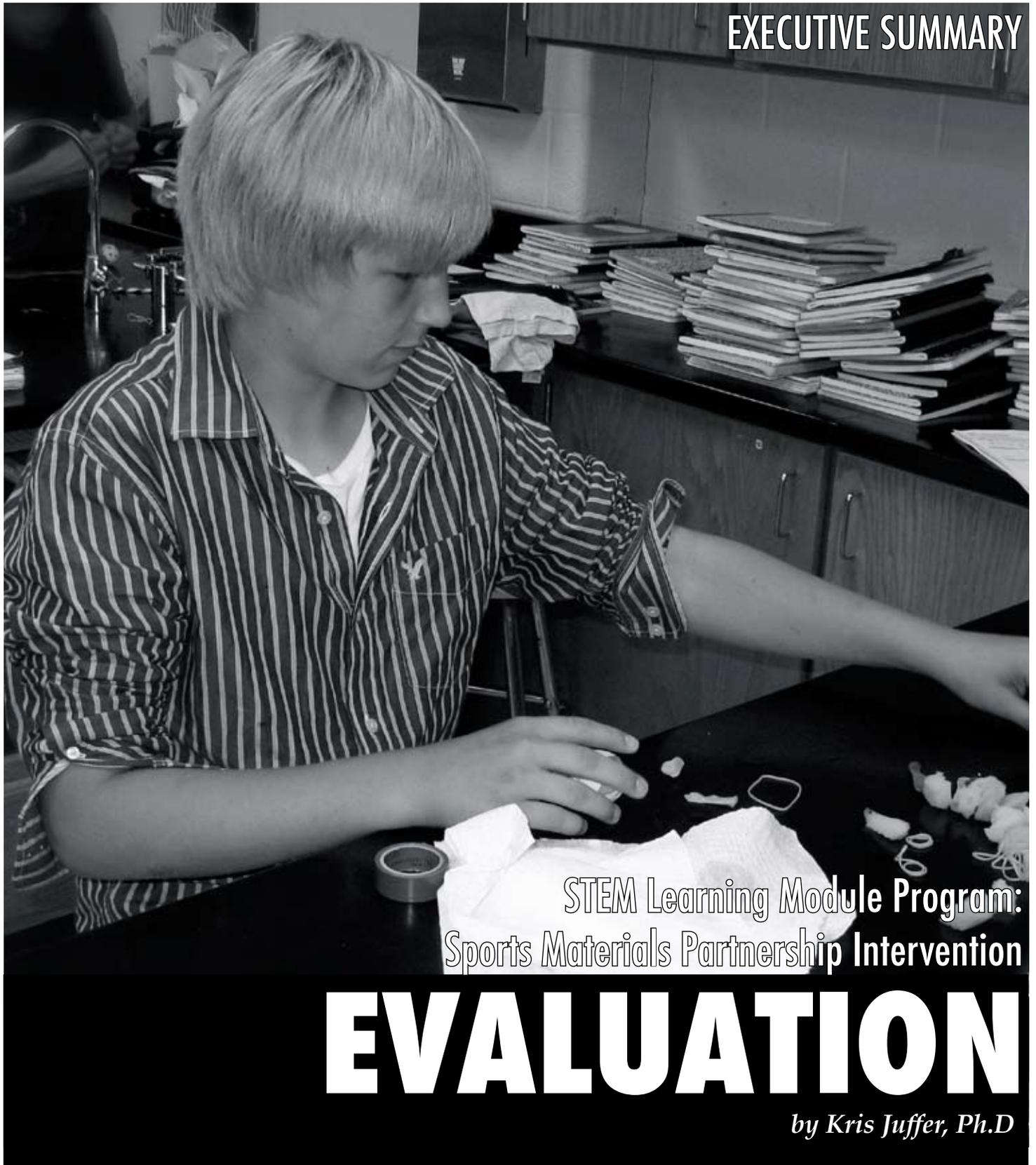


EXECUTIVE SUMMARY



STEM Learning Module Program:
Sports Materials Partnership Intervention

EVALUATION

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Conducted Spring 2008
Harford County Public Schools (Maryland)
Aberdeen Proving Grounds Army Research Laboratory



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EXECUTIVE SUMMARY

Evaluation of the NDEP STEM Learning Modules Program

Sports Materials Partnership Intervention - Spring 2008

EVALUATION BACKGROUND, OBJECTIVES AND DESCRIPTION

This report forms part of the second phase of a rigorous multi-phased evaluation plan for DoD's NDEP STEM Learning Modules (SLM) Program, conducted by Action Research & Associates, Inc. Further support of the program may depend significantly on the results of rigorous evaluation.

The **Phase I** evaluation conducted during a 2006 Summer Institute at Garrett College produced encouraging statistically significant results suggesting that students learning with hands-on, inquiry-and-design-based Materials Science modules learned significantly more science and measurably improved their attitudes towards studying science, compared to Control Group students. The evaluation, a random control trial assessing 82 middle and high school

students randomly selected and assigned to Treatment and Control Groups, was selected by the American Evaluation Association for presentation at the 2007 National Convention attended by more than 1000 researchers, and was well-received within the evaluation community. Because the 2006 Summer Institute was a 24-hour, 7-days-a-week, 4-week residential science immersion program, during which the students received 3 hours of science instruction and 3 hours of math and technology instruction daily, it was important to determine if similar findings would result if STEM learning tools were used in regular science classrooms during the school year. Since a defining feature of the K-12 NDEP program is to forge partnerships between classroom teachers and DoD scientists and engineers (S&Es), it was also important to begin building an evidence base regarding the effectiveness of those partnerships.

The site designated for the **Phase II** Evaluation is Harford County, Maryland. DoD selected eighth grade classrooms in Harford County Public Schools (HCPS) for several reasons. First, Harford County is the site of the Aberdeen Proving Ground, a large Army Research Laboratory with a history of community outreach in STEM education. Second, HCPS has shown a strong interest in improving STEM education as the result of an ongoing DoD base realignment that will bring





thousands of additional S&Es to the area. Third, HCPS administrators and teachers had helped pilot the dissemination of *Sports Materials* and other learning modules during the 2004-05 school year. Fourth, Harford Community College had received a DoD grant to support SLM teacher training.

Phase II builds on the quasi-experimental design approach and measurement instruments developed for the 2006 evaluation. Phase II was developed in two stages: Stage 1, the **Process Evaluation** occurred Spring 2008; and Stage 2, the **Summative Evaluation**, during the 2008-

2009 school year. Both Stages evaluated the effectiveness of the “*Sports Materials* Partnership Intervention” (“SMPI”). For details, see the *Description of the Intervention* on page 4. A number of key factors shaped this decision:

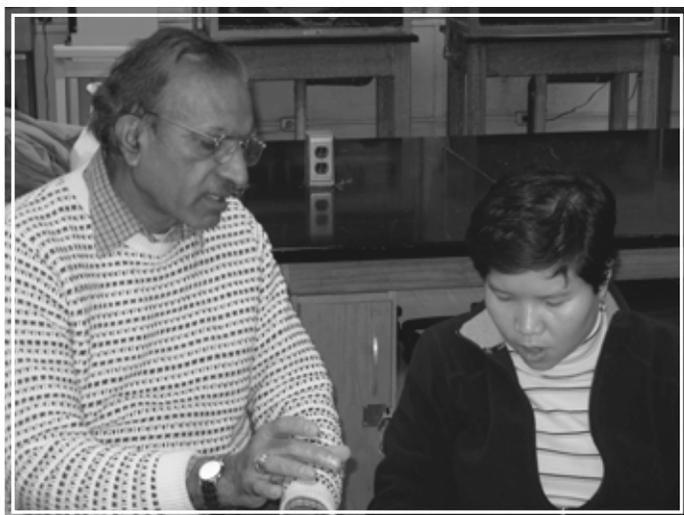
1. The Process Evaluation of the SMPI created an opportunity to train teachers while also enabling them to gain classroom experience with SMPI in the classroom. The Process Evaluation also made it possible to identify best practices for effectively integrating S&Es into an eighth grade classroom through empirical research, independent observation and feedback.
2. A rigorous Summative Evaluation requires a pre-test for all students – both Control and Treatment – before they are exposed to the science concepts taught in *Materials World Modules Sports Materials*. During Fall Semester 2007, all HCPS eighth graders had been taught the target science concepts via their regular textbook. It was, therefore, impossible to get valid baseline pre-test data in January 2008 when DoD funding became available. For the Summative Evaluation, pre-test data was gathered on new eighth grade students in September 2008; they will be post-tested in June 2009 after SMPI exposure in order to be able to calculate the relative gains that Control vs. Treatment students experience.

Purposes of the Spring 2008 Process Evaluation of SMPI (and related Deliverables)

- Gather data to provide initial Outcomes data to prepare for the Summative Evaluation. (*Deliverables: Powerpoint presentation/discussion delivered to NDEP, BEST, APG, RDECOM and HCPS on June 30, 2008, and this report delivered November 2008.*)
- Evaluate the SMPI training program to facilitate CASE to assist teachers and S&Es in achieving increased fidelity with the SMPI inquiry-and-design student-centered approach. (*“Action Research Flash Report” delivered April 2008.*)
- Identify “Lessons Learned” for effectively integrating S&Es into the classroom. (*Report delivered November 2008.*)

Description of the Intervention

The “*Sports Materials* Partnership Intervention” (“SMPI”) consisted of MWM-trained eighth grade science teachers implementing the *Materials World Modules (MWM) Sports Materials* unit daily (average of 14.5 instructional hours) over 4 weeks May-June 2008 working with DoD S&Es in the classroom an average of once a week. The S&Es were paired with teachers to assist weekly in introducing middle school students to real-world applications of science concepts and reinforcing student-centered scientific inquiry and hands-on design processes. Partnering with S&Es provided teachers and students a scientist role model and expert in the classroom that was able to link science and technical knowledge with real world experience, thus adding a “reality factor” for students. The S&Es contributed 290 hours, overall, in the classroom, averaging 20.7 hours each. On average, S&Es visited each class of students a total of 4.5 hours by the end of the intervention or a little over 1 hour a week per classroom.



The *Sports Materials* Module is a hands-on, interdisciplinary approach to teaching science and pre-engineering that provides students opportunities to learn science and math in the context of real-world applications. Students explore the materials, design and function of a wide variety of balls used in athletics. They also test and analyze the interaction of the balls with the many surfaces they come in contact with during play. Students design a suitable ball for use in a newly-invented game. Through this process, students strengthen their abilities to do scientific inquiry and iterative design, including

the ability to generate scientific questions, design and conduct scientific investigations, formulate and test models, redesign the products, communicate and defend explanations, and describe the experimental process, and results.

A Working Group of all interested parties was formed during the summer of 2007 to plan the Harford SMPI intervention and ensure that it met the parameters of evaluation. Members included the HCPS Supervisors of Science Education; the NDEP STEM Learning Modules (SLM) Coordinator at the Aberdeen Proving Grounds Army Research Laboratory; the Dean of STEM Education at Harford Community College; the CASE for Learning Director and Assistant Director; and the Executive Director of Action Research & Associates, Inc. The Group was successful in overcoming multiple barriers, conducting delicate negotiations to secure final approvals from the school district administration, as well as approvals from Harford Community College and APG administrations to participate in the SMPI Evaluation. The Group had to clear significant hurdles, including 1) finding an agreeable timeframe in the school year to implement SMPI that met evaluation parameters; 2) providing evidence to HCPS administrators that *MWM Sports Materials* content tracked closely with the eighth grade curriculum and Maryland State Science Standards; 3) creating positive teacher and S&E interest to volunteer their time and effort to participate in the project, as well as cooperating with and meeting the rigors of the evaluation; 4) gaining formal

school district approval of the evaluation plan; and 5) scheduling and planning two training Workshops for Teachers and S&Es.

HCPS identified a timeframe for implementing SMPI in the classroom during the last 4-5 weeks of school—May-June 2008—after the eighth grade had completed the Maryland State Science Assessments (MSAs) scheduled April 2008. Following a presentation to 28 eighth grade science teachers in November 2007, 15 teachers from 9 middle schools volunteered to participate. To capitalize on teachers clustering in two schools, to create a sufficient sample size, as well as minimize disruption in other schools, BelAir MS and Southampton MS were identified as those whose students would participate in the study.

The APG SLM Coordinator recruited a sufficient number of S&Es to match the number of teachers. Lab-based S&Es were given DoD-funded released time to participate in training and classroom implementation. Fifteen teachers and 14 S&Es participated in the evaluation (One S&E covered two teachers.)



To accommodate varying time constraints on teachers and S&Es, CASE for Learning conducted two 24-hour training workshops: a) February 29-March 1 and March 8-9, 2008 (Teachers and S&Es); and b) April 16-18, 2008 (S&Es). Each workshop reviewed the fundamentals of inquiry-and-design-based learning and introduced the *MWM Sport Materials* curriculum to the teacher and S&E participants – creating an opportunity for all trainees to immerse themselves in the module as “students,” but not as “teachers.” CASE built into the S&E training, some opportunity for them to practice using the inquiry- and-design questioning of “students,” practicing with each other.

In May-June 2008, the teachers developed their individual approaches and supplemental materials to implement the *Sports Materials* Partnership Intervention in the classroom. Each S&E was paired with an eighth grade science teacher to assist in introducing students to real-world applications of science concepts via *MWM Sports Materials*.

Sample Selection and Description

Students: Overall, 1,313 eighth grade science students in nine Harford County middle schools taught by 15 teachers were exposed to the Materials World Modules (*MWM Sports Materials*) module daily over four weeks during Spring Semester 2008. Of these, 533 students (taught by seven teachers in Bel Air MS and Southampton MS) who completed all four parts of the study -- pre- and post-*MWM* tests and pre- and post-*MWM* surveys -- formed the final student sample. The majority (84%) of the eighth graders in the final sample described themselves as White, and about half were girls and half, boys, tracking closely with the overall Harford County demographics. Another 6% of the student sample were Black, 5% Hispanic; 4%, Asian; 4%, multi-racial, and fewer than 1% were American Indian, Alaskan Native, Native Hawaiian or other Pacific Islander.

The demographic proportions for these subgroups varied from the proportions found in Harford County's 2000 census. In addition, 9% (48) of the students had IEPs (Individual Education Plans for Special Education). About half the students were 13 years old, the other half were 14.

Teachers: Of the HCPS 28 eighth grade science teachers, 15 teachers from nine Harford middle schools volunteered to participate in the Spring 2008 SMPI Evaluation. Fourteen of the 15 teachers completed the study. Sixty percent of the participants were female, while the remaining 40 percent were male. All participants described themselves as non-Hispanic Whites. Most participating teachers (73%) had earned masters-level degrees; the other 27% had bachelors' degrees. Eighty-seven percent were certified to teach science. Nearly half of the teachers had taught 11 to more than 21 years. Forty percent of the teachers had been teaching for 6-10 years. Two teachers had less than five years of experience.

Scientists & Engineers: Fourteen APG scientists and engineers (S&Es) partnered with 15 HCPS eighth grade science teachers in delivering the *Sports Materials* Partnership Intervention, with one S&E working with two teachers. The most frequently mentioned motivation for participating in SMPI was to promote students' interest in science and engineering. Approximately 70% of the S&Es were male and 30% female. Sixty-four percent were White, 29% Asian, 14% Hispanics and one "Other." About a third each were in their thirties, forties, or fifty and older, respectively. Most S&Es (57%) had earned Ph.D.s; 21% had masters' degrees; and 21%, bachelors' degrees. Forty-three percent had been trained as scientists, compared to 21% trained as engineers; 36% were trained as both. More than half had worked in their field for 16 or more years, while slightly less than half were relatively new employees, having worked for ten years or less. The majority had less than 10 days of previous classroom experience working directly with middle school students. Most S&Es (71%) were new to MWM; however, 29% had previous MWM experience.

Evaluation Instruments

Action Research & Associates, Inc, a research firm with test development expertise, developed a series of data collection instruments for the Phase I 2006 evaluation of STEM Learning Modules' *Materials World Modules* to measure cognitive and attitudinal changes in students and teachers. These instruments formed the basis for the Spring 2008 Evaluation. The *Sports Materials* test of MWM-related items has since been standardized and the standardized items were used in the Spring 2008 Science Knowledge Test. The cognitive and attitudinal instruments were modified for the HCPS classroom evaluation, adding questions about the role of the S&Es in the classroom to which the students and teachers responded. Action Research developed a new survey instrument for the S&Es. The data from the students were triangulated against the perceptions of their teachers, the S&Es, and the independent researchers' observations. The scientifically-developed instruments, supplemented by classroom observations, included:

Student Pre- and Post-Test for *Sports Materials*: Science Knowledge tests were administered via the web to students before (early May 2008) and after (June 2008) exposure to the *Sports Materials* module to measure gains in student content knowledge. The final test consisted of 15 items, with 45% from MWM and 45% from the HCPS science textbook selected to match *Sports Materials* Learning Objectives, and 10% from the on-line sample of the Maryland State Assessment (MSA) for eighth grade science. The resulting knowledge test had an estimated reliability of .65 (*coefficient alpha*).

Student Pre- and Post-SMPI Surveys: The survey instruments captured the students' self-assessed changes from the regular classroom experience (Pre-survey-Early May) compared to

their experience with SMPI (Post-survey-June 2008) to measure the following: 1) their attitudes toward science and interest in science careers, 2) their science skills; 3) their ability to use scientific inquiry to problem-solve; 4) students' observations of changes in teachers' methods; and 5) their perceptions of the impact the S&Es had on them as science students.

Teacher Pre- and Post-SMPI Surveys: The teachers rated the following elements as they occurred in the regular classroom (Pre-Survey) compared to during SMPI instruction (Post-Survey): 1) the frequency they observed students doing inquiry skills; 2) the frequency they used traditional Science versus Constructivist Teaching Methods; 3) their observations of what the S&Es contributed to the classroom, and 4) their opinions about working with *Sports Materials* and the S&Es. The Pre-Survey was administered via the web in February 2008 prior to beginning MWM training, and the Post-Survey was administered in June 2008 after completing the implementation of SMPI in the classroom.

S&E Pre- and Post-SMPI Surveys: A new survey was developed for the S&Es to gather demographic information and rate the frequency they did various tasks with students and teachers and their opinion about working with *Sports Materials*, the teachers and students. The Pre-Survey was administered via the web in February 2008 prior to beginning MWM training, and the Post-Survey was administered in June 2008 after completing the implementation of SMPI in the classroom.

Statistical Analysis

To determine the Value-Added of students learning science with the *Sports Materials* Partnership Intervention compared to the regular or science classroom approach, the Percent Value Added (also called the "Simple Percent Gain") was calculated. (See the "Statistical Analysis" Section of full report for a more detailed explanation of "PVA.") PVA is generally used by educational evaluators and the U.S. Department of Education. The equation for computing Percent Value Added (PVA) for a group is:

$$\frac{\text{Post-Test Mean Scores} - \text{Pre-Test Mean Score}}{\text{Pre-Test Mean Scores}}$$

For example, a PVA of 42% means that the group has increased its knowledge by 42% more than they knew before the intervention. Follow up *t*-tests were conducted to test for statistical significance.

Institutional Review Board

HCPS District officials reviewed Action Research's evaluation plan for Human Subjects protections, and other key factors and approved it for implementation in the school district prior to beginning the evaluation. A formal letter from HCPS' Supervisor of Accountability was received and is on file.

RESULTS

To conduct the Phase II evaluation, Action Research assembled a team of researchers (“Associates”) expert in their fields. In addition to the Principle Investigator (PI), the team consisted of methodologists, psychometricians, statisticians, database experts, and science educators.

The results are reported in three sections: A. Top Line Results; B. Implications for NDEP; and C. Statistical Evidence.

A. Top Line Results

Gains in Students’ Science Knowledge

- The *Sports Materials* Partnership Intervention helped students make significant improvements in science knowledge (27% Percent Value Added, $p < 0.000006$), compared to what they had gained from their regular science classes.
- Science Knowledge gains were comparatively greater for students that often traditionally under-perform in science. *Examples:* Girls made greater science gains than the Boys (32.7%, 19.9% mean PVA gain). Hispanics and Whites made larger average gains in science knowledge than did Asians or African Americans (32%, 28% vs. 19%, 13% mean PVA gain). IEP students made larger average gains than did Non-IEP students (45% vs. 25% mean PVA gain).

Attitudes about Studying Science, Inquiry, and Science Careers

- Overall, students learning with SMPI expressed positive science-related attitudes and skills (ranging between 60-88%.) For example, two-thirds of students liked learning science with SMPI, and felt that SMPI helped them better understand science.
- Ten percent more students reported their interest in considering or pursuing a career in science or engineering significantly increased (to 68%) after studying science via the *Sports Materials* Partnership Intervention, over their regular science classes (58%).
- Students reported their ability to use inquiry-and-design skills and to problem-solve improved significantly (items ranged 66%- 88%). Teachers’ independent evaluations confirmed this result.

Impact of S&Es on Students

- Most students (74%) liked having S&Es help them learn science.
- S&Es had the strongest impact on students when S&Es applied inquiry methods -- asking students questions, listening to their thinking, guiding their thinking, and not lecturing or providing answers.
- Using SMPI as a vehicle, 85% of students reported that S&Es served as role models and had a valuable impact on their science education. Their teachers agreed.

Impact of S&Es on Teachers

- Thirteen (86%) teachers of 15 thought the S&E partnership worked well—two did not.
- Most teachers and S&Es were satisfied with their partnerships, generally. Overall, teachers were happier with the partnership than were the S&Es, indicating a need for more training.

Teachers' Ability to Use Inquiry in the Classroom

- Teachers changed their instructional methods to provide students with significantly more frequent opportunities to engage in higher-order science inquiry and problem-solving than they did with the regular science curriculum.
- SMPI had the desired effect to encourage teachers to decrease their reliance on "Traditional" teacher-centered classroom strategies; but in some cases, it decreased some inquiry-and-design activities.
- This mixed result indicates the need for additional training for Teachers.

B. Implications for NDEP

Based on results from the 2006 Summer Institute Evaluation and the Spring 2008 Process Evaluation of SMPI, and pending the outcome of the 2008-09 Summative Evaluation —

The Sports Materials Partnership Intervention appears to be an effective vehicle for NDEP to:

- Forge *partnerships* between classroom science *teachers* and DoD *S&Es*.
- Train *S&Es* to work more effectively with middle school students, so students appreciate, value and accept their contributions.
- Train *S&Es* to focus efforts on coaching students to practice higher level inquiry skills, such as encouraging students to construct, test, refine and expand their first-hand knowledge and understanding of scientific principles; link data to scientific principles; present, challenge and defend hypotheses, results, and processes; learn from errors; and analyze data and procedures for sources of error.
- Excite *students* to be more engaged and interested in science.
- Introduce *students* to the world of engineering.
- Attract significantly more *students* to consider careers in science and engineering.
- Significantly upgrade *teachers'* working knowledge of science.
- Significantly upgrade *teachers'* ability and comfort level to incorporate higher-level scientific inquiry processes into classroom instruction.
- Significantly upgrade the quality of *science instruction* to give *students* more frequent exposure to real life, hands-on experiences applying the scientific inquiry process.
- Magnify the *S&Es'* impact on *students* beyond what would normally be expected by their limited (4.5 hour average) classroom exposure.

Multiple exposures to the same S&E over multiple weeks appears to matter!

Repeated exposures:

- Increased *students'* comfort level with and acceptance of the S&E – including accepting their guidance, the knowledge they provide, and accepting them as role models.
- Increased *S&Es'* comfort level and confidence in working with students, thereby allowing

them to be more effective working one-on-one with students, as well as knowing better how to address the class to capture their attention.

- Increased **teachers'** abilities to more effectively incorporate S&Es into lesson plans.
- Reduced most **teachers'** "psychological barriers" towards S&Es, thereby, increasing their willingness to ask for and accept S&Es' expertise into the lessons.
- Increased **teachers'** reliance on the S&Es as professionals who could have a positive impact and be useful in the classroom with students.

Well-designed SMPI Training Component appears to matter!

- Well-designed training for **teachers** and **S&Es** is important. Good training requires a strong emphasis on practicing higher-level inquiry questioning and skills in student coaching, in addition to a strengthening teachers' science knowledge base.
- Effective SMPI Training with a practice component made a significant difference for the **S&Es** to more effectively reach and interest middle school **students** in science. This resulted in increasing how much the students accepted and acted on what the S&Es said to them.
- The SMPI training component appears to make a significant difference to improve **S&Es'** effectiveness with **students** in the classroom. With SMPI Training, S&Es were 1) trained to coach students using questioning techniques, and avoiding being directive, 2) trained to coach/guide students to work at higher scientific inquiry levels, and 3) given the opportunity to practice the new techniques in context.
- HCPS teachers report that SMPI-trained **S&Es** were more effective with **students** than previous S&Es working with students in other contexts.
- **The Spring 2008 SMPI training component did NOT provide teachers a similar opportunity to practice teaching** the SMPI content and approach, applying questioning and coaching techniques with "students," or to practice working with students at higher scientific inquiry levels. This gap mattered, and affected teachers' classroom performance, and likely, student performance.
- **It is clear the opportunity to practice SMPI questioning, coaching, and higher level inquiry skills is also important to improve teachers' effectiveness.** Trainers need to adjust training to ensure teachers have the opportunity to practice teaching the SMPI materials during training to bring up teachers' skill levels.
- SMPI Training's approach to train teachers and S&Es together provides a natural way for effective partnership to form. Without this natural exposure, partnerships have a higher incidence of failure.

SMPI content and approach appear to matter! – Independent of the partnership.

- **The tool matters! It is not just the partnership that is responsible for the student changes.**
- The SMPI content and approach – in particular, the hands-on inquiry & design approach focusing on higher level inquiry skills – positively impacts students to help them make significant gains in science knowledge and in applying the scientific process – independent of the S&E partnership. It is not just the partnership that matters.

SMPI also appears to impact teachers to make desired changes in classroom teaching style.

Teachers:

- Began to think of the **S&Es as a partner and resource** they can call on.
- Planned **more interesting and engaging science lessons** for students.
- **Increased the time students practiced on higher inquiry and problem-solving skills.**
- Planned **more frequent opportunities for students' to work on and improve higher level inquiry skills beyond just gathering data** to include such important skills as analyzing data for underlying patterns, relating data to scientific theory, creating/analyzing models, analyzing for sources of error, presenting and defending findings, problem-solving, etc.
- **Upgraded their science knowledge** through *Sports Materials* curriculum, and through professional contact with the S&Es.
- With **highly trained science teachers** who are more competent in teaching higher levels of inquiry and with coaching skills, and who know how to work well with S&Es, **NDEP can "multiply" its efforts to influence successive classes of students to be more interested in science, engineering and careers.**
- Once teachers change their teaching style to a) be **more student-centered**, b) focus efforts on **higher inquiry skills**, and c) **involve S&Es in the classroom**, they can better influence **hundreds of students to enter science and engineering fields** every year for years to come.

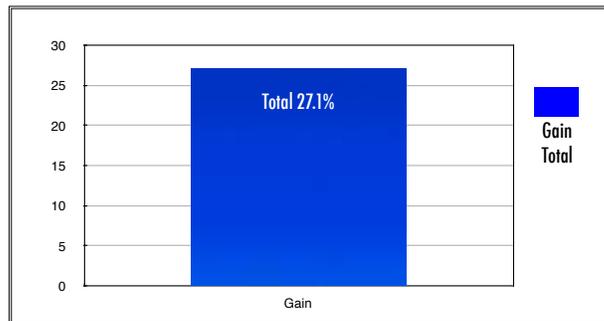
C. Summary of Statistical Evidence

Impact on Students' Science Knowledge

ALL STUDENTS' SCIENCE KNOWLEDGE:

- Middle school students – and all demographic subgroups -- made significant gains in science knowledge with the *Sports Materials* Partnership Intervention over four weeks, on average, compared to what they had learned from their regular science curriculum over eight months. (27% gain, $p < 0.0000000006$) (Graph 1)

Graph 1: Student Average Overall Science Knowledge Gains - by Total (N=533)



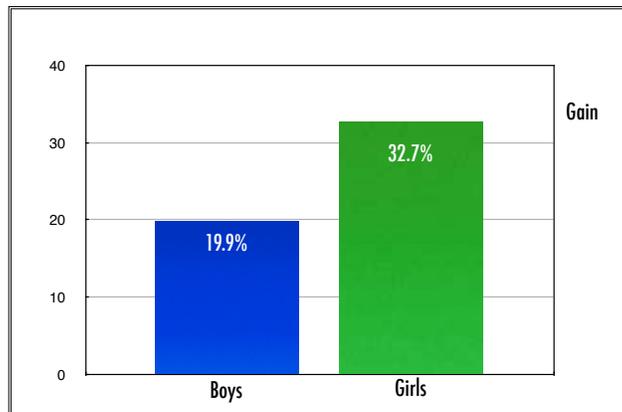
Note: To interpret Graphs 1-5, the bottom line represents the Pre-Test score (regular science curriculum), and the bar represents the student Science Knowledge gains on the Post-Test (MWM instruction.)

SCIENCE KNOWLEDGE GAINS BY DEMOGRAPHIC GROUP

- On average, traditionally under-performing groups in science — Girls, Hispanic-Americans, African-Americans, and IEP Students – as well as White students -- learned significantly MORE science knowledge with SMPI.

Science Knowledge Gains by Gender

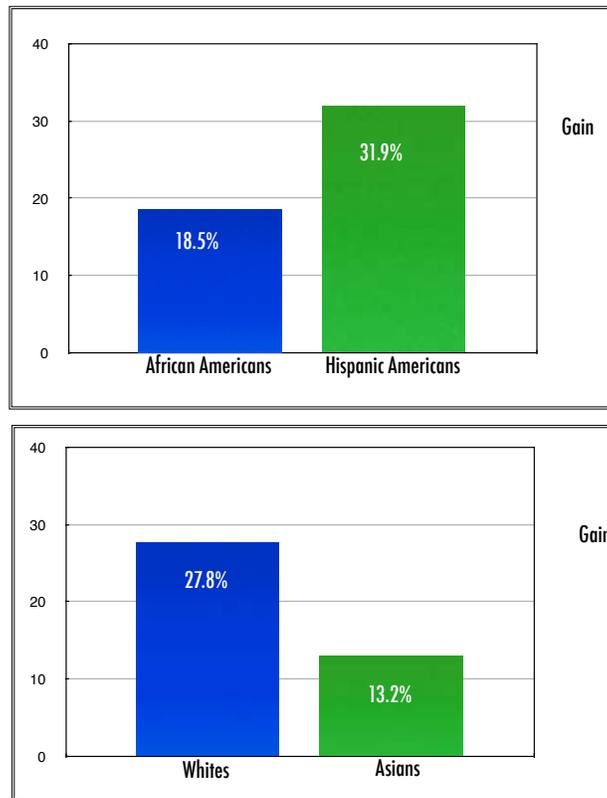
Graph 2: Student Science Knowledge Gains – by Gender (N=533)



- SMPI helped both Boys and Girls make statistically significant gains in science knowledge ($p < 0.0000000003$). The good news is that, Pre- to Post-test, Girls made higher science gains with SMPI than the Boys (32.7%, 19.9% avg. PVA gain).

Science Knowledge Gains By Race and Ethnicity

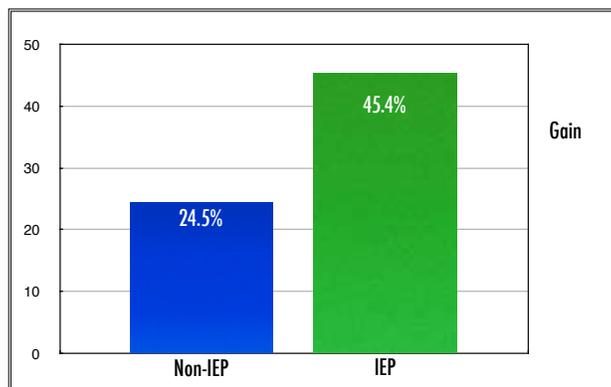
Graphs 3 & 4: Student Science Knowledge Gains – by Race and Ethnicity



- On average, Hispanics and Whites made larger average gains in science knowledge with SMPI than did Asians or African Americans (32%, 28% vs. 19%, 13% avg. gain).

Science Knowledge Gains by IEP

Graph 5: Student Science Knowledge Gains - by IEP and Non-IEP N=533)



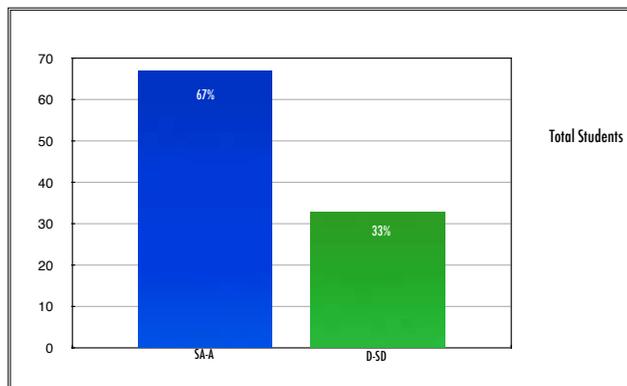
- Using SMPI, both IEP (Individual Education Plan for Special Education) and non-IEP middle school students achieved significant gains in science knowledge. **However, IEP students made larger average gains with SMPI than did non-IEP students (45% vs. 25% avg. gains).**

Impact on Students' Attitudes Toward Science

- With SMPI, students significantly improved their attitudes toward studying science.

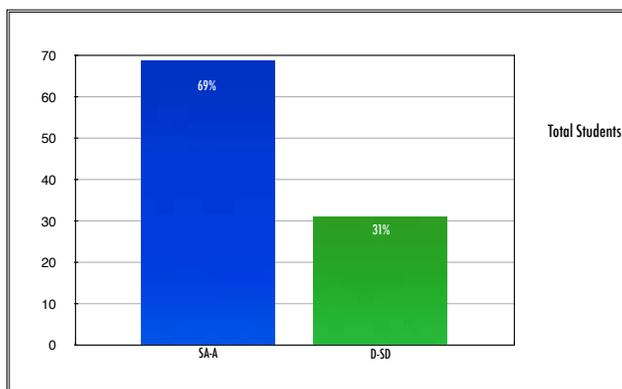
Changes in students' attitudes and behaviors Pre- to Post-SMPI were assessed through a battery of self-report questions, administered to students via surveys. In Graphs 6-9, students were asked if they agreed or disagreed with a series of statements. "SA-A" indicates "Strongly Agree-Agree" and "D-SD" is "Disagree-Strongly Disagree." (Graphs for other results appear in the full report.)

Graph 6: I liked learning science through Sports Materials.



- Two-thirds of students liked learning science through SMPI

Graph 7: I feel like I was more actively engaged in learning science with Sports Materials, than in my regular science class.



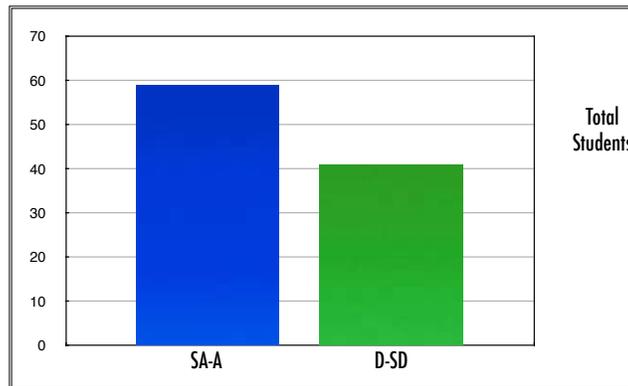
- Learning through SMPI, 69% of students reported feeling more engaged with learning science than in their regular science class.
- With SMPI, 3 out of 4 students enjoyed talking about science with their team mates.
- SMPI encouraged 3 out of 4 students to ask more questions about science.
- Two-thirds of students felt that SMPI helped them better understand science.
- Four out of five (80%) students agreed they had learned new science concepts with SMPI.
- Learning with SMPI, 62% of students felt they took **more** responsibility for their own learning.

Impact on Students' Problem-Solving and Scientific Inquiry Skills

- Students made significant gains in improved problem-solving and science skills with MWM Sports Materials, compared to the regular curriculum.

STUDENTS' PROBLEM-SOLVING SKILLS

Graph 8: MWM helped me understand how to problem-solve better (N=533)

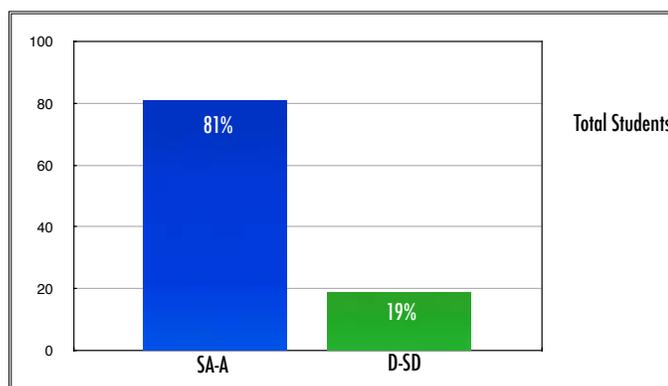


Key: "SA-A"=Strongly Agree/Agree "D-SD"= Disagree/Strongly Disagree

- Three out five middle school students (60%) felt they learned to problem-solve better with MWM Sports Materials.
- With MWM, two out of three students better understood the importance of logical scientific thinking to effectively problem-solve. (See full report for corresponding graphs below.)
- With MWM, 82% of middle school students learned the importance of learning science from analyzing mistakes.
- With MWM Sports Materials, 77% of students learned that there may be more than one way to solve a problem.

STUDENTS' DESIGN SKILLS

Graph 9: I liked designing new products (balls). (N=533)

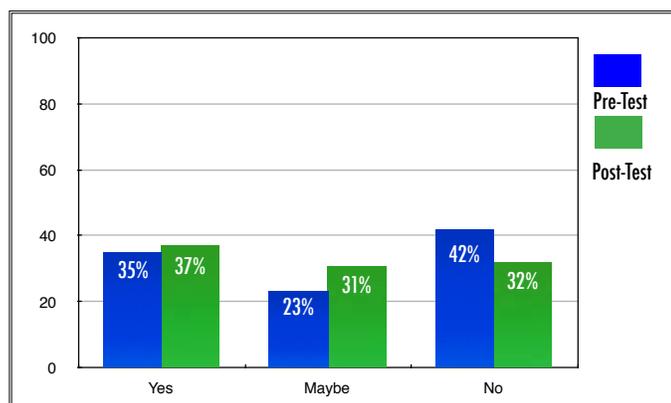


- With SMPI, more than four of five students (81%) liked designing new products.

Impact on Students' Interest in Science Careers

- With SMPI, students' interest in pursuing careers in science significantly increased.

Graph 10: Pre-SMPI survey: Have you considered a science career?
Post-SMPI survey: Has working with Sports Materials and the S&E made a career in science/engineering more interesting to you?



- Asked during their regular science class, a plurality (42%) of students reported they were NOT considering pursuing careers in science.
- However, after studying *Sports Materials* with S&E mentors (SMPI), the students' interest in pursuing a career in science significantly increased 10%—from 58% to 68%.
- After working with SMPI, 3% of students who previously were undecided about going into science careers were convinced to switch to “Yes,” they were interested in pursuing careers in science.
- The number of students rejecting careers in science and engineering dropped 10 points, from 42% to 32%.

S&Es' Impact on Middle School Students ¹

- Students strongly agree that S&Es working with *Sports Materials* made a positive contribution to increasing students' interest in science learning, scientific inquiry and in careers in science and engineering, as measured by 19 items. Teachers agree.
- Overall, students learning with SMPI reported improving their science-related attitudes and skills more dramatically than they did previously in their regular science.
- With the *Sports Materials* Partnership Intervention, students reported larger pre- to post-instructional improvements on key science-related attitudinal and skill items relative to what they experienced in their daily science classes.

¹ More details regarding the S&Es' impact and how best to integrate them into the classroom are presented in a separate report prepared by Action Research & Associates, Inc., and delivered November 2008.

WHEN STUDENTS WERE ASKED ABOUT THE IMPACT OF THE S&Es ON THEM, THEY SAW THE S&Es

- be a positive role model (85%);
- interact positively with students (85%);
- guide by questioning (80%);
- talk about science understandably (79%);
- talk about their job (76%);
- provide extra science info (75%);
- use questions to problem-solve (75%);
- lead them to value errors (69%);
- talked about careers in science (69%);
- coached students in labs (67%), etc.

TEACHERS INDEPENDENTLY AGREED WITH THE STUDENTS' ASSESSMENT OF THE S&Es'S IMPACT ON STUDENTS. SOME THINGS TEACHERS SAW THE S&Es CONTRIBUTE TO STUDENTS INCLUDED:

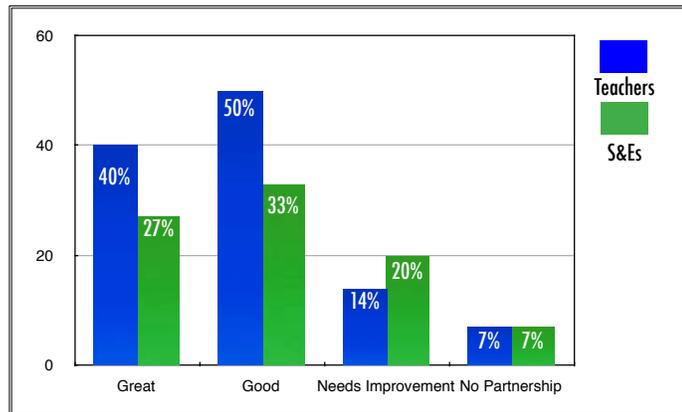
- Interacted positively with students ("Very great extent");
 - Guided students' thinking by asking questions ("Very great extent");
 - Adjusted their talk to meet students' knowledge level ("Very great extent");
 - Were a positive role model to the students ("Great extent");
 - Listened carefully to students talk about science; asked appropriate questions ("Great extent")
 - Served as a coach to the students as they worked in labs ("Great extent");
 - Led students through questions to problem-solve ("Great extent");
 - Talked to students about a career in science or engineering ("To a moderate extent"), etc.
- With SMPI, students reported significantly increased interest in considering or pursuing a science career after studying science, over what they experienced in their science classes.
 - Students reported more strongly improved attitudes towards studying science, then they experienced in their regular science classes.
 - Students reported more improvement in their ability to use inquiry skills and to problem solve, than they experience in their regular science classes.
 - Students and teachers agree that working with students on SMPI, S&Es had a valuable impact on students' science education.
 - Overall, students learning with SMPI reported improving their science-related attitudes and skills more dramatically than they did in their regular science classes.
 - Students reported larger pre- to post- instructional improvements on key science-related attitudinal and skill items relative to what they experienced in their science classes.
 - Students reported significantly increased interest in considering or pursuing a career in science after studying science via SMPI, then during their regular science classes.

- Students reported more strongly improved attitudes towards studying science with SMPI.
- Students reported more improvement in their ability to use inquiry skills and to problem solve, than they experienced in their regular science classes.
- Overwhelmingly, most students (88%) found working with S&Es to be a highly positive experience. Only 12% had either mixed to negative comments about the S&Es in the classroom. Some comments may be highly subjective; others provide insights into opportunities for enhanced involvement of the S&Es in the classroom.
 - *“I liked how they led me through errors and problems that I had. To correct my errors, they showed me how to analyze the data and how scientists like them solve everyday problems in the world. I believe the help of this scientist has given me more knowledge of my future and what I have to prepare for in high school and as a young adult.”*
 - *“I liked that X connected what they did at APG to what we were doing in our labs... They made what we were doing sound really interesting and...used real-life examples connecting what their work involved to what we do in our lives. They were positive role models...and made the class excited [to do MWM.] ... It makes me want to have a job in the science field.”*
 - *“I enjoyed having an APG scientist join our science class, for the short time they were here. However, I wish that X could have made more contributions to the class. Perhaps it is just my personal opinion, but it seemed to me that X did not speak with students all too much.”*
 - *“I found it difficult to pay attention to their lecture.... But I did enjoy the slight interaction they had with us, because that part of the lecture was rather interesting. If more of the lecture was similar [to the interactive part] my thoughts may have been different.”*

S&Es' Impact on Teachers

- **Thirteen (86%) teachers out of 15 reported their partnerships worked well — two did not.**
- Positive teachers reported the S&Es –
 - supplemented [their] ability to teach science by providing [them] or the students with extra facts, answering science questions, etc. (avg. 5-7 times over four weeks);
 - jumped in at appropriate times to add something to the class (avg. 5-7 times);
 - served as a resource to expand [their] science knowledge (avg. 4-5 times).
- **Most teachers' (86%) enthusiastically endorsed the experience:**
 - *“There isn't enough space here for me to fit all the good things X brought to my students (and my teaching). They were amazing! They are knowledgeable, patient, genuine. The kids loved them!”*
- However, a couple of teachers stated the S&E brought *“No benefit I can think of.”*
- There are significant gaps in S&E and teacher classroom expectations and training. This points to the need for enhanced training for teachers and S&Es to better prepare both to create a strong partnerships to better reach students.

Graph 11: How would you rate the Teacher/S&E partnership? (Teachers vs. S&Es)



Almost all teachers and S&Es were satisfied with their partnerships, generally -- teachers were happier with the partnership than were the S&Es.

- Forty percent of teachers rated the partnership as “Great!” compared to 27%, S&Es.
- Fifty percent of teachers vs. 33% of S&Es rated the partnership as “Good.”
- 14% of teachers vs. 20% of S&Es rated the partnership as “Needs Improvement.”
- One teacher/S&E partnership did not work, and was dropped from the final analysis.

Impact on Teachers’ Abilities to Train Students to Apply Higher Level Inquiry Methods to Problem Solve

- Analysis of the middle school teachers’ results suggests that **teaching with SMPI provides students with significantly more frequent opportunities** (1.1 *Once a week” vs. 2.8 (3 times weekly, almost a 200% increase, $p < 0.01$) to engage in 19 higher-order science inquiry and problem-solving skills than does the regular science curriculum.

Graph 12: According to Teachers, Average Times Weekly that Students Engaged in Higher Level Inquiry – Regular Classroom vs. MWM



Note: To interpret Graph 12, the bottom line represents the Pre-Survey score, and the bars represent the gains on the Post-Survey indicating the increased frequency that students engaged in higher-order science inquiry tasks during MWM instruction compared to the regular science curriculum.)

- *Materials World Modules'* teacher training, approach and classroom implementation have the desired effect to encourage teachers to decrease their reliance on "Traditional" teacher-centered methodologies and behaviors.
- There was a cadre of teachers who were relatively "high implementers" of *MWM's* Inquiry and Design ("Constructivist") approach.
- However, on average, **teachers too often stopped short at the data gathering stage, and did not get students to more deeply analyze the data**, relating it to scientific principles and/or finding sources of error.
- Whereas, on average, teachers increased some inquiry methods when teaching *MWM*, they also *decreased other inquiry methods* from what they practiced during the year.
- The decrease in some aspects of Inquiry Teaching Behavior appeared to be related to **some teachers choosing to take a "laissez faire" approach (let the kids go off on their own without teacher coaching)** to teaching *MWM*, rather than complying with a full Constructivist approach.
- It is clear that **teachers require additional enhanced training to practice teaching *MWM* to more effectively and comfortably implement higher-level inquiry** in the classroom.
- ***MWM* curriculum materials, while strong overall, have aspects that need enhancement to make them more effective and easier for teachers to use in the classroom. Training needs to more effectively address these issues.**



Action Research & Associates, Inc.

Background

Action Research & Associates, Inc., established in 1999, is a research firm serving the Greater Washington DC/ Baltimore metropolitan area, the Nation, and the World. The Principal Investigator for the multi-year DoD *MWM* Evaluation study is Kris Juffer, Ph.D., Executive Director of Action Research & Associates, Inc. Dr. Juffer is well-qualified to conduct the SMPI evaluation, since she has been a professional researcher and evaluator for more than 25 years, specializing in evaluating federal and state STEM education programs.

Action Research conducted the experimental design study of *MWM*'s effectiveness during the 2006 Summer Science Institute conducted at Garrett College with randomly-selected 6th-12th grade Maryland students. Action Research completed the Process and Outcomes Evaluation of SMPI (*MWM Sports Materials*) in 15 HCPS eighth grade classrooms in 9 middle schools during Spring Semester 2008, and is currently conducting the 2008-09 *Summative Evaluation of Materials World Modules Sports Materials*.

Additional experience relevant to the STEM Learning Modules -- Dr. Juffer is one of the few evaluators who has conducted evaluation research that the U.S. Department of Education has indicated meets the federal standards for "Scientifically Based Research-SBR." In addition, Action Research has conducted high caliber research and educational program evaluations for such clients as the National Science Foundation, the National Institutes of Health – Office of Science Education, U.S. Department of Health and Human Services, Centers for Medicare & Medicaid Services (CMS), U.S. Department of Education, the Public Broadcasting Service's (PBS) Kids *Ready To Learn* TV Programming (*Sesame Street*, *Between the Lions*), the Department of Defense's Educational Outreach Programs, U.S. Information Agency, the Fulbright Program, the Voice of America radio and television programming, Arbitron (national radio station ratings), CBS network television and radio, ABC network television, Clear Channel radio corporation, WAMC Northeast Public Radio (NPR), and other media companies; Prince Georges (MD) County Public Schools, Garrett (MD) College, the University System of Maryland's Chancellor's Office and other non-profit agencies, corporations, universities and school districts.

In addition, Dr. Juffer is an experienced developer of tests and assessments. She has conducted psychometric research for the Iowa Testing Program, a subsidiary of American College Testing (ACT), developing reliable and validated assessment instruments and achievement tests. She has also researched cross-cultural adjustment, developing a highly reliable (.95), nationally-recognized psychological test, the *Culture Shock Adaptation Inventory* (CSAI ©1983), which is considered a break-through in its field and which in many countries around the world.

With masters and doctorate degrees in Education, Dr. Juffer has worked in education for more than 25 years, as a classroom teacher, master teacher, district administrator, curriculum developer and coordinator, university professor, federal government official, contractor and professional evaluator. She has also conducted educational research, as well as media and communications research for major clients and fluent in Spanish.