FOUNDATIONAL APPROACHES IN SCIENCE TEACHING (FAST)

SUMMARY OF EVALUATIONS

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FAST PROGRAM DESCRIPTION

The *Foundational Approaches in Science Teaching* (FAST) program is a series of three inquiry science courses designed specifically for students ages 12 to 15. In FAST students replicate the activities characteristic of the science disciplines by providing investigative experiences in the physical, biological, and earth sciences. Content is organized into three strands called physical science, ecology, and relational study. Relational study focuses on the interrelationships of the science disciplines and the interactions of science and society.

The goal of FAST is the development of a scientifically literate student who has 1) the background necessary for understanding the environmental concerns arising in our technological society, and 2) the foundational tools for further study in the sciences. The principal objectives of FAST are to develop thinking skills, laboratory skills, and knowledge of foundational concepts of the disciplines of science.

FAST is currently being used in schools in 36 states and 10 foreign countries. It has been translated and used in science clubs in Japan, and most recently translated and used as a pilot program for science education reform in Russia and Slovakia. FAST has also been translated into Braille.

FAST MEETS NEW STANDARDS FOR SCIENCE (1994)

FAST was identified in an independent nationwide search as a science program that meets the new standards for science education.

Leaders in science and mathematics education are calling for drastic changes in the way science and mathematics are structured, sequenced, and taught in order to achieve the eight national goals of education recently enacted into law (Goals 2000: Educate America Act)—especially goal 4, that by the year 2000, American students will be first in the world in mathematics and science achievement. To address this goal, 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.

The process for selecting programs involved 4 stages. During the first stage, each laboratory solicited nominations from its region. The second stage involved reviews in each region by panels of mathematics and science educators of the nomination information and other descriptive or evaluative information submitted in each region. The criteria used to evaluate each program included the degree of match with national curriculum standards, evidence of effectiveness, and transferability. The third stage involved a national review by representatives from all laboratories to insure consistency. During the fourth stage, site visits by independent researchers were conducted to confirm that the selected programs were actually as described in the nomination and review materials.

The result of this independent, nationwide effort was the publication of *Promising Practices in Mathematics & Science Education*[1] identifying 66 programs of promising practice—20

[1] U.S. Department of Education. Office of Educational Research and Improvement. *Promising Practices in Mathematics and Science Education*. Washington, DC. 1994.

mathematics, 27 science, 20 multidisciplinary K–12, and 8 technology-centered practices K–12. FAST is one of the programs identified in this extensive, independent process as meeting the National Center for Improvement of Science Education (NCISE) standards. Further analysis shows that FAST also addresses the goals of the American Association for the Advancement of Science (AAAS) as described in their publication Project 2061, Science for All Americans.

Table 1 shows the match of FAST with NCISE standards and Project 2061 goals. An analysis of the match of FAST to the Project 2061 Benchmarks and the draft standards of the National Research Council (NRC) are available on request.

Table 1. FAST meets new standards in science

STANDARD	**FAST Courses**
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.	√

CONSUMER'S GUIDE TO SCIENCE CURRICULUM (1993)[1]

In an independent review of science programs appropriate for high-ability students, the College of William & Mary's Center for Gifted Education conducted a comprehensive analysis of available science programs under their National Science Curriculum Project for High Ability Learners K–8 Project. FAST was one of 27 programs assessed. Though FAST is not intended specifically for high-ability students, the reviewers rated the curriculum design 2.76 and its classroom design 2.63 (on a 1–3 scale with >2.33 being recommended for use with high-ability students). In the categories Exemplary Science Content, Exemplary Science Process, and High Ability Learners, the reviewers rated FAST 3.25, 3.93, and 3.46 respectively on a 5 point scale. Scores above 2.30 are considered adequate for use with high-ability learners.

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1 Boyce, L.N., D. T. Johnson, B.T. Sher, J. M. Bailey, S.A. Gallagher, J. VanTassel-Baska. *Consumer's Guide to Science Curriculum*. The College of William & Mary. Center for Gifted Education. Williamsburg, VA. 1993.

In addition, the reviewers noted that

the FAST program offers a laboratory-based curriculum that is especially designed for middle-school students. The curriculum is especially strong in science process. In addition, the curriculum includes physical science, ecology, and relational study strands that attempt to integrate fundamental science concepts with societal issues. The high involvement that the program provides through investigations, discussion, and group work makes it particularly successful with students of low socioeconomic status and girls who might otherwise avoid science.

INTERNATIONAL RECOGNITION (1994)

FAST has been identified as the only American middle-school science program for translation and pilot study into Russian by the Russian Academy of Sciences in collaboration with 5 schools and 4 universities in diverse regions of the country. In Russia, the program is called *World Around Us*. It establishes a new generation science curriculum that enables teachers not just "to teach science" but to teach students how to work together in the classroom and with students in other towns and countries. The model curriculum gives students in compulsory school an opportunity to do "real science" in their classrooms and cooperate with their partners through telecommunication networks around the world. The model helps to more closely integrate science classes, informatics (computer science) classes, and language classes in Russian and English. Through this innovative approach, teachers of different schools and subject areas are joining together to work on educational reform through their own classes.

Similarly, FAST was selected by education researchers at the State Institute for Pedagogy in Slovakia for translation and field testing with students in 11 schools in that country. The pilot project is supported by the Ministry of Education, U.S. Peace Corps, and the U.S. Information Agency. All three courses in FAST have been translated into Slovak. The project is intended to be the core of science education reform in Slovakia.

In Hawaii, FAST is being translated into Hawaiian for use in the Hawaiian language immersion schools. In addition, FAST 1 has been translated into Braille by the Mid-Continent Braille Association.

In recognition of the importance of these collaborative efforts, the United States Congress included the following language in the 1994 Foreign Operations Appropriation Bill:

Foundational Approaches in Science Teaching

The Committee is aware that the FAST Program is being used in 36 states and 8 foreign countries and that FAST materials are being translated for use in five Russian and five Slovakian schools. There are plans to train teachers and expand the FAST Program to other schools in Russia and Eastern Europe. The Committee encourages AID to consider supporting this effort.

A PROGRAM FOR HETEROGENEOUSLY GROUPED STUDENTS (1992)

The Foundational Approaches in Science Teaching (FAST) program was cited and described in *Crossing the Tracks: How Untracking Can Save America's Schools*[2] as an exemplary program in science for students in heterogeneous classes and a major contributor to the untracking of schools. The chapter includes a case study of FAST in Kennebunkport, ME where students of widely ranging abilities are achieving high standards in seventh-grade science.

[2] Wheelock, A. *Crossing the Tracks: How Untracking Can Save America's School*. The New Press: New York. pp 174–177. 1992

EXEMPLARY MIDDLE-SCHOOL SCIENCE PROGRAM (1991)

FAST received unique recognition in 1991 as one of only two programs named as the best available comprehensive middle school science curricula.

"To be considered for this review, a program had to be practical and effective. It had to have national support and a successful track record either with a study or with reports of teachers…This curriculum (FAST) is the best of the American science materials currently available and represents an important evolutionary step that sets it above the others." FAST de-emphasizes the rote learning of facts and focuses more on problems and experiments. The materials actively allow for ambiguity in answers which facilitates the potential for Socratic dialogue.

The report was commissioned by the University of Arizona. The independent panel consisting of Dr. Paul DeHart Hurd, Professor Emeritus of Stanford University, Dr. Robert Yager, Professor of Science Education, University of Iowa, and Dr. Susan Sprague, Superintendent of Schools in Texas reviewed 63 available programs and textbooks in middle-school science. As stated in the opening pages "the primary goal was to identify the best of available comprehensive science curricula for middle school. A comprehensive curriculum is one with at least a year's worth of daily activities."

EFFECTS OF FAST INSTRUCTIONAL STRATEGIES ON LABORATORY SKILLS, SCIENCE PROCESS SKILLS, AND UNDERSTANDING SCIENCE (1988)

An intact sample drawn from grades 6 and 7 was drawn from two populations (FAST and traditional textbook approach), was administered three instruments in a pre-test/post-test experimental design in 1988. Instruments included the Laboratory Skills Test (LST) as a performance measure of laboratory skills abilities, the Performance of Process Skills Test (POPS) as a measure of facility in using process skills, and the Fukuoka, Ishikawa, Nakayama (FIN) test as a measure of understanding science. The California Achievement Test (CAT) total battery scores were used as a covariate in the data analysis.

Multivariate analysis of covariance using the MANOVA subprogram of the SPSS statistical package show that laboratory skills, science process skills, and science achievement as a whole are significantly affected by FAST instruction at each grade level. Results are consistent with previously reported evaluations. See Tables 2 and 3 below.

Table 2. Univariate analysis of covariance, 6th grade

Test	Non-FAST n = 38	FAST n = 477	ANCOVA F-value (df = 1,82)
LST Total Test			
Observed mean	0.76	2.57	
Adjusted mean	0.82	2.51	19.45***
LST Laboratory Skills			
Observed mean	0.11	0.72	
Adjusted mean	0.12	0.71	19.05***
LST Process Skills			
Observed mean	0.45	1.40	
Adjusted mean	0.48	1.37	8.44**
LST Knowledge			
Observed mean	0.21	0.45	
Adjusted mean	0.23	0.43	4.58*

* $p<.05$
** $p<.01$
*** $p<.001$

Table 3. Univariate analysis of covariance, seventh grade

Test	Non-FAST n = 58	FAST n = 83	ANCOVA F-value (df = 1,139)
LST Total Test			
Observed mean	1.88	3.75	
Adjusted mean	1.83	3.79	28.74***
LST Laboratory Skills			
Observed mean	1.24	1.83	
Adjusted mean	1.21	1.86	7.60**

* $p<.05$
** $p<.01$
*** $p<.001$

CALIFORNIA ASSESSMENT PROGRAM (CAP) TEST (1987)

One of the problems in collecting impact data in some states is that they are in the process of designing a new statewide assessment guidelines and instruments. This is the case in California where the California Assessment Program has been implemented. One portion of the test battery assesses student performance in science. Data are reported as scaled scores with accompanying expected low and high scaled scores based on the demographic characteristics of the district's population. Table 4 shows data obtained on FAST and non-FAST schools from the same district over a two-year period. It appears that students in the FAST program scored substantially higher than even the highest expected score on this state assessment instrument, while students not enrolled in FAST are scoring significantly below the highest expectations. For the 1985–87 testing period, the FAST schools reported did not differ significantly from the **highest expected scores** based on population characteristics.

Table 4. California Assessment Program test scores (science) 1985–87

	n	Scaled Score Obtained	Expected **High** Scaled Score
1985–86 FAST School*			
1	40	269	212
2	85	262	258
3	79	232	222
4	93	284	277
5	84	291	265
6	91	275	251
1985–86 Non-FAST School			
1	82	245	255
2	94	275	271
3	93	266	273
4	91	256	290
1986–87 FAST School**			
1	79	227	233
2	82	253	253
3	93	280	288
1986–87 Non-FAST School***			
1	94	256	290
2	81	252	280
3	91	265	281

n = number of students

* Mean scaled score over 6 schools is significantly higher than the highest expected scaled score based on population characteristics at the p = <0.10 level based on the small sample t-test.

** Mean scaled score over 3 schools is not statistically significantly different from the highest expected mean scaled score based on population characteristics.

*** Mean scaled score over 3 schools is significantly lower than the highest expected scaled score based on population characteristics at the p = <0.01 level based on the small sample t-test.

SERVING MINORITY AND FEMALE POPULATIONS (1987)[3]

In a nationwide search, Educational Testing Service (ETS) with funding from the Ford Foundation, identified FAST as an exemplary program serving minority and female populations in science during the middle-school years. The resulting directory of intervention programs was the result of an extensive nomination process, solicitation of program descriptions, and in-depth study of successful programs. Criteria for selection included that the program was currently in operation, minority or female students in grades 4 to 8 were targets for the intervention, and the program focused on mathematics, science, or computer science. Of 396 programs initially identified, 163 were finally selected for inclusion in the published directory. Particularly cited in the directory were FAST's emphasis on inquiry/discovery approach, investigations in the field and laboratory, and student-designed research projects.

[3] Clewell, B.C., M. E. Thorpe, B. T. Anderson. *Intervention Programs in Math, Science, and Computer Science for Minority and Female Students in Grades Four through Eight.* Educational Testing Service: Princeton, NJ. 1987.

VALIDATED AS AN EXEMPLARY PROGRAM OF THE NATIONAL DIFFUSION NETWORK (1985)[4]

FAST has been re-validated as an exemplary science program by the Program Effectiveness Panel (PEP) of the U.S. Department of Education and is included in the National Diffusion Network. Originally validated by the Joint Dissemination Review Panel (JDRP) in 1982, additional data on the continuing positive impact of FAST on student achievement was submitted to the PEP in 1986 resulting in its confirmation as an effective science program. FAST is included in the NDN catalog of exemplary programs called *Educational Programs That Work*. The data submitted for PEP review is summarized below.

The CTBS Science Level H Form U is the currently available version of the standardized test instrument originally used in the submission to JDRP for validation of the effectiveness of FAST. The previous edition is no longer in print, however, since the test is intended by the publisher to replace the previous edition, scores on both tests are expected to be equivalent. The new version is norm-referenced for grades 6.6 to 8.9 and is therefore appropriate for use with seventh grade students.

Table 5 summarizes the evaluation data available from FAST adoption sites on the CTBS test. These data demonstrate that students continue to perform well on the CTBS standardized science test. Data from all the adoption sites remain consistently higher than the original validation data. The impact of FAST can best be summed up in a comment made by a district evaluation specialist who upon analysis of that district's data wrote:

> *As a closing general statement, it would seem that the FAST program more than meets the expected skills levels in the content areas tested by CTBS even though not all of those tested areas are covered by FAST.*

[4] U.S. Department of Education. Office of Educational Research and Improvement. *Science & Mathematics Education. Programs That Work*. Washington, DC. 1994.

Table 5. Comparison of CTBS data for FAST and non-FAST students original evaluation to 1985

	n	mean	s.d.	scaled score	percentile rank
Non-FAST original	15 (62)	20.5	5.2	675	30
FAST original	15 (66)	24.1*	4.0	696	43
FAST 1984 (Schools previously tested)	9 (219)	26.2	4.4	706	50
FAST 1984 (Hawaii new adoptions)	5 (129)	26.9*	1.5	711	53
FAST 1984 (California new adoptions)	8 (132)	25.4	0.8	702	47
FAST 1985 (California schools tested 1984)	5 (534)	28.7**	(not reported)	721	60
FAST 1985 (Washington new adoption)	1 (35)	33.7**	4.5	752	80
FAST 1985 (Hawaii new adoption)	1 (130)	34.2**	3.0	752	80
FAST 1986 (California schools tested 1984)	5 (423)	27.0**	(not reported)	711	53
FAST 1986 (South Carolina new adoption)	1 (80)	(not reported)	(not reported)	719***	58

n = number of schools. Number in parentheses indicates number of students tested.
* p<0.05 comparison of FAST and non-FAST data in original evaluation
** p<0.05 comparison of FAST 1984 data from new adoptions with FAST original data
*** p<0.05 for students taking FAST between pre and post tests on CTBS Fall 1985 - Spring 1986 using Sandler's A statistic.

Laboratory Skills Test (LST)

The Laboratory Skills Test is a project-developed, criterion-referenced instrument used in the original validation study of FAST with JDRP. Previous reports described the validity and reliability of this instrument. Table 6 summarizes data collected on the LST from 1978–1986 by various ability groupings. In all of the samples tested the mean scores were statistically significantly greater than the FAST scores in the original validation study.

Table 6. Comparison of LST data for FAST students 1978–1986.

	n	Mean	s.d.
HAWAII			
Original high ability group	33	39.2*	11.1
Original low ability group	26	20.5*	9.5
Original heterogeneous group	45	33.2*	13.0
1984 high ability group	43	51.4**	6.3
1984 heterogeneous group	67	41.5**	7.6
1986 heterogeneous group	25	39.1**	8.9
CALIFORNIA			
1984 heterogeneous group	55	47.5**	8.7
1984 heterogeneous group	35	45.1**	5.9
NEW YORK			
1986 low ability group	9	27.3**	14.0

n = number of students
* $p<0.05$ comparison of FAST over non-FAST students.
** $p<0.01$ comparison of new FAST adoptions with original FAST data.

In addition to the data reported in Table 6, pre- and post-testing were done in 4 public schools in New York. The project coordinator who conducted the evaluation and analyzed the data submitted only a final report to the FAST project director. The report states

> *Students were tested on a pre-post-basis, mean gains and losses were computed, and a paired t-test was performed to determine significance.*
>
> *Data was analyzed to determine both performance changes, and to form the basis for inference relative to the overall impact of the pilot project.*
>
> *The results of data analysis indicated a mean gain of 3.42 percentage units in the interval between pre- and post-testing, with a t-value of 4.6455, on the Project FAST Laboratory Test. The gains demonstrated by the students proved significant to the < .001 level.*
>
> *FAST 2 final test scores of students who received FAST 1 in seventh grade were compared to FAST 2 students who did not receive FAST I in seventh grade. Results indicated a difference of 12.15 percentage units in favor of those students receiving FAST I treatment. This difference was significant (<.001 level).*

IMPACT ON THINKING SKILLS (1986)

This study compared the effect of the FAST with a traditional science textbook approach on 1) science achievement, 2) the development of process skills, and 3) the development of creative thinking in seventh grade students.

The study consisted of a pretest/posttest randomized block design. Seventh-grade students (253 students; 125 males; 128 females) in a nonpublic school in Hawaii, were randomly assigned to treatment (FAST, 130 students; 61 males, 69 females) or control (123 students; 64 males 59 females) groups. Students took science for two trimesters, a total of 24 weeks.

Pretest measures included the Learning Style Inventory (Kolb, revised 1984) and the Comprehensive Test of Basic Skills (CTBS), Form U, Level H science test (CTB/McGraw Hill). Posttest measures included these two instruments and the Torrance Tests of Creative Thinking, Verbal and Figural batteries (Scholastic Testing Service), and the Stanford Achievement Test (SAT) (Harcourt Brace Javanovich). Validity and reliability data on these instruments are reported elsewhere and were deemed acceptable for the study.

SPSS^{x} Subprogram MANOVA was used to test the three main hypotheses and six subhypotheses in the study. A 2 X 4 (treatment by learning styles) factorial multivariate analysis of covariance and a 2 X 2 (treatment by sex) multivariate analysis of covariance were performed on the eight dependent variables (adjusted for outliers).

To investigate the treatment effect on the individual dependent variables, the correlations among dependent variables were examined. In addition, the univariate F values were examined and post hoc stepdown analysis was performed. Homogeneity of regression was evaluated and found satisfactory. An experimentwise error rate of 5% for each effect was achieved by apportioning alpha according to the values shown in the last column of Table 7.

Table 7. Summary of univariate and stepdown tests of effects of treatment dependent variables after adjustment for covariate in 2 x 4 factorial mancova

Dependent Variable	Univariate		Stepdown		
	df	F	df	F	alpha
CTBS Science Test	1/244	12.13*	1/244	12.13**	0.01
Verbal Originality	1/244	20.50*	1/243	19.93**	0.01
Figural Elaboration	1/244	63.41*	1/242	41.47**	0.01
SAT Science Test	1/244	0.24	1/241	1.00	0.01
Verbal Fluency	1/244	0.12	1/240	41.34**	0.0025
Verbal Flexibility	1/244	0.32	1/239	2.96	0.0025
Figural Fluency	1/244	2.06	1/238	1.41	0.0025
Figural Originality	1/244	0.26	1/237	3.98	0.0025

* $p < .01$ in the univariate context
** $p < .001$

Principal components analysis was performed to further examine the relationships among the dependent variables. It appears that the dependent variables can be separated into five unique dimensions that might be labeled “basic thinking skills” (CTBS test), “science achievement” (SAT test), “verbal creative thinking” (Verbal Fluency, Verbal Flexibility, and Verbal Originality subtests of the TTCT verbal battery), “figural creative thinking” (Figural Fluency and Figural Originality subtests of the TTCT figural battery), and “figural elaboration” (Figural Elaboration subtest of the TTCT figural battery).

In the 2 X 2 (treatment by sex) factorial MANCOVA, the overall omnibus F was significant ($F_{8,241} = 22.79$, $p < .001$) using Wilk’s criterion, thus warranting further analysis. Interaction among independent variables was not significant ($F_{8,241} = 1.28$). The main effect of sex did not significantly affect dependent variables ($F_{8,241} = 1.25$). The only significant effect was associated with the FAST treatment ($F_{8,241} = 20.66$, $p < .001$) after adjusting for the covariate CTBS pretest. FAST treatment accounted for 41 percent of the variance in the combined dependent variables.

FAST appears to have a significant effect on the development of basic thinking skills as measured by the CTBS science test and on creative thinking as indicated by the Verbal Originality and Figural Elaboration subtests of the Torrance Tests of Creative Thinking compared to more traditional instruction in science. These results held for students of all four learning style preferences and for both males and females. FAST accounted for approximately 38 to 41 percent of the variance in the dependent variables.

Students in the treatment group did not perform significantly differently ($p < .05$) on mastery of science concepts as measured by the Stanford Achievement Test or on the creative thinking measures of Verbal Fluency, Verbal Flexibility, Figural Fluency, and Figural Originality.

The Stanford Achievement Test and the Comprehensive Test of Basic Skills are widely used standardized measures of student achievement in science. Students in both treatment and control groups achieved above-average scores on these tests when compared to national norms, indicating that both courses effectively provided students with the kinds of knowledge tested and used in national comparisons.

However, each test measures something different. The SAT is a measure of recall of science concepts at a relatively low level in Bloom's taxonomy. Students in treatment and control groups did not differ significantly on this test. The CTBS test, on the other hand, measures basic thinking skills along a continuum of Bloom's taxonomy, including some of the higher-level processes. Students in the FAST group did significantly better on this test than did students in the control group. Joyce (1987) has popularized the use of effect size introduced by Glass et. al. (1981) to indicate the size of the gains made in educational practice. Effect size is the ratio of the mean difference of the treatment and control groups compared to the average standard deviation. For the CTBS test in this study, the effect size is 0.33. Talmadge (1977) suggests that to be educationally significant effect size should be 0.25 or greater.

Results on the creative thinking measures used in this study are more difficult to interpret. Treatment students performed statistically significantly better on measures of Verbal Originality and Figural Elaboration. Verbal originality refers to the ability to produce responses that are novel, nontraditional, or unexpected using words. Figural elaboration is the ability to develop, embellish, embroider, carry out, or otherwise extend ideas in nonverbal responses (Torrance, 1974). Torrance and Ball (1984) associate the verbal TTCT with left-hemisphere functions and the figural TTCT with right-hemisphere functions. FAST apparently did affect these two indicators of creative thinking. The effect size for the verbal originality measure was 0.72; for figural elaboration, it was 1.05.

The significant effects on these two creative thinking measures may be because students in the FAST group were frequently required to observe phenomena in detail both in and out of the classroom and to record and report their observations. They hypothesized, predicted, tested, and provided evidence for their explanations of phenomena. They worked together collaboratively and communicated with one another about their observations, hypotheses, test designs, data interpretations, and applications. These activities required active processing of information which may have combined to affect students' abilities to use words and figures in creative ways.

This study demonstrated that FAST significantly affects student achievement of basic thinking skills, verbal creative thinking, and figural creative thinking, while not jeopardizing mastery of science concepts. These results held regardless of sex or student learning style preferences. It would appear that for the same investment of instructional time, students taught using the FAST model can achieve mastery of content and significantly higher development of basic and creative thinking skills, regardless of their sex or preferred learning style.

JDRP VALIDATION AS AN EXEMPLARY SCIENCE PROGRAM (1980)

Evaluation of the impact of FAST and non-FAST on seventh-grade students in Hawaii was conducted in 1978. Students randomly selected from 50 classes (25 FAST, 25 non-FAST) were administered the Laboratory Skills Test and the CTBS Level 2, Form S, science test in a posttest-only, quasi-experimental design. Equivalency of the two samples was established on the basis of standardized reading and math scores as post hoc measures of ability. Students represented the full range of ability levels normally found in public schools.

Data resulting from the Laboratory Skills Test provide evidence of significant impact of FAST. Means and standard deviations were calculated by ability groupings. Two-tailed t-test comparisons were made between FAST and non-FAST students' scores. Results are shown in Table 8. In addition, more conservative analyses on the total LST were conducted using the class at the unit of analysis as shown in Table 9. FAST means were higher both statistically and educationally.

Table 8. Mean LST student scores

Ability Grouping	LST subtest	FAST n	FAST Mean	FAST s.d.	Non-FAST n	Non-FAST Mean	Non-FAST s.d.	df	t
High	Total LST	33	39.2	11.1	37	22.9	13.6	68	5.4**
	Lab subtest	33	8.5	3.5	37	4.2	3.0	68	5.5**
	Desk problems	33	30.8	8.9	37	18.7	12.4	68	4.6**
Low	Total LST	26	20.5	9.5	25	11.4	10.2	49	3.2**
	Lab subtest	26	4.3	2.2	25	3.0	1.9	49	2.2*
	Desk problems	26	16.2	9.3	25	8.4	9.7	49	2.8*
Heterogeneous	Total LST	45	33.2	13.0	31	13.0	12.6	74	6.7**
	Lab subtest	45	6.7	3.5	31	2.4	2.4	74	5.9**
	Desk problems	45	26.4	11.1	31	10.7	11.0	74	6.0**

* $p < 0.05$
** $p < 0.01$

Table 9. Mean LST class scores

Ability Grouping	FAST n	FAST Mean	FAST s.d.	Non-FAST n	Non-FAST Mean	Non-FAST s.d.	df	t
High	8(33)	39.1	7.6	8(37)	23.8	6.1	14	4.4**
Low	7(26)	21.3	6.5	7(25)	11.4	8.3	12	2.5*
Heterogeneous	10(45)	33.6	5.7	10(31)	12.4	8.9	18	6.3**

* $p < 0.05$
** $p < 0.01$

Data from the CTBS Level 2 Form S Science test provides evidence of the impact of FAST on student achievement. Two-tailed t-test comparisons of FAST and non-FAST student groups were made. Results are shown in Table 10.

Table 10. Mean CTBS student scores

FAST			Non-FAST				
n	**Mean**	**s.d.**	**n**	**Mean**	**s.d.**	**df**	**t**
66	24.2	5.6	62	20.6	6.9	126	3.2**

** $p < 0.01$

In addition to the t-tests using students as the unit of analysis, more conservative analyses on the CTBS test were conducted using the class as the unit of analysis as shown in Table 11.

Table 11. Mean CTBS class scores

FAST			Non-FAST				
n	**Mean**	**s.d.**	**n**	**Mean**	**s.d.**	**df**	**t**
15(66)	24.1	5.4.(	15(62)	20.5	5.2	28	2.1*

* $p < 0.05$

These data show that FAST students scored significantly higher statistically than non-FAST students on both the Laboratory Skills Test and the CTBS Science test. The results of the study were submitted to the Joint Dissemination Review Panel of the U.S. Department of Education and on December 9, 1980, FAST was approved by the JDRP as an exemplary science program. The term “exemplary” is conferred only after a project has been reviewed by JDRP. The panel has the responsibility for validating the effectiveness of a program by examining and judging the evidence presented to it for both statistical and educational significance. JDRP validated programs are included in the Education Department’s publication Educational Programs That Work an are eligible for dissemination through the National Diffusion Network (NDN).

STUDENT ACHIEVEMENT IN SOUTH CAROLINA (1978)

Further evidence in support of the impact of FAST on student achievement comes from a study conducted in Berkeley County, SC. A sample of 45 sixth-grade students and 45 seventh-grade students were randomly selected from a pool of students identified as of average or above average ability as determined by 1) scores on the CTBS test battery and 2) assessment by teachers.

A norm-referenced pretest/posttest evaluation design was used to determine the impact of FAST on students. The CTBS Level 2 Form S Science test was administered as a pretest in May 1977 and as a posttest in May 1978. Means and standard deviations for both pretests and posttests were calculated. Percentile rank conversions of the pretest means indicate the general ability levels of the test populations. Expected posttest mean scores were calculated based on normative data provided by the CTBS publishers. T-test statistics for significance were calculated comparing the expected posttest mean scores and the actual posttest mean scores. Results are shown in Table 12.

Table 12. CTBS test results in South Carolina 1978

Grade level	n	Pretest mean	s.d.	Percentile conversion	Expected posttest mean	National s.d.	Actual posttest mean	s.d.	df	t
6	45	526.5	62.3	75	555	92.6	581.2	50.6	44	4.4*
7	45	562.6	56.4	78	589	97.2	618.2	65.9	44	4.6*

* $p < 0.05$

LONG RANGE EFFECTS (1977)[5]

A study of high-school students in Hawaii by Tamir and Yamamoto found significant differences between FAST and non-FAST students in a number of variables:

- FAST students show higher achievement in high-school biology
- FAST students show greater interest in the further study of science
- FAST students choose science as a hobby in far greater numbers than non-FAST students
- FAST students show greater inquiry-oriented cognitive preferences
- FAST students show higher preference for critical questioning as a mode of learning.

Information was collected from 614 high-school students in nine public and non-public schools in Hawaii on 1) achievement in science, 2) interest in science, 3) expected major field of study, and 4) cognitive preference in learning biology. Thirty-three percent had not studied FAST; 36% had studied FAST for only 1 year; 31% had studied FAST for 2 or more years. Ninety-five percent of the students reported that they intended to go to college.

FAST students showed significantly higher high-school biology grades and greater interest in science. The authors write "data pertaining to achievement in science reveal a very substantial superiority of the FAST students, especially in their achievement in high-school biology. Apparently, a substantial portion of the variance pertaining to achievement in high-school biology may be attributed to the FAST experience."

The study also measured cognitive preferences among the sample students using the Biology Cognitive Preference Inventory (BCPT). Cognitive preferences constitute a kind of cognitive style. Four modes of attending to biological information can be identified:

- recall of facts and terms
- principles and explanations
- critical questioning of information
- application relating to usefulness of information in a general, social, or scientific context.

FAST students showed a significantly lower preference for recall and a higher preference for questioning and principles than non-FAST students. In a similar study in Australia with eighth-grade FAST and non-FAST students, Dekkers (1978)[6] found FAST students to have a high preference for questioning and for field and laboratory work. In both studies these results were taken as favorable outcomes of the FAST program, based on its stated objectives.

Close to half the students who had FAST for 2 or more years as compared to only a third of the non-FAST group reported having a hobby dealing with plants or animals. The data also show that FAST students tended to choose the physical and biological sciences as a field of study in college more than the non-FAST students did.

The authors conclude, "These results serve as an indication that FAST has provided the students with meaningful learning, more so than other intermediate science programs.…It may be concluded that on the whole, the FAST program has had pervasive positive effects on the students regarding achievement, interest, and cognitive preference style."

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[5] Tamir, P. and K. Yamamoto. "The effect of the junior high 'FAST' program on student achievement and preferences in high school biology." *Studies in Educational Evaluation.* 3:1:7-17. 1977.

[6] Dekkers, J. "The effects of junior inquiry science programs on student cognitive and activity preferences in science." *Research in Science Education.* 8:71-78. 1978.

CURRICULUM RESEARCH & DEVELOPMENT GROUP

The Curriculum Research & Development Group (CRDG), including the University Laboratory School, conducts systematic research, design, development, publication, staff development, and related services for the elementary and secondary schools of Hawaii and other schools in the university's service area. 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. The CRDG is the senior member of a cooperative program of eight universities in the United States to improve schooling in science, health, and technology in elementary schools. It is a founding member of the 18-year-old Pacific Circle Consortium of universities, major school systems, and educational ministries in Australia, Canada, Japan, New Zealand, and the United States. CRDG-developed programs are being used experimentally in other countries, including Australia, Israel, New Zealand, Russia, Singapore, and Slovakia. The University Laboratory School with its culturally diverse student population provides an essential experimental ground for developing and testing educational ideas and programs. The CRDG draws upon the scholarly resources of relevant university fields. Its publications division distributes 635 titles.

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