External Evaluation Final Project Report

Improving the Quality of Arizona Teachers of Physical Sciences and Mathematics

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Excerpts: **physics** **Modeling Workshops teacher and student graphs.**
Also Executive Summary, Introduction to the Project, Program Success reflected in Testimonials, Dissemination, Objectives: Summative Information.
(13 pages; compiled by Jane Jackson in April 2011)
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Final Project Evaluation Report

Year 1	**January 3, 2008 to June 30, 2009**
Year 2	**July 1, 2009 to June 30, 2010**
No-cost Extension	**July 1, 2010 to January 31, 2011**

Executive Summary

From 2008 through 2010, 288 Arizona high school and metro Phoenix middle school teachers of mathematics and the physical sciences (most teaching out-of-field and/or in low SES LEAs) participated in professional development consisting of modeling workshops, other content courses and follow-up sessions intended to improve pedagogy and ultimately to increase students' understanding of mathematics and science content as a result of teachers' better instructional strategies. During the 2008 and 2010 summer sessions, the Arizona teachers were joined by 21 physics and chemistry teachers sent by the Ministry of Education in Singapore specifically to experience modeling instruction.

Testimonials from individuals who participated in the summer sessions and follow-up Saturdays, including those who had been mentored, indicated their high level of satisfaction with the modeling workshops. They noted that students who experience modeling instruction are more engaged in learning and interacting with their peers and the curriculum.

Dissemination of project findings has been accomplished through publication of a journal article, oral presentation at a national conference, newsletter feature and emailing of an annual report to hundreds of educators and state leaders. Other strategies include expansion to other schools and future contacts with the new Arizona Superintendent of Instruction and the district U.S. Representative.

Implementation surveys administered by the Project Director in 2009 and 2010 garnered feedback on content, methods, coordination with other science and/or math colleagues, and the extent to which the modeling workshops enhanced pedagogy and content knowledge. Teachers provided information about their implementation of instructional methods consistent with modeling including modeling discourse. Respondents were very positive about the value of modeling both for students' learning and for improving instruction. Challenges included the time demands of modeling and the need for more support (resources, practice and additional professional development).

In response to a Physics Implementation survey completed in 2009 and 2010, the majority of teachers reported that the Modeling Workshop(s) enhanced their teaching pedagogy at a high level and improved their content knowledge in physics at a high level. A few noted that they had been able to coordinate their physics courses with science and math colleagues so that the courses enhanced each other and students learned more. Teachers also reported the extents to which each of the nine Mechanics units and six components of modeling instruction were implemented.

In response to a Chemistry Implementation survey completed in 2009 and 2010, the majority of teachers reported that the Modeling Workshop(s) enhanced their teaching pedagogy at a high level and improved their content knowledge in chemistry at a high level. A significant number of teachers noted that they had been able to coordinate their physics courses with science colleagues so that the courses enhanced each other and students learned more; a few noted that coordination with math colleagues had been successful. Teachers also reported the extents to which each of the nine Chemistry units and six components of modeling instruction were implemented.

In response to a Physical Science Implementation survey completed in 2009 and 2010, the majority of teachers reported that the Modeling Workshop(s) enhanced their teaching pedagogy at a high level and improved their content knowledge in physical science at a high level. A few noted that they had been able to coordinate their physical science courses with math colleagues so that the courses enhanced each other and students learned more. Teachers also reported the extents to which each of the five units and six components of modeling instruction were implemented.

Continuation of the professional development services has been negatively impacted by fewer funding opportunities. In summer 2010 120 teachers participated in the ASU Modeling Instruction program, choosing from five different Modeling Workshops, an astronomy course, and a Leadership Workshop. In summer 2011 a full set of eight summer courses will be offered, with funding relying on out-of-state enrollees' tuition to pay instructor wages, donations from local companies and counting on 50 tuition exemptions from the College of Liberal Arts and Natural Sciences.

The project's objectives to increase student and teacher content knowledge were met. Students and teachers gained content knowledge based on increases in pretest and posttest mean scores on concept inventories including the *Force Concept Inventory*, *Mechanics Baseline Test*, *Chemical Concepts Inventory*, *Physical Science Concept Inventory*, *Mathematics Concept Inventory*, *Assessment of Basic Chemistry Concepts*, *Conceptual Survey in Electricity and Magnetism*, *Simplified Force Concept Inventory*, *Matter Concept Inventory*, *Diagnostic Electric Circuits Test*, and the *Conceptual Survey in Electricity and Magnetism*.

During fall semester 2009, two Modeling Instruction Mentors mentored sixteen chemistry teachers and four physical science teachers who had expressed interest in being mentored. Mentoring included classroom visits followed by either phone conversations or follow-up visits in which teachers were provided feedback. Teachers evaluated the benefits of being mentored, as well as the performance of individuals who provided mentoring, and indicated high levels of satisfaction.

A retired expert physics and chemistry teacher, Earl Barrett, was hired as a short-term consultant to establish a self-sustaining mechanism in Phoenix Union High School District for education and communication among school principals, assistant principals and teachers who use modeling instruction. The Phoenix Union High School District Science Specialist led a series of educational sessions for principals and assistant principals in the district. The purpose of the training meetings was to show administrators what modeling instruction looked like so when they evaluate teachers they are more aware of what the best practices are in Modeling Instruction. Through this project's work with the school district, administrators were encouraged to help teachers incorporate these practices, specifically, to do labs, utilize modeling best practices and use technology.

Earl Barratt was hired as a short-term consultant during fall semester 2009 to establish a self-sustaining mechanism in Gilbert and Chandler school districts for education and communication among school principals, assistant principals, physics teachers and chemistry teachers who use modeling instruction. He surveyed all the physics teachers in the two districts in November and December 2009. He also surveyed all the physics and chemistry teachers in Deer Valley SD and met with school administrators. Following meetings with district administrators and a study of the survey responses from the physics and chemistry teachers, the consultant noted that teachers using modeling to reform pedagogy need the support and encouragement of the district administration, that the mid-year assessment of student performance did not align with the modeling sequence in chemistry and that this situation needs to be addressed. Mr. Barrett recommended a dialogue with modeling leaders dealing with this issue and the lack of equipment needed to fully employ Modeling Instruction.

Follow-up Saturday workshops provided teachers with an opportunity for ongoing professional development. They included teachers with modeling skills and modeling instruction novices. The RTOP or RTOP assessment materials was an important component of each workshop, and the external evaluator observed that "It would make sense for the RTOP to be introduced during the summer professional development sessions so that teachers understand that it is an important component of implementing modeling."

Introduction to the Project

The project's goal was to provide professional development in modeling instruction to 75 Arizona high school and metro Phoenix middle school teachers of physics, chemistry, physical science, and mathematics, most out-of-field and/or in low SES LEAs, each summer for two years in three-week modeling workshops and other content courses with three full-day follow-up sessions yearly. The project envisioned that through participation in the modeling instruction professional development teachers would become more highly qualified and highly effective. The implementation plan included providing principals an initial training session and continuous involvement in the project.

The anticipated outcomes for teachers included improved pedagogy by incorporating the modeling cycle, inquiry methods, critical and creative thinking, cooperative learning, and sound use of classroom technology. Modeling workshops included thematic strands in scientific modeling, structure of matter, energy, use of computers as scientific tools, and discipline-specific content. Mathematics instruction was integrated through mathematical modeling. The ultimate aim was to increase students' understanding of content through better instructional strategies.

The lead partner LEA was Phoenix Union High School District (PUHSD) and other formal partners were high-need charter schools in metro Phoenix. Informal partners were schools throughout Arizona. Dr. Jane Jackson, Co-Principal Investigator, reported that 54 teachers became Highly Qualified (NCLB) as a result of participating in Modeling Instruction professional development supported by ASU ITQ grants in 2006 -2010 and an additional 16 teachers are still progressing toward becoming Highly Qualified (HQ).

Program Success Reflected in Testimonials

THE MINISTRY OF EDUCATION IN SINGAPORE

In summers 2006, 2007, 2008, and 2010, the Ministry of Education in Singapore sent a total of 21 of their best physics and chemistry teachers here! Since Singapore students have the highest math and science scores in international tests this speaks highly for the quality of Modeling Instruction. Because of the H1N1 flu outbreak, Singapore did not send teachers in 2009. (Dr. Jackson, Co-Principal Investigator)

SUMMER 2008 TEACHERS

Thanks to taking physics modeling course work, I am highly qualified in physics.

I learned a tremendous amount and am all fired up to teach physics this fall!

I learned more about teaching and physics this summer than in 5 years of college!

I LOVE this program!

It was, without a doubt, the single greatest professional development experience of my career.

SUMMER 2009 TEACHERS

This year, my school (three teachers in eight sections of regular and three sections of honors physics) implemented CASTLE for studying electrical circuits. Even the average students from other times in the year could discuss the physics of an electrical circuit with more accuracy than AP students who had studied circuits without CASTLE.

Awesome, wonderful program; it helps students to really understand physics.

Great curriculum; our entire chemistry and physics departments are modeling and it's working really well.

Major turnarounds for some students: increased confidence led to 10 student internships in the Future Renewable Electrical Engineering Delivery and Management Program at ASU.

Modeling class prepared me for teaching physical science with confidence.

SUMMER 2010 TEACHERS

I found the Physics II modeling class to be incredibly educational, on both pedagogical and content levels.

Thank you so much for giving AZ teachers the chance to take the modeling classes without charge. I know that I learned a lot, and I can't wait to try to implement as much as possible this coming school year.

Attending the workshops this summer was amazing; and now that I am in the classroom I am so glad that I attended the workshops! I will be coming back for more!

My students seem to be taking to the modeling really well. I am having a lot of fun teaching it.

MENTORED TEACHERS

Our Mentor has been an inspiration in modeling; he has great listening skills and useful suggestions.

His mentoring was extremely useful. Although I have been modeling for a few years it was great to have a fresh pair of eyes in my classroom. He pointed out things which were going well in my classroom which I had previously taken for granted. We talked about how other modeling teachers have taught the same lab in different ways which I found very useful. It was a great experience.

Many thanks to our Mentor; he is a wonderful teacher, and Dr. Jane Jackson is a wonderful organizer of the program.

Our Mentor is awesome.

I thank the Mentor for the encouragement, guidance and support that she gave me throughout the mentorship process.

I highly recommend that our Mentor continue the magic that she brings to our partnership and the benefits that my students gain by engaging in this collegial process.

SCHOOL YEAR SATURDAY FOLLOW-UP WORKSHOPS

I’m so glad I came.

This (January 24, 2009) has been the **best** Saturday meeting.

Modeling exercises keep student highly engaged and excited about the lesson.

Modeling Instruction lets students take control of their work and teach one another; this increases peer-to-peer interaction.

An advantage of Modeling Instruction is that students are challenged to think and figure out concepts. The curriculum is not a "cookbook".

Dissemination

Dr. Jane Jackson, Project Director, wrote the article, ***Arizona State University's preparation of out-of-field physics teachers: MNS summer program***, which was published in the *Journal of Physics Teacher Education Online, 5*(4), summer 2010. This article was part of the dissemination plan in this project's funded proposal, specifically, dissemination to national K-12 physics leaders:

> Results of our work will be disseminated to the Arizona Science Coordinators listserv (120 subscribers), state leaders in K-12 science education, Arizona Department of Education, Arizona K-12 Center, the Governor's P-20 Council Staff and Teachers Committee and national K-12 physics leaders. Dissemination at local and state levels entails expansion to other schools.

In July 2010, Dr. Jackson also gave a ten-minute oral presentation to 65 people on ASU's preparation of out-of-field physics teachers at the American Association of Physics Teachers (Portland, OR). Dr. Jackson also emailed an annual report of the Modeling Program's Arizona's activities to several hundred educators and state leaders in all other categories listed in the project's dissemination plan. (At the time this report was written Dr. Jackson had strategies to inform the new Arizona Superintendent of Instruction and her new district U.S. Representative about the Modeling Program at ASU.)

The Master of Natural Science program was featured in the July 2009 ***Physics Flash*** published by the ASU Department of Physics.

Objective 1 Summative Information

Objective 1: Annually 75 Arizona teachers (majority in high-need districts) participating in June and July Modeling Workshops and other content courses will improve their physics, chemistry, physical science and/or mathematics content knowledge as demonstrated by concept inventories.

- **Arizona teacher enrollment in ABOR ITQ workshops and courses far exceeded the goal (75 teachers); it totaled 288: 2008 (109 teachers), 2009 (93 teachers) and 2010 (86 teachers)**.
- **In 2008 and 2009, 39% of the ITQ teachers taught in Title 1 schools. In 2010, 52% of the ITQ teachers were from Title 1 schools.**
- **Teachers from rural schools comprised 6% of the ITQ participants in 2008, 11% in 2009 and 12% in 2010.**
- **47 (43%) of the summer 2008 Arizona teachers were not highly qualified in one or more sciences or math that they taught or expected to be assigned in the next three years. Three of the 47 teachers passed the AEPA test in physics in the year after summer 2008.**
- **19% of summer 2009 and 30% of summer 2010 teachers were not highly qualified (NCLB) in a science to which they expected to be assigned.**
- **Teachers participating in this project were from 39 LEAs in 2008, 32 LEAs in 2009 and 35 LEAs in 2010.**
- **This project served teachers from 89 schools in 2008, 70 schools in 2009 and 60 schools in 2010.**
- **In 2008 this project served teachers from 5 parochial schools and 12 charter schools. Teachers from 9 charter schools and 4 parochial schools participated in 2009, and in 2010 there were teachers in the project from 2 parochial schools and 7 charter schools**
- **College credits earned by teachers in this project were: 318 credits (2008), 214 credits (2009) and 198 credits (2010).**
- **In summer 2009 there were six participants from five new high-risk LEAs: Camp Verde UD, Chinle UD, Glendale ESD, San Carlos UD (2 teachers) and Santa Cruz UD.**
- **Teachers demonstrated increases in science content knowledge as demonstrated by gains from pretest to posttest on the *Force Concept Inventory*, *Mechanics Baseline Test*, *Chemical Concepts Inventory*, *Physical Science Concept Inventory*, *Mathematics Concept Inventory*, *Assessment of Basic Chemistry Concepts*, *Conceptual Survey in Electricity and Magnetism*, *Simplified Force Concept Inventory*, *Matter Concept Inventory*, *Diagnostic Electric Circuits Test*, and the *Conceptual Survey in Electricity and Magnetism*.**

PRE/POST TESTING RESULTS FOR SUMMER 2008 TEACHERS

Charts of pre/post test results for Arizona teachers who participated in this project's Modeling Instruction professional development in 2008 are displayed in Appendix C. The five tests were designed, administered, data analyzed and charts created by the ASU Modeling Instruction Office (Dr. Jane Jackson and Dr. Sharon Osborn Popp). The maximum possible score on each of the five tests was 100. Descriptive statistics for each of these assessments are displayed in descending order of pretest to posttest gain in the following table. The largest mean gain from pretest to posttest was on the Force Concept Inventory.

Table: Pretest and posttest results on five assessments for summer 2008 teachers

	N	Pretest mean	Posttest Mean	Gain
Force Concept Inventory	18	74	86	12
Mechanics Baseline Test	19	58	69	11
Chemical Concepts Inventory	22	71	78	7
Physical Science Concept Inventory	18	78	84	6
Mathematics Concept Inventory	19	83	86	3

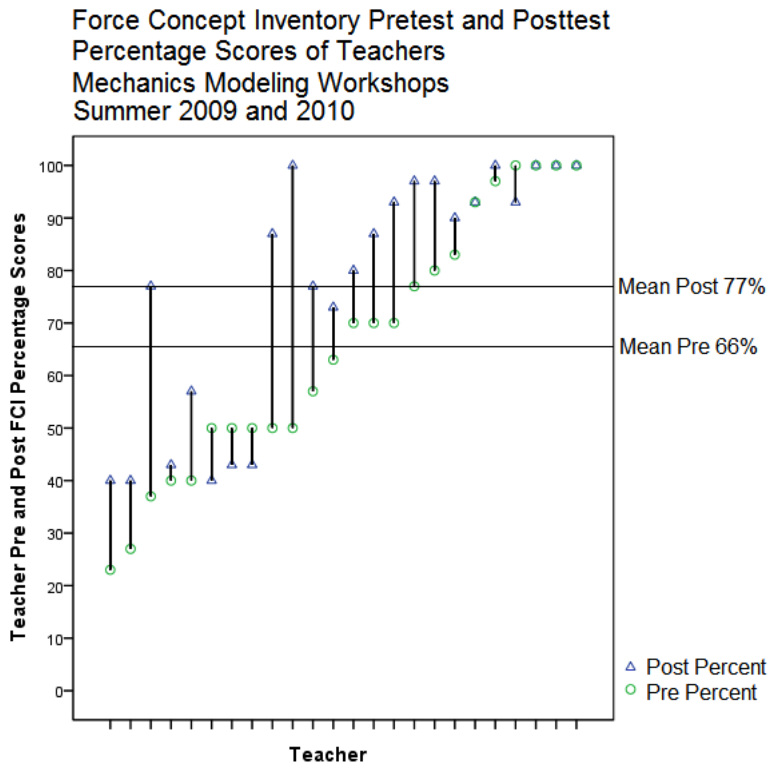
PRE/POST TESTING RESULTS FOR SUMMER 2009 AND SUMMER 2010 TEACHERS

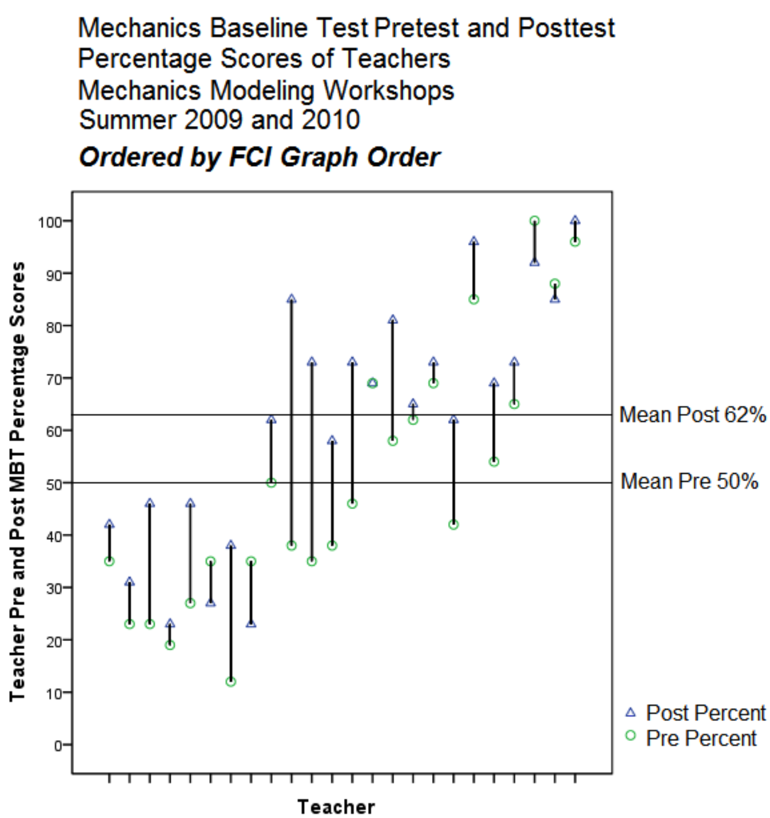
Charts of pre/post test results for Arizona teacher-participants in summer 2009 and summer 2010 Modeling Instruction workshops were provided by the ASU Modeling Instruction Office (Dr. Jane Jackson and Dr. Sharon Osborn Popp). These charts are displayed in this section.

Pre and post assessment results on 9 assessments were reported for 168 teachers who participated in the project's workshops in the summer of 2009 (with one chart displaying 2007 and 2009 combined) and/or the summer of 2010. The *Mechanics Baseline Test* pretest and posttest mean scores were higher for summer 2008 teachers than for summer 2009 teachers. The gains in mean scores from pre to post were nearly identical: 11 points (from 58 to 69) for summer 2008 teachers and 12 points (from 50 to 62) for summer 2009 teachers.

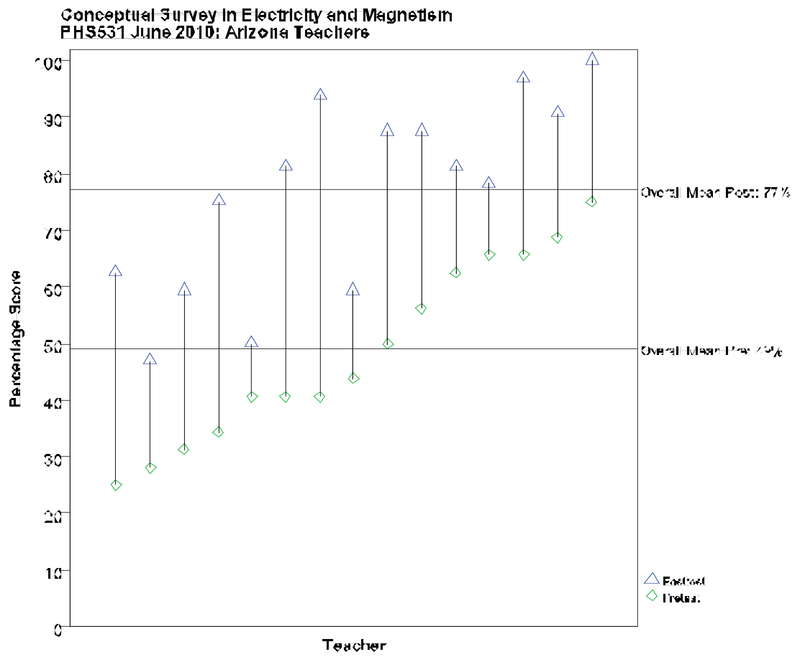
Force Concept Inventory pretest and posttest mean scores were also higher for summer 2008 teachers than for summer 2009 teachers. The gains in mean scores were similar to those on the *Mechanics Baseline Test*: From pre to post 12 points (from 74 to 86) for summer 2008 teachers and 11 points (from 66 to 77) for summer 2009 teachers.

The correlation between *Mechanics Baseline Test* scores and *Force Concept Inventory* was computed by Dr. Sharon-Popp ($R^2 = 0.81$). This is a high correlation ($R = 0.90$). Additional analysis of these test scores by Dr. Jackson is included in Appendix D.

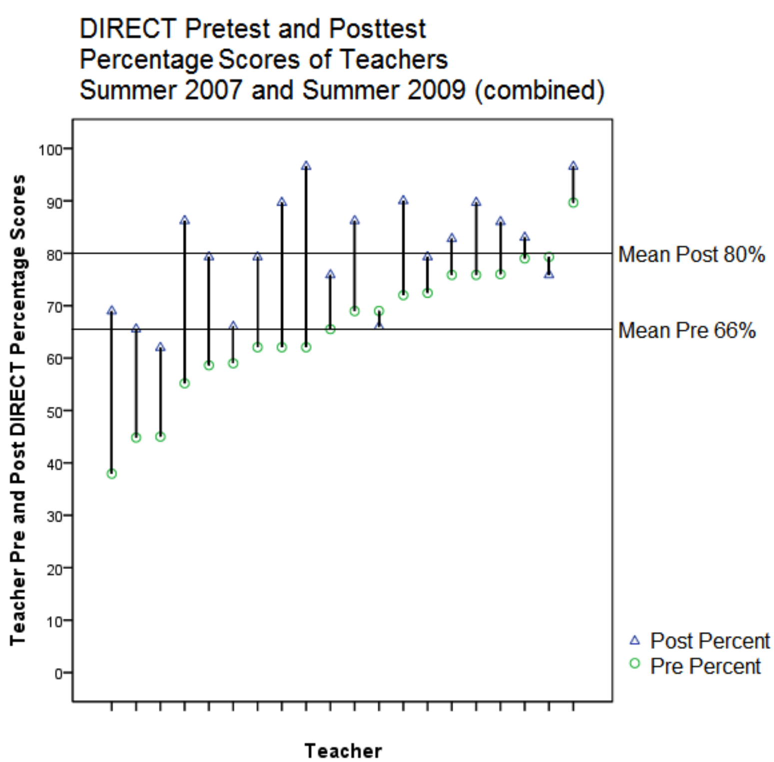

Force Concept Inventory Pretest and Posttest
Percentage Scores of Teachers
Mechanics Modeling Workshops
Summer 2009 and 2010
Teacher Pre and Post FCI Percentage Scores
100
90
80
70
60
50
40
30
20
10
0
Mean Post 77%
Mean Pre 66%
Post Percent
Pre Percent
Teacher


Mechanics Baseline Test Pretest and Posttest
Percentage Scores of Teachers
Mechanics Modeling Workshops
Summer 2009 and 2010
Ordered by FCI Graph Order
Teacher Pre and Post MBT Percentage Scores
100
90
80
70
60
50
40
30
20
10
0
Mean Post 62%
Mean Pre 50%
Post Percent
Pre Percent
Teacher

The following chart displays results for 15 Arizona physics teachers in the 2nd Modeling Workshop: PHS 531 (microscopic models of electricity & magnetism). The posttest mean score (77%) was substantially greater than the pretest mean score (49%). This chart was provided by Dr. Jackson.



The following chart displays results for 20 Arizona teachers in the 2nd Modeling Workshop: PHS 594 (modeling-adapted CASTLE electricity: circuit electricity).



Objective 2 Summative Information

Objective 2: Teachers who participate in June and July Modeling Workshops and other courses will improve STEM instructional strategies including effective classroom discourse management and content organization.

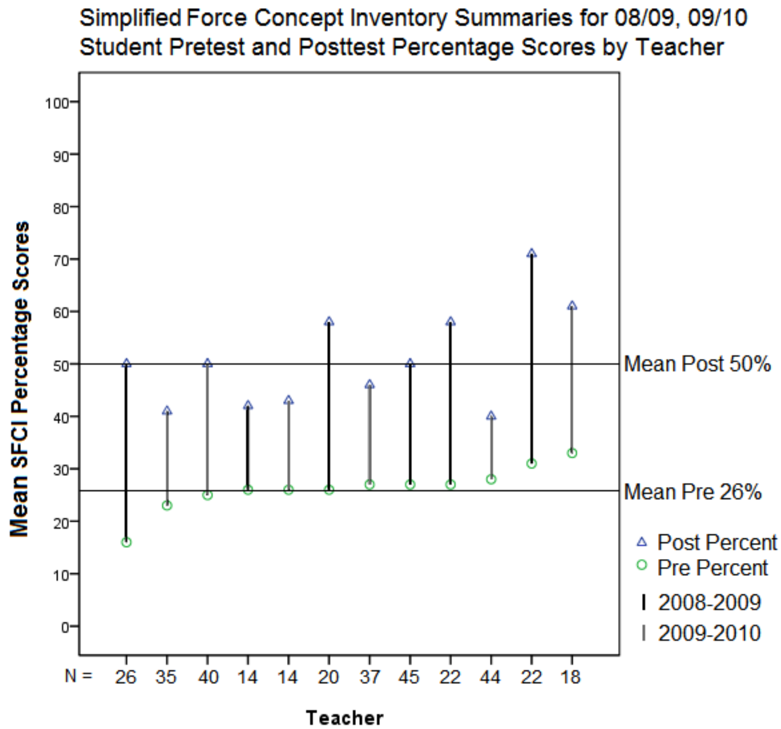
- **At the end of the school year after their summer participation, 80-92% of physics and chemistry teachers and 72-75% of physical science teachers reported that the Modeling Workshops enhanced their teaching pedagogy.**
- **Physics teachers implemented the "Particle Moving with Constant Velocity" unit at the highest level.**
- **Chemistry teachers implemented more modeling units at higher levels than did physics and physical science teachers.**
- **Physical Science teachers implemented the modeling unit, "Force, Newton's Laws" at higher levels in both 2008-09 and 2009-10 than other units. A close second in implementation was the unit, "Modeling physical properties of matter: density".**
- **Socratic questioning and cooperative groups were implemented at higher levels by participating teachers than were circle-white-boarding, white-boarding and modeling discourse.**
- **Higher percentages of 2009-10 than 2008-09 physics, chemistry and physical science teachers reported substantially higher levels of coordination of their science courses with science and mathematics colleagues so that the courses enhanced each other. The intent of this collaboration is to improve student learning.**

Objective 3 Summative Information

Objective 3: Students in classrooms of participating teachers who implement Modeling Instruction will demonstrate pre/post content gains.

- **Although some teachers administered both pre and post tests to their students most teachers administered a pretest but not a posttest. Even so, matched pre and post test data were collected, analyzed and summarized for 685 students.**
- **The Simplified Force Concept Inventory was administered pre and post in 2008-09 and 2009-10 to 337 matched students. Mean scores increased substantially from pre (26) to post (50).**
- **The Assessment of Basic Chemistry Concepts was administered both pre and post to 348 matched students in 2009-10. The pretest mean score was 36 and the posttest mean score was 48, an average gain of 12 points.**

The following chart of student results on the Simplified Force Concept Inventory was provided by Dr. Sharon Osborn Popp, with the note: Preliminary research on 337 students from grades 11 and 12 with the FCI and SFCI indicates comparability between scores on the FCI and SFCI (i.e., the simplified language of the SFCI does not provide an unfair advantage, but may be an appropriate accommodation for younger students and/or students with limited English proficiency).[1] These 337 students were taught by 12 teachers. The mean pretest score was 26 and the mean posttest score was 50.



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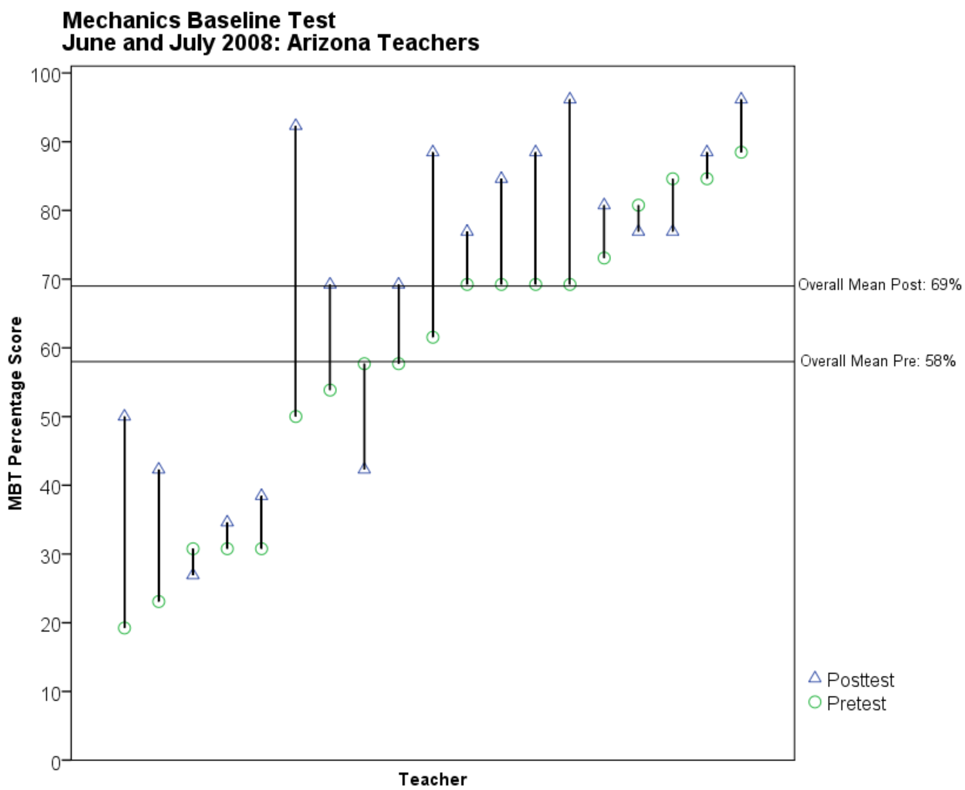
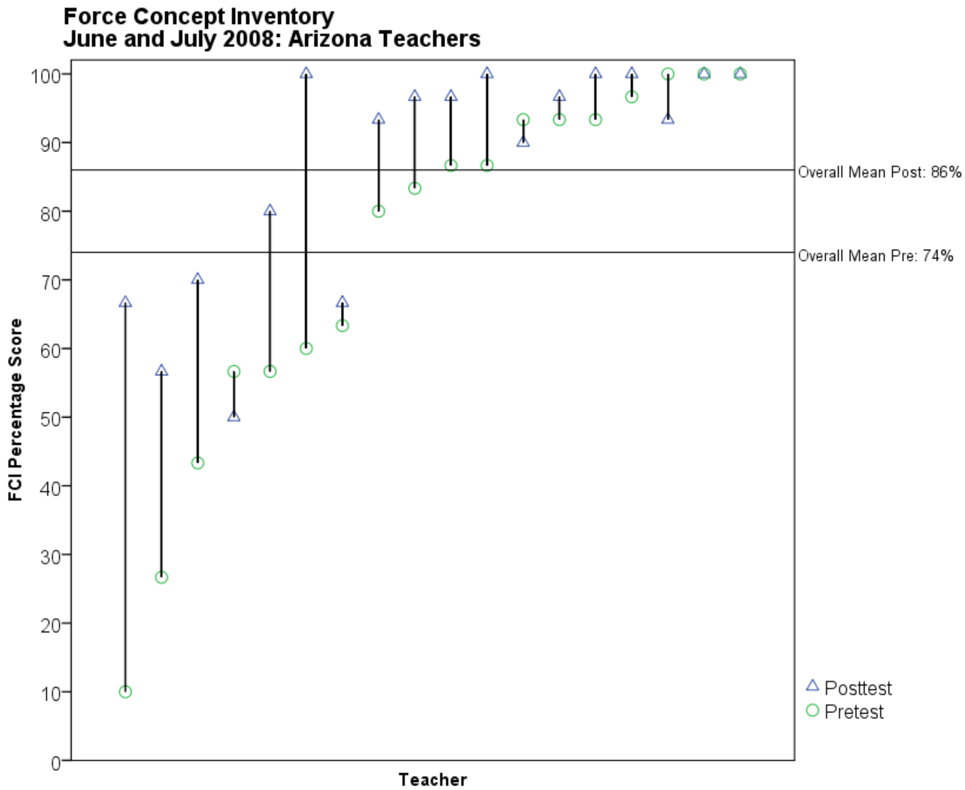
[1] Osborn Popp, S. E., & Jackson, J. C. (2009, April). Can assessment of student conceptions of force be enhanced through linguistic simplification? A Rasch model common person equating of the Force Concept Inventory (FCI) and the Simplified Force Concept Inventory (SFCI). Paper presented at the Annual Meeting of the American Educational Research Association in San Diego, CA.

Appendix C: Pre/post test results for summer 2008 teachers

These results were presented in previous evaluation reports. They are included in this appendix because of their value in documenting the increases in content knowledge of teachers who participated in the ASU ABOR ITQ Modeling Instruction courses and workshops.

Mechanics Baseline Test
Force Concept Inventory
Mathematics Concept Inventory
Physical Science Concept Inventory
Chemical Concept Inventory




Force Concept Inventory
June and July 2008: Arizona Teachers
FCI Percentage Score
Teacher
Overall Mean Post: 86%
Overall Mean Pre: 74%
Posttest
Pretest
0
10
20
30
40
50
60
70
80
90
100