An Evaluation of the *Exploring Energy & Matter Collaborative* (E^2MC) Mathematics and Science Partnership Project

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Executive Summary

With the ever-increasing need to provide students with high-quality science education, it is imperative that teachers have access to quality professional development (PD) that supports them in effectively addressing the science standards in their classrooms. In response to the need for quality PD opportunities, Northern Arizona University collaborated with Peoria Unified School District and Gilbert Public Schools to offer the *Exploring Energy and Matter Collaborative* (*E²MC*) project, funded by the Arizona Department of Education's Mathematics and Science Partnership (MSP) program. *E²MC* PD providers utilized the WestEd Making Sense of SCIENCE (MSS) Matter and Energy courses to support teacher content knowledge and effective pedagogical practices.

In an effort to understand the efficacy of *E²MC* in meeting its objectives, Peoria Unified School District contracted with Magnolia Consulting, LLC, an independent evaluation firm, to conduct a study of the program during the 2014–2015 school year. Participants in the study included 78 teachers (39 treatment and 39 comparison) and a sample of 524 students in participating teachers' classrooms.

Study Design & Methods

The purpose of the study was to evaluate the effectiveness of the *E²MC* project in increasing teachers' physical science content knowledge and understanding of effective science pedagogy. The study also sought to understand impacts on students in participating classrooms. Evaluators used a quasi-experimental design with a matched comparison group for the study. Teacher measures included the following: the Reformed Teaching Observation Protocol (RTOP), the Diagnostic Teacher Assessments for Mathematics and Science (DTAMS) physical science test, the Understanding Science for Teaching Matter and Energy Assessments (USTMEA), formative classroom observations, instructional artifacts, and treatment and comparison teacher implementations surveys. Evaluators used the USTMEA for assessing student learning in sample classrooms.

Program Perceptions and Perceived Impacts

Key Question:
How do teachers perceive the quality, utility, and effectiveness of the *E²MC* professional development?

E²MC teacher participants felt that the program was of value to their understanding of physical science concepts related to matter and energy. Teachers valued many aspects of the experience, particularly working collaboratively across middle and high school grade levels with peers to plan and design lessons. They came away with a better understanding of how matter and energy are connected and how concepts relate to other areas of instruction. Teachers felt the Making Sense of SCIENCE courses provided valuable resources for their instruction. They appreciated the connections of literacy to science content. They also greatly valued the opportunity to practice their learning through hands-on investigations. Teachers indicated that the biggest barrier to implementing learning from the PD is lack of time for planning and reflecting on lesson design and implementation.

Key Question:
How well prepared do teachers feel to apply *E²MC* learning in their science classrooms?

Teachers who participated in the *E²MC* professional development program indicated higher confidence in their abilities to use mental models in their science instruction

than did nonparticipants. They also felt more confident in their ability to make connections between matter and energy in their instruction. Participants felt most confident with respect to guiding students to use evidence in developing explanations, providing opportunities to present findings in a scientific format, supporting students to communicate and justify their explanations of phenomena, and helping students to understand which types of questions can be answered through scientific investigations. Participants rated themselves higher than nonparticipants on many of the instructional strategies targeted in the PD sessions.

Applications to Practice

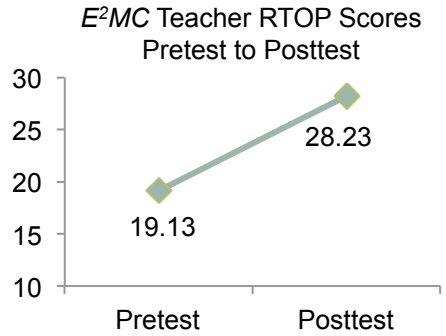
Key Question:
How does participation in the *E²MC* project impact teacher practice with respect to effective lesson planning and implementation?

Formative observations showed that *E²MC* teachers use a variety of resources and collaborative learning strategies in their instruction. Observed lessons were structured coherently and logically. Teachers appeared to need more support for active learning strategies and opportunities to answer scientific questions, which were emphasized in the PD sessions. Teachers are making stronger connections between matter and energy in their instruction. Unit plans showed varied proficiencies at aligning instruction to learning goals.

Impacts on Instruction

Key Question:
Does participation in the project have a statistically significant impact on teachers' ability to implement effective science instructional strategies and pedagogy?

Teachers who participated in the *E²MC* PD program showed significant gains in instructional practice aligned to reformed teaching as evidenced by their gains from pretest to posttest on the RTOP. Treatment teacher gains corresponded to a large effect size of 0.51.



E²MC teachers scored higher on the postobservation than did comparison teachers. Differences between treatment and comparison teacher posttest scores corresponded to a small effect size (eta squared =.07).

Impacts on Teacher Content Knowledge

Key Question:
Does participation in the *E²MC* project have a statistically significant impact on teacher understanding of interconnected core ideas and crosscutting concepts relating to matter and energy?

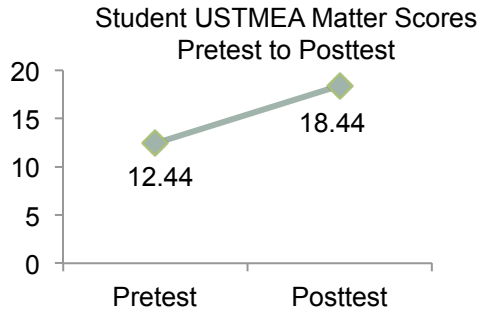
E²MC teachers made significant gains on the DTAMS from pretesting to posttesting on the *Total Content* and *Total Knowledge Type* scores. Teachers also made significant gains on the energy subtest and subscores for schematic knowledge and pedagogical content knowledge. *E²MC* teachers did not score significantly higher than comparison teachers on the posttest *Total Content* and *Total Knowledge Type* scores.

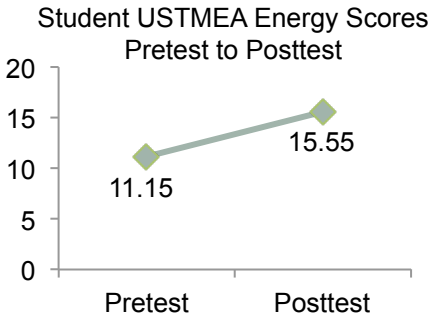
E²MC teachers made statistically significant gains on the USTMEA tests of matter and energy content knowledge aligned to the Making Sense of SCIENCE courses. Gains corresponded to large effect sizes for matter (0.41) and energy (0.63).

Student Performance Results

Key Question:
Do students in participating teachers' classrooms experience statistically significant gains in content knowledge over the course of the study?

On average, student matter and energy scores statistically significantly increased from pretest to posttest, and results corresponded to large effect sizes.





Exploratory analyses of student and teacher characteristics show that student grade is statistically significantly related to matter gain scores, with students in higher grades earning more than students in lower grades. For teacher characteristics, teachers' years of experience is also a statistically significant predictor for energy gain scores, with the students of more experienced teachers gaining more than the students of teachers with fewer years of experience. For the remaining subgroup analyses, results indicate that students performed similarly over time. For teacher implementation, results were not statistically significant but corresponded to *substantively important* effect sizes (>0.25), suggesting that larger implementation scores corresponded to larger gains.

Conclusions

Teachers who participated in the *E²MC* professional development felt that the program deepened their understanding of energy and matter concepts and of effective science teaching strategies. Teachers valued the ability to collaborate with peers to develop unit plans and appreciated the cross-grade collaborations between middle and high school teachers. Teachers gained confidence in designing opportunities for students

Overall, findings from this evaluation study found that the *E²MC* professional development project showed many of the characteristics of effective PD. Use of high-quality curricular materials, such as the Making Sense of SCIENCE courses, supported structured and systematic learning for teachers and allowed them to experience content and investigations as their students would experience them. PD sessions emphasized alignment of activities, lessons, and units to instructional goals and promote active learning in the classroom.