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ABSTRACT

The GALAXY Classroom is a package of integrated curricular and instructional approaches, supported by the first U.S. interactive satellite communications network designed to facilitate the introduction of innovative curricula to improve student learning in elementary schools. GALAXY Classroom Science for grades 3-5 features the organization of instruction around themes presented through television broadcasts and classroom hands-on activities that are facilitated by fax technology and ongoing teacher support. The broadcasts are built around a video adventure series that dramatizes the GALAXY themes through the real-world adventures of a multicultural group of students, the S.N.O.O.P.S. The report describes the effects on students and teachers of the various curricular, technological, and staff development components of the program in schools throughout the United States. It was concluded that the GALAXY Science program was successful in getting students and teachers excited about science and motivating them to begin exploring and asking questions. GALAXY's broadcasts motivated student interest and provided a realistic context for the hands-on science activities. The thematic structure of the curriculum helped to integrate a wide variety of experiences: participating in hands-on inquiry, writing and communicating through the fax, and doing take-home activities. (JRH)

Far West LABORATORY

Evaluation of GALAXY Classroom Science for Grades 3-5

Final Report

Executive Summary

January 1995

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I. INTRODUCTION

"GALAXY has enriched my teaching. It has made me enthusiastic and happy about teaching science. I have enjoyed and learned a lot about how children learn, i.e., investigate, explore, share. Having the materials readily available has been GREAT. My teaching has been RECHARGED!!!"

— GALAXY teacher from California

The Galaxy Classroom is a package of integrated curricular and instructional approaches, supported by the nation's first interactive satellite communications network designed to facilitate the introduction of innovative curricula to improve student learning in elementary schools. Challenging curricula and learning experiences are made available to all students, including those who ordinarily lack such access.

GALAXY Classroom Science for Grades 3-5 features the organization of instruction around themes presented through television broadcasts and classroom hands-on activities that are facilitated by fax technology and ongoing teacher support. The broadcasts are built around a video adventure series that dramatizes the GALAXY themes through the real-world adventures of a multicultural group of students, THE S.N.O.O.P.S. The stories feature characters with whom students can identify and who model for students the use of various scientific techniques and processes to explore and understand their world.

The evaluation found that GALAXY science for grades 3-5 is a highly successful initiative:

- On measures of classification processes, GALAXY students had a statistically significant gain that was more than double the gain of non-GALAXY comparison students.
- Scores on curriculum-based performance assessments indicate that the majority of GALAXY students across all three grades were able to demonstrate that they understood the "big ideas" or core science concepts of the GALAXY curriculum.
- In general, when comparison non-GALAXY students were evaluated on some of the same measures, GALAXY students outperformed them in almost every case.
- In addition, GALAXY teachers displayed significantly more positive attitudes than they had initially regarding their own comfort with and preparation for teaching science and the adequacy of their science materials.
- Participating in GALAXY Classroom Science led to statistically significant positive changes in attitudes among GALAXY students, when compared to their non-GALAXY peers, toward participating in science class and engaging in activities to which they did not know the right answer.

Evidence from the evaluation shows that GALAXY works: in GALAXY classrooms science is being regularly taught, students are learning, and teachers are developing a new enthusiasm for science and science teaching. The evaluation further shows that the whole of GALAXY science is greater than the sum of its parts. The components by themselves represent exemplary efforts in science education. Together, they create a powerful package.

II. EVALUATION OVERVIEW

"We get to touch things and discover stuff."

— GALAXY student

The GALAXY Classroom Project was developed as a nationwide reform effort to infuse new student-centered curricula into elementary schools, to spark the interest of teachers and students in learning, and to provide innovative educational opportunities for all students including those who have traditionally been considered academically "at risk."

GALAXY Classroom Science for Grades 3-5

The curriculum for GALAXY Classroom Science for Grades 3-5 is built upon the fundamental view that students can construct knowledge about science from the content and context of their daily lives. GALAXY's goals for elementary science have been three: to foster the development of the thinking processes that are tools for constructing knowledge of science (e.g., observing, communicating, comparing, organizing, relating), to provide students with some of the "big ideas" or core science concepts that are fundamental to understanding science, and to aid teachers through ongoing professional support.

> *"Although I am a veteran teacher, I felt at a loss as to how to teach science. The concepts of the arcs [themes] — patterns, experiments, and black boxes — made sense to me.... I could teach the concepts rather than information and knowledge I frequently lack."*
>
> — GALAXY teacher from California

The "big ideas" are communicated through the GALAXY inquiry-based, hands-on/minds-on science curriculum which is organized around three six-week themes: (1) using patterns as evidence, (2) doing experiments to describe and compare materials, and (3) building models to explain and invent ideas. Each of these themes was designed to be age-appropriate; to use investigations that teachers can expand; to work in an interdisciplinary science program; and to support national, state, and local frameworks and standards.

The Evaluation Approach

The Far West Laboratory for Educational Research and Development (FWL) conducted a comprehensive evaluation of the implementation and impact of GALAXY Classroom Science for Grades 3-5 for the initial demonstration phase.

The evaluation gathered quantitative data on GALAXY's impact by testing student learning through performance-based assessments, surveying student and teacher attitudes and teacher practices, and asking teachers to record their use of the GALAXY Classroom Science curriculum. Performance-based assessments, in contrast to most multiple-choice tests, ask students to do something and then record what they have discovered. Administration of four of the performance-based assessments and the attitude surveys followed a pre/post design. Four other assessments were more closely linked to the curriculum and activities, and they were administered during the course of GALAXY science.

In addition to these quantitative measures, a series of observations and interviews were carried out in five case study schools throughout the country, with shorter visits to several other schools. These case study classrooms were spread across the nation and varied in the ethnicity of the students as well as whether their setting was urban, suburban, or rural.

GALAXY Classroom Science for Grades 3-5 Demonstration Program

GALAXY Classroom Science for Grades 3-5 is a package of integrated curricular themes and hands-on science activities. Instruction is organized around three themes presented through television broadcasts and classroom hands-on science activities and supported by the use of fax technology in the classroom and take-home science activities.

During the demonstration phase for GALAXY Classroom Science for Grades 3-5, classrooms in thirty-eight schools (later forty) were connected by an interactive satellite communications network. The demonstration phase ran for eighteen weeks of class time in the fall of 1993 and winter of 1994.

> *"[GALAXY] worked well with all students because of high interest cliff-hanger broadcasts backed up with interesting, program-coordinated hands-on learning activities."*
>
> — GALAXY teacher from West Virginia

Broadcasts The television broadcasts dramatized the GALAXY themes through a continuing program about the adventures of a multicultural group of students, THE S.N.O.O.P.S., interacting together as they solved various mysteries. The stories featured characters with whom students could identify and modeled for students the use of various scientific techniques that the characters employed to solve the problems and puzzles they encountered.

> *"The program hooks in all kids because they can relate to it."*
>
> — GALAXY teacher from California

> *"They put your name on TV! We can't wait 'til the program comes on again."*
>
> — GALAXY student

The evaluation found that students were entranced with the broadcasts; the broadcast mysteries received the highest ratings from students at case study schools among all the GALAXY components about which they were asked. Similarly, more than 90% of the teachers who completed the end-of-year survey judged the broadcasts to be of "great educational value."

Hands-on Activities Each classroom used a set of GALAXY-provided hands-on science kits that are parts of the Great Explorations in Math and Science (GEMS) or the Full Option Science System (FOSS) curricula, both developed by the Lawrence Hall of Science at the University of California, Berkeley.

> *"Hands-on activities are wonderful. These activities really reach the interest levels of all students."*
>
> — GALAXY teacher from West Virginia

FWL evaluators found that both teachers and students were extremely pleased with the GALAXY hands-on materials and activities. Teacher enthusiasm at case study sites stemmed from having all the materials they needed and receiving them at one time, using the GEMS and FOSS guides that were easy to follow and adapt for their classes, and knowing that students loved the activities and were therefore eager and interested learners. This enthusiasm was echoed in the end-of-year survey when nearly all the teachers rated the activities as having "great educational value."

> *"Hands-on activities and take-home kits made the kids feel like they could do anything."*

— GALAXY teacher from Indiana

Teacher enthusiasm was tempered in a few cases by factors such as the significant amount of time necessary for setup, the inevitable mess associated with hands-on materials, and the perception among some teachers that a few of the activities were too difficult for third graders. In addition, some teachers thought that the Teacher's Guide could have provided more assistance on how to link the ideas and themes of the broadcast with the hands-on experiences.

Students were, if anything, even more enthusiastic than their teachers about the hands-on activities. More than 90% of the interviewed students gave the activities their highest rating.

Fax One of GALAXY's unique features is facilitating student and teacher interaction with one another across the city or across the country and with the broadcasts' producers through a dedicated satellite network and classroom fax machines.

> *"I think that GALAXY Science worked well with all of my students because their ideas were recognized no matter what they submitted (i.e., pictures, photographs, etc.).*
>
> — GALAXY teacher from Massachusetts

Interviewed students were very positive about faxing, some citing the chance of seeing their names in the broadcast. Additionally, many of the students' ideas that were sent to Database (headquarters for THE S.N.O.O.P.S.) appeared in *The Scoop*, a two-page fax bulletin that was sent periodically to GALAXY classrooms. However, fax problems prevented some classes from receiving it.

Teachers also valued faxing, with more than 80% of teachers who responded to the end-of-year survey rating sending faxes as having "great educational value" for their students and more than 70% reporting that students were "very enthusiastic" about sending faxes to Database. An even higher proportion of teachers said that their students were "very enthusiastic" about seeing their names and/or faxes on the broadcasts.

> *"The fax machine is integral. The kids were disappointed when they worked for days on faxes to S.N.O.O.P.S. and missed the fax deadline because our fax machine did not work."*
>
> — GALAXY teacher from Wisconsin

During the demonstration phase, technical difficulties produced frustration for many teachers. Only 12% reported that their fax machine always worked, and others commented that they were never sure whether their faxes reached their destinations. When these kinds of technical problems occurred, whether at the classroom, school, or network level, students became disappointed: "Our faxes never got to Database — they got ate up by the satellite."

FWL evaluators concluded that, when the fax machines worked, they provided powerful motivational incentives for GALAXY students.

***Snoopers Loop* Take-Home Kits** Materials for each theme included four different home investigation science kits that students were encouraged to explore with family members and friends. All the necessary materials plus instructions for doing an investigation at home with an adult were included in each kit.

> *"My class begged for the take-homes. Please keep them in."*
>
> — GALAXY teacher from Pennsylvania

Each of the take-home kits arrived at school in parts and required time for assembly (e.g., placing each of the parts and instructions in plastic bags). While some teachers asked parents to help put together the kits or held a "family science night," others were overwhelmed by trying to do it themselves. However, even though preparing the kits was fairly labor-intensive, they were rated well by both students interviewed (more than 70% at case study sites) and the majority of teachers (more than 60% rated them as "very useful" and having "great educational value").

III. Developing Scientific Thinking Processes and Results from Performance-Based Assessments

Recognizing that there is a progression to the development of scientific thinking skills, researchers at FWL adapted four performance-based assessments from the California Learning Assessment System (CLAS) to test GALAXY and comparison students' progress in several crucial areas. FWL researchers measured classification and organization (critical components of scientific thinking for grades 3-4 and 5-6) with two hands-on assessments using fossils in the pre-test and leaves in the post-test. Skills related to experimentation were measured by two other pre/post performance-based assessments using rocks and soils, which were administered in a crossover design. Additionally, students took a multiple-choice test of science process skills.

Results from the Classification Pre/Post Assessments

The evidence shows that participation in GALAXY had a statistically significant positive effect on students' classification abilities. These results are based on testing 600 GALAXY and 610 comparison students in the same grades at twelve GALAXY schools. Each of the two assessments had three tasks that were scored from 0 (no attempt) to 5 (accurate and informative). Figure 1 shows the average (mean) scores for GALAXY and comparison students in each of the three grades, both before GALAXY science started (pre) and after it was completed (post).

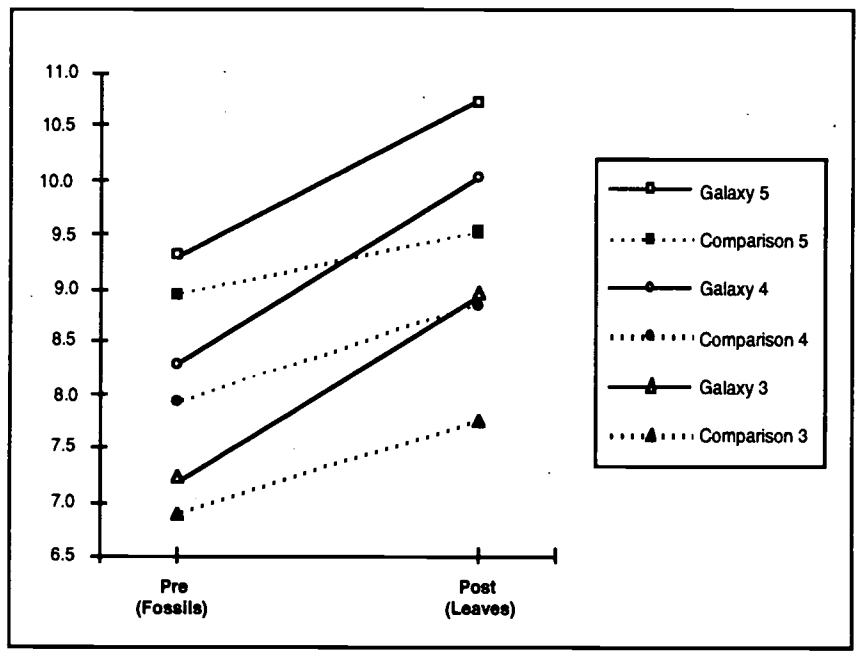

Figure 1. Pre/Post Mean Total Scores on Classification Tasks

- GALAXY students had statistically significantly greater gains than comparison students on each of the three classification tasks in the assessments. (Task 1: .50 vs.

.19, p<.001; Task 2: .34 vs. .11, p=.016; Task 3: .79 vs. .48, p<.001).

- GALAXY students had statistically significantly greater gains than comparison students at each grade level (third, fourth, and fifth).
- Figure 1 illustrates the GALAXY and comparison mean gain at each grade for overall classification scores (the sum of the three individual task scores). *The most dramatic result is that, for third and fourth grades, GALAXY student post-test scores surpassed not only those of their grade level counterparts but also the pre-test and post-test scores of comparison students in the next grade.*
- Looking at all the data from all three grades together, students who participated in GALAXY science had a statistically significant gain in classification abilities that was more than double that of comparison students (1.63 vs. .79, p<.001).
- The gains measured by this assessment were similar across all three grade levels and unaffected by gender, ethnicity, Chapter 1 status, language spoken at home, or previous participation in GALAXY Language Arts.
- GALAXY is appropriate for both high-achieving and academically at-risk students as evidenced by fairly similar gains for students regardless of their initial performance on these assessments.

Observing, communicating, comparing, and classifying are crucial scientific thinking processes for students in grades 3-5. Based on the results of the classification assessments, GALAXY appears to have met the goal of fostering the development of these processes. *Indeed, the results suggest that GALAXY science can work for every type of student and can carry many of them up to a par with students who are a year ahead of them.*

Results From Pre/Post Assessments of Experimental Skills

During the fifth and sixth grades, students expand their repertoire of scientific thinking skills to include the abilities to recognize relationships between ideas and to design simple experiments. During this period students also develop the ability to isolate and manipulate variables in an increasingly systematic manner.

Researchers at FWL tested these experimental skills by adapting two existing CLAS performance-based assessments to use in a pre/post crossover evaluation design. GALAXY and comparison students participated in either the Rocks or the Soils assessment as a pre-test and the other as a post-test. Unlike the classification assessments, which yielded results for individual students, the assessments of experimental skills gave information about groups of students. Because the skills being measured were known to be developmentally beyond most third graders, the tests were administered to fourth and fifth graders only.

Results from the Rocks Assessment

The patterns of scores shown by fourth and fifth graders on the four tasks of this assessment reflect the difference in their developmental levels of understanding about experimentation.

Results for fourth graders indicate no pattern of significant change on this test. Although some growth is evident, neither comparison nor GALAXY fourth graders show gains that are statistically significant.

In contrast to the results for fourth graders, an interesting and promising pattern emerges for GALAXY fifth graders on the essential components of the test, particularly in independently repeating experiments (Task 2) and in using evidence to support experimental conclusions (Task 4).

- On Tasks 2 and 4 of this assessment, the post-test GALAXY fifth grade cohort shows statistically significantly higher scores when compared to pre-test GALAXY students.
- GALAXY fifth graders performed statistically significantly better than comparison students on Task 2, and, although GALAXY students display greater gains than comparison students on Task 4, it falls short of statistical significance at the .05 level (p=.084).
- Results from the other two tasks indicate no real difference between the GALAXY and comparison fifth graders.

Although the Rocks assessment did not prove to be an age-appropriate measure for fourth graders, several of its components did help to demonstrate that *fifth graders who participated in GALAXY Science were better able than their non-GALAXY peers to recognize relationships, isolate and manipulate variables in an experiment, and generalize information to new situations.*

Results from the Soils Assessment

The Soils assessment, like the Rocks assessment, tested more advanced scientific thinking processes: observing, understanding relationships, and making simple inferences and predictions. Similar to findings from the Rocks assessment, the developmental differences between fourth and fifth graders appear to be reflected in the results.

The fourth grade results for the Soils assessment show little difference in performance between GALAXY and comparison students. The results for the fifth graders indicate both that the test was more appropriate for these students and that GALAXY students outperformed their comparison counterparts:

- The vast majority of GALAXY and comparison fifth graders got good scores on Task 1 for both pre-tests and post-tests. It would appear that this measures something that they already know (how to replicate an experiment and observe accurately).
- Task 2 shows a statistically significant positive change for GALAXY fifth graders and a smaller, not statistically significant, change for comparison students, but the difference in their growth was not statistically significant.
- On Task 3, GALAXY fifth graders showed a statistically significant gain between the two administrations (from 1.24 to 1.74, a gain of .50). The two groups of comparison students scored roughly the same at pre-test and post-test (1.43 and 1.40), indicating that they had not learned much in this area. The difference in gain is statistically significant (p=.01). These results suggest that students participating in GALAXY had learned more than comparison fifth graders about generalizing information they had just learned to a new situation.

The fifth grade results from the Soils assessment and, in particular, Task 3, indicate that GALAXY Classroom Science helps foster the development of scientific thinking processes, in particular comparing variables, relating procedures, and solving new problems.

Results from the Science Process Assessment

FWL administered a multiple-choice test of scientific thinking processes, the Science Process Assessment, developed in the late 1980's to reflect curricular reform in Pennsylvania. This test was selected to assess scientific thinking in areas not specifically addressed in the GALAXY curriculum. Figure 2 shows the results in terms of mean total scores.

The results are ambiguous for the fifth grade, but they are more clear for the fourth grade.

- The data suggests that students in fourth grade GALAXY classrooms learned an array of scientific reasoning skills reflective of the new reforms in science education (particularly forming hypotheses and experimenting) better than their peers in comparison classrooms.
- GALAXY fourth graders had gains on the thirty-one item test that were statistically significantly greater than those of comparison students (1.93 and .05, respectively, $p<.001$).

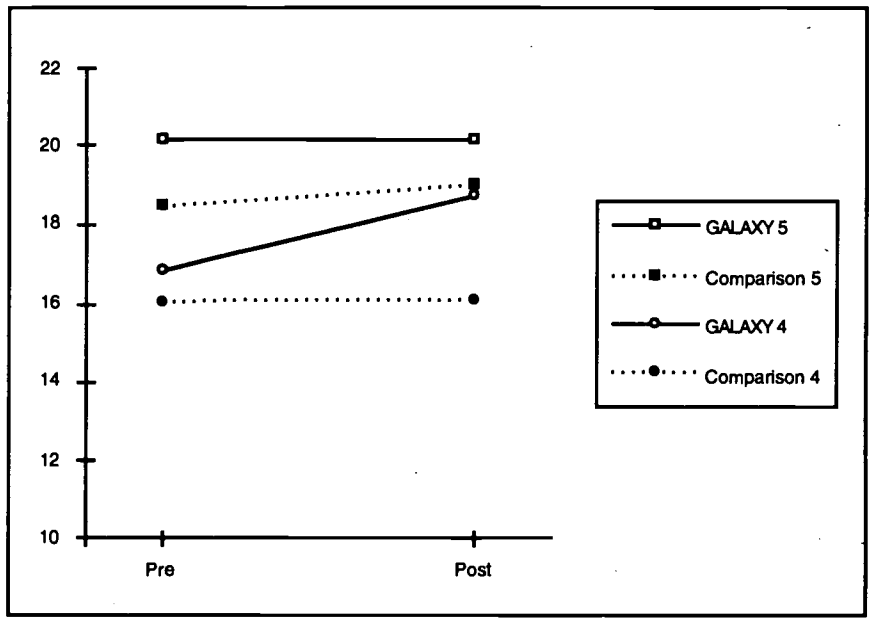

Figure 2. Mean Total Scores on Modified Science Process Assessment for GALAXY and Comparison Students

These results, comparing GALAXY and non-GALAXY students, suggest that GALAXY science can contribute to the development of scientific thinking processes among fourth graders.

IV. Understanding the Big Ideas of the Three GALAXY Themes and Results from Performance-Based Assessments

FWL evaluators devised a series of four curriculum-embedded performance assessments to evaluate students' understanding of the "big ideas" presented in the three themes of the demonstration phase curriculum. GALAXY classrooms were asked to participate in all four embedded assessments; comparison students participated in two. In addition, small groups of students were videotaped while working on tasks related to the core science concepts of the three themes.

Results for Theme 1: Science is Finding Patterns as Evidence

The GALAXY curriculum for Theme 1 had students viewing broadcasts and participating in activities that focus on recognizing and using patterns as evidence to solve crimes or explain events. Results from both the Theme 1 videotaped performance assessment and the performance-based embedded assessment (*Reading the Beach*) show that a large majority of third, fourth, and fifth grade GALAXY students understood and could apply what they had been taught about finding and using patterns as evidence.

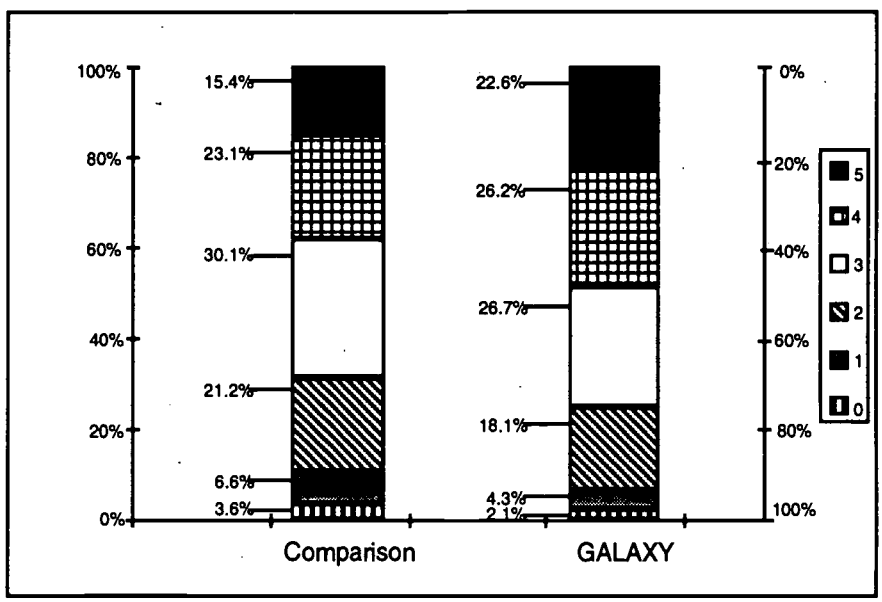

Figure 3. *Reading the Beach* Scores for Comparison and GALAXY Students

- The overall difference in the distributions of scores between GALAXY students and non-GALAXY comparison students, as shown in Figure 3, is statistically significant (chi-square=17.98 with 5 d.f., p=.003) and indicates that GALAXY students outperformed their comparison peers on this assessment.
- As Figure 3 shows, 75.5% of GALAXY students demonstrated a level of competence or better (score of 3, 4, or 5 out of 5) compared with 68.6% of comparison students.

On the embedded assessment for Theme 1, in which comparison students also participated, *GALAXY students demonstrated that they were more skilled at recognizing, using, and interpreting patterns than their non-GALAXY peers.*

Results for Theme 2: Science is Doing Experiments

Theme 2 focused on the core concept of doing experiments to describe and compare materials. GALAXY Classroom students joined the broadcast characters in trying to solve mysteries through hands-on experimentation with familiar materials. The purpose of the FWL videotaped assessment in this theme was twofold: to see if GALAXY facilitated students' working in small cooperative groups and to determine if GALAXY students approached the open exploration of a novel substance with greater curiosity or in a more systematic manner than non-GALAXY students.

- More than half of the GALAXY groups were able to organize themselves and to assign themselves different roles while none of the non-GALAXY groups organized themselves for the task.
- About half of the GALAXY groups, but only one of the non-GALAXY groups, systematically tested the properties of the unknown substances, spontaneously making predictions and then revising them based upon testing.

These results from case study schools indicate that GALAXY students understood the core concepts of Theme 2 and were better at working in small groups and at systematic testing.

The embedded performance assessment for Theme 2, *Chemical Reactions*, asked GALAXY students to (1) observe an experiment involving chemicals, (2) change the variables in some way, (3) perform the revised experiment and record observations, (4) draw a conclusion based upon the two experiments, and (5) design another experiment using the same chemicals and make a prediction about its results.

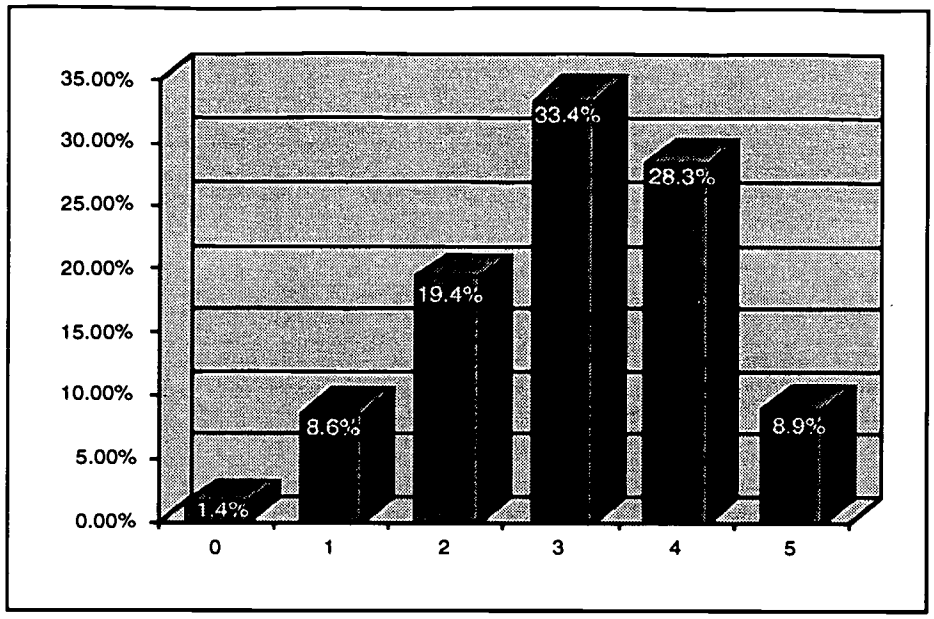

Figure 4. Percent of GALAXY Students Achieving Competency on *Chemical Reactions* Tasks

- As Figure 4 shows, about 71% of the GALAXY students consistently demonstrated on three or more of the five parts of the assessment that they understood the concept of experimentation and could manipulate variables and predict what would happen.
- It is not surprising that the students had difficulty explicitly stating a cause and effect relationship among the variables (part 4) because of the complexity of the thinking involved.

These results indicate that GALAXY students had developed an implicit understanding of the concepts involved in experimentation, but many were not yet able to reflect upon that understanding and communicate it explicitly to others.

Results for Theme 3: Science is Building Models

The "big idea" presented in Theme 3 involved building and using models to invent and explain ideas. While watching the broadcasts, GALAXY students were challenged to explain surprising phenomena in a "haunted" theater. In addition, GALAXY gave students hands-on practice in the classroom with building and using a variety of models.

The videotaped performance assessment for this theme asked students working in pairs to construct a model from materials provided. The model was to be a device that would solve a specific problem (retrieve a cat stuck in a tree). The results for this assessment show no difference between GALAXY and non-GALAXY students. Possible explanations for this finding include the lack of time spent on this theme because of inclement weather during the winter and a perception by some teachers that a few of the Theme 3 activities were too difficult for their students.

The curriculum-embedded assessment for Theme 3, *Models and Designs*, asked students to use models in three different ways. Students were asked to design a model that was based on the redesign of an existing object (in this case, a bicycle), a model of what was inside a black box (a drinking fountain), and lastly, a model of a tool that could be used to solve a specific problem (unstick a basketball stuck in a net). In each case students were asked to draw a model and to

write a description explaining their model. The results show that GALAXY students performed very well on the three tasks of this assessment; the assessment was not given to comparison students.

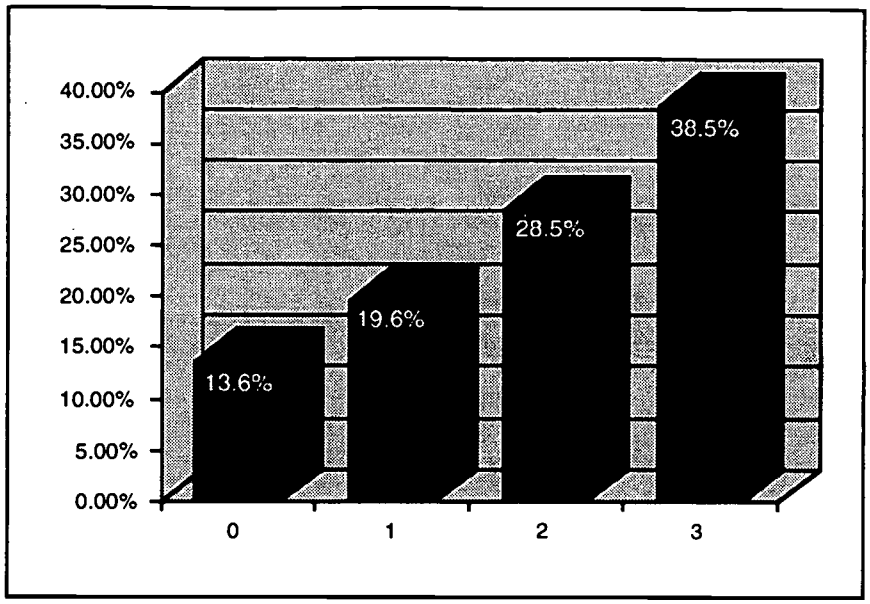

Figure 5. Percent of GALAXY Students Achieving Competency on *Models and Designs* Tasks

- For GALAXY students at all grade levels, the percentage of students demonstrating competence or above were 65.3%, 88.3%, and 87.9% respectively for the three tasks.
- Figure 5 gives the distribution of competency among GALAXY students who participated in *Models and Designs* and shows that, under fairly stringent criteria, two-thirds of the GALAXY students across all grades achieved competency on two or more of three tasks, and 39% could display competency on all three tasks.

Although each task tested a different aspect of using models, the evidence from this assessment suggests that students displayed competence at using models generally.

Culminating Embedded Assessment: *A Mystery*

A Mystery, the final embedded assessment, was given to both GALAXY and comparison students after GALAXY science was completed. It was intended to evaluate the ways that students reason about and investigate the possible causes of unexplained phenomena (strange noises being emitted from an abandoned house). Students were asked to choose among three possible explanations for the cause of the noise — a ghost, people playing tricks, or the wind. "Wind" and "people" were considered appropriate responses; "ghost" indicated that the student might still rely on magical explanations. In addition, students were asked to describe what they could do to determine if their explanation was correct.

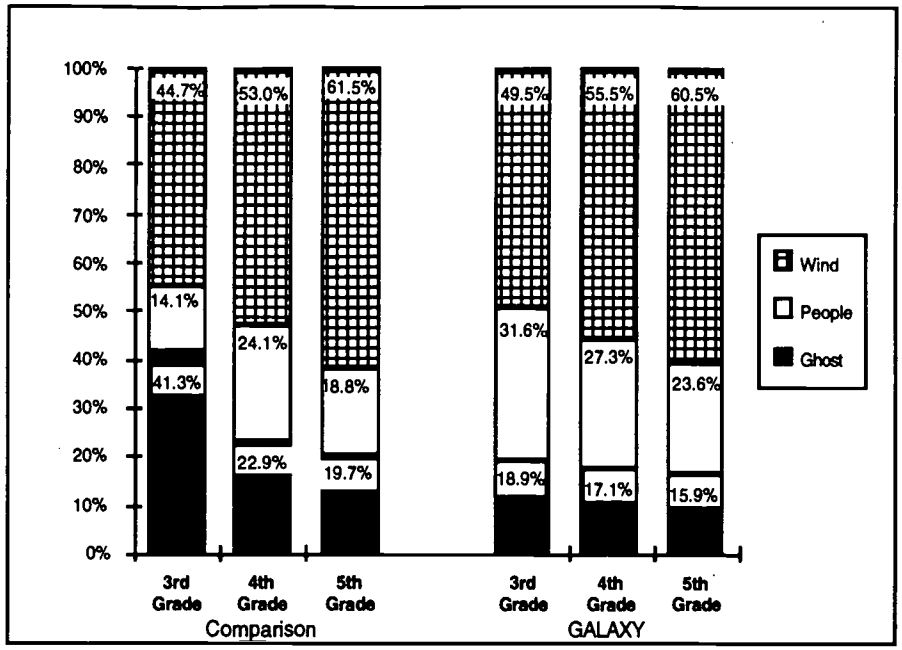

Figure 6. Percentage of Students Choosing Each Explanation for Task 1 of *A Mystery* by Grade for All GALAXY and Comparison

- As Figure 6 shows, GALAXY students more consistently chose "the wind" or "people" over "ghosts" as a plausible explanation for the noises than did their non-GALAXY peers.
- Significantly more GALAXY students (29.4%) chose experimental approaches for determining the real cause of the noise over simple observation or explanation than did comparison students (20.3%), as Figure 7 shows.

On both parts of this assessment, GALAXY students outperformed their comparison peers at levels that are statistically significant. These results indicate that GALAXY science was successful in achieving its goal of reducing magical thinking (fewer GALAXY students chose "ghost") and increasing understanding of experimentation (more GALAXY students chose active or inactive testing).

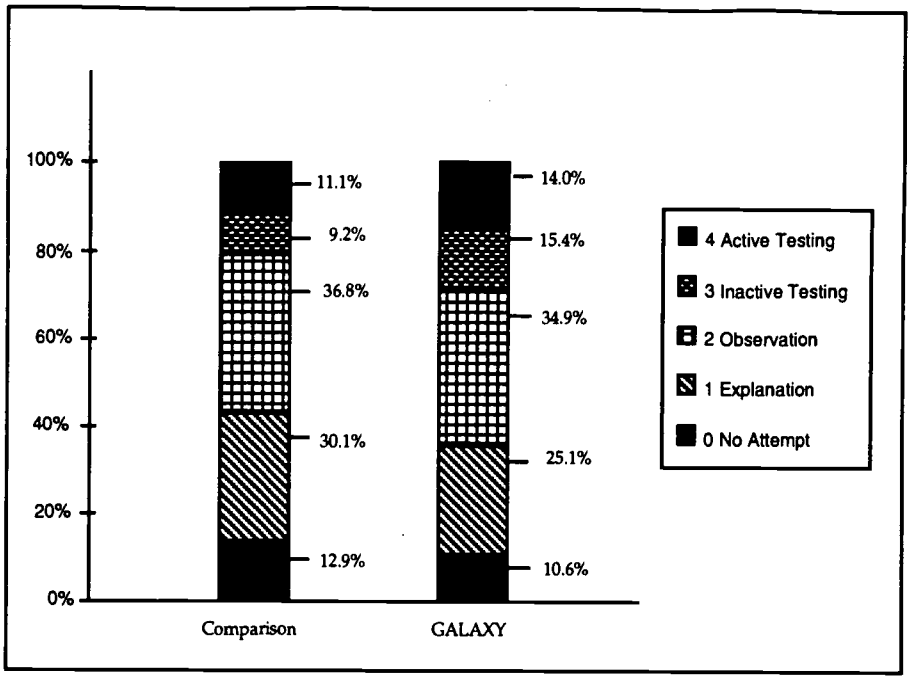

Figure 7. Scores of Matched GALAXY and Comparison Students on Task 2 of *A Mystery*

Summary of Embedded Assessments

The special videotaped performance assessments and performance-based embedded assessments proved to be useful vehicles for evaluating the extent to which GALAXY students understood the core science concepts presented in each of the themes. Though there did appear to be some age-related differences in understanding these concepts, *the majority of GALAXY students across all grades demonstrated that they understood these "big ideas" and often were able to apply them in new contexts. Further, when non-GALAXY comparison students were evaluated on two of the four assessments, GALAXY students outperformed them in almost every aspect.*

V. CHANGES IN ATTITUDES

The philosophy of GALAXY Classroom Science has been expressed as "science is the investigation of phenomena by exploring about, asking questions, inventing ideas, and loving it!" Teachers and students who participated in the demonstration phase of GALAXY science spanned a continuum from being uncertain about whether they liked science to being strong supporters of hands-on science. Evaluators were interested in what changes in attitudes among both teachers and students might be produced by participation in GALAXY science.

Teacher Attitudes

FWL researchers surveyed teachers' attitudes towards teaching science both before and after they taught GALAXY Classroom Science for Grades 3-5. Ratings ranged from 1 (strongly disagree) to 5 (strongly agree) on items such as comfort in teaching science, hands-on exploration by students, and availability of appropriate materials.

The scores of GALAXY teachers on the pre-GALAXY survey were quite high, indicating that they already supported hands-on science and were fairly confident about their ability to teach it. For example, teachers very strongly agreed (4.5 out of 5) that elementary students should participate in hands-on science and that boys and girls were both interested in science.

Given these initially high levels of appropriate attitudes and practices, it was somewhat surprising to find statistically significant changes among GALAXY teachers in a number of key areas (5 out of 24 attitude items and 3 out of 9 teaching practices). Teachers moved from comfortable to very comfortable about teaching science (from a mean of 3.79 to 4.52, $p<.001$) and from calling their materials slightly inadequate (2.78) to quite adequate (4.12, $p<.001$). They also indicated that they were better prepared to teach science (3.26 to 4.15, $p<.001$). They even reported an increase in favorable parent comment about students enjoying science (3.29 to 3.86). Statistically significant gains also were reported in the frequency with which GALAXY teachers encouraged students to write about science, used science to teach math, and had hands-on science activities in class. In addition, the reported frequency of science teaching increased.

When teachers were asked on the end-of-year survey how GALAXY had affected their teaching, a number of them gave responses that indicated that their **teaching**, not just their science teaching, had been permanently changed:

> *"It's changed my philosophy and how I plan for teaching both in terms of goals and how I interact in class: asking questions, probing for better answers, striving for excellence."*
>
> — GALAXY teacher from Texas

> *"I will never be textbook bound again; even in third grade, children still need the hands-on experience to explore concepts before higher level thinking can consistently occur."*
>
> — GALAXY teacher from South Carolina

> *"I have done a better job at accepting all ideas and seeing how some strange comments do fit. I have done a 100% better job teaching science. I have lost some of my fears about experiments. I have tried more group projects in other subject areas."*
>
> — GALAXY teacher from Colorado

> "[As a result of GALAXY,] *I've also changed to using more cooperative activities throughout the curriculum (math, social studies, etc.). I feel this has made me a more*

effective teacher, and my kids are having fun."
— GALAXY teacher from California

"GALAXY has shown me that my role in the classroom should be more as 'facilitator' and less as 'lecturer.' I have also learned how much more children enjoy learning when it is learner-driven and they have control over what they learn and how they learn it."
— GALAXY teacher from Maryland

Participation in GALAXY Classroom Science facilitated a very positive set of outcomes among the teachers. Hands-on science requires an extra commitment of both time and intellectual engagement by teachers, factors that may deter many from doing it. The evaluation data indicates that being a part of the GALAXY Classroom overcame these impediments and brought exciting science teaching into the lives of teachers and students throughout the country.

Student Attitudes

FWL evaluators developed a 27-item survey to measure student attitudes to science and administered it to both GALAXY and comparison students before and after GALAXY Classroom Science. As part of the analysis, the 27 attitude items were clustered into groups based on their intercorrelations and a cluster score was computed.

There was empirical evidence for four clusters of items, and each was given a descriptive name for convenience of reference: "fun," "learning," "mystique," and "world" clusters. The changes associated with these four clusters are shown in Figure 8.

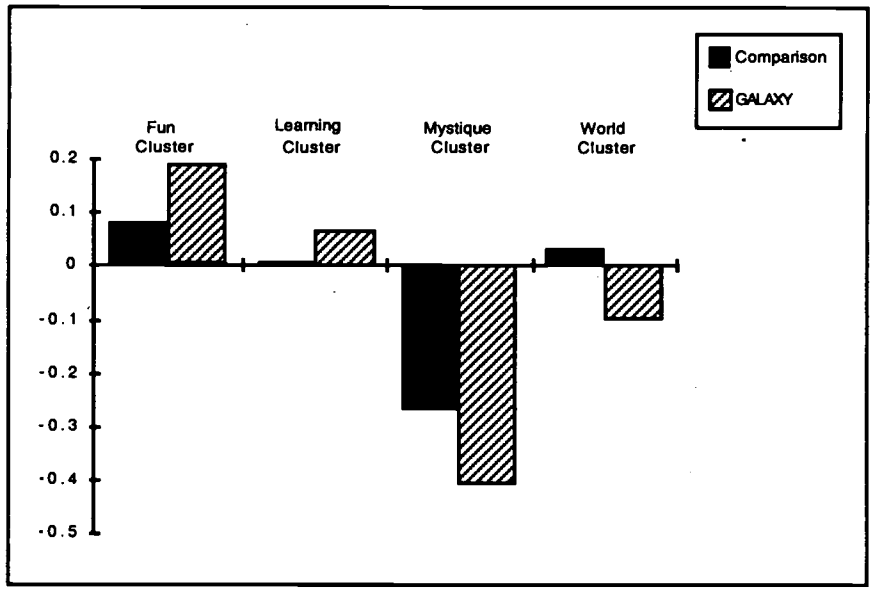

Figure 8. Mean Attitude Change by Cluster for GALAXY and Comparison Students

For a group of nine items, labeled the "fun cluster," GALAXY students had a more positive attitude than comparison students towards how much fun science was at the pre-test, and that gap widened significantly by the time of the post-test (see Figure 8). GALAXY students showed a statistically significant improvement in their perspective on five out of nine items related to doing science at school, whereas comparison students only had such changes on two items. *This evidence suggests that participating in GALAXY Classroom Science positively changes student attitudes about science class.*

Another cluster was a "learning" cluster consisting of four items. Overall, the "learning" cluster score started with GALAXY students significantly more positive and ended with the gap even larger, but the difference between the two groups in the amount of increase was not statistically significant. At the post-test, GALAXY students had higher mean scores than the comparison students by .10 to .13 for all four individual items, a consistent and substantial margin. The evidence from this cluster suggests that participating in GALAXY science classes had a beneficial effect on students' attitudes to engaging in activities in class and not being afraid to make mistakes. GALAXY students are not afraid to "mess around," one of GALAXY's goals.

Five more items comprise a cluster that relates to the "mystique" of science. The changes on the "mystique" cluster score and on the negatively-phrased items in this cluster indicate that science had lost much of its mystique for both GALAXY and comparison students, with a significantly greater decrease for GALAXY students. All of the significant differences for this cluster of attitude items favor GALAXY over comparison students.

The fourth cluster, the "world" cluster, is composed of nine items that generally relate to the relationship between science and the world outside school. This cluster provides some counterpoint to the strongly favorable results from the other three clusters of student attitudes. For these items, GALAXY students not only do not have more positive attitudes than the comparison students at post-test, their decrease in agreement is significant and significantly greater than the change for comparison students (who actually improved slightly). The main exception is an item that said "Science teaches us to try out new ideas," on which GALAXY students increased their agreement markedly more than comparison students, to extraordinarily high levels.

The evidence from this "world" cluster is unexpected and suggests that GALAXY students are having difficulty making the connection between the fun things they do in science class and the way science is used in the real world. Perhaps the GALAXY Classroom Science curriculum needs to be strengthened in areas making the link between the classroom and the larger society.

The results of the student attitude survey confirm that *participation in GALAXY Classroom Science positively affected the attitudes of students towards participating in science class, engaging in activities in which they did not know the right answer, and feeling comfortable with GALAXY-promoted learning strategies. But the attitude survey results also suggest that the connection between what was happening in the classroom and the larger world might have eluded them.* This is an area that can be added to the curriculum, now that GALAXY has been successful in getting students to like science class.

VI. CONCLUSION

"I have been absolutely thrilled with this science program. It has been an incredible experience to watch my children become 'scientists' in the classroom. I have not used any program as well-integrated or as motivating to all my students as the GALAXY science program."

— GALAXY teacher from Oregon

One of GALAXY's primary objectives has been to get students and teachers excited about science and to motivate them to jump in, begin exploring, keep asking questions, and have fun. As the evaluation evidence from both teachers and students indicates, GALAXY Classroom Science is a highly successful initiative.

GALAXY's broadcasts motivate student interest and provide a realistic context for the hands-on science activities. The thematic structure of the curriculum helps to integrate a wide variety of experiences: participating in hands-on inquiry, writing and communicating through the fax, and doing take-home activities. The teacher institutes and ongoing teacher support have assisted teachers in weaving these elements together.

Although teachers are still learning how to use GALAXY science optimally in their classrooms, the evaluation results point to positive experiences in most classrooms: science is being taught regularly, students are excitedly engaged in hands-on activities, and teachers are developing a new enthusiasm for science and science teaching.

The preceding sections of this report describe the effects on students and teachers of the various curricular, technological, and staff development components of GALAXY science in schools throughout the country. As this report indicates, it is certainly the case with GALAXY science that the whole is greater than the sum of its parts. The components by themselves represent exemplary efforts in science education. Together, they create a powerful package.

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