



**ACTION RESEARCH**

**EVALUATION OF  
MATERIALS WORLD MODULES:  
2006 SUMMER INSTITUTE**

*conducted at Garrett College  
in Deep Creek Lake, Maryland*



*Executive Summary prepared for*

Building Engineering and Science Talent and the U.S. Department of Defense



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### Evaluation Objectives

As the first phase of a multi-year plan to measure the effectiveness of *Materials World Modules (MWM)*, the U.S. Department of Defense (DoD) sponsored a Summer Institute for 82 middle and high school students at Garrett College, in Deep Creek Lake, Maryland, from July 9 - August 5, 2006. The Summer Institute was a residential immersion science and math institute designed to explore the relative effectiveness of a traditional teacher-directed science curriculum and textbook compared to the *Materials World Modules* materials and methods, an inquiry- and design-based materials science program.

DoD has made a multi-year commitment to support the scale-up of *MWM* in areas that host a significant concentration of DoD research facilities. A rigorous evaluation of *MWM* was deemed essential to the success of its dissemination and the development of a national rollout model. DoD selected Garrett College to implement this plan.

Employing a multi-method, quasi-experimental design with random assignment of students to Treatment and Comparison Groups in matched pairs, the evaluation of the Summer Institute had three main purposes:

- To gather preliminary evaluation data to inform decisions of stakeholders about *MWM*;
- To develop reliable assessment instruments that can be used in a more comprehensive classroom evaluation in Maryland and elsewhere; and
- To provide formative feedback to guide the training of teachers to teach *MWM*.

### Description of the Intervention

During the Summer Institute every effort was taken to control key aspects of the students' environment during the four-week, 24-hour, seven-day Summer Institute, every effort was taken to ensure that only the independent variable of interest – *MWM* versus traditional classroom science methods and text – varied between Treatment and Comparison Groups. The Summer Institute focused on four science units - Composites, Sports Materials, Concrete and Polymers. One unit was taught each week for three hours per day Monday through Friday.

Prior to the Summer Institute, a curriculum committee developed common “Learning Objectives” for each unit, delineating key science principles to be covered in each unit by both groups. The Treatment Group was taught with a predominantly student-centered, hands-on approach using MWM reading materials and inquiry-based hands-on laboratory experiences combining data collection, design challenges, and interactive class presentations. The Comparison Group was taught science in a traditional classroom style, with predominantly teacher-centered lectures, teacher-directed lab experiences, and a science textbook (Pearson Prentice Hall’s *Physical Science: Concepts in Action: With Earth and Space Science*).

A weekly incentive program replaced the motivating factor of earning “grades” for academic work. The combination of 1) physical separation of the treatment groups during the day; 2) classroom groups assigned neutral names like “Platinum” and “Silver;” and 3) quality teaching of the same content areas, irrespective of group assignment, resulted in students not discovering which treatment group they had been assigned to until the final week of the study.

### **Sample Development and Selection**

The Summer Institute recruited from a pool of more than 400 middle and high school students in order to fill 96 spots. To develop this pool, in April 2006, Garrett College sent professionally-designed program announcements and posters to the Maryland Science Teachers Association and to every Maryland school district via superintendents, principals, science curriculum coordinators, and department chairs. The materials invited the students to apply for the Institute via the Internet. Financial cost was not a barrier to student participation because DoD paid the expenses for all selected students, enabling students from a wide range of socio-economic backgrounds to attend. Students came from virtually every county across Maryland, from inner-city schools, private schools, parochial schools, charter schools, large public schools in suburban and urban areas, military academies, technical schools, and “home schools.” As a result, it was possible to recruit and select a diverse cross-section of students from every part of the state.

A two-tiered random sampling method was developed to first select the participants, and then assign them to a treatment group in order to create a probability sample. The sampling model reflected Maryland’s demographics regarding race and sex, adjusted proportionately to a sample of 96 participants. In the final sample, of the 82 students who completed the four-week Institute, the demographic factors were evenly distributed between the Treatment and Comparison Groups. Sample attrition (due to first day “no shows,” home sickness, discipline issues, and family vacations) was distributed evenly between the two treatment groups. Both groups had 13 high school and 28 middle school students. The proportion of male and female students was evenly split, with 41 of each, and proportionately split across middle and high school levels. Proportions of Black, White, and “Other” students in the final sample were 33%, 60%, and 7%, respectively, comparable to the U.S. Census Bureau’s statistics for Maryland.

## Evaluation Instruments

Action Research & Associates, Inc., an independent research firm with test development expertise, developed a series of data collection instruments to measure cognitive and attitudinal changes in students. The data from the students were triangulated against the perceptions of their teachers and with the independent researcher observations. The scientifically-developed instruments, supplemented by classroom observations, included:

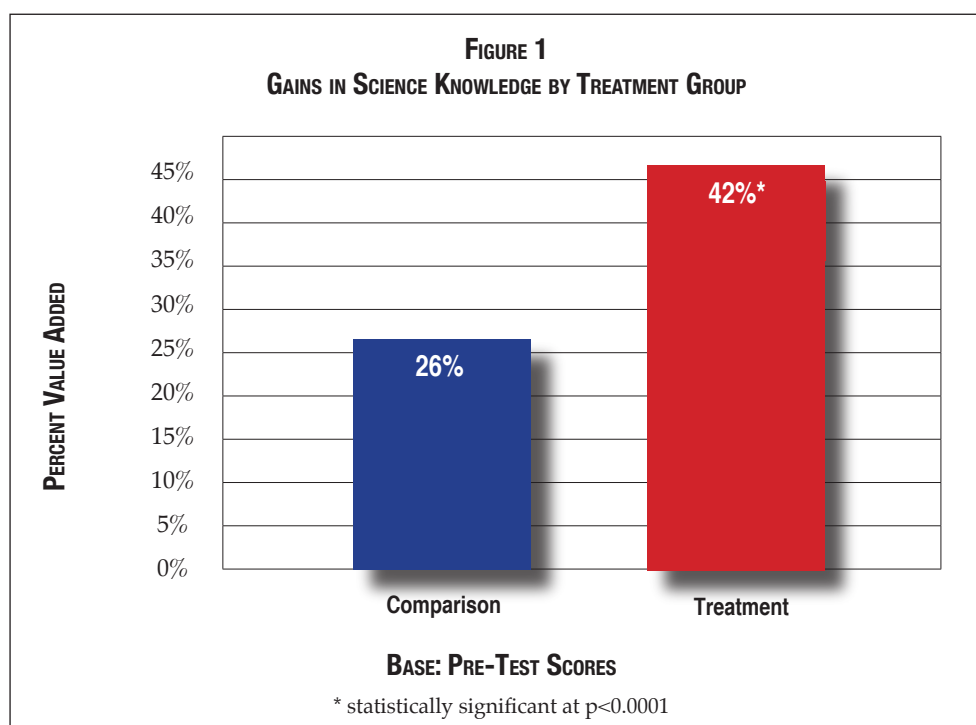
**Pre- and Post-Tests:** Weekly tests administered before and after each module which measured gains in student content knowledge. Tests consisted of 20-33 items each, with about half from *MWM* and about half from the Pearson Prentice Hall text. The resulting combined tests had a respectably high estimated reliability of .93 (coefficient alpha).

**Pre- and Post-Institute Student Surveys:** The survey instruments captured the students' self-assessed changes in the following: 1) their attitudes toward science and careers; 2) their science skills; 3) their team-work skills; and 4) their ability to use scientific inquiry to problem solve in the classroom before and after the Institute.

**Teacher Post-Module Surveys:** The Control and Treatment teachers provided weekly information on their perceptions of changes in the students' attitudes, science and inquiry skills and ability to problem solve in the classroom.

## Results

The evaluation of the Summer Institute measured the cognitive and attitudinal gains of a randomly selected, small, yet diverse sample of students in a controlled environment. The objectives were 1) to assess the potential benefits of *MWM* relative to traditional classroom instruction, and 2) to prepare for a full-scale evaluation that will measure additional variables. With this qualification in mind, the following preliminary findings stand out:



## Students' Science Knowledge Gains

### Control versus Treatment

Summer science immersion programs produce noteworthy gains for all students, but ***MWM* students made significantly larger knowledge gains than those in the Comparison Group for the same time investment.** (Figure 1, previous page).

Due to the two-tiered randomized selection process, Control and Treatment students achieved the same average scores on the baseline pre-tests. By the end of the Institute, Treatment and Comparison students both made appreciable gains in science knowledge. However, the Treatment Group improved their pre- to post-test science knowledge scores by an average 42% Percent Value Added relative to the Comparison Group, which averaged a 26% gain.

**This result represents a statistically significant ( $p < 0.0001$ ) difference, suggesting a strong probability that the treatment (*MWM*) was more effective than traditional classroom approaches in helping students learn more science.**

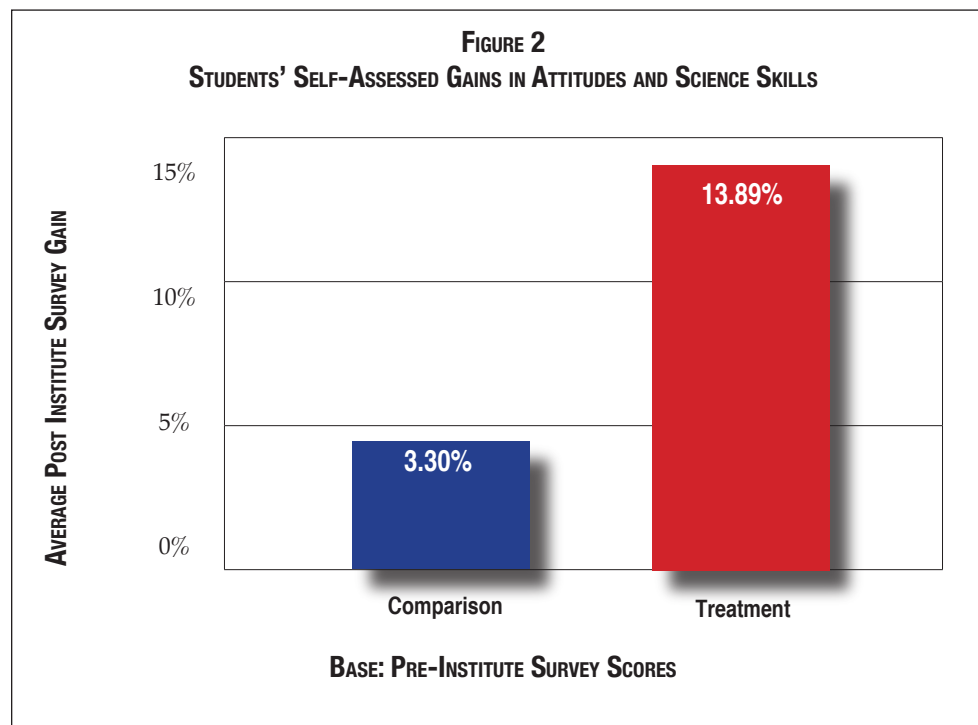
### Demographic Groups

The gains of the Treatment Group students varied across demographic groups.

Both girls and boys taught with *MWM* out performed their Comparison Group peers, with **Treatment girls gaining an average of twice as much science knowledge as Control Group girls.**

White students achieved a 44% Percent Value Added compared to their Comparison Group counterparts' 27% gains in science knowledge. **Non-White Treatment students (37%) out-gained the Comparison Group Non-White students (25%) as well as the Comparison White students (27%).**

**Both middle and high school Treatment students (41% respectively) out performed the Comparison Group middle and high school students (29%, 31% respectively).**



### Student-Reported Attitudinal Changes

Treatment and Comparison students entered the Summer Institute with similar self-assessed attitudes toward science as well as similar science skills. Due to the two-tiered randomized selection process, a pre-Institute battery of more than 50 items produced virtually the same



average results for Treatment and Comparison students.

The items measured students' self-assessed favorability toward science study and career aspirations, use of inquiry and problem-solving, and teamwork skills.

**After receiving the same amount of instruction, Treatment students learning with MWM reported more improvement in their attitudes toward science and in science skills than did Comparison students over the course of the Institute.**

The two Groups' average positive change (13.89 - Treatment vs. 3.30 - Comparison) approaches a level of statistical significance ( $p < 0.07$ ) (Figure 2, previous page).

**Table 1: Students' Perceived Gains in Attitudes and Science Skills-Selected Items**

<i>Attitudes, Skills, Behaviors</i>	<i>Comparison</i>	<i>Treatment</i>	<i>t-test</i>
<b>Attitudes towards Science Scale</b>	<b>0.25</b>	<b>2.45</b>	<b>0.12</b>
Science classes are interesting.	-0.28	0.24	0.02
Laboratory science is boring.	0.30	-0.18	0.04
I enjoy doing science experiments.	-0.08	0.34	0.04
<b>Inquiry Skills and Problem Solving Scale</b>	<b>0.80</b>	<b>3.68</b>	<b>0.05</b>
My teacher asks questions to stimulate me to come up with my own answers.	-0.13	0.50	0.01
Science classes encourage me to discuss my ideas.	-0.08	0.45	0.05
I develop scientific explanations following rules of logic and evidence.	-0.20	0.29	0.03
I provide alternate explanations to solve a problem.	-0.18	0.21	0.06
I apply concepts/ideas I've learned in real-world design problems	0.08	0.63	0.03
I design useful things in science class.	0.13	0.55	0.04
Design a test of the product/project or lab	0.15	0.61	0.07
<b>Team Skills and Personal Improvement Scale</b>	<b>-0.65</b>	<b>0.74</b>	<b>0.07</b>
Be more inquisitive	-0.35	0.08	0.04
Be more self-reliant and take charge of my own learning	-0.05	0.32	0.06
<b>Total Scale (53 items)</b>	<b>3.30</b>	<b>13.89</b>	<b>0.07</b>

## Conclusion

Since the evaluation results from the Summer Institute are based on a small test sample, the findings will be evaluated and validated with larger student samples taught in standard school-year educational environments between 2007 and 2009 in Maryland. Nonetheless, the findings from the Summer Institute evaluation provide a preliminary indicator of the *Materials World Modules*' potential to positively impact student science learning via inquiry- and design-based instruction. Commencing in 2007, the Department of Defense is funding a pilot program to support the use of inquiry- and design-based instruction through MWM and other instructional materials in the State of Maryland and nationwide.