Curriculum Research
& Development Group

Developmental Approaches in Science, Health and Technology

A Summary of Evaluations

2001

University of Hawai‘i at Mänoa

Published by the Curriculum Research & Development Group

Distributed by the *DASH* Project
Curriculum Research & Development Group
University of Hawai‘i
1776 University Ave
Honolulu, Hawai‘i 96822

DEVELOPMENTAL APPROACHES IN SCIENCE, HEALTH AND TECHNOLOGY

A SUMMARY OF EVALUATIONS

PROGRAM DESCRIPTION

Developmental Approaches in Science, Health and Technology (DASH) is a comprehensive K–6 program that weaves together science, health, and technology. It reaches the spectrum of learners in typical classrooms through 650-plus interconnected, developmentally appropriate, hands-on activities that align with national standards.

The goal of *DASH* is to capture the imagination of elementary students by engaging them in questioning and making sense of things unknown, inventing and building to solve problems, and caring for themselves through their experiences in learning science, health, and technology. To accomplish this goal, *DASH* activities at each grade level are organized into ten content clusters: Learning; Time, Weather, and Sky; Animals; Plants; Food and Nutrition; Health and Safety; Wayfinding and Transportation; Energy and Communication; Conservation, Recycling, and Decomposition; and Matter, Space, and Construction. Content is sequential and spiraled to promote reinforcing, multi-year development of concepts and skills. Students work inside and outside the classroom as a research community, modeling real-world roles of scientists and technologists. The teacher acts as research team leader. Assessment is integrated into instruction; each activity has a portfolio-building product; each grade level has a concept-and-skill inventory for student self-assessment. *DASH* articulates well with language arts, mathematics, social studies, physical education, and the arts. *DASH* is used by over 12,000 teachers in 26 states. *DASH* teachers are supported by a network of 14 universities and a cadre of 175 teacher instructors. DASH has earned the following recognitions:

- one of seven programs designated as promising by the U.S. Department of Education's Expert Panel on Mathematics and Science Education (2001)
- described as a curriculum package with a strong assessment component in *ENC Focus: A Magazine for Classroom Innovators* (2000).
- cited as an innovative curricula by the Eisenhower National Clearinghouse *in ENC Focus: A Magazine for Classroom Innovators* (1999).
- cited as an example of high-quality intensive technical assistance in the U.S. Department of Education's report to Congress titled *Federal Education Legislation Enacted in 1994: An Evaluation of Implementation and Impact* (1999).

- selected and featured as one of eight school programs that offer solid proof of their success in the classroom by *Parent's Magazine* (1998).
- identified as an effective program in School Health: Findings from Evaluated Programs, a collaborative publication of the American School Health Association and the U.S. Department Health and Human Services (1998).
- identified as one of three research-based, effective science "skill and content" reform models in a nationwide search by the Northwest Regional Educational Laboratory for the U.S. Department of Education's *Catalog of School Reform Models* (1998).
- identified as one of five effective science programs in *Results Based Practices Showcase 1997–1998* (1997), a nationwide search by the Kentucky Department of Education.
- featured as an active learning with hands-on resources in *ENC Focus for Mathematics and Science Education* (1995).
- described in *Promising Practices in Mathematics and Science Education*, published by the U.S. Department of Education, as addressing Goals 2000 and meeting the new standards in science education (1994).
- recognized as an exemplary program by the National Diffusion Network (1993)
- validated as an effective program by the Program Effectiveness Panel (PEP) of the U.S. Department of Education (1993).

The remainder of this document describes each program evaluation in reverse chronological order.

For further information contact

***DASH* Project**
Curriculum Research & Development Group
University of Hawai'i
1776 University Ave.
Honolulu, HI 96822
Phone: 800-799-8111 **Fax: 808-956-6730**
Email: crdg@hawaii.edu **URL: www.hawaii.edu/crdg**

EXPERT PANEL ON MATHEMTICS AND SCIENCE EDUCATION PROMISING PRACTICE (2001)

The Educational Research, Development, Dissemination and Improvement Act of 1994 established panels of appropriate qualified experts and practitioners to evaluate educational programs and recommend to the U.S. Secretary of Education those programs that should be designated as promising or exemplary. The Expert Pane on Mathematics and Science Education is the first of those panels. It is the purpose of the Expert Panel to oversee a valid and viable process for identifying and designating promising and exemplary programs in mathematics and science so that practitioners can make better-informed decisions in their ongoing efforts to improve the quality of student learning. Programs submitted for review are evaluated on criteria that fall in three categories: (1) Quality of the Program; (2) Usefulness to Others; and (3) Educational Significance. Programs that satisfy criteria under these categories are then reviewed by an Impact Review Panel on criteria in a fourth category, Evidence of Effectiveness and Success. Promising programs are those that satisfy the first three criteria and provide preliminary evidence of effectiveness in one or more sites.

In January 2001 the Expert Panel completed its review of 27 programs submitted for review and recommended to the Secretary of Education that seven programs, including *DASH*, be designated as promising. Field reviewers were drawn from a nationwide pool of educators with backgrounds in science programs and asked to identify their area of expertise. There were matched with submittals in those areas. In addition to specialty area expertise, factors such as grade level experience were weighted in determining which candidates were selected as reviewers. Almost 100 teachers and other researchers and practitioners with expertise in science were trained for three days in the review process.

Each science program submitted to the panel was evaluated by at least two field-based teams with two members each; a total of four individuals reviewing each submission. These teams reviewed the quality of the program, its usefulness to others, and its educational significance based on materials submitted. Programs that received high ratings from this procedure were then reviewed by program evaluation experts who assessed the quality of the evaluation data and the claims of effectiveness made by the submitters. The full Expert Panel then reviewed all the programs, along with the ratings and comments of the review teams, to determine which programs to recommend to the Secretary of Education as exemplary or promising. Following are the Panel's findings for *DASH*.

Program Quality. Reviewers and evaluators found the program's goals to be exceptionally clear, easy to follow, developmentally appropriate, and based on time-honored research in science and mathematics. The content is challenging, and it aligns with learning goals. The program provides excellent opportunities for students to grow in science inquiry and develops in-depth content knowledge. The cluster format and spiral approach to learning are significant because they give students important scientific concepts for a knowledge foundation and a formidable beginning for future learning. Students are guided through exploration, application, generalizations, and explanations as they work through year-long and multi-year activities. Reviewers noted that *DASH* is exceptionally focused on an instructional design that encourages all students and promotes an environment that is appropriate, engaging, and motivating. The student's role as scientist is defined in each lesson, and the connection made to everyday occupations gives students a rationale for learning the material. *DASH*'s attention to pedagogy, sequencing activities, building on prior experiences, valuing students' prior work and products, and clear guides to facilitating discussions and building questioning skills—all these are outstanding. The program's assessment system is based on the premise that there are a variety of learning styles and ways to assess those styles. The assessment system promotes strong teacher-student dialogue and trust for the instructional program.

Usefulness to Others. Reviewers concluded that the program's low cost and clear instructional plan, combined with support materials for each cluster, make it accessible to most K–6 classes. Training is offered throughout the country and can be conducted in local school districts. No special facilities or materials are required, and lessons are clear and easy to implement.

Educational Significance. Reviewers noted that the program's pedagogy and assessment align with national standards. *DASH* manuals clearly display the correlation of the national standards with specific program activities. The program addresses important individual and societal needs through its broad base of gender- and ethnic-free activities; long-term, multi-year approach to building depth and breadth of learning; focus on both in- and out-of-school issues; attention to societal issues such as health protection and environmental needs; and accommodation for diverse learning styles.

Program Effectiveness and Success. Reviewers found that *DASH* provides evidence that students in grades K–5 at five sites (14 case studies) demonstrated an understanding of fundamental science concepts and the use of essential skills, such as inquiry and data-gathering techniques, along with integration and application of science concepts. The main evidence was provided through a well-designed, -conceptualized, and -implemented multiple-case study evaluation. Program claims were supported through the case study methodology by triangulation of data from many sources, including observations, artifacts, documents, and interviews. The program provided some limited data on students' achievement in the form of comparisons of (a) standardized test score data for

DASH students with state and district data and (b) pre- and post-test *DASH* test scores in one district.

Evidence showed change in teachers' attitudes about science and approaches to teaching elementary science. Other evidence demonstrated that teachers' participation in *DASH* professional development strategies increased their knowledge and use of standards-based instructional strategies in elementary science.

STANDARDS–BASED TEACHER EDUCATION THROUGH PARTNERSHIPS (1994–1998)

In 1994 the Curriculum Research & Development Group (CRDG) succeeded in competing for funds from the U.S. Department of Education for the Standards-based Teacher Education through Partnership (STEP) project in the Fund for Improving Education (FIE) program. Recognizing that teachers are key to achieving the national science education standards, STEP used research-based, incremental professional development to assist over 3,400 teachers reach that goal, using *DASH*. CRDG and its project partners—Carnegie Mellon University, East Carolina University, Florida Atlantic University, Illinois State University, Louisiana State University, Miami University of Ohio, Michigan State University, Middle Tennessee State University, Pacific Lutheran University, University of Mississippi, University of Missouri at St. Louis, University of North Alabama, University of Vermont, and the Catholic Archdiocese of St. Louis, in collaboration with the schools in their service regions—created STEP to empower teachers to lead in the standards-based movement. *DASH* was the program used to achieve STEP goals at the elementary-school level. The following impact data were collected in evaluating STEP.

ADDRESSING NSES PROFESSIONAL DEVELOPMENT STANDARDS

The National Science Education Standards (NSES) published in December 1995 include six sets of standards, one set each for teaching, assessment, professional development, content, programs, and systems. The professional development standards for science education were an excellent match with STEP objectives. The evaluation team created a 21-item observation instrument based on the NSES set for professional development standards. External evaluators observed teaching for two full-day sessions in two different *DASH* institutes in summer 1996, using four categories to rank the observations. Table 1 shows the working definitions of each category.

Table 1. Rankings and definitions for the “Observation of STEP Institutes” instrument

Ranking Category	Working Definition
Observed: Clear Focus	This ranking denotes that the element was observed by the evaluator. The instructor clearly focused on the element, either by addressing it at several different points in the observed presentation or by an extended discussion or demonstration of the element at a single point. The essential content, point, or purpose of the element was thoroughly communicated to participants.
Observed: Adequately Addressed	This ranking denotes that the element was observed by the evaluator. The instructor addressed the element at some point in the observed presentation. The essential content, point, or purpose of the element was communicated to participants.
Observed: Somewhat Addressed	This ranking denotes that an element was observed by the evaluator. The instructor addressed the element at some point in the observed presentation. A part of the essential content, point, or purpose of the element was communicated to participants.
Not Observed	This ranking denotes that the element was not observed by the evaluator.

In addition, the evaluator interviewed participants and the instructor to check his observations. He ranked and annotated his rankings for each component of the observation instrument. At the end of the observation, the evaluator asked instructors to rank their perceptions of the degree to which each feature on the instrument had been addressed in the institute, using a 5-point Likert-type scale (with 1 defined as clearly focused on this element and stressed its importance and 5 as did not touch on this feature at all).

Responses from the external evaluator and instructor were converted to percentages that clearly/ somewhat addressed the standards or that did not address the standards across the institutes observed. Table 2 summarizes the findings.

Table 2. Professional development standards addressed in 1996 *DASH* teacher institutes

Standard	***DASH*** **(*n* = 2 institutes)**	
	Clearly/ Somewhat	Not Addressed
Professional Development Standard A. **Science learning experiences for teachers must** A.1 Involve teachers in actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings consistent with currently accepted scientific understanding.	100%	0%
A.2. Address issues, events, problems, or topics significant in science and of interest to participants.	100%	0%
A.3. Introduce teachers to scientific literature, media, and technological resources that expand their science knowledge and their ability to access further knowledge.	100%	0%
A.4. Build on the teacher's current science understanding, ability, and attitudes.	100%	0%
A.5. Incorporate ongoing reflection on the process and outcomes of understanding science through inquiry.	100%	0%
A.6. Encourage and support teachers in efforts to collaborate.	100%	0%
Professional Development Standard B. **Learning experiences for teachers of science must** B.1. Connect and integrate all pertinent aspects of science and science education.	100%	0%
B.2. Occur in a variety of places where effective science teaching can be illustrated and modeled, permitting teachers to struggle with real situations and expand their knowledge and skills in appropriate contexts.	100%	0%
B. 3 Address teachers' needs as learners and build on their current knowledge of science content, teaching, and learning.	100%	0%
B.4. Use inquiry, reflection, interpretation of research, modeling, and guided practice to build understanding and skill in science teaching.	100%	0%
Professional Development Standard C. **Professional development activities must** C.1. Provide regular, frequent opportunities for individual and collegial examination and reflection on classroom and institutional practice.	100%	0%
C.2. Provide opportunities for teachers to learn and use various tools and techniques for self-reflection and collegial reflection, such as peer coaching, portfolios, and journals.	100%	0%
C.3. Support the sharing of teacher expertise by preparing and using mentors, teacher advisors, coaches, lead teachers, and resource teachers to provide professional development opportunities.	100%	0%

Table 2. Professional development standards addressed in 1996 *DASH* teacher institutes (*continued*)

Standard	***DASH*** **(*n* = 2 institutes)**	
	Clearly/ Somewhat	Not Addressed
C.4. Provide opportunities to know and have access to existing research and experiential knowledge.	100%	0%
C.5. Provide opportunities to learn and use the skills of research to generate new knowledge about science and the teaching and learning of science.	100%	0%
Professional Development Standard D **Quality preservice and inservice programs are characterized by** D.1. Clear, shared goals based on a vision of science learning, teaching, and teacher development congruent with the NSES.	100%	0%
D.2. Integration and coordination of the program components so that understanding and ability can be built over time, reinforced continuously and practiced in a variety of situations.	100%	0%
D.3. Options that recognize the developmental nature of teacher professional growth and individual and group interests, as well as the needs of teachers who have varying degrees of experience, professional expertise, and proficiency.	100%	0%
D.4. Collaboration among the people involved in the program, including teachers, teacher educators, teacher unions, scientists, administrators, policy makers, members of professional and scientific organizations, parents, and business people, with clear respect for the perspectives and expertise of each.	100%	0%
D.5. Recognition of the history, culture, and organization of the school environment.	100%	0%
D.6. Continuous program assessment that captures the perspectives of all those involved, uses a variety of strategies, focuses on the process and effects of the program, and feeds directly into program improvements and evaluation.	100%	0%

Participants' Evaluations

Every *DASH* institute was assessed for quality using a simple evaluation form that included items addressing (a) specific curriculum content, (b) quality of the workshop, and (c) major professional development standards. The instrument was given to participants to complete the last day of the ten-day institute. They circled responses to each item on a 5-point, Likert-type scale from "strongly agree" to "strongly disagree," subsequently converted to a numerical scale with 1 = strongly disagree, 2 = disagree, 3 = neutral or no opinion, 4 = agree, and 5 = strongly agree. Its intent was to check on the alignment of the activities in the institutes with recommended best practices.

Table 3 summarizes data from 1995 through 1998. Grand means were calculated from the weighted institute means. Numbers of respondents and institutes represented are shown at the bottom of each table.

The data show that the institutes were effective in meeting the professional development standards to a high degree and were consistent from year to year. Ranges of participants' ratings across 107 institutes were from 3.0 to 5.0. Questions which tended to have lower mean scores, such as questions 5 and 11, refer to areas of professional development that are affected over the long term and within the school context and are less likely to be affected in a ten-day teacher institute. These areas are addressed through the academic-year support services provided by the staff and consortium members.

Table 3. Summary of *DASH* institute data on addressing professional development standards

QUESTIONS	Mean 1995	Mean 1996	Mean 1997	Mean 1998
1. The institute included theory, demonstration, practice and coaching.	4.8	4.8	4.8	4.8
2. The institute was conducted in a learning climate that was collaborative, informal, and respectful.	4.8	4.8	4.9	4.9
3. The institute increased my ability to provide a challenging, developmentally appropriate curriculum based on desired skill and knowledge outcomes for all students.	4.6	4.6	4.8	4.7
4. The institute prepared me to demonstrate high expectations for student learning.	4.5	4.5	4.6	4.5
5. The institute improved my ability to engage parents and families in improving their children's educational performance.	4.1	4.1	4.2	4.1
6. The institute prepared me to use an evaluation process that is ongoing, includes multiple sources of information, and focuses on all learners.	4.4	4.3	4.5	4.4
7. The institute increased my understanding of how to provide school environments and instruction that are responsive to the developmental needs of students.	4.7	4.5	4.6	4.6
8. The institute enhanced my ability to have students exercise the meaningful application of knowledge.	4.4	4.6	4.7	4.7
9. The institute prepared me to use research-based teaching strategies appropriate to my instructional objectives and my students.	4.5	4.4	4.6	4.5
10. The institute enhanced my ability to provide an equitable and quality education to all students.	4.6	4.5	4.6	4.5
11. The institute helped me learn and apply collaborative skills to work collegially with others.	4.3	4.6	4.7	4.6
12. The institute prepared me to develop and implement classroom-based management plans that maximize student learning.	4.3	4.4	4.5	4.4
Number of Respondents (n)	895	1,010	687	380
Number of institutes sampled	68	90	55	42

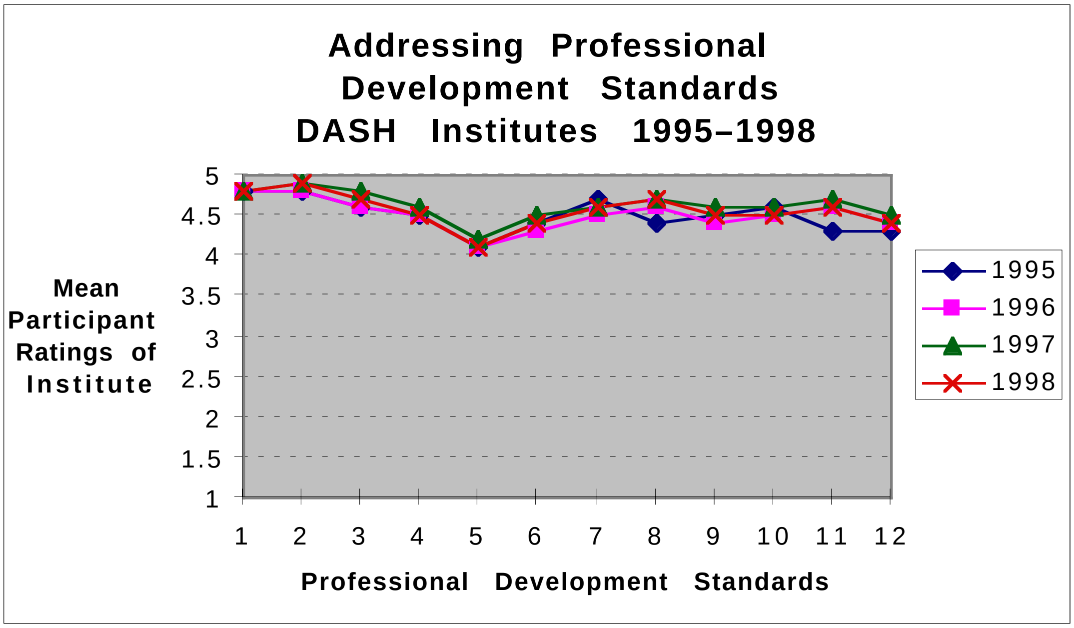


Figure 1. Teachers' ratings on professional development standards for *DASH* institutes 1995–1998

ADDRESSING NSES ON TEACHING AND CONTENT

For the project, the STEP staff set objectives that included (1) making teachers aware of the teaching and content standards for science, (2) helping them fulfill the standards in their classes, and (3) enabling them to become leaders in the reform effort. As indicators of success, they documented the alignment of the *DASH* content with the NSES standards for content, the AAAS Benchmarks, and selected state science frameworks. They also used evidence that teachers know and can give examples of the science teaching standards, teachers' self-reports on changes in their teaching, and videotaped evidence of the impact of *DASH* training on teaching.

Teachers' Knowledge and Implementation of the Standards

To collect data from teachers, STEP devised two instruments based on the national science teaching standards (NRC, 1995). Both used a self-report approach. One instrument, called "Meeting the NRC Science Teaching Standards," uses six open-ended response items. It was given to *DASH* institute participants in 1996, 1997, and 1998 on the last day of instruction to gather their estimates of how effective the *DASH* institute was in addressing NRC standards.

The instrument served two purposes. First, appropriate responses to an item showed that teachers were aware of the standard. Second, the quality of their responses indicated their grasp of the standard's meaning. The following scoring criteria were used. Table 4 gives samples of actual responses and how the judges scored them.

0 No response or not intelligible
1 Gives an example, but misses the mark
2 Gives an example that partially addresses the standard
3 Gives a response that directly addresses the standard

Table 4. Sample responses by scoring criteria

Item 1. **Teachers of science plan an inquiry-based science program for their students.**
Sample Teacher Responses **Scored as 1** "This has been planned for us in our all-school science program." "Activities that encourage and stimulate students." **Scored as 2** "This course allows the teacher to use the process for looking for the answer that works and to start where the kids are at and keep going." "Everything that you do with the kids would be inquiry based. One is constantly asking questions." **Scored as 3** "Students carry out experiments to investigate problems, answer questions they have, understand concepts of science, and start seeing connections between all subjects." "Pose a question to the class such as how does density affect buoyancy. Discuss their predictions. Let them experiment to test their predictions. Experiments could be clarified or let them do their own. After experiments, chart results. Discuss students' findings and draw conclusions."

In 1996, 1997, and 1998, a sample of completed questionnaires was randomly selected from all *DASH* institutes for scoring by two judges familiar with the activities and content of the program. Interjudge reliability was established by independent scoring of 150 items by both judges. Results showed in 80% full agreements, 18% scores varying by 1, and 2% varying by 2. Data were analyzed using StatView (1994). Table 5 summarizes the findings.

Table 5. Summary statistics on meeting the NSES science education standards

Question	**1996 (*n* = 157)**		**1997 (*n* = 215)**		**1998 (*n* = 100)**	
	Mean	SD	Mean	SD	Mean	SD
1. Teachers of science plan an inquiry-based science program for their students.	2.32	.63	2.48	.68	2.66	.517
2. Teachers of science guide and facilitate learning.	2.36	.65	2.47	.62	2.67	.57
3. Teachers of science engage in ongoing authentic assessment of their teaching and of student learning.	2.38	.61	2.62	.52	2.67	.71
4. Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science.	2.31	.62	2.25	.60	2.67	.60
5. Teachers of science develop communities of learners that reflect the rigor of scientific inquiry.	2.25	.63	2.24	.69	2.34	.73
6. Teachers of science actively participate in the ongoing planning and development of the school science program.	2.27	.69	2.35	.62	2.57	.71

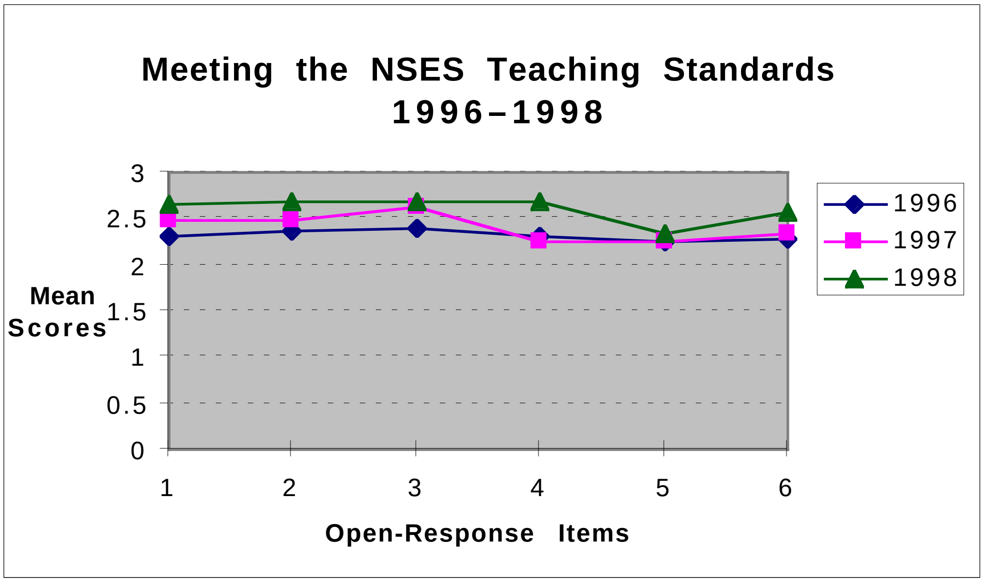


Figure 2. Ratings of teachers' ability to cite examples of NSES teaching standards in *DASH*

DASH institutes consistently yielded high-quality responses from participants for all six NSES teaching standards. ANOVA analysis revealed no statistically significant differences across years. Data show that the *DASH* professional development institutes consistently made teachers aware of the standards and provided specific examples of ways to modify their instruction to align with the national standards for teaching science.

Self-Report about Teaching

The *Self-Report about Teaching* instrument is based on original statements and examples given in the NSES teaching standards. The instrument uses a 4-point, Likert-type scale (strongly disagree–strongly agree) for teachers to give feedback on their classroom teaching (as opposed to their feedback on the effect of the teacher institute). The instrument was administered to participants the first hour of instruction of the *DASH* institutes in 1996. A follow-up survey with a random sample of participants was conducted in May 1997. Of the 758 participants in the 55 *DASH* institutes sampled, 267 returned surveys (35% return rate).

Data were analyzed using StatView (1994). Summaries of results are shown in Table 6, which in addition to significance levels includes effect sizes (the difference between scores as a proportion of the pooled standard deviations). The results for many items exceeded the criteria set forth in the rule of thumb (Tallmadge, 1977) for educational significance, that effect size equals or exceeds one third of a standard deviation.

Table 6. *DASH* teachers' self-reported use of NSES teaching standards: pre and post (n = 265)

Survey Item	Pre M [a] / Post M [a]	Pre SD / Post SD	Effect Size	t test Significance
1. I use an inquiry-based approach to teaching science.	3.24 3.45	0.53 0.51	0.41	****
2. I orchestrate discussion among my students about scientific ideas.	3.38 3.52	0.55 0.51	0.27	***
3. I challenge my students to accept and share responsibility for their own learning in science.	3.32 3.45	0.60 0.56	0.23	**
4. I encourage my students to develop and use the skills of scientific inquiry.	3.31 3.48	0.57 0.52	0.31	****
5. In my class, I model the skills of scientific inquiry.	3.19 3.38	0.56 0.53	0.34	****
6. I analyze assessment data to guide my science teaching.	2.90 3.13	0.63 0.54	0.38	****
7. I guide my students in self-assessment.	2.99 3.10	0.57 0.56	0.18	*
8. I use student data, observations of teaching, and interactions with colleagues to reflect on and improve my teaching practice.	3.47 3.46	0.58 0.59	–0.03	
9. In my class, I encourage skepticism that characterizes science.	3.16 3.29	0.62 0.56	0.24	**
10. I have developed a framework for both year-long and short-term science education goals for my students.	2.96 3.13	0.69 0.67	0.24	**
11. I select teaching strategies that nurture a community of science learners.	3.24 3.42	0.56 0.52	0.32	****
12. I work together with my colleagues within and across disciplines and grade levels.	3.25 3.14	0.74 0.73	-0.15	*
13. I structure the time available so that my students are able to engage in extended investigations.	3.09 3.17	0.64 0.62	0.13	
14. For my science teaching, I identify and use resources outside the school.	3.27 3.43	0.62 0.59	0.27	***
15. I nurture collaboration among my students.	3.44 3.59	0.53 0.49	0.30	****
16. I have helped plan and develop my school's science program.	2.53 2.65	0.90 0.84	0.18	**
17. I have participated fully in planning and implementing my professional growth and development.	3.50 3.56	0.57 0.57	0.11	

Note: Pre- and post-surveys were given 11 months apart.
[a] Strongly Agree = 4, Agree = 3, Disagree = 2, Strongly Disagree = 1.
*p < .05. **p < .01. ***p < .001. ****p < .0001.

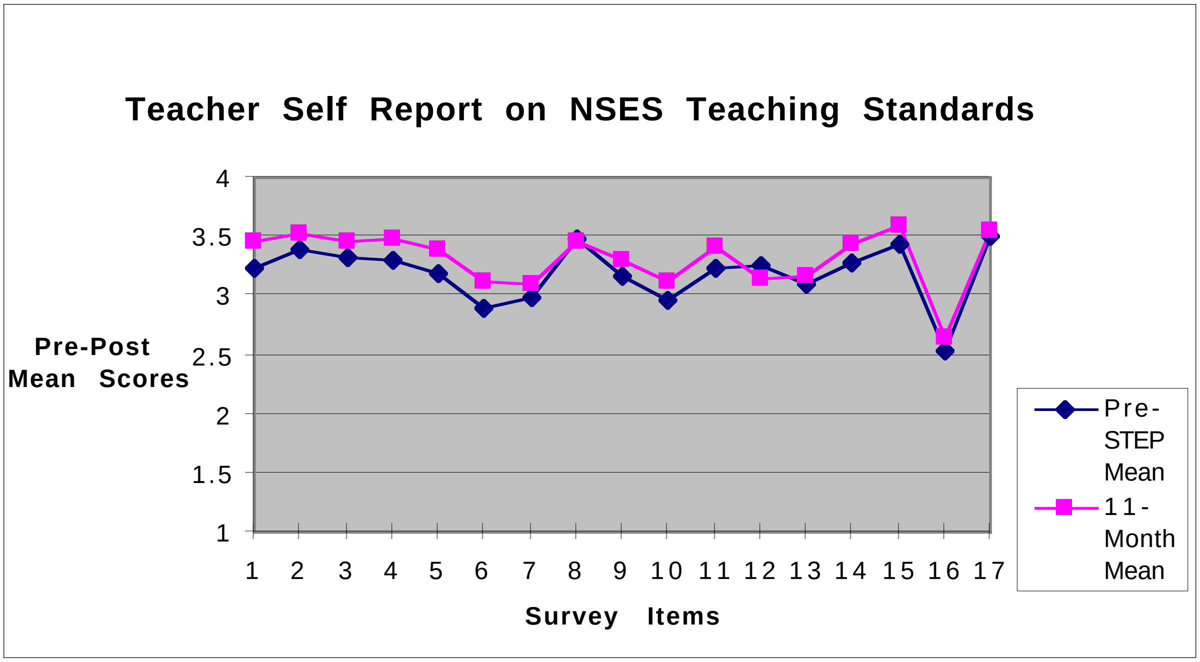


Figure 3. Teachers' self-report on using teaching standards pre-*DASH* institute and 11 months later

Data show that using *DASH* resulted in a significant shift in teachers' self-reports on teaching toward inquiry, as called for in the national science education standards. See particularly items 1–7, 9, 11, 15, and 16. Conversely, items 8, 13, and 17 did not change significantly. This is to be expected, since these items deal with long-term behavior changes within the context of the school setting and are not likely to be influenced as much by a ten-day professional development institute as are the other cited items.

VIDEOTAPES OF TEACHERS' "BEST LESSON"

Selected teachers were asked to videotape their "best science lesson." This indicator was used to validate the self-reports of teachers using the *Self Report about Teaching* instrument. Selection criteria and protocols for taping were developed and shared with teachers who agreed to participate. Experienced *DASH* teachers who had participated in a teacher institute and were implementing the program for at least one year were matched with new applicants to the *DASH* institutes. In some cases "best lessons" were obtained from teachers before and after they had participated in *DASH* professional development activities.

Blind analysis as to whether the videotapes were pre- or post-*DASH* was done by an independent external evaluator using the *Instrument for the Observation of Teaching Activities* (IOTA). IOTA was developed by the National IOTA Council as a research-based observation instrument that produces a profile of teaching behaviors. In evaluating teaching competence, each teacher's performance is measured against accepted criteria rather than the performance of other teachers. The observation portion includes 14 categories. Data collected on each category are later rated on a 5-point Likert-type scale, creating a profile of teaching. The resulting profiles are shown in Figures 4–8. In presenting the profiles, categories 4, 5, 7 and 10 for which there were no corresponding teaching standards were deleted. A zero (0) means "no rating," indicating that no data on this IOTA category were observable in the videotaped lesson and therefore cannot be rated.

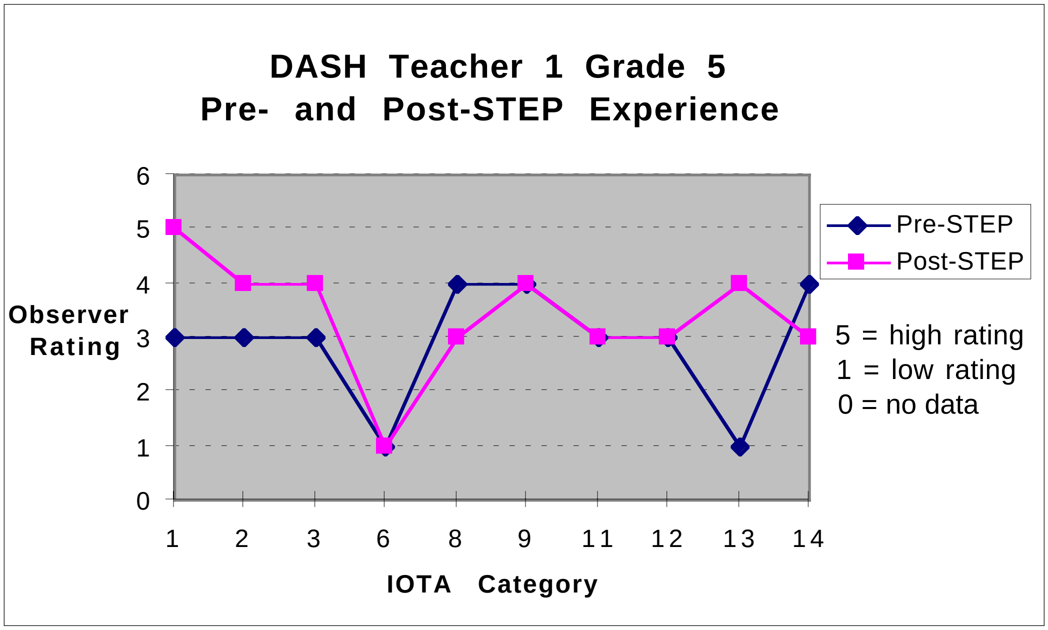


Figure 4. IOTA scaling of “best lesson” prior to the *DASH* institute and 11 months later after participating in *DASH* professional development activities

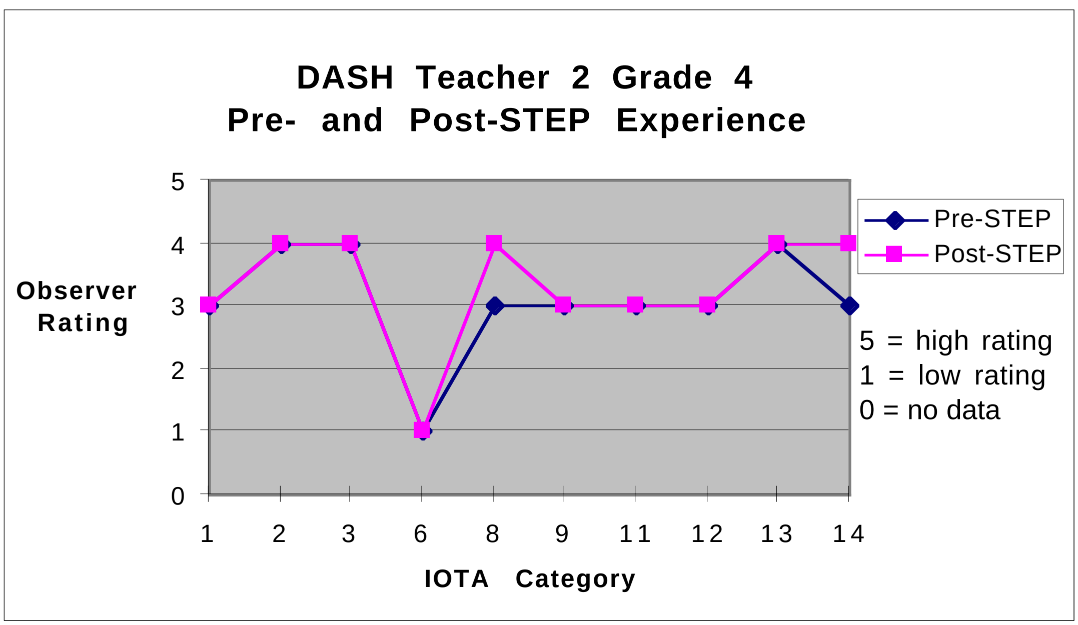


Figure 5. IOTA scaling of “best lesson” prior to the *DASH* institute and 11 months later after participating in *DASH* professional development activities

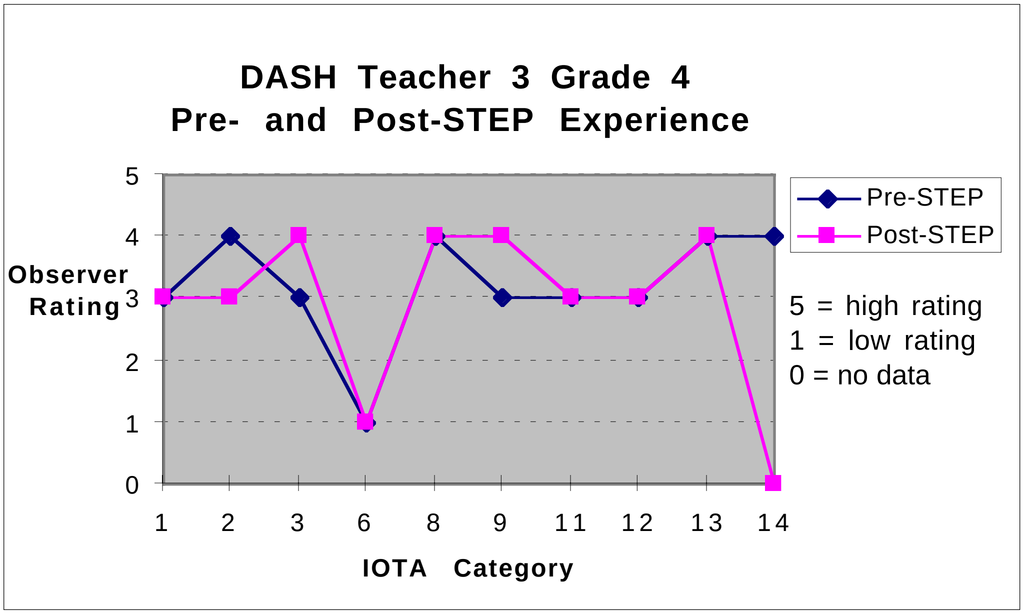


Figure 6. IOTA scaling of “best lesson” prior to the *DASH* institute and 11 months later after participating in *DASH* professional development activities

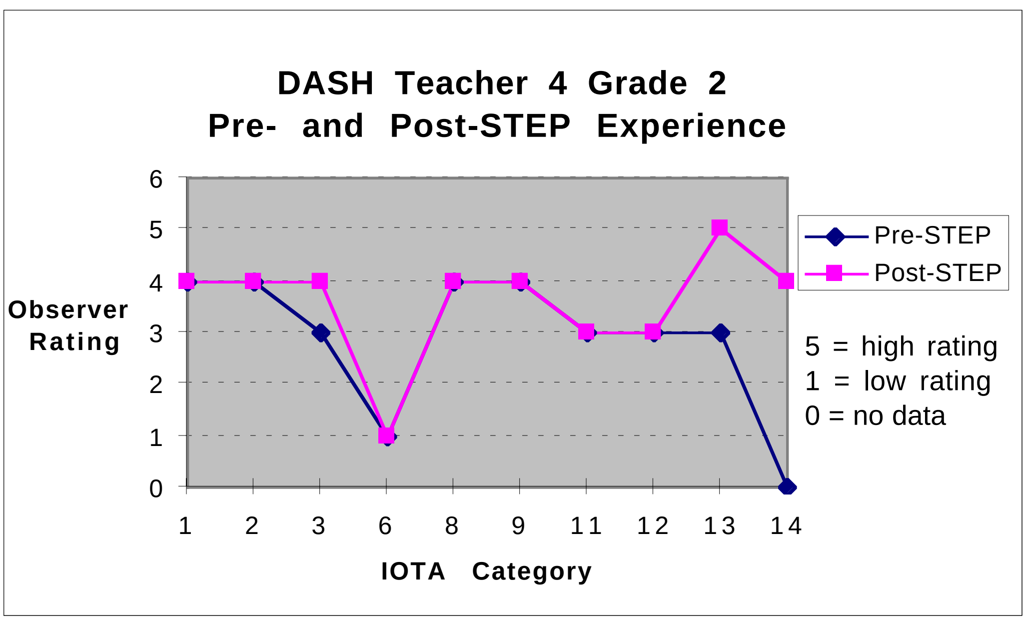


Figure 7. IOTA scaling of “best lesson” prior to *DASH* institute and 11 months later after participating in *DASH* professional development activities

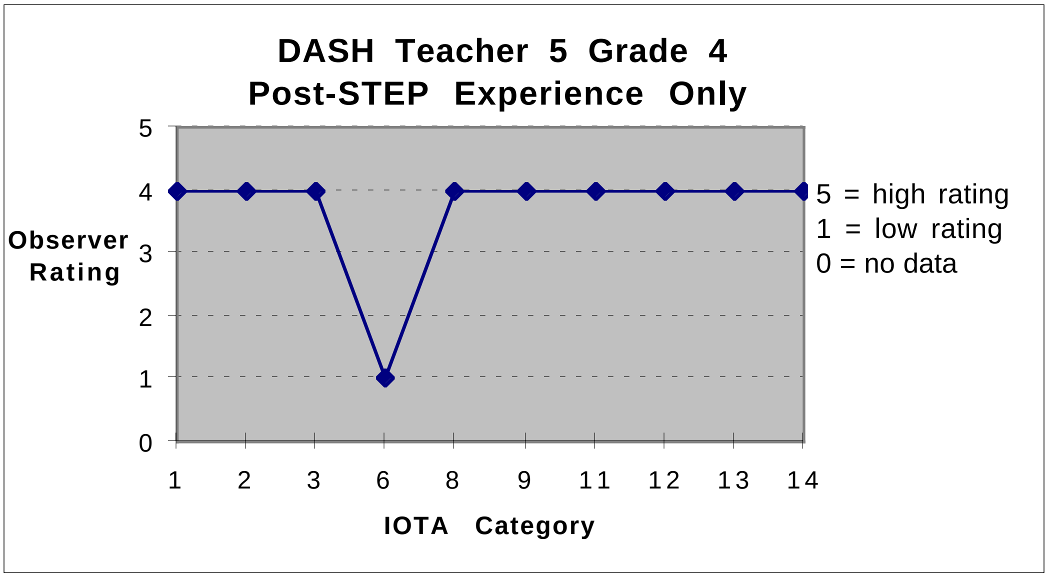


Figure 8. IOTA scaling of "best lesson" after participating in *DASH* professional development activities (no pre-*DASH* lesson available)

The resulting data show promising shifts in teachers' profiles toward the approaches called for by the NSES teaching standards. Especially noteworthy is the consistently higher performance of teachers who have experienced *DASH* professional development activities in IOTA categories (1) Classroom Objectives, (2) Variety in Learning Activities, (3) Use of Materials of Instruction, (8) Opportunity for Participation, (9) Teacher Reaction to Student Response, (13) Assessing Student Achievement, and (14) Current Application of Subject Matter. All seven of these IOTA categories correspond well with the NSES teaching standards.

TEACHERS' PORTFOLIOS

Three selected teachers representing first-year implementers, 2–5 year implementers, and certified instructors were asked to prepare portfolios addressing specific questions in a STEP project-provided protocol for portfolio preparation. Excerpts from the portfolios follow.

***DASH* Teacher 1:** *I have clearly experienced the quality education that can emerge when teachers are able to plan and implement learning that builds upon prior knowledge and experiences deliberately sequenced across grade levels.* Teacher 1 has 15 years of experience. He first attended a *DASH* teacher institute in 1987 and became a certified instructor in 1991. Teacher 1 has provided strong leadership in two elementary schools. Both used *DASH* as the core of systemic revision and school improvement. In the first school *DASH* was incorporated in an initiative to implement school-community based management (SCBM) with a strong focus on improving teaching and learning. The school was one of the first in the state to successfully change to SCBM and was the second elementary school in the state to achieve accreditation in 1993. In the second school this teacher provided the initiative and leadership to establish a school of 160 students within a school of 900 students in 1995. Teacher 1 states in his portfolio:

> *My experiences working with teachers from elementary schools throughout the state of Hawai'i have led me to believe very strongly in the need for curriculums like DASH. I have clearly experienced the quality education that can emerge when teachers are able to plan and implement learning that builds upon prior knowledge and experiences deliberately sequenced across grade levels.*

Parents' comments taken from the portfolio regarding the use of *DASH* in the school-within-a-school setting:

> *The DASH program encourages my child with much-needed hands-on experiences. She enjoys this very much and often relates new ideas or concepts and interesting bits of information.*
>
> *Not only have we seen a great improvement in the development of higher order thinking skills, but also present are: the student sense of belonging, student attitudes toward school in general and particular subjects, social bonding between teachers and students, hands on learning, and cooperative learning. More importantly, the personal growth of my son has been remarkable.…Once a quiet and shy student, he has become very confident and outspoken, unafraid to communicate his ideas either verbally or in writing.*
>
> *Our DASH curriculum is a cohesive vein that has allowed my son to build on his science expertise grade after grade. The intimidation of difficult science concepts has been diffused by the vertical building through each grade level. Failure due to complex material is replaced by understanding from a strong foundation.*
>
> *A few nights ago my first-grader called my husband outside and said, "Look, Dad, it's a gibbous moon tonight." We knew something great was happening. That something is DASH.…Science instruction is usually a dry reading program, isolated from the rest of the elementary curriculum. But DASH incorporates reading, writing, math, and other subjects in teaching science through everyday experiences.*

***DASH* Teacher 2:** *I have found that DASH makes science easily accessible to all my students.* Teacher 2 is an experienced teacher of 20 years working in elementary schools in Illinois and New Mexico, where she was instrumental in introducing the *DASH* program into the curriculum. A nationally certified *DASH* instructor since 1991, Teacher 2 documents in her portfolio her development as a school and science leader. In fact, when she moved from Illinois to New Mexico, she brought the *DASH* program with her and successfully implemented it in her new school in Gallup. Her portfolio reveals that among other examples of developing leadership she

- taught an in-school course for Gallup teachers called Topics in Education: *DASH* in the Second to Fourth Grade Curriculum as a one-credit professional development course accredited by the University of Hawai'i.
- presented workshops at multiple conferences, including Argonne National Laboratory Conference *What Works in K–8 Science Education*, 1991; NSTA area conferences in 1995 and 1998; New Mexico Science Teachers Association in 1995 and 1996; New Mexico Tribal and New Mexico Coalition in 1997.
- conducted numerous awareness presentations on *DASH* for teachers, boards of education, parents, and other school districts in Illinois and New Mexico.

Teacher 2's portfolio includes a grade 2 standards-based unit she developed that is based on but extends *DASH* core activities. Her portfolio includes case studies of two girls, both eight-year-old Native Americans, as examples of how her students have been impacted by *DASH*. In the conclusion of her portfolio, Teacher 2 states,

> *Within the DASH program there exists a means for working on vocabulary, an area of great need for my limited English speaking students. The DASH method of defining words by using category, form and function is perfect for my L.E.P. students. The Navajo language is based on form and function. Having these*

children begin with form and function, which is natural to them, rather than with category, which is the more traditional beginning, works to my advantage.…

For students with particular difficulty writing, the calendar work and lesson worksheets can be drawn. The work, and many times the assessment, need not be written but adapts well to expressive projects or art.…From this I begin working toward data collection in written form.

The framework of DASH easily accommodates students with special learning needs so adaptations beyond its basic structure are few. I have found that DASH makes science easily accessible to all my students.

***DASH* Teacher 3:** *I feel I have become a better science teacher because of DASH. I learn something new every time I teach a DASH lesson. I feel the reason for this is that my students are more inquisitive than they were before.* Teacher 3 is an experienced teacher in western Pennsylvania. Her portfolio of her work at grade 5 describes how she has creatively adapted *DASH* activities to address her district's guidelines and special education students and developed a new *DASH*-like unit based on learning experiences at the Pittsburgh Zoo. Her *DASH* experience has enabled her to provide leadership in her school and district, where she has made presentations to the PTA, school board, National Science and Technology Week Professional Development Program, and the Pennsylvania Science Teachers Conference. Regarding her teaching, Teacher 3 states,

I also try to incorporate science into other curricular subjects. For example, I use our science weather data in math. The students use the data to make charts, graphs, and to do simple math. Also, I incorporate the writing process for when they do reports and for various other writing assignments.…I feel I have become a better science teacher because of DASH. I learn something new every time I teach a DASH lesson. I feel the reason for this is that my students are more inquisitive than they were before.

Teacher 3 included a statement from the special education teacher with whom she works in partnership in teaching science to the special-needs students in her class. The teacher states,
I have been impressed with the DASH program in regard to special education inclusion students. The 5th graders that have been identified Learning Support students have greatly benefited from the practical hands-on experiences included in the DASH program under the direction of Ms. L. All students were included in each DASH experience including daily recordings of weather of high and low temperatures, barometric pressure, cloud formation, precipitation, humidity and many other experiences involving daily record keeping. I have observed the L.S. students actively involved in creating projects and working in collaboration with other students in the room to design projects and express opinions as to the feasibility of the experiments. I have observed peer tutoring during DASH lessons, independent studies that have been meaningful to the special needs students as well as the special education student, interaction of all students that has developed self-confidence in all students as risk takers in all subjects, not only science and health. In DASH experiments every person's opinion counted as observed by a group of Johnston teachers in March 1998, giving special attention to our inclusion program. Those teachers were amazed by the amount of interaction of all students. In conclusion, I was truly impressed with the DASH program as it satisfied many of the needs and goals of the Learning Support students' I.E.P in an inclusive setting.

COMPREHENSIVE SCHOOL REFORM SKILL– AND CONTENT–BASED MODEL (1998)

As part of the Comprehensive School Reform Demonstration (CSRD) program established by Congress in 1997, the Northwest Regional Educational Laboratory (NWREL), with assistance from the Education Commission of the States, was contracted to conduct a nationwide search for programs that effectively met the nine criteria specified in the law establishing CSRD. The resulting *Catalog of School Reform Models: First Edition* provides schools with preliminary information about 44 school reform models they found that meet the nine criteria. *DASH* is one of three research-based, effective science "skill and content" reform models included in the publication.

The selection criteria that must be met for inclusion are that the program provides

- effective, research-based, replicable methods and strategies
- comprehensive design with aligned components
- measurable goals and benchmarks
- support within the school
- parental and community involvement
- external technical support and assistance
- evaluation strategies
- coordination of resources

"Although schools themselves are responsible for developing plans that integrate these nine components, the CSRD legislation encourages them to consider adopting externally developed research-based reform models as a central part of their plan.…Research-based models should be able to provide evidence along four dimensions, including (1) the theoretical or research foundation for the model, (2) evaluation-based evidence of improvement in student achievement, (3) evidence of effective implementation, and (4) evidence of replicability.…The primary criterion for consideration [for inclusion in the *Catalog*] was the extent to which a model had been recognized in a number of recent and/or soon-to-be-released publications describing research-based resources for comprehensive school reform. Once models were selected for consideration, the primary criterion for inclusion was the strength of impact on student learning."

VERMONT DATA (1998)

Orwell: School officials at Orwell Village School provided the STEP project with a summary of sixth-grade student achievement data on the 1998 Vermont Science Assessment. Orwell School, a small rural school in central Vermont, is part of the Addison Rutland Supervisory Union. *DASH* is the primary science program, and teachers have participated in its professional development activities. The data shown in Figure 9, while sketchy, provide further evidence that the STEP efforts are supporting science improvement. Performance levels are an indication of overall scientific understanding of key Vermont science, math, and technology content standards.

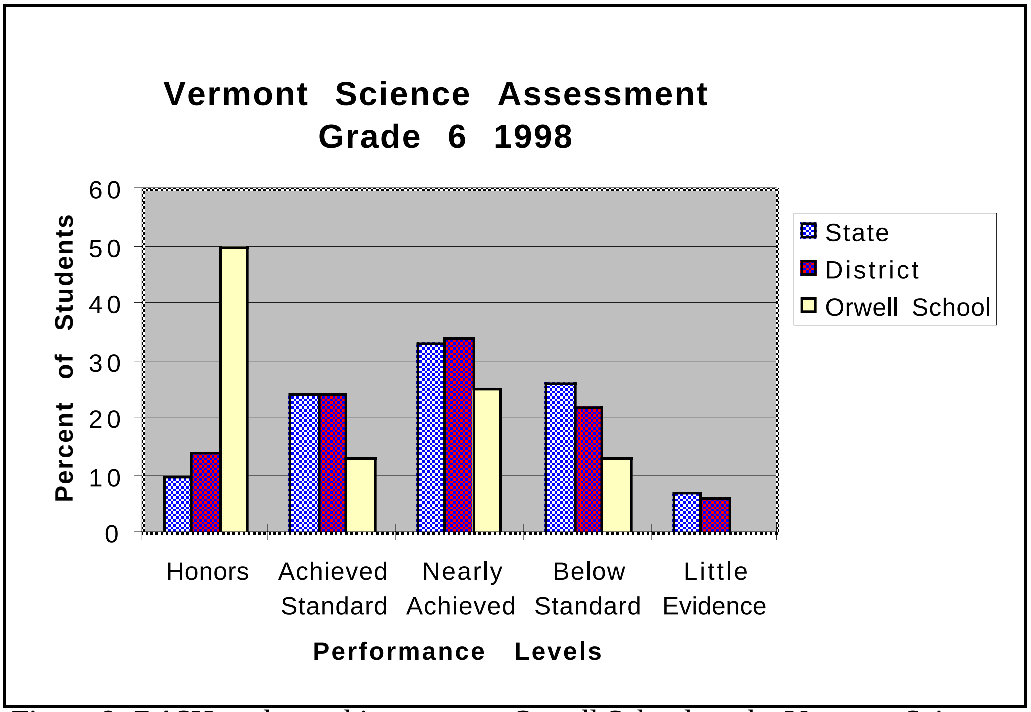


Figure 9. *DASH* student achievement at Orwell School on the Vermont Science Assessment 1998 (*n* = 16)

RESULTS–BASED PRACTICES SHOWCASE (1997)

DASH is one of five effective science programs included in the *Results-Based Practices Showcas*e compiled and published by the Kentucky Department of Education. In 1997 a team of five department employees began a "hunt" for good instructional programs that could consistently deliver 20% or greater improvement in student achievement sustained over 2 to 3 years.

In their search the panel contacted all 50 state departments of education, as well as universities, federal educational laboratories, professional associations, publishers, and others, to find effective curricula and instructional programs. Though nearly 500 programs were identified, when the panel applied their rigorous criteria to data provided by the developers and in focused interviews, only 61 could produce hard evidence of efficacy. Ninety percent did not have any performance results at all. The goal of the search and publication was to assist educators in becoming more sophisticated consumers of curricula.

The panel also found that the effective programs had common features: focus on student results; more fully developed and coordinated instructional methodologies; assessment; on-site technical assistance; and quality control.

CARNEGIE MELLON UNIVERSITY STUDY (1995–1997)

The staff of the Center for University Outreach at Carnegie Mellon University has conducted follow-up evaluations of the impact of the STEP professional development activities on teacher change and implementation as part of Eisenhower grants supporting professional development in science. All new teachers were interviewed at the beginning of the *DASH* institute and again at follow-up meetings at their respective school sites during the year. In addition, a survey was mailed to all *DASH* teachers in southwestern Pennsylvania in October 1995. As an incentive to return the survey, 50 memberships in NSTA were given to randomly selected returnees. Return rate was 25%. Data were also collected during classroom visits at monthly professional development support meetings. Resulting data were reported in narrative form summarizing findings from all sources.

On time spent on science instruction, evaluators reported that in interviews conducted at the beginning of the *DASH* institute, teachers talked about the amount of time spent teaching science in terms of a specified number of time blocks each week. When asked the same question on surveys later in the year and during school visits, many teachers stated that it is difficult to determine the exact number of minutes because science is no longer confined to a specific number of blocks each week. Time has been added for ongoing science activities. Before *DASH,* the majority of teachers did not teach health because it was assumed to be incorporated in physical education. After implementing *DASH,* teachers report that the health activities in *DASH* are designed to fit with the science topics. Teachers' understanding of the term *technology* is also enhanced by *DASH*. In initial interviews, teachers thought technology meant computers. After the institute, teachers recognized the importance of technology as application of knowledge and inventions that help meet biological needs. In this way the amount of education about technology has increased greatly.

In another follow-up study conducted by CMU in 1997, 77% of the teachers reporting said that they had increased the amount of time they spend on science. Of those who said they had not, five were in schools where science is departmentalized; three mentioned they had integrated science with other subjects, which seems to indicate they are teaching science more; one reported starting a science club after school; two others stated that though the amount of time had remained constant, the quality of instruction had improved.

On integration, the evaluators found that in all cases teachers were incorporating at least one other subject area with science instruction. Many teachers expressed surprise at how "intertwined" mathematics and science are and how easily language arts and music can be integrated with science. Teachers went beyond the *DASH* materials to design their own connections. Teachers also focused on making connections outside of school

In the 1997 study, evaluators asked teachers to list at least two examples of integration of science with other subjects in their classroom. All teachers who responded to the survey answered this question, with many offering more than two examples. Frequencies by subject area are shown below.

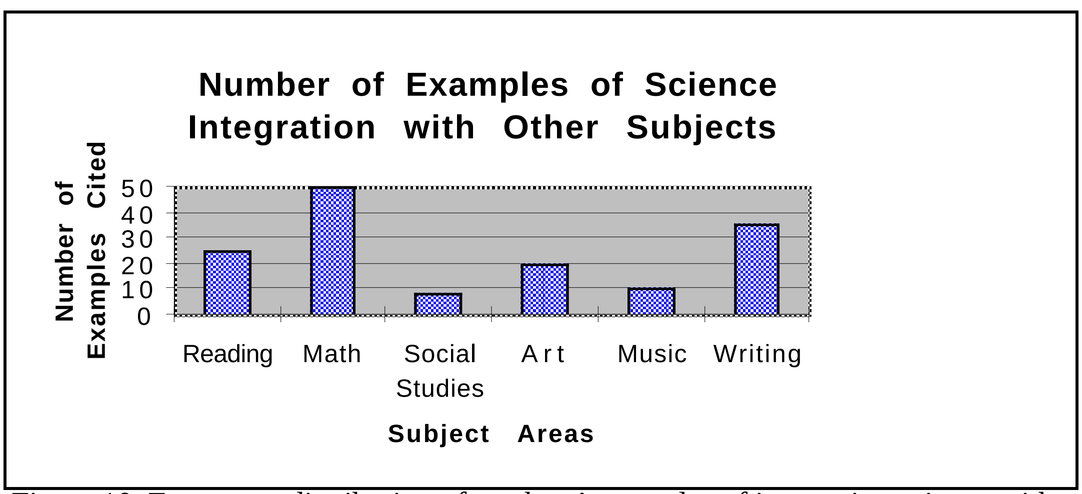


Figure 10. Frequency distribution of teachers' examples of integrating science with other subjects

On content knowledge development, using a concept-and-skill inventory before and immediately after the teacher institute, the evaluators found that all teachers reported a greater understanding of many science concepts and skills. This finding was verified in the school visits and interviews later in the year.

On questioning techniques, evaluators reported that teachers found this skill difficult to master. Even though *DASH* materials provide examples of open-ended questions, and instructors modeled inquiry questioning strategies, teachers need a great deal of practice to master good questioning strategies. Teachers reported they were taught to give answers and always appear to students to be "right." Inquiry-based instruction requires that teachers withhold answers and allow children to develop explanations and hypotheses. Newly trained teachers report they are more aware of the importance of inquiry questioning and are working to increase their skill in this area. Teachers who have been implementing *DASH* at least one year are more likely to use questioning strategies consistent with constructivist learning theory, as verified by classroom observations.

On use of multidimensional assessment, evaluators noted that many teachers were using concept maps, journals, portfolios, and students' project evaluations to assess achievement. Teachers expressed frustration in trying to use multidimensional assessment while being required by their district to assign a letter grade. A large number of respondents said that their districts were reviewing the assessment policies. According to teachers, parents are resisting changes in assessment reporting and find it difficult to understand why students should not just get letter grades.

In 1996, the Pennsylvania Higher Education Eisenhower Professional Development Program implemented new impact evaluation guidelines and assessment forms for funded projects. Carnegie Mellon University, having received an Eisenhower Higher Education grant to complement the STEP efforts in their service region, has reported impact data on the new forms for 1996–1997 and 1997–1998. The *Professional Development Assessment Form* was administered on the final day of the *DASH* teacher institutes in 1996 and 1997. Means were calculated on a 4-point scale from participant responses to each item, using the following conversion:

1 = Not well at all
2 = Not very well
3 = Well
4 = Very well

Summaries of the data for both years are shown in Table 7. Remarkably, mean scores increased on every item from 1996 to 1997.

Table 7. Pennsylvania Professional Development Assessment Form responses

Quality Professional Development Indicator	**Mean 1996 (*n* = 91)**	**Mean 1997 (*n* = 101)**
1. Uses the best information available	3.56	3.75
2. Integrated two or more subjects	3.67	3.91
3. Incorporated NSES Standards	3.46	3.82
4. Encouraged collaboration or networking with other teachers	3.66	3.82
5. Promoted cooperative learning among groups of participants	3.86	3.93
6. Used state-of-the-art instructional strategies	3.25	3.29
7. Will include follow-up activities to support and extend your learning	3.46	3.69
8. Used "inquiry-based" instruction	3.76	3.91
9. Used strategies or technologies to promote analytical reasoning and problem-solving skills	3.55	3.88
10. Used hands-on/minds-on activities	3.87	3.98
11. Used alternative forms of assessment	3.49	3.62
12. Caused you to reflect on how to improve teaching and learning effectiveness	3.70	3.77
13. Required you to plan how to implement new instructional strategies	3.57	3.63

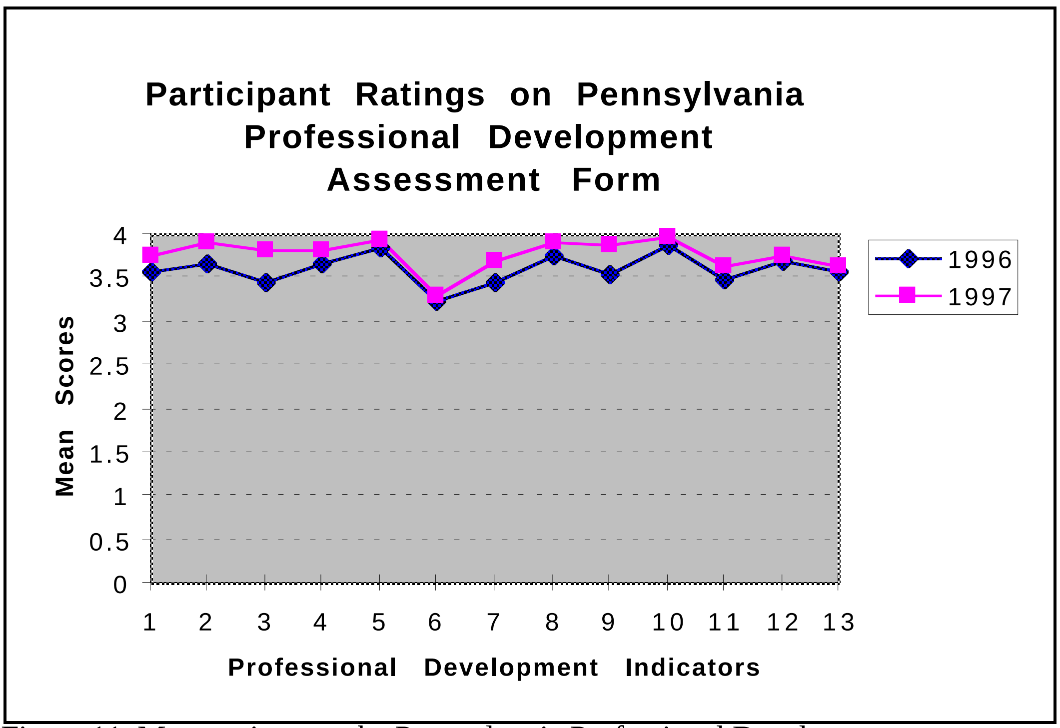


Figure 11. Mean ratings on the Pennsylvania Professional Development Assessment Form at the end of *DASH* institutes 1996 and 1997

During the spring of the following year, the *Survey of Practice* instrument was administered to teachers who had participated in the previous summer's institutes. Means were calculated on a seven-point scale using the following conversion:

0 = Not sure
1 = Never
2 = One time per year
3 = One time per month
4 = One time per week
5 = 2-3 times per week
6 = More than 3 times per week

Summaries of the data for both years are shown in Table 8. As these data reveal, teachers over the two years reported a consistently high degree of implementation or use of standards-based instruction after only a few months of opportunity.

Table 8. Survey of Practice Form responses

Quality Professional Development Indicator	**Mean 1996 (*n* = 91)**	**Mean 1997 (*n* = 64)**
1. Uses the best information available	4.6	5.5
2. Integrates two or more subjects	5.2	5.4
3. Incorporates NSES standards	3.7	4.4
4. Collaborates or networks with other teachers	4.4	4.6
5. Promotes cooperative learning among groups of students	5.3	5.2
6. Uses state-of-the-art instructional strategies	3.5	3.7
7. Uses follow-up activities to support and extend prior learning	5.1	5.3
8. Uses "inquiry-based" instruction	5.0	5.1
9. Uses strategies or technologies to promote analytical reasoning and problem-solving skills	4.9	5.0
10. Uses hands-on/minds-on activities	5.4	5.5
11. Uses alternative forms of assessment	4.5	4.6
12. Reflects on how to improve teaching and learning effectiveness	5.1	5.5
13. Plans how to implement new instructional strategies	4.6	4.9
14. Participates in professional development	3.8	3.7

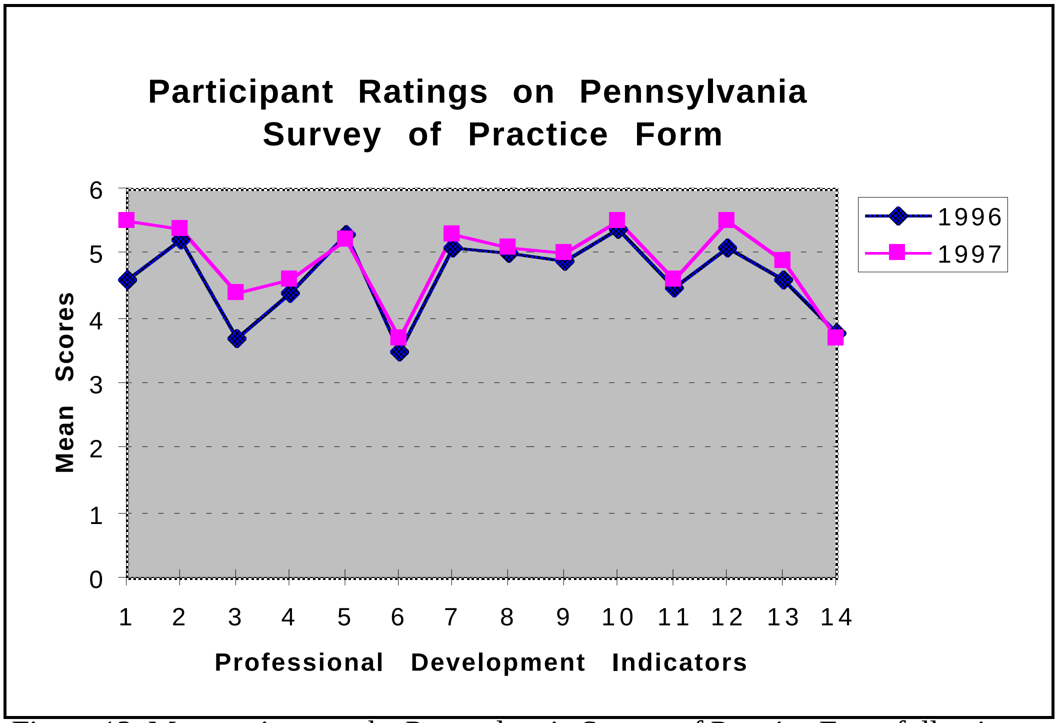


Figure 12. Mean ratings on the Pennsylvania Survey of Practice Form following *DASH* institute and follow-up activities 1996 and 1997

Effectiveness: The Carnegie Mellon University data provide evidence that the STEP-trained teachers use standards-based pedagogy at least 70% of the time. Though many of the reported data come from self-reports, they have been verified through site visits to classrooms and direct observation.

MICHIGAN DATA (1996–1997)

Upper Peninsula: At Mid Peninsula Elementary school, fifth-grade students are scoring exceptionally well on the science portion of the Michigan Educational Assessment of Progress (MEAP), the statewide testing program designed to measure how well schools are doing in achieving the Michigan Essential Goals and Objectives for Science Education (MEGOSE). The fifth-graders have scored 90.3% at the “proficient” level in 1996 and 91% proficient in 1997. Mid Peninsula is a small rural school district in the center of Michigan’s Upper Peninsula. The K–12 enrollment is 389 with a free/reduced lunch enrollment of 44.2%. Ten teachers compose the K–5 staff, seven in the classroom, two in Title 1, and one in special education. It is a *DASH* school.

The Northwoods Math Science Center at the Delta Schoolcraft ISD devised a written survey for the K–5 staff to complete to try to account for the school’s success. Eight teachers responded. They are aware of the MEGOSE and focus their teaching on these standards. They have participated in the *DASH* professional development activities and use the program in the school. Six of the teachers specifically mentioned *DASH* as providing research-based science-teaching methods. One teacher said, “The way you teach and then reteach makes the difference between the ‘bell-curve attitude’ and the attitude that all kids can learn at least most of what you teach.” The evaluator concludes that the Mid Peninsula elementary teachers seem to do a good job of implementing teaching improvements in their classrooms.

MISSOURI DATA (1995–1998)

St. Louis: An independent evaluation of the impact of *DASH* on attitudes toward science was conducted by researchers at the University of Missouri at St. Louis in 1995–96 with students and teachers in Maplewood-Richmond Heights school district and the St. Louis Archdiocese school system, where *DASH* has been implemented. The Science Student Survey (SSS) Form A (Granger, 1994) was administered to 263 students in grades 3–5 from 13 classes in the Maplewood district and 223 third-grade students from 9 classes in the Archdiocese schools. The SSS was used to determine the degree to which the hands-on, student-centered, problem-solving *DASH* program was used in the classroom and to assess the attitude students had toward the study of science and the use of scientific process skills. Since the *DASH* program is not mandatory in either school system, it was critical to determine the degree of use through the Students Perceived *DASH* Experience (PDE) in the classroom while at the same time assessing the Student Attitude Toward Science (ATS), both subsets of the total Student Science Survey Index.

Results from the two school systems were analyzed separately and then comparaed to determine whether there was a significant difference between systems. Using the Pearson correlation statistic and the 0.01 level of significance, a correlation between *DASH* program use and the degree of positive attitude by students in the Archdiocese was 0.84 and for the public schools was 0.83. This indicates an unusually strong correlation between students'attitude and their use of *DASH*. There was no statistical difference in the level of achievement between the two school systems with regard to students'attitude as a function of the degree of use of *DASH* by teachers.

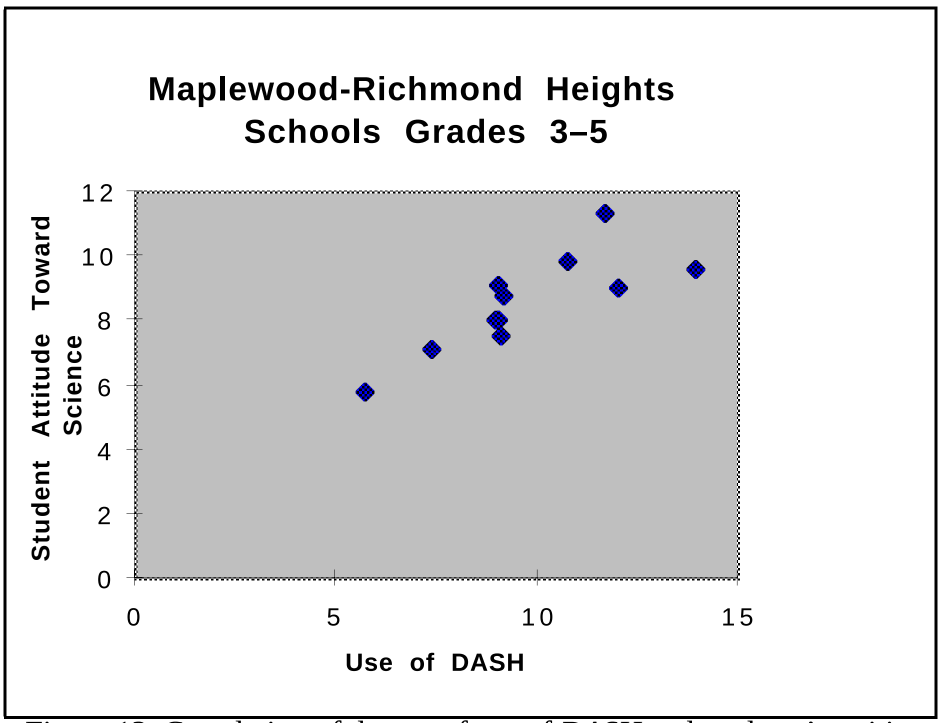


Figure 13. Correlation of degree of use of *DASH* and students' positive attitude toward science in public school district (Pearson statistic 0.83 at the 0.01 level of significance)

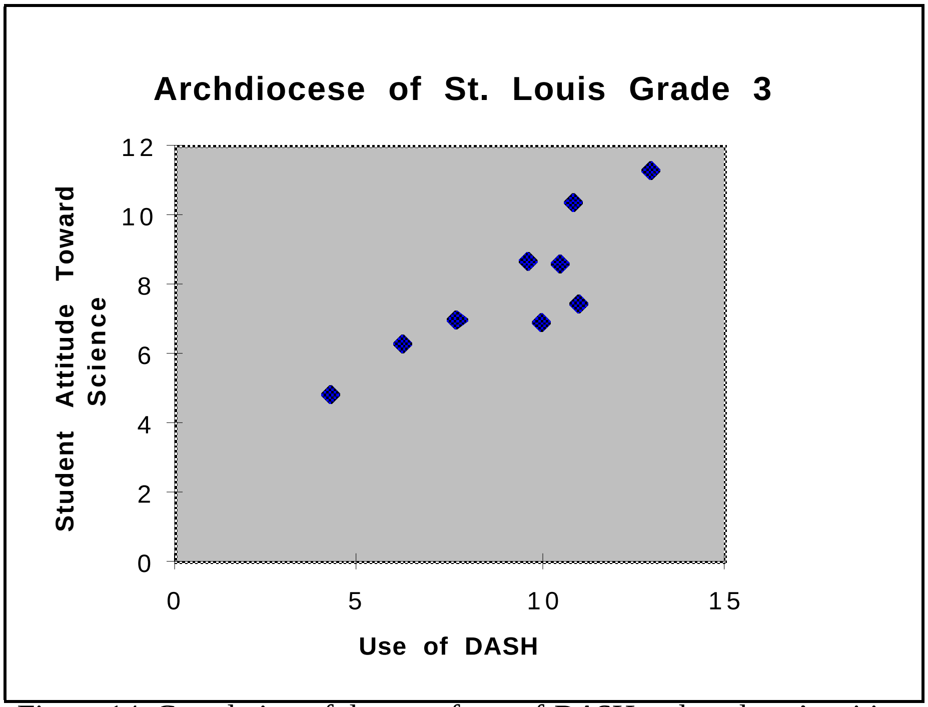


Figure 14. Correlation of degree of use of *DASH* and students' positive attitude toward science in Archdiocese of St. Louis (Pearson statistic 0.84 at the 0.01 level of significance)

The conclusion from this study was that the more a teacher uses *DASH*, the more positive the attitudes of students toward science.

St. Louis: The 1998 science achievement level results for the state of Missouri's Mastery and Achievement Tests were recently reported for St. Louis public schools. Chaney School, which is using *DASH* as its science program, shared its results with the STEP project. There are two parts to the test. Part A, a criterion-referenced section that compares the tested grade level at each school with expected proficiency for the state criteria, and Part B, a norm-referenced portion of the test which gives national percentile results for all students tested. Part A is reported in five sections starting with "Step 1," which indicates lack of understanding. The next section, "progressing," indicates minimal understanding. A child who scores in the progressing section has shown evidence of developing some understanding of the concepts and processes being tested. As you move along the continuum, students' scores are reported in the "nearing proficiency," the "proficient," and the "advanced" levels. Results in Figure 14 are reported in percentiles for Part A by section. The end column on the right side shows the test results for Part B.

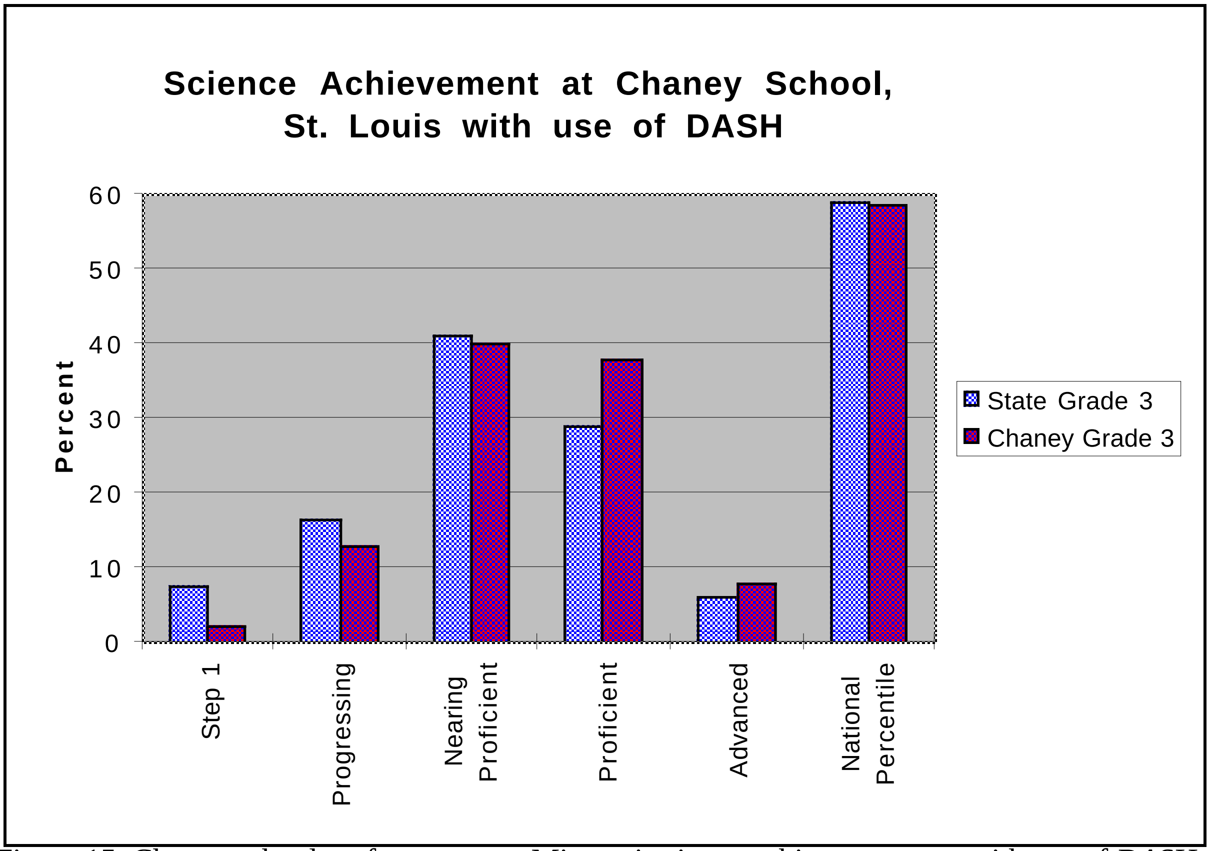


Figure 15. Chaney school performance on Missouri science achievement test with use of *DASH*

Part A indicates that in all sections, Chaney students were achieving above the state norms. For example, Chaney School had only 2% of its students tested scoring at Step 1, while in the state as a whole 7.4% of the students tested did not achieve a basic level of understanding of the concepts and processes being tested. Part B shows that nationally tested third-grade students scored at the 59th percentile, while Chaney School's third-graders scored about the same at 58.5%. School officials credit *DASH* with these student achievement results.

St. Louis: The Archdiocese of St. Louis began implementing *DASH* in 1992, with additional funding support from the Monsanto Fund. The Archdiocese points to the following successes:

Students

- A positive attitude toward science is consistently articulated by students and parents.
- Students are engaged in more hands-on activities in science and using more science equipment in class.
- Catholic high schools are offering more science courses.
- More students are receiving ribbons and recognition at the annual Science Fair sponsored by Monsanto and the *Post Dispatch;* seventh-graders who took the Duke University Talent Search scored high on the science section. They reported they thought the science part was "relatively easy because the material was similar to what was taught in science class."

Professional Development

- Over 750 elementary teachers have been trained in *DASH*.
- Out of 162 schools, 124 are implementing a hands-on approach in teaching science in grades K–8.
- Twelve elementary teachers have been trained as *DASH* instructors.

- *DASH* support sessions are held monthly for teachers.

System Development

- Local science team leaders have been identified and trained at each school to enhance communication and ownership of the improvement process.
- Science teachers are part of a network and support system through sharing sessions, curriculum development, newsletters, and telephone communications.
- Administrators have been supportive of the changes in science education.
- Interest has been expressed by several local universities on how they can support *DASH* implementations.
- The science education program was recognized by *Today's Catholic Teacher* as an Outstanding Diocesan Program.
- More Archdiocese teachers are members of NSTA and its state affiliate.

PENNSYLVANIA DATA (1995–1996)

<u>Pittsburgh</u>: In 1995–96 the staff of the Center for University Outreach at Carnegie Mellon University conducted a follow-up evaluation of the impact of the *DASH* professional development activities on teacher change and implementation. All new teachers were interviewed at the beginning of the *DASH* institute and again in follow-up interviews at their respective school sites during the year. In addition, a survey was mailed to all *DASH* teachers in southwestern Pennsylvania in October 1995. Return rate was 25%. Data were also collected during classroom visits as part of monthly professional support meetings. Though many of the data were on teacher impact, a part of the study dealt with student equity issues. Resulting data were reported in narrative form.

On the question of equity, more than 95% of those who submitted surveys see no difference in the way that boys and girls approach experiential science activities in classes. Several commented that boys tend to enter the classroom with a greater background knowledge of science topics, but the hands-on, inquiry approach to learning encourages all students to excel in science.

Equity topics were included in the *DASH* institute and also in the large group follow-up meetings. While many teachers report an awareness of the need for equity in education, most feel that they provide equitable treatment of all students. Classroom observations do not always support these claims, but the project has succeeded in helping to raise the awareness of all aspects of equity.

HAWAI‘I TEST DATA (1992–1995)

<u>Mountain View</u>: In 1995, a K–6 school-within-a-school of 160 students called Connections was begun at Mountain View with *DASH* as the core of the curriculum. The student body is 64% Asian or Pacific Islander, 30% Caucasian, 6% American Indian, African American, or Hispanic, Of the total, 75% receive free or reduced lunch. In the formative evaluation of the impact of Connections (Dagumn et al., 1997) the teachers chose to verify each of the assertions from the previous case studies of the impact of *DASH* on student learning in the following way:

1. Students consistently demonstrate a high proportion of engaged learning time.
   The report cites examples where many students chose to stay in from recess to work on their DASH projects.

2. Students demonstrate knowledge and understanding of important concepts and skills in science, health, and technology.
Through inquiry-based approach, the seeds of curiosity are planted that will ultimately manifest into intrinsically motivated learners. The students' conversations center around connections they have made through constructing their own meanings.

3. Students integrate and apply important science, health, and technology concepts across content areas.
DASH is easily integrated with the writing, speaking, and listening components of the language arts, social studies, and math curriculum. The students are beginning to see a curriculum without walls between the disciplines.

4. Students integrate new science, health, and technology concepts with prior knowledge and experiences.
As students move up through the grades, the teachers are given the opportunity to build an experiential foundation for the introduction of new knowledge. It relieves the teacher of much of the diagnostics required when one is not sure of each student's prior knowledge.

5. Students connect and apply what they learn in school to their lives.
Many of the students carry on experiments or make things at home connected to what is being done in the classroom. Parents become involved not only with the 'inventions,' but also with discussions revolving around the DASH curriculum.

6. Students demonstrate proficiency in investigative skills.
The teacher allows the students to become the facilitator or the discussion leader. The teacher is there to promote meaningful group interaction, to stimulate responses, and to help the group generate its own data.

7. Students consistently take and share responsibility for their own learning and classroom operations.
The teacher is there to provide options for students to see that there is more than one way to do something.

8. Students use cooperative learning strategies when appropriate.
Leadership abilities, group organizational skills, self-monitoring, and evaluation become evident.

9. Students demonstrate positive attitudes toward school, science, self, and others.
The students enjoy school because Connections has provided a program where the students feel like they are a part. DASH students take on a different role than students in traditional classrooms. They are actively engaged in hands-on, real-world activities.

<u>Honolulu,</u>: At Mililani Uka Elementary School, data were collected on the Environment subtest of the Stanford Achievement Test (SAT). The SAT reading and mathematics batteries are administered to all schools yearly in Hawai‘i. Other subtests may be administered by schools at their own expense and initiative. Mililani Uka is a large (1,200 students) suburban school on Oahu serving a middle-class community of diverse ethnic mix. *DASH* is the main science curriculum of the school. Figure 12 shows the stanine distribution of one class of grade 2 students on the SAT reading, mathematics, and environment subtests after two years of *DASH.* The teacher attributes the students' mathematics and science performance to their *DASH* experience.

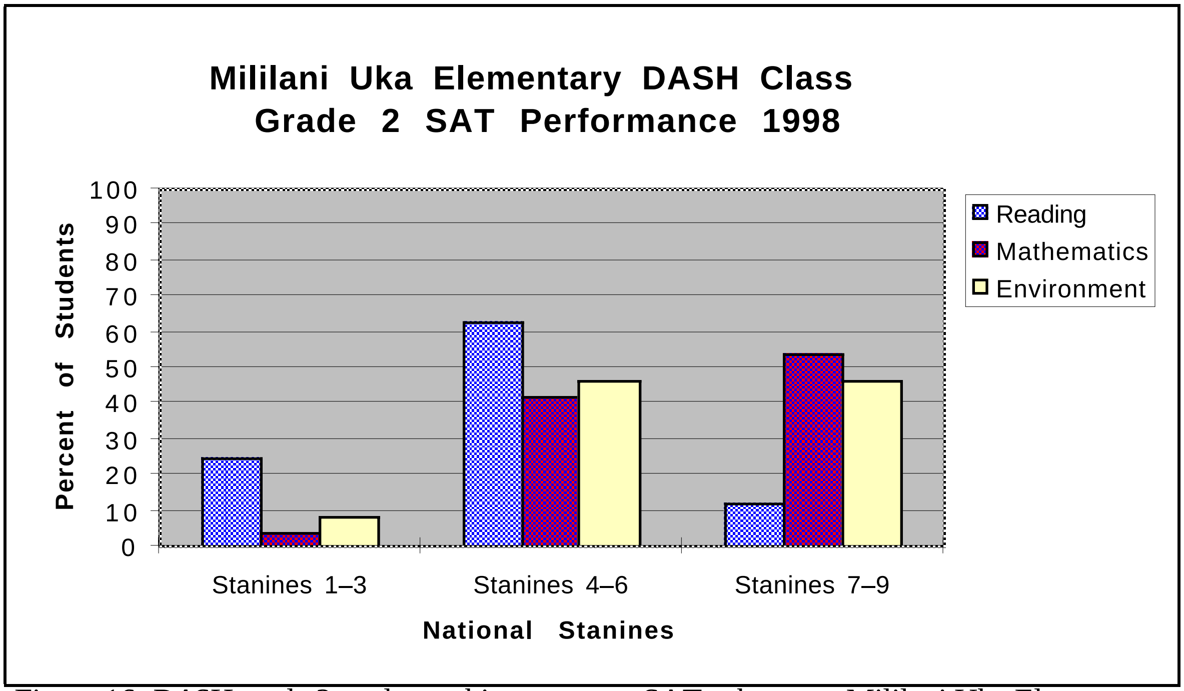


Figure 16. *DASH* grade 2 student achievement on SAT subtests at Mililani Uka Elementary School

Kailua: Ka‘elepulu School on O‘ahu became one of the first school-community-based management schools in the state in 1989. As its core curriculum the faculty selected *DASH* and participated in the professional development institutes and follow-up activities. Ka‘elepulu is a small (200 students) suburban school in a middle-class community of diverse ethnic composition. The school program was thoroughly evaluated by an external team in 1992, resulting in its accreditation by the Western Association of Schools and Colleges (WASC). Ka‘elepulu was only the second elementary school to achieve such status in Hawai‘i at that time. Among the data examined by the accreditation team was students’ good performance on the Stanford Achievement Test (SAT) subtests for mathematics and science at grades 3 and 6, which school personnel attributed to *DASH*. Figures 13–16 summarize the SAT data for the state, district, and school by stanines.

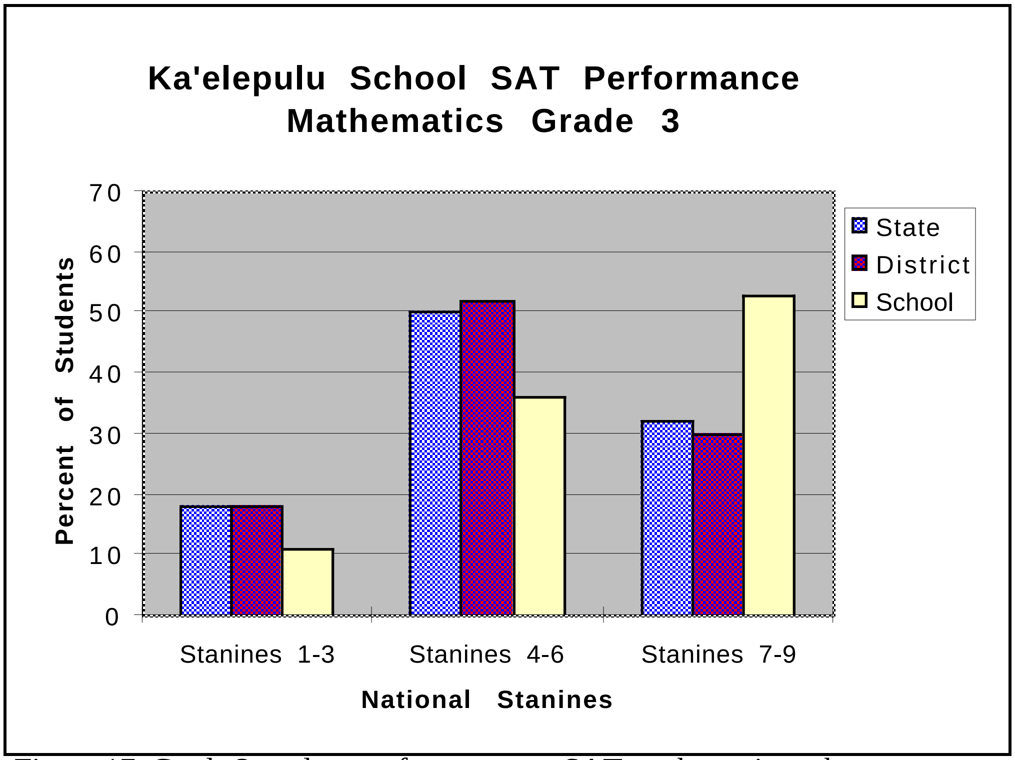


Figure 17. Grade 3 student performance on SAT mathematics subtest

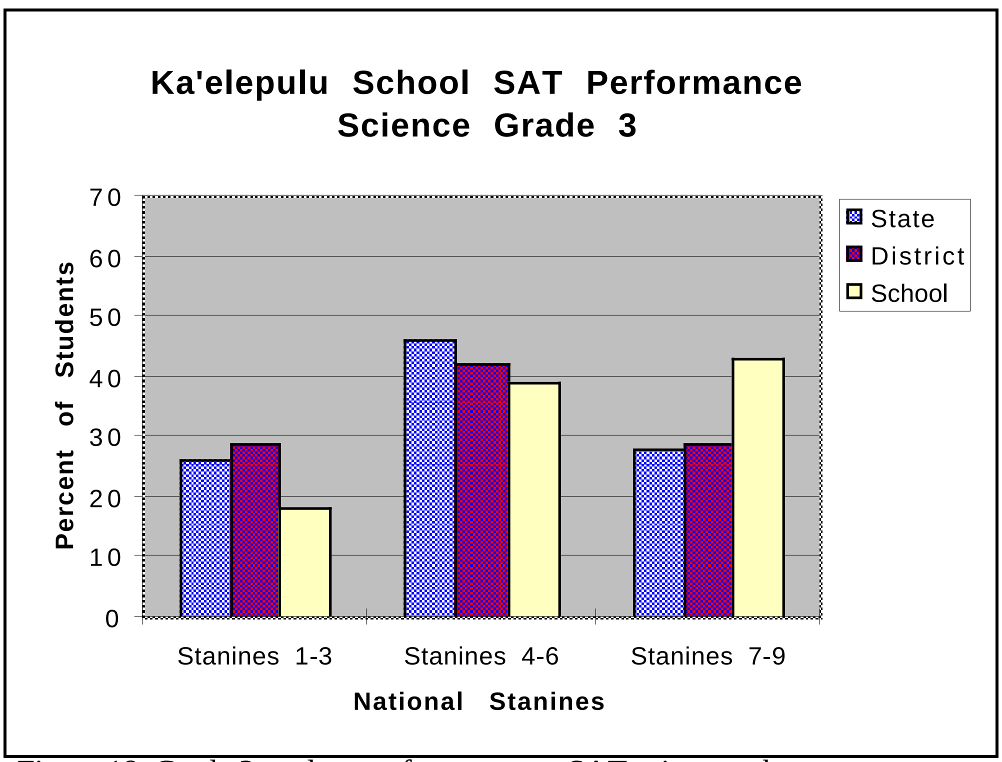


Figure 18. Grade 3 student performance on SAT science subtest

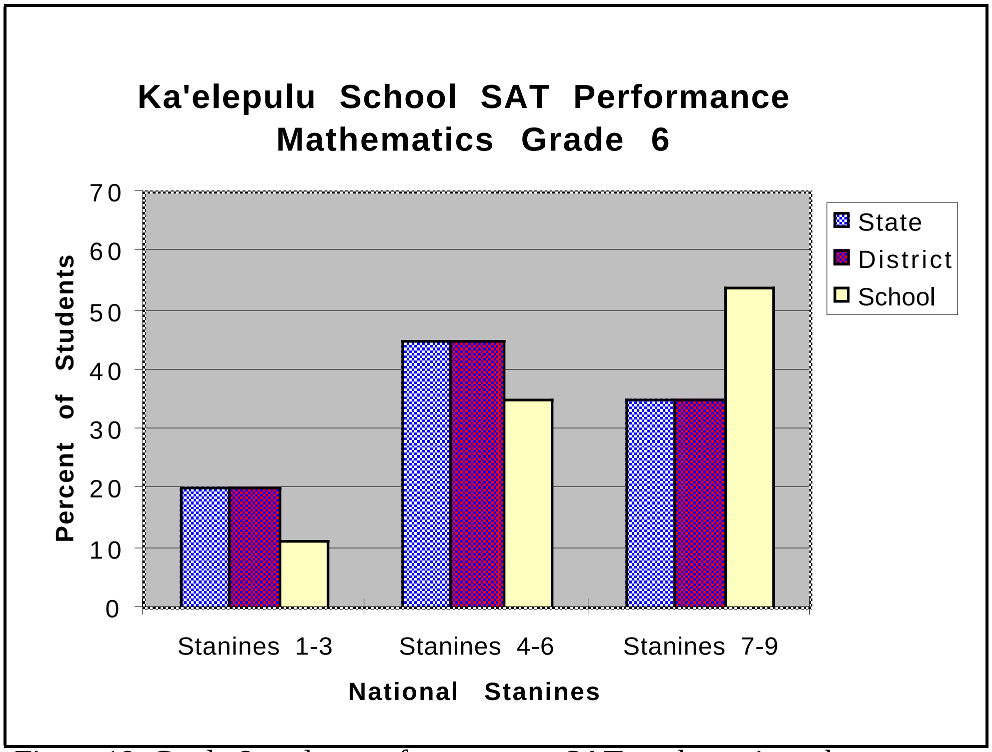


Figure 19. Grade 6 student performance on SAT mathematics subtest

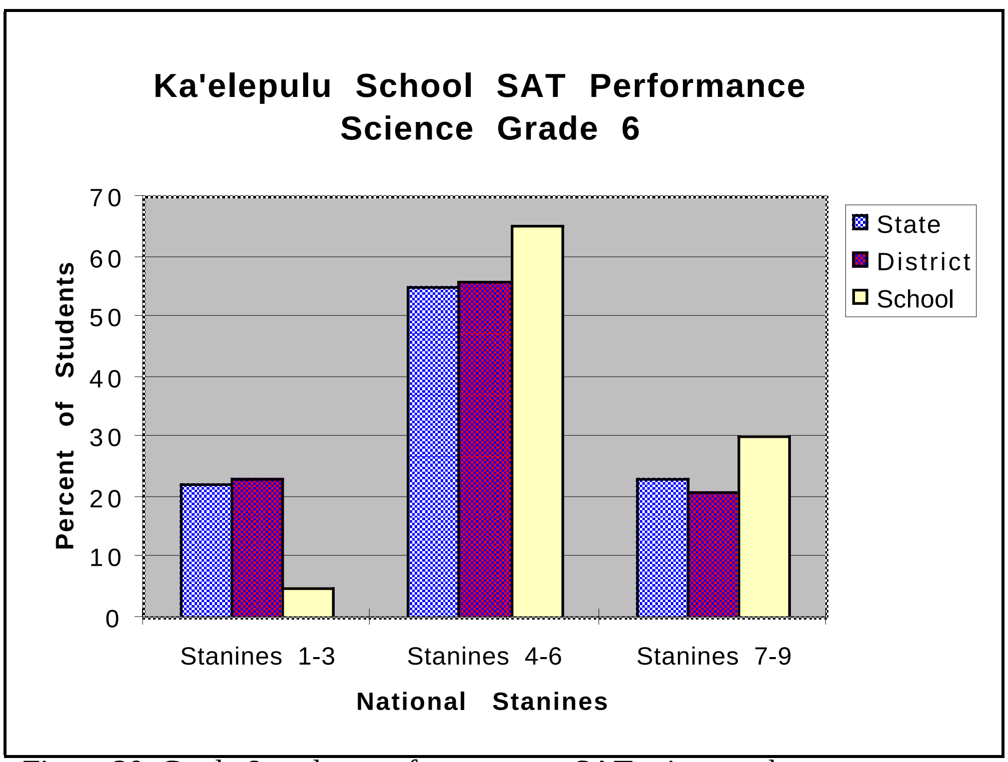


Figure 20. Grade 6 student performance on SAT science subtest

DASH MEETS NATIONAL SCIENCE EDUCATION STANDARDS (1994)

DASH was identified in an independent nationwide search as a science program that meets the national science education standards.

The Laboratory Network Program, funded by the U.S. Department of Education through the Regional Educational Laboratories, conducted a nationwide search to identify promising practices that would address Goal 4 of the Educate America Act—that by the year 2000, American students will be first in the world in mathematics and science achievement.

The selection process had four stages:

1. Each laboratory solicited nominations from its region.
2. Panels of mathematics and science educators reviewed descriptive and evaluative information about the nominated program, using as criteria the degree of match with national curriculum standards, evidence of effectiveness, and transferability.
3. Representatives from all laboratories reviewed the programs to insure consistency in evaluating them.
4. Independent researchers visited each site to confirm that the selected programs were actually as described in the nomination and review materials.

The result of this effort was the publication of *Promising Practices in Mathematics & Science Education,* which identified 66 promising programs—18 mathematics, 20 science, 20 multidisciplinary K–12, and 8 technology-centered K–12. *DASH* is one of the programs identified as meeting the standards of the National Center for Improvement of Science Education (NCISE).

Table 9 shows the match of *DASH* to NCISE standards and the American Association for the Advancement of Science's (AAAS) Project 2061 goals.

Table 9. *DASH* meets national science education standards

STANDARD	***DASH***
National Center for Improvement in Science Education	
Accessible to all students.	√
Builds on student's prior experience and knowledge.	√
Uses an instructional model based on the scientific processes.	√
Relates to personal and social needs.	√
Selects developmentally appropriate concepts in multiple disciplines.	√
Develops scientific thinking skills, e.g., using inferences, creating models, drawing conclusions based on evidence.	√
Develops scientific habits of mind, e.g., curiosity, skepticism, honesty.	√
Uses authentic assessments to chart teaching and learning.	√
Shifts teacher role from imparter of knowledge to facilitator of learning.	√
Seeks relevant applications of science content to students' lives.	√
Project 2061 Goals (AAAS)	
Being familiar with the natural world, its diversity and unity.	√
Understanding key concepts and principles of science.	√
Being aware of the interdependence of science, math, and technology.	√
Knowing that all three are human enterprises and have weaknesses.	√
Having a capacity for scientific ways of thinking.	√
Using scientific knowledge and ways of thinking for social purposes.	√

VALIDATION AS AN EXEMPLARY PROGRAM OF THE NATIONAL DIFFUSION NETWORK (1993)

DASH was validated as an exemplary science program by the Program Effectiveness Panel (PEP) of the U.S. Department of Education and included in the National Diffusion Network (NDN). Impact data on the effectiveness of *DASH* on students' achievement and on teachers' performance submitted to the PEP confirmed *DASH* as an effective science program. *DASH* is included in the NDN catalog of exemplary programs called *Mathematics, Science & Technology: Education Programs That Work* (1994). The data submitted for PEP review are included below.

Development and field-testing of CRDG programs take place over a three- to four-year cycle. Initial testing and formative evaluation of *DASH* were done at the University of Hawai'i Laboratory School, administered by CRDG, where learning and teaching are closely monitored. The school's students are selected to represent a cross-section of the state's school population by ethnicity, socioeconomic level, and ability. *DASH* was further field-tested in rural, suburban, and urban public and private schools in Hawai'i (1,200 teachers; 30,000 students) and in schools collaborating in the *DASH* Development Consortium in Washington, Pennsylvania, North Carolina, Florida, Alabama, and Louisiana (650 teachers; 20,000 students). Pilot-test schools represent the rich diversity of student populations, geographic locations, and socioeconomic conditions of these states. Hawai'i population statistics by ethnic group show Japanese 23.9%, mixed part-Hawaiian 21.4%, Caucasian 20.3%, Filipino 12.6%, mixed non-Hawaiian 11.9%, Chinese 5.1%, other unmixed 1.3%, Korean 1.1%, pure Hawaiian 1%, Samoan 0.5%, Puerto Rican 0.3%, and Black 0.3%.

Evaluation sites were selected through the *DASH* Consortium institutions in Hawai'i, Pennsylvania, North Carolina, and Washington where teams were available to participate in the data collection. The teachers and classrooms selected for study were identified by previous observation as implementing *DASH* with fidelity to the program design and pedagogy. Selected teachers had been teaching *DASH* for more than one year. Table 10 shows the diversity of the evaluation sites.

Methodology

DASH is a complex program incorporating the best available knowledge of materials design, instructional strategies, teacher training and continuing support, and assessment. It incorporates new definitions of learning and teaching that focus on changing the interactions of students and teachers in the contexts of classrooms where variables cannot be controlled.

Though *DASH* and similar NSF-supported curriculum efforts attempt to incorporate the best of what is currently known about learning, teaching, and assessment, little is known about what teachers do with these new programs in their classrooms. Ample research documents the fact that teachers and administrators can talk enthusiastically about innovations without any evidence of these innovations in classrooms (Crandall et al. 1983, Joyce & Showers 1984, Huberman & Miles 1984, Hall & Loucks 1987, Fullan 1987). For example, though recent surveys show teachers and administrators favor hands-on science, there was a 10% decline in the use of hands-on activities in elementary classrooms between 1976 and 1987 (McCormick, 1989).

The recognition of multiple ways of learning, teaching, and assessing, along with the lack of current knowledge about classroom and school use of innovations dictates that in order to understand and learn from the changes proposed by *DASH* for science education, in-depth classroom study must be conducted. *In other words, the assessment of impact of new programs such as DASH must also be multidimensional, reflecting the assumptions on which they are based.* Time must be spent in schools to determine what students, teachers, administrators, and others do with these new approaches—how they adapt them to contextual demands, how the innovations interact with other educational initiatives, and how both affect student performance.

Table 10. Settings and participants in evaluation site

	Hawai‘i		Pennsylvania		North Carolina		Washington
DATA	Grade 1	Grade 3	Grade K	Grade 3	Grade K	Grade 2	Grade 1
Location	Rural	Suburban	Suburban	Rural	Rural	Rural	Urban
Free/Reduced Lunch (%)	31.8	8.6	16.8	41.4	42.0	42.0	45.5
School Ethnicity (%)							
Asian	2.5	40.6	0.5	0.5	0.0	0.2	2.9
Black	1.5	0.5	1.3	3.2	56.0	48.3	3.3
Hispanic	3.3	0.0	0.0	0.0	0.0	0.5	3.3
Pacific Isl.	78.0	14.2	0.0	0.0	0.0	0.0	0.0
Caucasian	6.7	42.2	98.2	96.2	44.0	50.7	88.0
Other	7.9	2.5	0.0	0.0	0.0	0.3	2.5
Enrollment							
District	30,320	19,116	3,216	1,228	17,425	17,425	3,355
School	1,154	199	384	508	174	590	209
Class	20	24	26	24	25	25	27
Ability Levels							
Above Ave	2	10	11	6	6	7	9
Average	6	7	10	10	12	7	12
Below Ave	10	4	3	5	7	11	6
Spec. Ed.	3	2	2	3	0	0	0
Teachers							
Sex	F	F	F	F	F	F	F
Ethnicity	Caucasian	Japanese	Caucasian	Caucasian	Caucasian	Caucasian	Caucasian
Education	B Ed	B Ed	M Ed	M Ed	B Ed	M Ed	M Ed
Yrs. Teaching	3	28	23	15	10	5	12
Yrs. *DASH*	2	2	3	2	3	2	3
Grade	1	3	K	3	K	2	1
Science Bkgd	no	no	no	no	no	no	no

`Under such circumstances, according to Ralph & Dwyer (1988) in *Making the Case: Evidence of Program Effectiveness in Schools and Classrooms* (page 12), a case study approach has strong advantages. A case study is an evaluation based on comprehensive descriptions of complex situations, recounting what happened and why (page 12). Case studies have a unique capacity for dealing with a full variety of evidence, including observations, interviews, documents, and artifacts.

Because of the nature of the learners involved and the nature of the *DASH* program itself, we used a multiple-case-study design based on Yin (1989). Such a design is robust in that multiple cases are considered multiple experiments, and resulting generalizations are based on analytic generalization rather than statistical generalization. The analysis follows cross-experiment rather than within-experiment logic and design. If two or more cases support the same assertion, replication can be claimed (Yin 1989). The methodology used in this study is diagrammed in Figure 21 and discussed below.

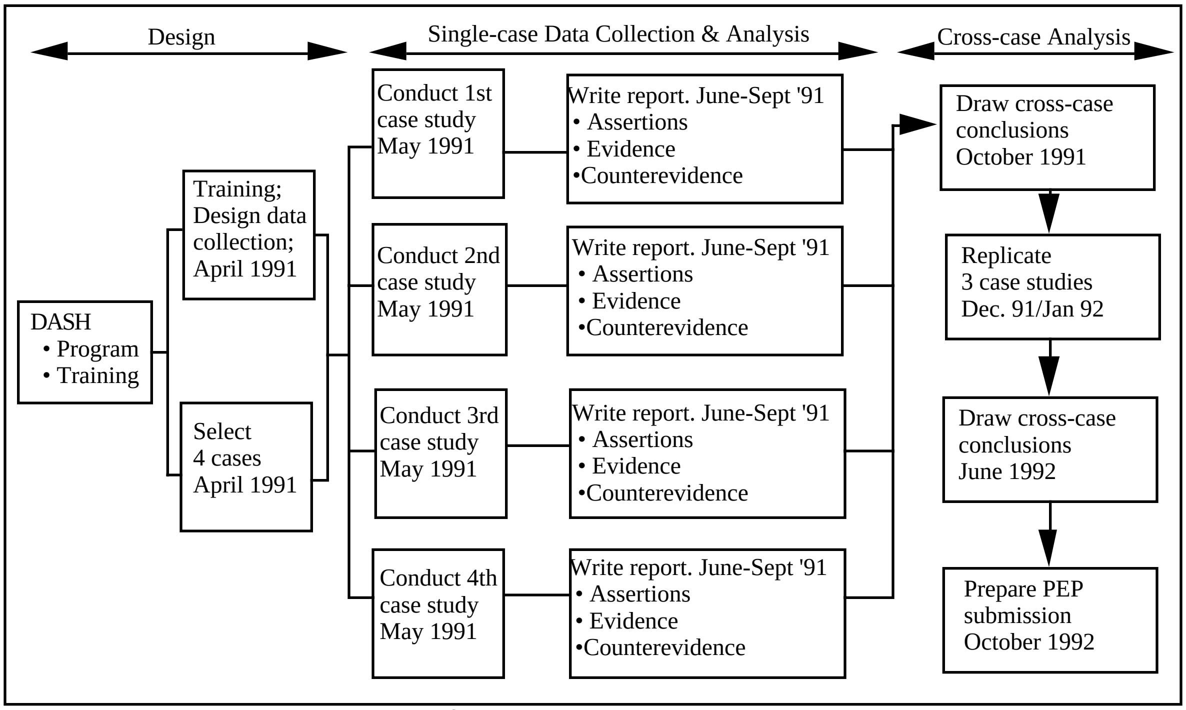


Figure 21. *DASH* Study Design (after Yin, 1989)

Data Collection Procedures

A study team of 11 senior researchers conducted the studies, each member contributing a unique perspective/expertise to collecting and interpreting the data. The team met for intensive three-day training that included readings and seminars, development of protocols for site selection and case studies, and pilot case studies by the entire team to advance the team's understanding of *DASH* and the questions under investigation.

Site teams of two or three investigators collected data in *DASH* classes over a five-day period, logging over 200 observer hours. Classes were videotaped for later analysis. Teams conducted interviews with teachers, administrators, and students, audiotaping the interviews. At each site two or more observers wrote daily field notes. Data were collected on student-created products and artifacts, engaged learning time, test data where available, and teachers' lesson plans. Classrooms and artifacts were photographed.

Each site team wrote single-case-study reports and prepared data base portfolios, including field notes and collected artifacts and photographs. Single-case-study reports were coded to field notes, creating a direct link between the voluminous data and the reports. The site teams agreed to the data interpretation in the single-case study reports, which were also verified by the teachers and administrators involved.

The study team met again to share, analyze, and compare data. Four days of additional training was provided in case-study-report writing and in cross-case analysis. Additional classroom observations were conducted by the study team in *DASH* classes to further develop observer reliability. The data in the single-case-study reports were reviewed by an independent third party who also conducted the cross-case analysis. Pattern matching (Yin 1989) based on predicted student and teacher outcomes derived from the *DASH* theoretical framework was used to analyze the single-case-study reports and supporting field notes. The study team reviewed and verified Gallagher's cross-case analysis and the resulting assertions common across sites. Three more case studies were conducted in Hawaiʻi, Pennsylvania, and North Carolina involving an additional 200+ observer hours to determine if the empirically derived assertions were replicated and sustained in grades 2 and 3. Single-case-study reports were written and verified by the teachers and administrators in the respective schools. A second round of pattern matching and cross-case analyses was followed by verification by the study team. The resulting supported assertions constituted the claims submitted to the Program Effectiveness Panel.

The strength of this multiple-case-study design lies in the common training of senior researchers, in use of multiple independent observers at each site, in use of an independent external evaluator in conducting pattern matching and cross-case analyses, and in the direct coded links from the cross-case analysis to the seven single-case reports to the raw data in field notes, interviews, and videotapes. Triangulation of evidence is applied in three ways—in multiple data sources at each site, in multiple perspectives of team members at each site, and in multiple case studies. Multiple cases are considered replications of experiments. Considering the diversity of the study sites, any common findings provide strong evidence of the impact of *DASH*.

Table 11. Matrix of data sources

Impact of *DASH* on	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Students' knowledge	√	√	√	√	√	√	√	√	√		√	√				√
Students' skills	√	√	√	√	√	√	√	√	√			√				√
Students' attitudes & self-concept	√	√						√	√	√	√	√				√
Engaged learning time	√	√														
Teachers' views about teaching, learning, & children	√	√								√		√	√	√	√	√
Teachers' knowledge and skills in teaching	√	√										√	√	√	√	
Teacher's knowledge of science	√	√										√	√	√	√	
Teachers' use of assessment	√	√	√	√	√	√	√	√	√			√	√	√		
How teachers build a program in their contextual situation	√	√										√	√	√		
What teachers actually do in their classrooms	√	√					√	√				√	√	√	√	
Interactions of students and teachers	√	√										√				
Interactions among students	√	√									√					
Interactions among teachers												√			√	
Interactions of teachers & administrators												√			√	
Interactions of teachers & parents												√			√	√
Sustained use in schools							√					√			√	

Assessment Data Source Codes

1. Classroom observations
2. Classroom videotape analysis
3. Analysis of available standardized test scores
4. *DASH* assessment techniques (*DASH* Learning Calendar; Science Record Book, concept maps, Working Dictionary, Wonder & Discover Book, Connections Book, etc.)
5. Concept and Skill Inventories
6. Performance assessment
7. Students' portfolios
8. Students' writing samples
9. Products, inventions, creations
10. Attitude scale
11. Student interviews
12. Teacher interviews
13. Lesson plans analysis
14. Teacher's portfolio
15. Administrator interview
16. Parent interview/questionnaire

CLAIM STATEMENTS

This submission made three claims of effectiveness of *DASH*. Supporting evidence in case studies was derived from four types of data: observations, artifacts, documents, and interviews. Multiple sources of evidence drawn from the case-study data bases link the theoretical framework to the data collected and converge to support the claims. Tables of assertions are used to summarize the voluminous data from the case studies. Triangulation was used to corroborate assertions. Only statements corroborated by more than one type of data were include

Claim 1.0 *DASH* students demonstrate understanding of fundamental concepts and use of essential skills in science, health, and technology as documented in case studies, including observations, artifacts, documents, and interviews.

The concepts and skills in *DASH* were validated as basic to understanding science, health, and technology by experts on the *DASH* Steering Committees and are identified as essential for scientific literacy in *Science for All Americans* (AAAS 1989). The primary purpose of science education is mastery of these concepts and skills. Table 12 presents documented evidences stated as assertions in support of Claim 1 and shows the sites and grades where these assertions were documented and the types of data used in the cross-validation.

1.10. Students demonstrate knowledge of concepts.

The *DASH* Learning Calendar, a long roll of paper on which students record what they learn each day, was used in all seven sites. The daily morning routine included measuring and recording weather data, temperature, wind direction, wind speed, time of sunrise and sunset, phase of the moon, and number of the days of school. At the end of each day students decided what they had learned that day and entered it on the calendar. Student groups reported what was recorded to the class, verifying the written record. Observations in all seven sites verified that students knew and used correct terminology for compass directions (north, south, east, west), moon phases (waxing, waning. gibbous, crescent, full, and new), temperature (both Celsius and Fahrenheit), wind direction, descriptions of daily weather, and other concepts being studied at the time of observation. Students in all sites demonstrated command of compass direction by correctly locating objects. (HI1,3/PAK,3/NCK,2/WA1/o) The coding used provides a direct chain of evidence from claims to the cross-case analyses to the single case study reports to the raw data sources.
(Sites: HI = Hawai'i; PA = Pennsylvania; NC = North Carolina; WA = Washington. Number indicates grade level. Type of data: o = observations recorded in field notes, audio and video tapes; t = teacher interview; a = administrator interview; i = student interview; p = parent data; s = student product or artifact).

The Learning Calendar at each site recorded what students learned in science, health, and technology from the first day of school. During observations in grades 1 and 3, it was unrolled. Students found and recorded on worksheets such things as the hottest and coldest day; the number of days, weeks, months, seasons, and moon cycles; the shortest and longest days. Randomly selected students were able to correctly teach concepts recorded on the calendar on any selected day, even from the previous semester, to observers. These data demonstrated knowledge of time, temperature measurement, moon cycle, number, and other significant science concepts. (HI1;WA1;PA3/o).

All classrooms were filled with student-made products from *DASH* activities—moon clock, weather clock, moon data sheets, windsocks, plant experiments, growth charts, concept maps, and other evidences of students' achievements (HI/PA/NC/WA/o).

DASH uses concept maps in all grade levels to record what students know or have learned about significant concepts. Concept maps were posted in 5 of the 7 sites. They were stored in the room in the other two sites. Concept map construction was observed in 3 sites. For example, in developing a concept map on transportation, grade 1 students demonstrated their knowledge of vehicles used for transportation. They also developed a concept map on air and on what they had learned in grade 1

Table 12. Claim 1 assertions and cross-validation

CLAIM 1.0 SUPPORTING ASSERTIONS	NC K	PA K	HI 1	WA 1	NC 2	HI 3	PA 3
1.10 Students demonstrated knowledge of concepts	otais	otais	otis	otis	otais	otais	otais
1.11 All students used the *DASH* Learning Calendar	otais	otais	otis	otis	otais	otais	otais
1.12 Students created the Learning Calendar	oti	oti	oti	oti	oti	oti	oti
1.13 Students accurately recorded scientific data and concepts	ots	ots	ots	ots	ots	ots	ots
1.14 Students orally reported the data on the Learning Calendar daily using scientific language	ot	ot	ot	ot	ot	ot	ot
1.15 Students taught others concepts on the Learning Calendar	oti	oti	oti	oti	oti	oti	oti
1.16 Students made concept maps	ts	ts	ots	ts	ts	ots	ts
1.17 Students made working definitions and dictionaries	ND	s	os	s	s	os	s
1.18 Students recorded questions in their Wonder and Discover Book	ND	ts	ots	otis	ts	tis	ts
1.20 Students used basic inquiry skills and data gathering techniques	otis	ots	otis	otis	otis	otis	otis
1.21 Students were engaged in observing, questioning, generalizing, predicting, and inferring	o	o	o	o	o	o	o
1.22 Students used library references and experts	o	o	o	o	o	o	o
1.23 Students made and used scientific measuring devices	otis	ots	otis	otis	otis	otis	otis
1.24 Students invented, developed, and used devices and techniques for problem solving	ND	ot	oti	oti	oti	oti	oti
1.30 Students demonstrate integration and application of concepts	oti	otip	oti	oti	oti	otaip	otai
1.31 Students accurately use scientific vocabulary	oti	otip	oti	oti	oti	otaip	oti
1.32 Students retain concepts from grade to grade			ti		ti	oti	otai

Types of data: o = study team observation recorded in field notes, audio, and video tapes; t = teacher interview;
a = administrator interview; i = student interview; p = parent data; s = student product or artifact.
ND = no data. For assertions 1.17 and 1.18, the Working Dictionary and the Wonder and Discover Book were not being used in the kindergarten class. For assertion 1.24, no invention activity was conducted during the data collection period.

(HI1/o). In grade 3 the teacher used the concept maps to solicit what students already knew and to summarize what the class had learned collectively from their activities. Through the concept maps students demonstrated knowledge of the following, including the ability to name examples of each: soils (composition, animals in soil, sand, texture, effect on plants, color, clay, and uses); animals (mammals, fish, reptiles, amphibians, birds, insect, arthropods, arachnids) (HI3/o). Similar concept maps were done in grade 2 on spiders and their habitats (NC2/o).

DASH Working Dictionaries were present in six of the seven sites. Students use the Working Dictionary to record definitions of concepts they are learning. Only student definitions are recorded, not textbook definitions. The Working Dictionary is thus a repository of what students know about a concept. Analysis of the contents of the six working dictionaries revealed correctly defined concepts, including sunset, sunrise, weather, horizon, intersection, traffic safety, vehicle, transportation, pet, plant, soil, insect, and others (HI1;HI3;PAK;PA3;WA1;NC2/o).

1.20. Students use basic inquiry skills and data gathering techniques.
DASH is designed to help students construct their understanding of science, health, and technology by doing the work of scientists and technologists. Today's science and technology are grounded in natural history, descriptive astronomy and meteorology, and in inventions to satisfy basic biological needs. *DASH* students work at the level of descriptive science to develop skills of observing, questioning, predicting, measuring, using equipment and resources, generalizing, and inferring. They use library resources and experts other than books and the teacher. Data collected in all seven case studies verify that students consistently used these inquiry skills (HI/PA/NC/WA/o).

For example, students used the information on the Learning Calendar in investigating new questions. In a first-grade class, after students had collected several months' data on the sequence of moon phases, the teacher asked, "How many more days to the new moon?" Students referred to their data on the moon clocks they made and predicted 3 or 4 days. Later they observed the moon to see if they were correct (WA1/o). Kindergarten and grade 1 students made predictions about the decomposition of their Halloween pumpkins and compared them to actual findings (HIK;PAK/o).

Students at all seven sites made data charts, growth charts, tooth charts, and graphs of water use, daylight and darkness, moon phases, and so on. When data did not seem to fit, students tested them empirically. For example, in a grade 1 class on measuring growth by the surface area of students' feet, one girl reported 31-1/2 square centimeters. Students replied, "No way." The data did not fit the class set. Students checked and corrected the data (WA1/o). In grade 3, students used metric balances they made to weigh the chickens they were raising and recorded daily weights on a posted graph (PA3/o).

Students also demonstrated skill and ingenuity in inventing and constructing devices needed for their activities. For example, grade 1 students designed and built vehicles from cardboard for a traffic simulation. They demonstrated skill in using tools. They investigated drying time, fastenings, strengths of different materials, ways of cutting materials, how crushing changes shapes and strengths, and so on (HI1/o). In grade 3, students planned and made windsocks, using a variety of materials and tools and demonstrating their technological uses—wood, fabric, paper, plastic, wire, tape and so on. Only one design failed. On another day, students worked in small groups to design an experiment on germinating seeds without soil as a follow-up activity to their concept map on soil. They used plastic trays, paper towels, cups, crushed rocks, sand, and other materials in the classroom to execute their design. They also demonstrated knowledge of plant needs for water and nutrients. All groups created successful designs (HI3/o).

1.30. Students demonstrate integration and application of concepts.
Consistent with the constructivist philosophy underlying *DASH*, the utility of knowledge is primary. Concepts unconnected to other concepts and to applications are of little value. One evidence of integration and application of concepts is the use of proper vocabulary in contexts other than those in which concepts are first learned.

Interviews were conducted with all seven teachers and five of the seven administrators. (One administrator was new to the school and unfamiliar with *DASH;* another was not interviewed during the site visits due to time constraints.) All teachers stressed the development of students' vocabulary of science, health, and technology and their integrating it with other knowledge. These teachers are considered expert judges because of their education and their experience in teaching these grades. Sample statements follow.

> *It increases the children's vocabulary. Parents are surprised when their children come home and use terms that they don't even know.* (PAK/t). The principal verified this claim saying, *Kids are using words that they had not been used to learning. DASH is teaching realistic skills that need to be taught. It's low cost and it works.* (PAK/a)
>
> *Definitely the vocabulary has increased. I find myself not talking down to them as much as I did before, or trying to explain it to them in a simpler sense. Word usage on the Iowa Achievement Test for every child was much higher. I didn't change my vocabulary to come down to their level. Instead, they came up to my level and used the technical terms I did. I had the lowest reading group. In the past the lowest reading group did not finish as much as the other groups. This year, they finished the same amount as the highest reading group with very little difference.* (PA1/t)
>
> *The vocabulary is definitely there. They know thermometer, decomposition, all these things through the process. So, it's more meaningful than it was before, when we picked the words out of the book and wrote the sentence to match.…And they remember a lot too. Ask them what are some of the things we do in science and they remember things. …Their thinking skills are way better. We were reading a story about storks that said there were no trees in this place. Then someone says, 'If there's no trees in this town, why do they have trees on the cover of the book?' That's real thinking. DASH is kind of the 'whole language' of science.…Students discovered a mistake in moon information on a commercially produced calendar while conducting their moon investigations. 'Look, it couldn't possibly be. We know from our chart that it's a crescent moon. So how can they say it's a new moon now and then it's going to go to this quarter? Either they skipped a crescent or they're backwards.' The grade 1 class wrote a letter to the publisher informing them of the error.* (WA1/t)
>
> *There is greater comprehension of what is going on. On our standardized science tests they did quite well.* (PA3/t) This was verified by the principal: *They (kindergarten and first graders) knew everything that had happened to them and they carried that information into the next grade. They were making connections and they could sit and talk with you about all the different activities. You could see just by observing and through conversation that the children were keeping their knowledge. They weren't forgetting over the summer.* (PA3/a)

Supplementary Evidence

Supplementary data were collected in the case studies that support Claim 1 on standardized test data, teachers' lesson plans, and parent feedback.

Standardized Achievement Test Data

Standardized achievement test data were available at some sites as part of their school-based testing program. Stanford Achievement Test (SAT) Environment subtest data were part of the school record for kindergarten through grade 2 at one Hawai'i site. Students there have consistently scored above national norms for the science subtest since the implementation of *DASH* (HI3/o).

In a Pennsylvania district (three schools; seven first-grade classes) where *DASH* was being used in four classes but not in three others, the data in Table 11 were provided to the study team.

Table 11. SAT Environment Subtest results for grade 1 (3 schools, 7 classes)

National Stanines	*DASH* CLASSES *n* =178				NON-*DASH* CLASSES *n* =148		
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
Stanines 7, 8, 9	88%	55%	67%	100%	32%	35%	61%
Stanines 4, 5, 6	12%	40%	33%	0%	68%	55%	39%
Stanines 1, 2, 3	0%	5%	0%	0%	0%	10%	0%

The *DASH* teacher in North Carolina reported that her first-grade class was the only one of four classes that fell into the middle and high ranges on the science subtest of the Metropolitan Achievement Tests. *I had no one in the low range, even though four of my students were really struggling in reading and two were almost nonreaders. The three other first-grade classes had students scoring in the low range area in science.* (NC2/t)

The principal reported that *DASH* students scored above the state averages on the North Carolina Comprehensive Achievement Test (CAT) and on the pilot test for the 1994 revision of the CAT (NC2/a).

This is the first year that I have not retained a student. The teacher attributes this success to *DASH*, in which *students help each other; slower students improve because of DASH.* (NC2/t)

A Pennsylvania principal noted, *If you are going to compare achievement test scores with activity-based education, you are assessing it incorrectly. We use portfolio assessment, including teacher observation, student work, checklists, parent comments, and anecdotal records. We work with the whole child. The main reason we do achievement testing is to receive Chapter 1 funds. Since DASH, our test scores have not gone down and on thinking skills they have come way up.* (PA3/a)

Teachers' Lesson Plans In their lesson plans, teachers in all seven sites identified the key concepts and skills in each *DASH* lesson, thus confirming that they aimed to teach these essentials in science, health, and technology. (HI1;HI3;PAK;PA3;WA1;NCK;NC2/o)

Parent Survey Data At two sites, survey data from grade 1 parents were collected. The survey brought 84 responses (98% return). All parents reported that their children talked about *DASH* activities and benefited from the hands-on approach. None made any negative comments. All urged that *DASH* continue in upper grades. These were among their responses:

He was able to teach us new things which gave him reinforcement of his learning abilities.

He and I both learned a lot through the DASH program. We became more family-oriented through the home activities. I became aware of the sunset and sunrise times. I never noticed them before.

DASH was talked about more than other school work.

We are currently recycling everything because of the awareness from DASH.

This teaching has really excited her. We still look for the moon when we are out driving. She watches for signs and tells their meaning.

My child has a lot to say about school instead of 'Oh, nothing.' (HI3;PAK/o).

Claim 2.0 *DASH* students are self-directed learners taking responsibility for their own learning as reflected in engaged learning time, planning and completion of tasks, and use of multiple resources as documented in case studies including observations, artifacts, documents, and interviews.

Research on learning shows that successful learners are knowledgeable, self-regulating, strategic, and empathic (Kuklieke et al., 1990). *DASH* Claim 1 focuses on knowledge, *DASH* Claim 2 on the responsibilities of learners. Table 14 presents documented evidences stated as assertions in support of Claim 2 and shows the sites and grades where these assertions were documented and the types of data used in the cross-validation.

2.10. Students consistently demonstrated 85%–95% engaged learning time.
Research over the past 36 years shows a consistent positive relationship between time-on-task and achievement (Carroll 1963, 1974, Stallings & Kaskowitz 1974, Bloom 1976, and others). "Engaged time…is defined as the simultaneous occurrence of allocated time and task engagement" (Borg 1980, p. 59) and "is essentially synonymous to time on task, attention, and participation—found in the research literature." (p. 55)

Table 14. Claim 2 assertions and cross-validation

		CLAIM 2.0 SUPPORTING ASSERTIONS	NC K	PA K	HI 1	WA 1	NC 2	HI 3	PA 3
2.10.		Students demonstrated 85%–95% engagement time	o	o	o	o	o	o	o
2.20 for		Students demonstrated self-directed responsibility assigned tasks	ots	otisp	otis	otis	otis	otisp	otisp
	2.21	Students carried out assignments on the responsibility chart	ot	oti	oti	oti	oti	oti	oti
on	2.2.2	Students collected and recorded information the Learning Calendar	os	ots	ots	ots	ots	ots	ots
	2.23	Students initiated learning activities	o	os	os	os	os	os	os
	2,24	Students used many different resources to complete projects without teacher direction		ot	ot	ot	ot	ot	ot
	2.25	Students completed learning activities	ot	ot	ot	ot	ot	ot	ot
2.30		Students demonstrated responsibility for fellow students and the classroom	ot	ot	ot	ot	ot	ot	ot
	2.31	Students maintained an orderly environment	ot	ot	ot	ot	ot	ot	ot
	2.32	Students required a minimum of disciplinary moves by the teacher		o	o	o	o	o	o

Types of data: o = study team observation recorded in field notes, audio, and videotapes; t = teacher interview;
a = administrator interview; i = student interview; p = parent data; s = student product or artifact.

Engagement times reported in the literature generally range from 50% to 90% of allocated time, with 70% reported as excellent (Bloom 1974, McDonald 1975, Good & Beckerman 1978, Rosenshine 1978, Borg 1980, and others). These data were reported mostly in elementary reading and math. No studies were found which measured engagement time in science.

Engagement time (ET) data were collected in this study. The method was adapted from procedures developed by the Far West Laboratory for Educational Research and Development (FWL) and the Southwest Regional Laboratory (SWRL). About 90% of the ET data were collected by a researcher who had 25 hours of training from the FWL and SWRL and who performed above the .80 calibration test during the early part of 1991.

ETs during 20 hours of observations ranged from 87.5% to 100%, with the greatest frequency being over 90% (HI1;HI3/o). Class scans of students by observation or review of videotapes showed ETs between 85% and 100% (PA/NC/WA/o). In one site this high ET was maintained over two hours each of five days of observation. Students ignored the recess bell and continued their activities (HI1/o). Only in one class did the engagement time fall below 70%. This was while the teacher was teaching by lecture from the chalkboard while students sat in their assigned seats (HI3/o). At the grade 3 site in Pennsylvania, the observers recorded 85% to 95% ET while students were doing *DASH* activities. ET fell to less than 70% when the teacher changed to non-*DASH* activities (PA3/o). Observations in six of the seven sites show minimal disciplinary moves by the teacher during *DASH* activities. This finding tends to confirm the high rate of engagement time (HI1;HI3;PAK;PA3; NC2;WA1/o).

2.20. Students demonstrated self-directed responsibility for assigned tasks.
In seven sites a *DASH* responsibility chart was posted. The chart lists names and assignments for classroom maintenance and learning activities such as the Learning Calendar. Study team members noted that students referred to the chart, then initiated and carried out their tasks without teacher intervention (HI/PA/NC/WA).

On each day of observation at all seven sites, students came in, checked the responsibility chart, and went directly to their tasks. For example, two students cleaned, fed, and watered the class animals. One got the windsock and went out to measure wind speed and direction. Two began recording on the Learning Calendar while another began taking attendance. Others measured the temperature in Fahrenheit and Celsius. Students conducted the daily report on the Learning Calendar—all without overt teacher direction. (HI/PA/NC/WA/o).

Student-made inventions, graphs, concept maps, drawings, worksheets, and other artifacts from *DASH* activities were reported on the classroom walls in all seven sites, attesting to task completion (HI/PA/NC/WA/o). The *DASH* Working Dictionary described in Claim 1 had many student entries (HI/PA/NC/WA/o).

In addition, *DASH* students in six of the seven sites used a class Wonder and Discover Book where students'questions were recorded. Many questions were explored later, and answers were entered as discovered. Students at all sites involved family members in trying to find answers. The Wonder and Discover Book provides a way to assess both the kinds of questions students have about their learning and the limitations of their knowledge. Example questions: *Why do we see the moon in the day? How high is the sun? How high will the clouds be in the future? Is the world a circle? Why are roses red? How old is the oldest person on earth? How many miles can a bird fly? How do you make a thermometer? How many eclipses are there in a year? How can a telescope see far distances? How do birds fly? How was the sun formed? Why do leaves fall off trees? Where did the ocean come from* (HI/NC/PA/WA/o)?

Students took responsibility for their room and used the resources in it for learning. For example, during the morning routine they referred to the numberline posted above the chalkboard to solve math problems. In writing, they used the word board in the back of the room for spelling (HI1/o). To determine the correct name of the phase of the moon, they used the moon clock and recorded the name on the Learning Calendar (HI/PA/NC/WA/o). Students selected and used materials from the *DASH* Inventor's Box to create their own inventions such as windsocks (HI3/o), vehicles and traffic signs (HI1;PAK/o), and mobiles (NC2/o), to solve problems such as concept mapping of animals and soils (HI3/o), building cages (NC2/o), and designing experiments on seed germination (HI3/o). They tested their designs empirically rather than seeking teacher authority. For example, they went outside to determine if their windsocks worked (HI3/o). Students used each other, their own artifacts, library resource books, other adults, and the teacher as sources of information in carrying out their activities (HI/PA/NC/WA/o). In all seven sites, students completed tasks in the time allotted by the teacher. They also cleaned up the room and put away materials without the teacher'sntervention (HI/PA/NC/WA/o).

2.30. Students demonstrated responsibility for fellow students and the classroom.
Students took responsibility for one another, including self-discipline. For example, they used silent signals (finger to mouth) to control their own behavior and that of others. They verbally and physically helped move other students to new activities when a shift was called for. They asked for assistance from other students when necessary (HI/PA/NC/WA). For example, grade 1 students unrolling the learning calendar identified and analyzed behavior problems from the last unrolling and decided on rules for conduct. They planned before the unrolling how they were going to collect required data (HI1;WA1/o). In working on windsocks, one boy remarked, "I want to put the string on. I never do nothing." Others in the group moved aside, watched, and suggested, but let the boy finish the windsock (HI3/o).

Supplementary Evidence
Supplementary data were collected in the case studies that support Claim 2 by teacher interviews and parent surveys.

Teacher Interviews
Teacher interviews in all seven sites verified the assertions for Claim 2. Example remarks:

> *Students have positive interactions in class. Students help each other, they share strengths. Slower students improve because of DASH* (NCK/t). This comment was supported by the principal, who said, *Students are actively engaged in the processes of learning, individually and through group participation. The DASH program encourages supportive relationships, good communication skills, and high-level thinking abilities while developing the basic concepts of science* (NCK/a).
>
> *They (students) have the background and DASH gives them the sense of wanting to know more. They have become better problem solvers* (NC2/t).
>
> *When I check the learning calendar it is usually done without reminding or teacher help. I see students checking the responsibility chart as they come to school; in fact, some will remember from the day before what their jobs will be. I observe students reminding each other and helping each other. There are about 4 who still cannot write, but will get their jobs done with the help of others.…What I've noticed is when they feel the success in these activities their attitude in general improves. For example, Q, when he first came he'd just say, 'I can't do this.' He had such a negative attitude and through experiencing some of these activities where he really felt, 'Hey, I did this great.' He started telling me, 'You know, I can do this.' They feel comfortable and confident in what they can do* (HI1/t).
>
> *I think that the children who benefit the most are those like M, the Samoan child, and special needs students—the students who aren't processing really well academically. They do well in DASH because it's a lot of hands-on activity and they enjoy it and get a lot out of it* (HI3/t).
>
> *So many improvements that I saw through the year that I hadn't seen in 17 years of teaching. Students didn't have as many adjustment problems to first grade as students usually do. There was no crying or wanting to go home. The day didn't seem as long for them. Children became much more responsible than I have ever seen any first-graders in all the years I've been teaching. They had specific jobs to do each week, including cleaning pet cages, taking weather data, and other activities that had to be done daily. I didn't have to remind them. They would just come in and get started on their jobs. They were able to work in groups and individually. They seemed to know which was appropriate to the*

activities. As an observer, I could see they were all attending to the problem at hand. By working together the whole group seemed to succeed. Students would volunteer to help each other, especially in other subject areas, once they learned that they could work in groups and be successful in groups. When one child was having problems in math, another child would ask if they could help them. And indeed, they did help them. They didn't tell the answer. I could see them up there actually teaching them how they came up with the answer (PA1/t).

Parent Surveys
The teacher-conducted parent surveys in Hawai'i and Pennsylvania support Claim 2 by indicating that learning behaviors carry over outside the classroom. Example statements:

It taught him a lot about responsibilities. He even feeds the dog now

My child seems to like school, including DASH. I can see a difference between my child that has been involved in DASH and my child who has not.

I think it allowed students to stretch themselves with their new knowledge. It made them think. It made me think because my child taught me.

I don't usually pick up the daily paper, but it's been a must so she can check up on the weather.

I know my child benefited from the DASH program. She experienced projects that normally wouldn't be offered in the regular school curriculum and had a good taste of science.

She never stopped babbling about all the projects. She especially liked the jobs that they were assigned to do each day.

Yes, it helped make him more inquisitive and helped him to attack problems on his own with reasoning skills.

She continues to watch the moon and name the phases. She keeps track of the dates on her own calendar. The program has been really stimulating for her.

She always told me about the DASH activities and she was very conscientious about doing the home activities.

Claim 3.0 Experienced *DASH* teachers changed their attitudes and approaches toward elementary science in ways that result in increased instructional time spent on science and focus on students' learning, as documented in case studies including observations, documents, and interviews.

The lack of instructional time spent, the lack of science background among teachers, and the dominance of the textbook in elementary science are well documented, especially at the K–3 level (Weiss 1987). A change in these crucial variables would significantly affect learning science. For students to be more actively engaged in learning science, health, and technology, teachers' behaviors must change. Table 15 presents documented evidences stated as assertions in support of Claim 3 and shows the sites and grades where these assertions were documented and the type of data used in the cross-validation. All teachers interviewed described the changes in their teaching. Sample interview data are provided below. Space limits more complete documentation.

3.10. Teachers became more positive in their attitudes toward teaching science.
Most elementary teachers are insecure about teaching science. *DASH* inquiry strategies shift the construction and processing of knowledge to students. *DASH* teachers create an environment that enables students to engage in learning science by effectively using an inquiry approach. Evidence for change in teachers' attitudes and approaches comes from teacher interviews with validation from independent administrator interviews.

> *I think that probably the one thing it has done for me is change my whole philosophy of teaching. I've been doing things much differently in my classroom than I have done in the last seventeen years. I'm not telling the children the answers. When they want to find something out, we find it out together.…You'll probably be able to tell by just looking around,…how the class is being run. That they are doing it in group. But, probably the atmosphere of the room. I know my atmosphere has changed greatly, since I got involved in DASH. I used to be more structured. I was strict.…Now, I think it's freer. If you walk around the room, the children are on task, you can hear them discussing what they're supposed to be doing, and they're really involved with the activity. But it probably is a little bit louder before.…Their whole feeling of their self-esteem was raised during the year. One girl sticks in mind. She was very unsure of herself. Besides having a lot of family problems she had a very low self esteem and seemed to be the type of child that when you called on her for an answer, would give you an off-the-wall answer. And you would think, 'Where did that come from?' But instead I would ask her to explain her answer. And sure enough, when she was explaining it, it did make sense in her own way. And the rest of the children would understand what she meant and they would applaud her or say, 'Yes, that is right.' I guess now whenever I compare back to three years ago when we used the science, and social studies, and health books, we didn't give them enough credit for what they were really able to learn.…I haven't felt this much gratification in teaching since my student teaching years and first year I taught. I've been rejuvenated by this program. It has affected my teaching of other subject areas as well. I have such a feeling of accomplishment. I'm looking forward to my next year of teaching more than ever.* (PA1/t).

Table 15. Claim 3 assertions and cross-validation

CLAIM 3.0 SUPPORTING ASSERTIONS	**NC K**	**PA K**	**HI 1**	**WA 1**	**NC 2**	**HI 3**	**PA 3**
3.10 Teachers became more positive in their attitudes toward teaching science	t	ta	t	t	ta	ta	ta
3.20 Teachers changed their approaches to teaching science.	otas	otas	ots	ots	otas	otas	otas
3.2.1 Teachers changed from textbook teaching to inquiry	ota	ota	ot	ot	ota	ota	ota
3.2.2 Teachers enable students to find answers rather than give answers	ot	ot	ot	ot	ot	ot	ot
3.2.3 Teachers used simple materials rather than science kits	os	os	os	os	os	os	os
3.2.4 Teachers allowed students greater independence in learning	ot	ota	ot	ot	ota	ota	ota
3.3.5 Teachers enabled all students to be successful in science	o	oa	o	o	o	oa	oa
3.30 Teachers spent more time teaching science than the national average	od	od	od	od	od	od	od
3.31 Teachers increased integrated subject areas	ND	odta	odt	odts	odtas	odtas	odtas
3.32 Teachers captured unused instructional time	ot	ot	ot	ot	ot	ot	ot

Types of data: o = study team observation recorded in field notes, audio, and video tapes; t = teacher interview;

a = administrator interview; i = student interview; p = parent data; s = student product or artifact; d = school document, lesson plans, and other written evidence. ND = No data. There was no evidence of integration during the observation period.

> The administrator says of this teacher: *L. was one of those people who, like many of us in our age bracket, maybe twenty years in education or more, have gotten stale for a lot of reasons. When I've gone to other schools or places where I talk about this program I talk about a teacher who was burned out, who, if you'd seen her before and you see her now, it's a difference of night and day.…From a personal and professional point of view there is a major difference. She feels a lot better about her job and it really shows. She's an outstanding teacher and I think this program has given her a lot more confidence about what she's doing.…She's learned a lot about teaching. We all have as a whole district.…There's been a lot of sharing about the program. All the components are there. That's what's exciting about it for me. When you think about the hands-on, we've known it's the way to go. We give kids credit for technical vocabulary. That's something new to this district. No question about it, they know about that stuff now. It caused the principal to be a lot more flexible about allowing kids to move around the building and go outside and measure snow and rain and that kind of thing. It links the parents to something. That's very hard to do, but you see a lot of parent involvement in this program* (PA/a).
>
> *I loved science, but it was by the book. That's where I thought we got science. Once in a while we used to do a science report on the solar system or what not, but we went through the chapters and we read about it and did discussion. I'd try to do experiment kinds of things. It certainly wasn't integrated. It was more fact science and the tests were there. We'd go through the book and I'd make leave out blanks where key vocabulary words were. Now, it's very student-centered and the children do the thinking rather than a one-right-answer kind of approach where you read the book.…They can do the research. I've got to find ways to get the information that they're looking for in a manner that they can understand it. It's not that I can say at the end of the month, 'This is what they all know and they have all passed this test.' It's developmental and they're on their way to coming to an understanding about a lot of things. They've got curiosity and desire and confidence in their own thinking skills.…I didn't realize it, but science is in the middle of just about everything. The whole curriculum is easily integrated into science or the other way around. It's certainly more meaningful than it was before when we picked words out of a book and wrote sentences to match. I thought you had to be really smart to teach science. I thought, 'I don't know anything.' I took geology and biology because that's what you had to take. And then I saw this stuff was fun. My friends are really amazed that I love science* (WA1/t).
>
> *I can see a difference in the children. When I first taught science, you were given topics and you were given x amount of time to cover certain pages. We didn't have a lot of materials. It was basically your science book and whatever else you could come up with. And looking at pictures of things isn't all that exciting. You can look at a picture of a tree and in the book it would say, 'This is a tree. There are different kinds of trees.' or 'This is a rabbit. There are many different kinds of rabbits.' Somehow it kind of lost its zest. In DASH we do things. As I said once before, a traditional science program is like someone showing you a picture of a roller coaster and saying, 'Boy this is a fun ride.' but DASH is like getting on the roller coaster and going up and down and feeling nauseous and feeling the thrill when you go up and down. You are actually experiencing it, not looking at something someone else has written down or a picture someone has taken. I think that is the best type of learning that there is.…Now I am facilitating and they are doing the actual experiments and activities. The children do a lot of collecting and saving things from home. I have to make sure that if we're going to make volume containers, we have sufficient quantities. I have to make sure we have necessary equipment. Or if we are going to dig a*

garden there are certain things that are going to have to be done. So I have to be able to set in advance what we are going to need or what we are going to do to make sure that we have the time and facilities to do it.…We've been doing our reading and DASH right along with it. Math varies. We do measuring and we do weighing. Graphing is something that the children didn't understand a lot and with DASH we do a lot of graphing and a lot of comparisons. That helps. We're doing crystal shapes in DASH. When we go through in math and talk about different shapes the kids will make the connection to the crystals (PA3/t).

These changes are supported by the principal, who said, *I've known her since she started teaching. She was something like myself. As I teacher, I knew something was wrong, we just didn't know what was wrong. We didn't know the term process learning. We knew that learning took a period of time, but they hadn't coined those phrases—process learning, or integration, or making connections, or DASH, or whole language. She used the book as a bible. So when she was able to have that freedom to fly like an eagle instead of hopping around like a robin, she grabbed onto it. That is the same as some of our other teachers. She was open to it and so that is why she was able to soar. The first year we got involved with DASH the students absolutely loved it because they weren't doing science worksheets. They were actively involved in their own learning. Meanwhile the teachers were frantic because it was a pilot program and they were used to their basals saying you do A, B, C. We had other teachers saying, 'Why is that teacher doing that?' They were frightened that they may have to do that. Change was difficult for the teachers and meanwhile the children were loving it. They were coming to school. We had perfect attendance, the attendance went way up, it wasn't down. And I learned from DASH that in order for things to work for teachers, they have to have staff development. …Parents like it. When the parents chimed in and said, 'I like this DASH,' and it wasn't coming just from me; it was an outside pressure; and the parents got the teachers to want to do it* (PA3/a).

3.20. Teachers changed approaches to teaching science.

Before DASH I would demonstrate science. Now, I won't teach a lesson unless every child has materials, each child has their hands on. DASH has shown me you can use everyday materials. You don't have to have a science kit.…I'm carefully going through questioning strategies. They have the background and DASH gives them the sense of wanting to know more. They have become better problem solvers.…We're integrating the curriculum. DASH integrates easily with language, measuring, social studies, and health.…Parents are excited about what we are doing. They will send in materials when they hear their child use words like predict and results" (NC2/t). The administrator notes, *"We chose DASH because it could be easily integrated with other subjects. We know it's working. Our students performed above state averages on the CAT tests* (NC2/a).

There is more hands-on now that we're into DASH.…(I) improved my questioning technique and as I said, it's child centered. It is better to let them discover things—they learn more than just having to memorize things. It carries over into all of the other areas of teaching, too. I can see myself questioning them about everything now. They're excited about it; they enjoy doing all of the activities; the parents seem to be very supportive, and they get involved in the activities. They send in extra things and they're more than willing to do the activities that we ask them to do at home like the moon watch and the pet sitting. I never had an animal in the classroom other than fish, which aren't very personal. They enjoy taking the bunny home for the weekend. There is more parent involvement; there are a lot of home activities. The DASH activities gave us a way to expand science (PAK/t).

The principal adds, *She was very much a structured person as far as her teaching. She used a lot of worksheets. She's gone from that type of a situation to a lot of hands-on activities for kids. She also has explored the fact that they can do things that I don't think* *she thought that they could do by giving them that flexibility and giving them a chance to work that way. DASH is teaching realistic skills where they need to be taught. In many ways the thing that was neglected in primary classrooms was science. If anything didn't get taught, it was science. DASH has given people some opportunities to explore some other strategies, ways to approach things, with hands-on activities, with kids exploring and involved in ideas and activities. DASH leads to integration of other subject areas. You're getting away from being totally textbook-oriented. Teachers aren't working in textbooks, they're doing hands-on, exploratory things. They're doing things that the kids are up moving around. You have to kind of turn your ears off to some of the noise, because there is noise, but it is busy noise. The kids are involved and talking and discussing things that need to be discussed that's busy noise* (PAK/a).

First grade, it's all reading. And the materials we had were very few for the content subjects and it was just open the book look at a picture and talk about it. We knew that what we were doing in our classroom we weren't happy with. We wanted to change in some way but we didn't know where to start. We were skeptical about DASH and taking the training, but then as we used the activities and in the classroom we were seeing some results that we hadn't seen before. Now after three years of teaching and using DASH, that the philosophy has really fit in for me and it's changed my other curriculum areas too.…To me DASH has it's own philosophy. It's being open, not always thinking there is a right answer. Or expecting one right answer. And not always giving what we know of as the right answer. And letting the students do more of the thinking than myself. basically I changed my style teacher and it's still changing.…It's brought the teacher and the parents closer, working more as a team. Before DASH, we did not have a real good relationship with the parents. I mean we got along with the parents, but it was separate. But with DASH we've have had them in to help us with activities plus asking for materials that we might need, and they've seen results coming home. They've seen their children come home and talk with them about what their doing in the classroom. And that's really been good for us because they become more involved in what we're doing (PA1/t).

A North Carolina teacher demonstrates her focus on the learning of all students: *Positive student interactions are taking place. Students help each other; they share strengths. Slower students improve because of DASH. This is the first year that I have not retained a student" (NCK/t).* Her principal adds, *The emphasis now is on the curiosity and exploratory nature of the child. Such hands-on experiences provide opportunities to use and develop science skills and leads gradually to the understanding of basic science and environmental concepts. Our students enthusiastically look forward to checking the wind, visiting a farm, or planting seeds* (NCK/a).

DASH is self-motivating. When I first started teaching they would say, 'Oh, science. What chapter do we have to read tonight?' Now it is, 'What can we bring to school so we can do these things?' (PA3/t).

3.30. Teachers spent more time teaching science than the national average.
Evidence of current practice is drawn from teachers' lesson plans, which show that in all seven sites teachers spend 50 to 150 minutes per day teaching science with *DASH*. This finding was verified by interviews and classroom observations at each site (HI/PA/NC/WA). This is a significant increase from the average of 18 minutes per day reported in recent studies of elementary science (Weiss, 1987). Data on what teachers and students do during this time is provided under Claims 1 and 2. The extra time for science does not come at the expense of other subject,s; it comes from judicious planning and integration of subjects. Example responses in teacher interviews follow.

The first year it was basically thirty minutes trying each day. Now it's to the point where some days I might run an hour or two hours, depending on the activity. And I try to tie it in *with, like I said the language arts. We feel that most of our social studies curriculum is met through DASH right now. A lot of the trade books we've been ordering now have science themes* (PA1/t).

There's a lot more science in my class now. I spend 3 or 4 periods everyday doing DASH. The thinking that goes on and the way that it is tied to other areas like math. It takes care of our social studies and health too (WA1/t).

I think DASH really has affected my teaching. The best thing that it has helped me with is to try to do inquiry method. I used to just give the answers, just blurt it out. Now I'm trying to train myself to say 'What do you think?'…Students have become more resourceful. I really saw it yesterday. They were really trying to get the answers using library references. They know now not to come up and always ask. They try to find out on their own.…When we did directions, we transferred it easily into social studies. When we did bubbles, we did graphing and math. Now I don't have to spend that much time in math on graphing. They've done it. Of course we still need work on it but it was a way to integrate it (HI3/t).

The changes were verified by the science supervisor: *This was the first time that I'd seen a program that actually used instructional design in a way it was supposed to. I've seen teachers that were kind of doing science hit and miss or they had favorite topics that they liked to do. They may have science intensely for a few weeks and that was it for the rest of the year. They'd think, 'Well we haven't had any science for a long time so maybe we'd better do science in case any of the parents asked.' The ones that became involved in DASH have really seen how they can use it in all different areas. Whether they realize it or not, they're integrating the DASH approach into almost everything they're teaching. They're seeing how to get the kids to work together cooperatively. They're seeing how to hold your tongue and not give all the answers and let the kids try to find the answers. And most of the time they can find the answers. And they've gotten confidence. I think that's probably the biggest thing. Most of the teachers have this inferiority complex about science and they feel, 'I am not good at science.' Once they got involved in DASH, they've seen they don't have to have all the answers. They can teach science and they can integrate it with other things that they're doing. And once they have that confidence to be able to use it, the doors are wide open. In second grade last year, you could walk in there on any day, at any time and they were doing something that related to DASH. All the evidence was right there. And I'm seeing that a lot more in third grade. I'm really seeing her get up to a point where she sees what she does is different. You don't have to have the periodic table memorized to be able to teach something about science* (HI3/a)

I used to teach AIMS. It's more choosy and it relies on cutesy activities with little teddy bear worksheets, jelly beans, and hearts. They're fun activities and it's good for children, but DASH relies a little more on the teacher's creativity.…In DASH I'm not worried about structure as much. You know, it's a teaching style, I think, that's affected. I'm not as edgy having children going outside and doing calendar measurements when some of us are doing attendance. That's one thing about DASH, you can't demand to have children sitting in their seats and you don't want them to.…Here we've integrated the curriculum, science, health, language arts, math, and technology. It was very easy to integrate.… And retention is there. The other day one of my students from last year came in and he said, 'Oh, you folks are doing decomposition.' I mean, it clicked and it stuck with him and that was a big impact to hear that it was something that was so internal in him" (HI1/t). This teacher integrates *DASH* into about 150 minutes of instruction daily (HI1/o).

Interpretation and Discussion of Results

Evidence supporting the claims comes from multiple data sources—observations, students' products and artifacts, school and class documents, and interviews with teachers and administrators.

Trained observers at seven diverse sites interpreted the data; an independent researcher analyzed and summarized the evidence across study sites. Claim 1, on understanding of concepts and use of essential skills, is directly observable and documented by multiple data sources. Claim 2, on becoming self-directed learners, relates indirectly to student outcomes in Claim 1 but follows from the constructivist philosophy that forms the theoretical framework of *DASH*. Evidence in support of Claim 2 is also directly observable and documented. Claim 3 relates indirectly to student outcomes but is consistent with the theoretical framework of *DASH*. That is, for Claims 1 and 2 to be achieved, teachers' behaviors must change in ways that enable students to engage more actively in their own learning. Teacher interview data, verified by independent supervisor interviews, provide evidence in support of Claim 3 on teacher changes in attitude and approach to teaching science, health, and technology. These data are also supported by the observational evidence presented in Claims 1 and 2 on teachers' practice in class. Across the seven diverse experimental sites, the common variable is use of the *DASH* program.

Claims are made only where verification is corroborated by more than one type of data. Counter-evidence, where it exists, does not detract from the convergence of data supporting the claims. In fact, no claims are made in areas where there is not significant triangulation of data across cases. Certainly not every student achieved all of the results claimed. But the conclusions from the multiple case studies make a strong case for the impact of *DASH* on students and teachers.

The case study design is robust. The multiple cases are replications or multiple experiments. Findings presented in support of the three claims demonstrate the replicable impact of *DASH*. The design intentionally uses intact groups in natural school settings where variables outside of treatment can affect outcomes. If two or more cases support the claims under such circumstances, replication can be claimed (Yin 1989). The diversity of study sites and data collection over different years reduces threats of history, selection, and mortality. Teachers, administrators, and observers in the study are considered experts in early childhood education. Their interpretations reduce threats of maturation. The use of multiple observers at each site and an independent evaluator reduce threats of instrumentation and expectancy. The research design addresses threats to construct validity through the use of multiple sources of evidence and review of the single-case-study reports by the teachers and administrators at the seven sites. Additional control for internal validity is provided through pattern matching by an independent analyst. External validity is enhanced by the use of multiple case studies. Reliability is established through training of observers, using multiple observers at each site, using established protocols for observations and interviews, video and audio tapes of observations and interviews, establishing portfolios of artifacts and documents from each site, and a direct, coded chain of evidence from the claims to the cross-case analysis to the single case study reports to the raw data.

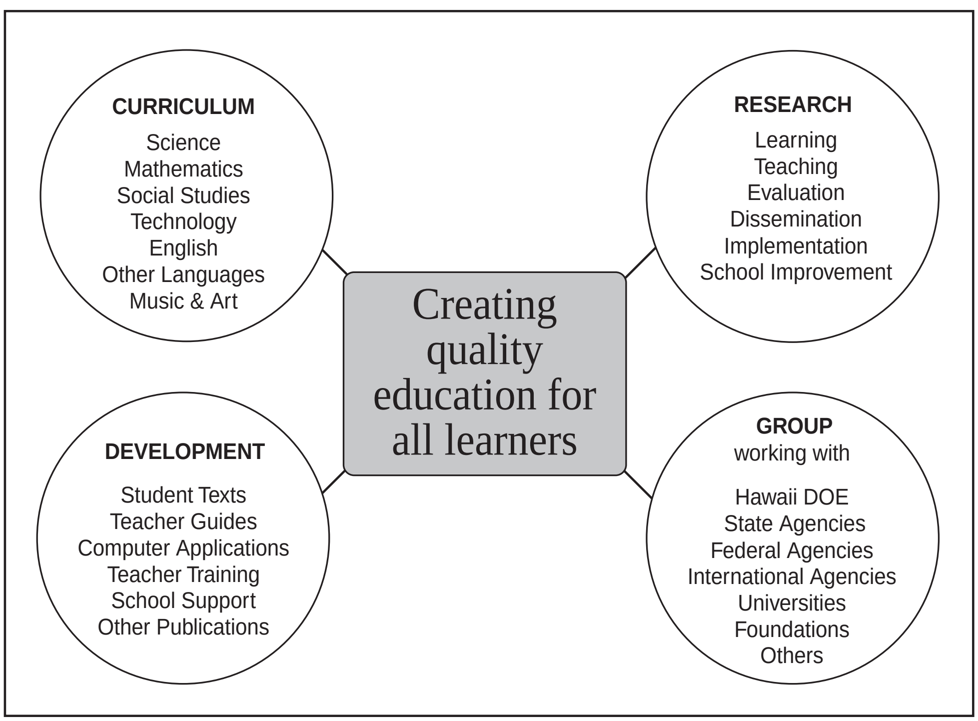
Curriculum Research & Development Group
University Laboratory School

The Curriculum Research & Development Group (CRDG), including the University Laboratory School, conducts systematic research, design, development, publication, staff development, and related services for elementary and secondary schools. The CRDG has curriculum development projects in science, mathematics, English, Pacific and Asian studies, marine studies, environmental studies, Hawaiian and Polynesian studies, Japanese language and culture, music, nutrition, art, drama, technology, health, and computer education. Research and school service projects focus on educational evaluation, teacher development, reduction of in-school segregation of students, and programs for students educationally at risk. CRDG's emphasis is on providing

- effective programs that work.
- professional development for teachers and others.
- sustained support services.
- documentation of results.

The CRDG is the senior member of a cooperative program of fourteen universities in the United States to improve schooling in science, health, and technology in elementary and secondary schools. It is a founding member of the Pacific Circle Consortium of universities, major school systems, and educational ministries in Australia, Canada, Korea, Japan, New Zealand, and the United States. CRDG is a lead member of the Pacific Mathematics and Science Regional Consortium along with Pacific Resources for Education and Learning (PREL).

CRDG-developed programs are being used experimentally in other countries, including Australia, Israel, New Zealand, Russia, and Slovakia as well as in international/American schools in Indonesia, Singapore, Morocco, United Arab Emerites, Saudi Arabia, and Japan. The CRDG provides professional development institutes and support services for all its projects. CRDG publishes and distributes its materials nationally and internationally.



*S*REFERENCES

American Association for the Advancement of Science. (1990). *Science for all Americans.* Washington, DC: Author.

American Association for the Advancement of Science. (1993). *Benchmarks for science literacy*. Washington, DC: Author.

Bloom, B. S. (1974). Time and learning. *American Psychologist* 29, 682–688.

Borg, W. R. (1980). Time and school learning. *Time to learn*. California Commission for Teacher Preparation and Licensing. U.S. Department of Education. 33-72

Carroll, J. (1974). Fitting a model of school learning to aptitude and achievement data over grade levels. *The Aptitude-Achievement Distinction*. Monterey, CA: CTB/McGraw-Hill.

Carroll, J. (1963). A model for school learning. *Teachers College Record* 64, 723–733.

Curriculum Research & Development Group. (1996a). *Alignment of Developmental Approaches in Science, Health and Technology (DASH) and the National Science Education Standards Grades K–4*. Honolulu, HI: Author.

Curriculum Research & Development Group. (1996b). *Alignment of the Developmental Approaches in Science, Health and Technology (DASH and Foundational Approaches in Science Teaching (FAST) Programs with the National Science Education Standards Grades 5–8*. Honolulu, HI: Author.

Dagumn, J. K., Kuniyuki, T., Miyazono, E., Nooney, D., Thatcher, J., & Thatcher, P. (1997). *An evaluation research of Connections School-within-Mountain View School, a restructuring for choice, change, and continued parental involvement.* Unpublished document.

Fullan, M. (1987). *Implementing educational change: What we know*. Ontario, Canada: Ontario Institute for Studies in Education.

Hall, G. & Loucks, S.. (1987). Teacher concerns as a basis for facilitating and personalizing staff development. *Teachers College Record* 80. 36–53.

Huberman, M., & Miles, M.. (1984). *Innovation up close: How school improvement works*. New York: Plenum.

Joyce, B. & Showers, B. (1984). *Power in staff development through research on training*. Alexandria, VA: Association for Supervision and Curriculum Development.

Kentucky Department of Education. (1997). *Results-based practices showcase*. Frankfurt, KY: Kentucky Department of Education.

Kuklieke, M., Bakker, J., Collins, C., Fennimore, F., Fine, C., Herman, J., Jones, B. F., Raack, L., and. Tinzmann, M. B. (1990). *Multidimensional assessment: Strategies for schools: A guidebook.* Elmhurst, IL: North Central Regional Educational Laboratory.

McCormick, K. (1989). Battling scientific illiteracy: Educators seek consensus, action on needed reforms. *ASCD Update*.

McDonald, F. J. (1975). *Research on teaching and its implication for policy-making:Report on phase ll of the beginning teacher evaluation study*. Paper presented at the Conference on Research on Teacher Effects: an Examination by Policymakers and Researchers, sponsored by the National Institute of Education, at the School of Education, University of Texas, Austin.

National IOTA Council. (1970). *Instrument for the observation of teaching activities.* Tempe, AZ: Author.

National Research Council. (1996). *National science education standards*. Washington, DC: Author.

National Science Foundation. (1993). *User-friendly Handbook for Project Evaluation: Science, Mathematics, Engineering and Technology Education*. Arlington, VA: Author.

National Staff Development Council. (1994). *National Staff Development Council's standards for staff development: Middle level edition.*

Northwest Regional Educational Laboratory. (1998). *Catalog of school reform models: First edition.* Portland, OR: NWREL.

Program Effectiveness Panel. (1993, December). *Guidelines for preparation and review of submissions for revalidation by the Program Effectiveness Panel*. Washington, DC: Author.

Ralph, J., & Dwyer, M. C. (1988). *Making the case: Evidence of program effectiveness in schools and classrooms*. Washington, DC: U. S. Department of Education, Office of Educational Research and Improvement.

Rosenshine, B. (1982). *Teaching functions in instructional programs.* Airlee House Paper.

Rosenshine, B. (1978). *Academic engaged time, content covered, and direct instruction.*

Stallings, J. A. and Kaskowitz, D. (1974). *Follow-through classroom observation evaluation.* Menlo Park, CA: Stanford Research Institute.

Tallmadge, G. K. (1977). *The Joint Dissemination Review Panel Ideabook.* Washington, DC: U.S. Government Printing Office.

U.S. Department of Education, Office of Research and Improvement. (1994). *Promising practices in mathematics and science education.* Washington, DC: U.S. Department of Education.

U.S. Department of Education, Office of Research and Improvement. (1994). *Science and mathematics education programs that work.* Washington, DC: U.S. Department of Education.

Weiss, I. (1987). *Report of the 1985–86 national survey of science and mathematics education.* Research Triangle Park, NC: Research Triangle Institute.

Yin, R. (1989).*Case study research: design and methods.* Beverly Hills, CA: Sage Publications.

For further information contact
Curriculum Research & Development Group
University of Hawai‘i
1776 University Ave.
Honolulu, HI 96822
Phone: 800-799-8911
808-956-7961
Fax: 808-956-6730
Email: crdg@hawaii.edu
URL: www.hawaii.edu/crdg