A Summary of Research on the TEEMSS II Project

by

Andrew A. Zucker
Robert Tinker
Amie Mansfield
Shari Metcalf
Carolyn Staudt

April 2007

NSF Grant No. 0352522
CC Project No. 34

The Concord Consortium
25 Love Lane
Concord, MA 01742

This paper summarizes research conducted as part of the Technology Enhanced Elementary and Secondary Science II project (TEEMSS) at the Concord Consortium. TEEMSS created, disseminated, and conducted research on fifteen technology-based science units for students in grades 3 to 8 (described at teemss.concord.org/curriculum/). TEEMSS also developed teacher supports, evaluated the effectiveness of the units, and disseminated them widely.

TEEMSS developed universal probeware software technology, called SensorPortfolio, which permits schools to use TEEMSS materials with computers running Windows, the Mac OS, or handheld computers, and with probes from any vendor. SensorPortfolio is the application in which the curriculum and probeware components are presented. In addition, SensorPortfolio is the software used for creation, storage, and retrieval of student work.

TEEMS Materials Were Tested Extensively

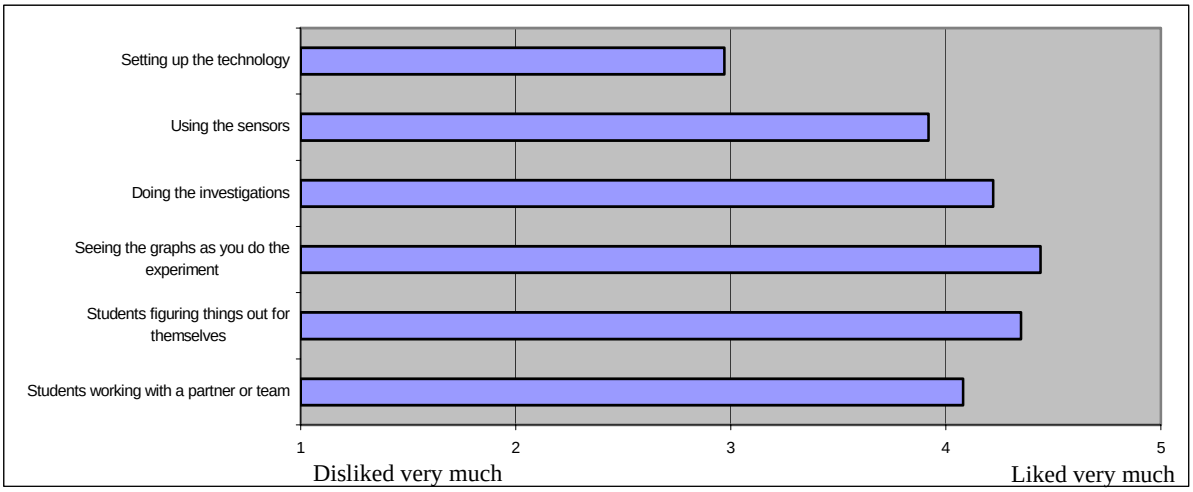
Nearly 70 teachers, located in 18 school districts in three states, worked with the project. Teachers used TEEMSS units in 2004-05, 2005-06, and 2006-07. School year 2005-06 was the year in which the largest numbers of teachers and students used TEEMSS as part of the project, providing pre- and post-test data on the TEEMSS unit tests; participants that year included 24 grade 3-4 teachers teaching 437 students; 10 grade 5-6 teachers teaching 386 students; and, 8 grade 7-8 teachers teaching 360 students.

Data were also collected in 2004-2005 from 21 teachers who taught the same topics as many of the TEEMS units, but without using the TEEMSS materials, including the probes and computers. Data from these classes provided a non-TEEMSS comparison group.

Teachers' and Students' Opinions of TEEMSS were Positive

Teachers' rated features of the TEEMSS materials on a scale of 1 to 5, where 1 means "disliked very much," and 5 means "liked very much." Teachers liked nearly everything about the TEEMSS materials; almost all features rated higher than 4. Examples of teachers' ratings are shown in Figure ES-1.

Figure ES-1
Teachers' Ratings of Selected TEEMSS Features



Teachers also reported that the TEEMSS units are at about the right difficulty level for students. On a scale where 1 means "much too easy," 3 means "just right," and 5 means "much too hard," the average for all TEEMSS units was 3.3.

Teachers agreed that the computers and sensors were "easy to use once we've learned to use it." The teacher rating was 4.1 on a 5-point scale that ranges from 1 ("disagree strongly") to 5 ("agree strongly"). After TEEMSS, teachers said they were more likely to use technology.

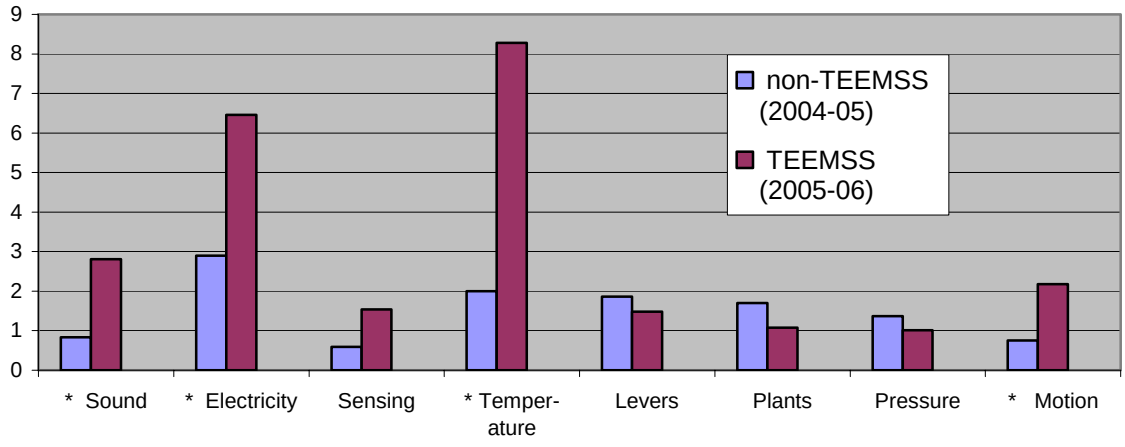
Students also reported that they liked using the TEEMSS materials. The highest ratings of different features of TEEMSS were given to using computers, designing their own experiments, and working with a partner or team.

The TEEMSS Units Were Effective for Teaching Science

Students' scores from pre-test to post-test increased by statistically significant amounts on all twelve TEEMSS units with pre- and post-test scores. (There were no pre- and post-tests for the three design units.)

A variety of comparisons were made between learning particular science units either with the TEEMSS materials or without them (as usual). In the most tightly controlled comparison, groups of teachers taught eight of the unit topics without TEEMSS one year and then the same teachers taught those topics with TEEMSS the following year. We found significant differences favoring the TEEMSS students for four of the eight units (Sound, grades 3-4; Electricity, grades 3-4; Temperature, grades 5-6; and Motion, grades 7-8). The effect sizes favoring TEEMSS were 0.58, 0.94, 1.54, and 0.49, respectively.[1] There were no significant differences between TEEMSS and non-TEEMSS students for the other four units (Sensing, Levers and Machines, Plants, and Pressure).[2] These data are shown below in Figure ES-2.

Figure ES-2
Gain Scores for the *Same* Teachers in Successive Years, non-TEEMSS vs. TEEMSS



* indicates statistically significant difference

[1] An effect size of 0.2 standard deviations is considered small, 0.5 standard deviations is medium, and an effect size of 0.8 standard deviations is considered large.

[2] Comparison data are not available for Weather, Seasons, Adaptation, and Water Cycle, as well as for the three design units.

Conclusions

Findings from research on TEEMSS units are consistent with prior research about the use of technology in science education and are also a useful contribution to the knowledge base about probeware. Many prior research studies have reported positive impacts of using digital technology. Notably, a meta-analysis of 42 studies of computer-assisted instruction (CAI) in science education, yielding 108 effect sizes, found an average effect size of 0.27 standard deviations, which means that "a typical student moved from the 50th percentile to the 62nd percentile in science when CAI was used."[3] That meta-analysis (2001) specifically noted that simulations and tutorials in science were more effective than drill-and-practice.

There are a limited number of earlier studies of the use of probeware in elementary and middle schools. What research does exist has often been done with small numbers of students. For example, one recent study of probeware (also called microcomputer-based labs, or MBLs) that reported significant positive impacts favoring the use of probes was based on a sample of only 65 fourth-grade students.[4]

The TEEMSS study is also noteworthy because the effect sizes reported here are larger than in most prior studies of the impacts of technology in science education. The effect size of 0.27 reported in the 2001 meta-analysis, for example, is considered small. For the four TEEMSS units on which statistically significant differences favored TEEMSS students, two of the effect sizes are medium in size and two are large.[5]

TEEMSS units making use of probeware and computers result in significant student achievement gains, and the teachers and students reported that they liked using the units and the technology. As computers become more common in schools than ever before, with entire states (including Maine and Pennsylvania) adopting "one-to-one" laptop programs for students, the smart use of technology will enhance the teaching and learning of science.

---

[3] Bayraktar, S. (2001). A meta-analysis of the effectiveness of computer-assisted instruction in science education. *Journal of Research on Technology in Education, 34*(2), 173-188.

[4] Nicolaou, C., Nicolaidou, I., Zacharia, Z., & Constantinou, C. (2007). Fourth graders ability to interpret graphical representations through the use of microcomputer-based labs implemented within an inquiry-based activity sequence. *Journal of Computers in Mathematics and Science Teaching,* 26(1), 75-99.

[5] An effect size of 0.94, for instance, means that a typical student in the experimental group performs at the 83rd percentile of the comparison group.