice questions representing the science content to be addressed in that institute. The number of test items varied, but there were usually 20 to 30 items. Each test (as well as proposed syllabi) was reviewed and discussed among project staff and instructors and modified each year of the program to exclude non-challenging items and add/delete content to match the institute’s standards-based content goals. The same instructor-developed test was given pre and post for each institute.

The pre and post percent correct was calculated for each participant to determine the number of participants that showed statistically significant (*t* test) knowledge gains in each institute.

Teacher Survey: The MnSTEP Pre-Post Teacher Survey was a project-specific, 85-item, Likert-type instrument developed by Hamline University to assess changes in attitude and classroom practice of participating teachers. Each of 12 instruments was custom designed to fit the concepts taught in each summer institute. The survey was completed online in late spring, before teachers attended a summer institute, and again in spring of the following year.

Selected Likert-type items were compared pre versus post for each institute to determine statistically significant differences (z tests) in responses related to confidence in their conceptual understanding of institute content, confidence in teaching specific science topics, amount of instructional time devoted to specific inquiry-based strategies, time required to prepare lessons on specific topics, and areas of professional growth. The large N and complexity of this self-reported instrument and administering the pre-post surveys one year apart helped reduce any Hawthorne effect.

Institute Evaluations: Each participant completed an institute evaluation providing feedback on the design, delivery and effectiveness of their summer experience. This evaluation data was used to modify institute syllabi, modify logistics and select future institute locations.

Student Content Tests: Project-developed student content knowledge tests were constructed from released, reliable standardized test items and faculty sources for each of the 12 summer science institutes. There were 10 separate student science content tests for the 12 institutes – ChemCAL and Secondary Chemistry use the same test as did PhASE and Secondary Physics. Teacher participants administered these content tests to their students in the spring before their involvement in summer institutes, and administered the same test to their new classroom of students the following spring, having taught a year of science after attending a MnSTEP institute.

In order to focus on the specific science topic of each MnSTEP institute (biology, chemistry, etc.), these student tests are combinations of grade-appropriate, released, valid test items from the National Assessment of Educational Progress (NAEP), the Massachusetts and Minnesota Comprehensive Assessments in Science, the Purdue High School Chemical Concepts Inventory Assessment, the American Chemical Society Chemistry Concept Inventory, and the Force Concept Inventory.

Teachers reported the percent correct for each question along with the number of students that took the test. This would allow for specific item analysis and comparison to national norms for specific questions. Test size ranges from seven (elementary physics) to 30 (secondary chemistry) multiple-choice items.

Achievement in science content was gauged by comparing scores of the teacher participants' students before attending a MnSTEP institute with those of their new students at the end of the following school year using z tests for independent samples.

To develop the added comparison groups, all teacher participants were asked to enlist the cooperation of a teacher colleague in their school district, preferably not in their building, who a) teaches the same grade(s), b) teaches the same science course(s), c) agrees to give the science content tests in late spring, and, d) for teachers of fifth, eighth or 10th grades agrees to provide their students' scores on the spring Minnesota Comprehensive Assessments Series II (MCA-II) science tests.

State Science Test: The MCA-II was administered statewide for the first time in spring 2008 to all fifth and eighth grade students and in one district-selected grade in high school (usually 10th

grade). The MCA-II science tests were of special interest as a uniform dependent measure of student achievement across the wide variety of school districts and classrooms likely to be represented in the MnSTEP project.

A scaled score from 1-99 is determined based on proficiency cut scores set by the state. This score is not percentage correct but is calculated by formula each year depending on the difficulty of the test and the number of test items per strand. A score of 50 indicated that the student has met proficiency in the science standards. Scores higher or lower than 50 indicate the level to which the student met or did not meet the science standards. The average student scaled scores for MnSTEP teachers (teaching fifth, eighth and 10th grade) are compared to average state scores. The project has two years of data (2008 and 2009) for the state science test from a limited number of MnSTEP participants that teach in grades five, eight and 10.

Project Performance

Data provided below is matched to each of the seven project outcomes.

1. Increase teacher content knowledge in science.

In all three years, in all institutes, teacher participants achieved a statistically significant mean pre- to posttest knowledge gain. (*t* test for paired observations, $p < .05$, two-tailed) ($n = 914$)

Large majorities of the participants made significant pre- to posttest gains in all institutes: 79% in 2007 ($n = 213$), 85% in 2008 ($n = 350$), and 87% in 2009 ($n = 351$) (paired sample *t* test, $p < .15$).

Both elementary and secondary teacher responses on participant surveys ($n = 131$) showed clear evidence of an increase in ability to answer student science questions and a decrease in the number who found it difficult to explain science processes to students. Also, a greater proportion of teachers agreed they had the skills and content background needed to effectively teach the science standards at their grade level.

For all participants as a group, the mean time indicated to prepare specific lessons for 20 content topics addressed in their institute decreased statistically significantly with the greater gains for elementary teachers.

2. Increase teacher skills in designing inquiry-based investigations.

Both elementary and secondary teacher survey results showed clear evidence of significant increases pre- to post-institute on teacher comfort and ability to plan inquiry-based investigations, help students design their own experiments, make student-directed projects a major part of their curriculum, and make an inquiry approach a common pedagogy in their classroom. This was corroborated by the significant increases in the frequency of use of inquiry strategies and student-directed inquiries in science units. ($n = 131$)

A repository of 848 MnSTEP lessons at the SERC website also demonstrates teachers' skills in

designing inquiry-based lessons. <http://serc.carleton.edu/sp/mnstep/activities.html>

3. Increase curriculum time devoted to science and student-directed investigations.

Both elementary and secondary teacher data show clear evidence of significant increases in the percentage of class time devoted to hands-on activities, student-directed investigations, and teacher-assigned projects. (n = 131)

For elementary teachers, we found important indirect evidence of increased time devoted to science by their increased disagreement with three attitudes: the claims that they usually teach science at the end of the school day, they don't like dealing with the materials and mess of science, and that science is not as important in the curriculum as reading and math. (n = 131)

4. Increase teacher confidence and enthusiasm for teaching science.

Both elementary and secondary teacher data show clear evidence of significant increases in their understanding of science concepts, comfort with their understanding of the science standards, and having the skills and content background needed to effectively teach all science standards at their grade level. Also, secondary teachers reported an increase in their students leaving their course excited about science. (n = 131)

Summer institute evaluations over the last three summers have been overwhelmingly positive. Participants were asked to rate their institute from 1 ("poor") to 5 ("excellent") on overall satisfaction, instructor quality, fit between actual content and project description, value of materials provided, value of inquiry, and workshop facilities. The mean rating across all institutes for overall satisfaction was 4.6. (n = 873)

5. Increase the repertoire and use of best practices in science teaching.

Both elementary and secondary teacher responses showed clear evidence of a significant increase in the frequency of use of inquiry strategies. All teachers (elementary teachers in particular) showed statistically significant increases in their use of inquiry-based activities, student-directed investigations, and teacher-assigned projects. Secondary teachers in particular showed statistically significant increases in using reflective writing, processing the learning from a lesson, and group work on problems. (n = 131)

6. Increase communication among teachers.

Both elementary and secondary teacher data show clear evidence of significant increases for having a network of fellow teachers they know and are comfortable talking to about science and science teaching. Similarly, participants feeling isolated as science teachers diminished. (n = 131)

7. Improve student science achievement.

Students of MnSTEP participants took topic-specific content knowledge tests prior to the

teacher's attendance at the institute (pre-test) and a year later after their attendance (posttest). In the 2008 report, comparing the 2007 participant students' pre- and 2008 posttests, more than half of the classes (63%) had an increase in mean percent correct on the posttest, 34% had a statistically significantly larger proportion of test items correct, and 12% had a statistically significant lower percentage correct. (n = 41) In the 2009 report, comparing the pre- and posttests of 2008 participant teachers' students, 37% had a statistically significantly larger proportion of test items correct, and 6% had a statistically significant lower percentage correct. (n = 54)

From the 2008 report, 15 participant teachers recruited a colleague to distribute the same science content test to a matching grade-level class of students. Eleven of the 15 MnSTEP participants' classes answered a larger proportion of the questions correctly than their colleague's classes. Five classes scored significantly higher than their matched comparison group, and one class scored significantly lower. (n = 15)

A total of 24 teachers submitted state MCA-II science test data during the project: nine with fifth grade tests, seven with eighth grade tests, and eight with high school tests (usually 10th grade) out of a possible 60 teachers that teach these grades and could have submitted data. For fifth grade classes of MnSTEP teachers, the mean percent proficient or higher was 55, compared to the combined state average of 42.5 for the 2008 and 2009 tests. For eighth grade classes, the mean percent proficient or higher was 43, compared to the state average of 40.7. For high school classes, the mean percent proficient or higher was 40, compared to the state average of 46. (n = 24)

Summary

Data show that MnSTEP has met all project goals. Forty-seven institutes involving 919 teachers were completed showing significant gains in teacher content knowledge for an average 84% of participants. Data from teacher surveys show that the project has increased teacher skills in designing inquiry-based investigations, increased time devoted to elementary science, increased confidence and enthusiasm for teaching science, increased use of best practices, increased communications with other science teachers, and (based on project pre/post testing) increased student achievement in science. These results are consistent across the three years of the project.

In addition to the results from statistical instruments, institute evaluations and correspondence from teachers have been overwhelmingly positive. Teachers appreciated the convenience of high-quality science workshops offered in their region with advanced content focused on the science standards they teach. They appreciated the teacher-focused, non-threatening, inquiry-based approach used by all 36 talented instructors in the 12 to 19 institutes provided each summer. "Increased confidence and enthusiasm for teaching science" was the most common statement heard from MnSTEP participants.

MnSTEP has been a powerful, efficient and effective professional development model for K-12 teachers of science.