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ABSTRACT

This paper presents the results of the Science Parent, Activities, and Literature (Science PALs) project. This project aims to promote parent involvement in children's hands-on science education by using take-home, literature-based inquiry, problem solving, and design activities that connect school and home. Parents are the most effective source of positive or negative attitude influences toward science and mathematics. The lack of science in home environments depends largely upon parents' fear or lack of success in science. The Science PALs project uses parents as a key instructional factor and involves them in their children's education. Teachers help parents in this involvement and provide updated information for children's learning processes. (Contains 16 references.) (YDS)

Empowering Families in Hands-On Science Programs

by
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EMPOWERING FAMILIES IN HANDS-ON SCIENCE PROGRAMS

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Achievement of education reform standards for science literacy will require, as the recently popularized African proverb suggests, the "whole village". In this paper we present results of the Science Parent, Activities, and Literature (Science PALs) project. Science PALs was designed to promote substantive involvement of parents (including relatives and caregivers) in their children's hands-on science education by using take-home, literature-based inquiry, problem-solving, and design activities that connect the school and the home.

Efforts to coordinate players within the "village" remain a major challenge for the science literacy movement. Of these various key players in the community partnership, the family group has been the most under-utilized in the current education reforms (AAAS, 1996). Miller (1989) states "the most effective source of attitudes toward science and mathematics is the family. The family can socialize either a very positive or a very negative attitude toward science. Parents want their children to study science and mathematics and encourage that through the selection of toys, visits to museums, subscriptions to magazines, and talk about topics and problems that involve science and mathematics" (p. 177).

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Nothing illustrates more clearly the family's validation of young children's learning than the refrigerator door. It is the refrigerator door where parents proudly display their children's work and implicitly make statements of validity, priority, and value. A quick survey of the refrigerator "bulletin board" usually finds products of language and art. Occasionally one sees evidence of some mathematics problem solving, but infrequently does one see evidence of science. The refrigerator door testimony of a low priority for science is supported by the dinner table talk about leisure time, daycare, and school. Again, science is rarely discussed.

Why this lack of focus on science at home? For the most part, it reflects the family members' own recollections of preschool, elementary, and high school. Parents, aunts, uncles, and grandparents are products of didactic science programs that stressed drill, skill, and memorization and were geared to preparing scientists and engineers, not a generally literate citizenry. A fair estimate is that few of them (20-30%) actually experienced activity-based science inquiry in their elementary and secondary schooling. Most express a lack of success in, even a fear of, science. Surveys indicate that adult science literacy is disappointingly low for an advanced technological society and for a nation in the midst of an information explosion (Associated Press, May 24, 1996). Only 25% of the adults surveyed by the National Science Foundation had satisfactory knowledge of basic science concepts. Furthermore, family members often have traditional, absolutist views of science that emphasize the quest for the "right" answer and a view of technology that emphasizes big industry, corporate solutions for most of societal

problems. Few view science as a human activity of inquiry that uses evidence based on ways of knowing which alternatives must be tested and evaluated. It is, therefore, not surprising that most families do not emphasize the importance of science with their young charges.

Parents, caregivers, village members, and schools have common goals regarding children, but frequently their efforts are uncoordinated and poorly understood by other villagers. Wang, Haertel, and Walberberg's (1994) meta-analysis revealed home environment and parent support were amongst the five most important factors influencing learning. They stated "the benefits of family involvement in improving students' academic performance have been well documented, as have its effects on improved school attendance and on reducing delinquency, pregnancies and dropping out" (Wang, et al., 1994, p. 77). Well-educated, well-served members of the village are aware of how schools work and are organized. They develop effective, efficient advocacy strategies regarding their priorities, goals, and children (Kelleghan, Sloane, Alvarez, & Bloom, 1993). Under-served parents are less fortunate and believe that several barriers reduce their effectiveness and relationships with schools and are generally less active on all fronts of their children's learning (Zill & Nord, 1994). These parents lack time, money, and knowledge to become involved in their children's education (AAAS, 1996).

Academic achievement is influenced by home learning resources, out-of-school learning activities, high family expectations, and parental instruction and involvement. Barriers to effective parental involvement are time, lack of understanding of academic decision making,

perceived lack of interest by teachers, feeling of disconnection, lack of training, language and lack of success. Clearly, many parents need education about science education reforms and science-related career awareness. Parents need to increase their confidence, develop techniques to increase their effectiveness and efficiency as advocates for children, increase their understanding of schooling and the new reforms, be aware of effective out-of-school inquiry and design activities and future science-related careers. Likewise, schools and teachers need to redouble their efforts to build trust, lower communication barriers, involve parents, and establish positive rapport and effective working relationships early in the schooling process and ensure these features are maintained and reinforced throughout the school process.

The Science PALs Project

The Science PALs project represents one school district's efforts to systemically reform its elementary science program. The strategies used in Science PALs are based on the earlier successes of a teacher inservice effort in which children's ideas were used as the foil and focus of professional development activities to enhance teachers' content-pedagogical knowledge (Shymansky, Woodworth, Norman, Dunkhase, Matthews, & Liu, 1993). Science PALs also utilizes hands-on activities with a focus on children's ideas but adds parents to the instructional loop and uses children's literature to simultaneously decrease teacher anxiety about science and connect the schools' hands-on activities to both the home and the language arts curriculum.

The Use of Literature in Teaching Science

The literature element of Science PALs is a central feature. Fictional pieces are used with hands-on activities to challenge, scaffold, and enhance science understanding. The literature pieces are not meant to be a substitute for science instruction but as a platform for inquiry. The rationale for using literature in science is multifaceted. In part, it provides a comfortable starting place for teachers and parents to discuss science ideas with students. Using stories with a science theme has added benefits beyond providing a comfort zone for teachers and parents. Trade books offer a wide variety of topics, alternative conceptions and viewpoints that excite and motivate students. Children are more excited about testing ideas in science if the ideas are personally relevant. When the ideas come from a story they have just read, there is an immediate personal connection. This provides a common starting point and a surrogate, prior experience, making learning more meaningful.

The idea of using stories to focus children's thinking to enhance science instruction while making it more relevant, connected, and meaningful to students is not new (Butzow & Butzow, 1989). When teachers are familiar with what their students think, or are likely to think, they are able to plan and present challenging situations that might compel students to restructure their thoughts. When parents are familiar with their children's thinking and prior knowledge, they develop increased appreciation and insights into the teaching-learning process. Furthermore, this

alerts teachers and parents to divergent interpretations as they respond, accept, and challenge children's ideas.

Though the use of children's ideas to focus discourse and instruction is not unique to Science PALs, the way that students' ideas are gathered and used in instruction is. In Science PALs, teachers develop a special activity bag for each science unit. The bags serve as the connection between the home and classroom. Each bag contains a piece of science-related children's literature, interview directions, suggested inquiries, and simple equipment to explore ideas related to science topics in the science unit. The activity bags are used by parents to assess their children's prior knowledge and to provide this information to their children's teachers. Parents and children read the story together and explore various science challenges in the story as they occur, using the activity guide and equipment provided in the activity bag.

A typical activity bag for the early years is illustrated by the activity bag designed to assess children's ideas about light and shadows in which The Bear's Shadow (Asch, F., 1985, Scholastic) serves as the problem focus. The activity bag contains a copy of the story; a small flashlight, a gummy bear on a toothpick, an index card; and interview questions and inquiries for the parent co-investigator. Other activity bags have also been developed for each of the district's science units: balls and ramps – The Ball Bounced (Tafuri, N., n.d., Greenwillow); living things – My River (Halpern, S., 1992, Scholastic); pebbles, sand, and silt - Roxaboxen (McLaren, A., 1991, Scholastic); balance and motion – Sheep in a Jeep (Shaw, N., 1986, Houghton Mifflin);

growing things – Miss Rumphics (Cooney, B., 1985, Puffin); and life cycles of butterflies – The Lamb and the Butterfly (Sundgaard, A., n.d., Scholastic).

Parents as Partners

A key feature of the Science PALs model is the use of parents as partners in the instructional loop. When parents are meaningfully involved in their children's education, many benefits accrue (AAAS, 1996). Most parents like to have tangible, significant ways to become involved in their child's educational experience (Daisey & Shroyer, 1995; Rutherford & Billig, 1995). Science PALs provides this opportunity. Parents and children collaboratively read the stories and do the inquiries, and the children's responses and experiences are recorded. Interview data collected by parents are then returned to the teacher and are used to confirm and assist the teacher's instructional planning. Preliminary research suggests that activity bags provide reasonably valid and reliable assessment data on children's prior knowledge (Chidsey & Henriques, 1996).

Science PALs teachers provide other meaningful opportunities for parents to be involved throughout the science unit: unit updates and activities are routinely sent home; invitations are extended to visit the classroom, to observe, help, or serve as an expert resource person; and conferences about the children's ongoing performance and formative assessments are regularly conducted. Collectively, these added opportunities allow parents to be true partners in their child's learning experiences, not merely volunteers or observers. More importantly, parents believe their involvement through the activity bags represent quality science learning and

provide effective, efficient, and enjoyable time with their children (Shymansky, 1997). Parents state (Shymansky & Dunkhase, 1996):

- Doing the science bags with my child was a great learning experience for both of us.
- My child enjoyed being asked his opinions. He felt that he was in the spotlight.
- We both learned from this experience, and it helped us to interact in a positive way through exchange of information.
- This interaction helps parents extend science topics into everyday at-home situations.
- This was an excellent project, and the time for accomplishing it was just right for one sitting. I wish my parents were involved back when I was a kid. This helps parenting skills.

Response to Science PALs

So, how are students, teachers, and parents responding to Science PALs—particularly the parent empowerment and the use of children's literature in science? Survey data were collected from Grade 1-2 children, parents, and teachers at the end of 1997 school year. The surveys utilized Likert items to assess students' and parents' dispositions toward specific ideas related to children's ideas, use of literature in science instruction, parental involvement, school science, and science careers. Teacher comments were solicited by an open-response format during a workshop.

Students' perceptions of science teaching and learning focused on students' views of : (1) teachers' use of student ideas, (2) parents' interest in science, (3) teacher's use of children's literature in science, (4) attitudes towards school science, and (5) science careers. These factors emerged from a factor analysis of student questionnaire responses. Original items were scored as disagree (1), do not know (2), or agree (3), and were assigned to factors using a varimax approach with minimum loading weights of 0.30. Items not meeting this condition or items not fitting the factor were deleted. This screening process resulted in a final Grade 1-2 survey of 27 items. Table 1 provides the number of items in each factor and the internal consistency based on data collected in the spring of 1997. Generally, the instruments were shown to have acceptable validities and reliabilities.

The students' surveys were scored, summarized, and sorted on the basis of the teachers' Science PALs training in years (0, 1, or 2+ years). Differences in student Likert scores were tested using simple pair-wise comparisons. The results generally indicate that Science PALs students perceived their teachers, parents, instruction, science, and science careers more positively than non-Science PALs students, with the major differences favoring the Science PALs groups occurring between students whose teachers had no Science PALs training and those whose teachers had one year of Science PALs training. Significant differences ($p \leq 0.05$) were found on the "parental interest" dimension and between students whose teachers had no Science PALs training and those whose teachers had one year of Science PALs training and on

the "attitude toward science" dimension between teachers with two years of Science PALs training.

Table 1: Descriptive Statistics for Grades 1-2 Student Survey Results from Classrooms with Teachers who have Different Years of Science PALs Experience

Perception/Attitude (number of items, internal consistency)	Years of Science PALs		
	0 Mean, SD (N = 68)	1 Mean, SD (N = 59)	2+ Mean, SD (N = 172)
View of Teacher (8, 0.69)	2.60, 0.34	2.82, 0.27	2.73, 0.31
Parental Interest (6, 0.69)	2.10, 0.49	2.45, 0.49	2.23, 0.52
Use of Literature in Science (3, 0.45)	2.65, 0.41	2.83, 0.36	2.72, 0.40
Attitude toward Science (6, 0.73)	2.44, 0.43	2.65, 0.37	2.52, 0.51
Careers in Science (4, 0.68)	2.21, 0.54	2.45, 0.47	2.20, 0.57

Analysis of informal parents' comments on the activity bags collected in 1995 and 1996 were used as a foundation for developing the parent survey. An 8-item Likert survey was developed and distributed as part of 400 activity bags in each of 16 elementary schools. The survey of parent participants in Science PALs revealed overwhelming support (> 70% agree to strongly agree) from the 183 respondents (45.8% response rate for 400 surveys distributed). Table 2 summarizes the respondents' beliefs about the Science PALs experience, activity bags, literature as springboards into science inquiry, parent-child involvement, parent orientation meetings, and transferability to other subject areas.

Table 2: Percentage Response for the Science PALs Parent Participation Survey

	Question	Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
1.	This experience is valuable for your child.	0	2	8	64	26
2.	The science bag activities lead to more discussions of science at home.	0	7	20	59	14
3.	Story reading is a good introduction to the activities.	1	2	9	55	33
4.	The science activity bag is useful in helping your child learn science at school.	1	1	17	62	19
5.	Parent training sessions are useful in helping you work with your child.	1	4	25	49	21
6.	No additional information or explanation sessions are required.	2	8	18	57	15
7.	The science activity bag helps you have a better awareness of the science your child is studying.	1	3	2	59	35
8.	Home connection activities should be used in other subjects like mathematics.	1	1	11	49	38

A survey of the 16 science advocate teachers in Science PALs about the values and benefits of working with parents revealed the following ten comments about parents as resource, parent as partner, parent as teacher, and parent as advocate:

1. *The Science PALs Project has finally given our **greatest resource (parents)** some power to participate in their child's education.*
    - *Parents are **great teachers**.*
    - ***Parents' interest motivates** students to learn.*
    - ***Parents help me** to learn about their children so that I can facilitate student learning in the best possible manner.*
    - *Parents want to **help their children** but do not always know how.*
    - *Parents **can help establish "where a child is at"** in their understanding of a topic before unit exploration begins.*
    - *Science PALs provides a great **springboard for getting parents involved in their child's learning, rather than merely "helping out" at school.***
2. *Working with **parent partners** has been rewarding to receive parent input in preparation for the actual classroom instruction.*
3. *Over the five years I have been involved in the project, I have seen a gradual change in parents' attitudes toward science and their critical role in the learning process. Parents seem to be **recognizing the value in "doing" science** rather than reading about it. They are **valuing their role** in the activity bag activities. One parent commented, "Each activity bag activity prompts a flurry of experimenting at our house! We love it."*
4. ***Involving parents has proved to be both exciting and beneficial** but at the same time a challenge. It is hard to convey the impact Science PALs has had on teachers and students in a short "cover-everything" parent meeting.*
5. *I learned almost all parents do like to be involved and **will get involved if given a good reason, specific directions, and valued task**. Children also benefit from parent involvement in education.*
6. *Parents have been most supportive. Although some parents feel that they do not know the science for activities, **they want to be involved in a substantive way important to their child's education.***

7. *Parents provided with a meaningful role in the interview process and through updates results in a sense of* ***parents as partners that is reinforced at conferences and meetings during the school year.***

8. *The importance of* ***helping parents stay informed*** *about the* ***science program*** *in elementary schools, the* ***"big" science ideas*** *we are addressing with our activities and investigations, and critical* ***role parents play in their children's success*** *is absolutely clear.* ***This needs to take place over a long period of time.***

9. *The Science PALs experience has allowed me to actively and directly work with parents on a unit of study for their child.* ***Parents responded in a very positive*** *manner.* ***Children have responded positively*** *when their parents are part of the education team.*

10. *Getting the parents more involved with our science units has been important. I feel they are* ***more informed about our "hands on" approach and eager to help their children*** *develop a stronger science background.*

Discussion and Implications

The Science PALs reform effort has been successful in many ways: elementary school science teachers are increasingly refocusing their hands-on teaching to incorporate and respond to students' ideas; parents are responding positively to their new roles as partners; and students are expressing positive feelings about their science instruction, their parents' involvement, their attitudes about science, and their performance in science. Science PALs teachers are now using students' ideas to plan instruction; they are more often challenging these ideas with activities and questions; they are attempting to use a greater variety of assessment techniques; they are trying to connect science to other areas of the elementary school curriculum; and they are increasingly involving parents in meaningful ways. Parents believe that Science PALs is making a difference

for their children and is allowing them to be meaningfully involved in their children's quest for science literacy.

Orchestrating effective and worthwhile parental involvement in children's science education has become more difficult with both parents working, single parents working two or more jobs, lack of extended families, and school environments with constant tension among schools, governments, and taxpayers. The National Parent and Teacher Association recently released a handbook of standards for parent involvement in children's education (NSTA, 1997). They identified six essential standards for effective parental involvement:

- Regular, two-way, meaningful communications
- Promotion and support of parenting skills
- Active parental participation in students' learning
- Open, welcome acceptance of parent volunteers
- Full parent partnership in school-related discussions about their children and family
- Community outreach for resources.

Coleman (1997) suggests that parents can assume the role of cultural ambassador—sharing cultural insights, customs, and traditions, of teacher—enriching and connecting school learning and family life experiences to ensure relevance, of family service coordinator—to develop an effective interface between social agencies and families and to interface with minority, non-English speaking parents, and of advocate—to ensure schools are

concerned about children and the public more clearly understands education. Santa Cruz, California, schools have developed a development matrix for teachers to judge and guide their parental involvement (Chrispeels, 1996). Table 3 illustrates a modified matrix that focuses on parental involvement in science, mathematics, and technology (SMT). Teacher and caregivers can locate their position on these nine dimensions and plan how they might improve their parental involvement, if needed.

Table 3: Analytical Scoring Rubric for Teachers' SMT Literacy Efforts (Adapted from Chrispeels, 1996)

	Category: Level of Development				
Dimension	Beginning (1)	Emerging (2)	Developing (3)	Integrating (4)	Innovating (5)
Children's cultural, physical, and cognitive attributes	May recognize diversity but does not relate to SMT curriculum and instruction	Identifies diverse cultural, physical, and cognitive backgrounds of learners but does not use these for planning and teaching SMT	Identifies diverse backgrounds and sometimes reflects these in planning and teaching SMT	Frequently addresses diversity in planning and teaching SMT	Consistently addresses diversity in planing and teaching SMT
Family and community resources	May recognize the value of family and community resources but does not use them in SMT teaching	Occasionally uses some family and community resources in SMT teaching without incorporating them in planning stages	Involves family and community resources in SMT teaching and may incorporate them in planning	Frequently involves community and family resources in SMT teaching and planning	Consistently involves community and family resources in SMT teaching and planning

Table 3 (continued)

Interdisci-plinary integration and relevance	Teaches SMT without connections to other subject areas and learners' interests and experiences	Occasionally connects SMT experiences to other subject areas	Articulates some connections between SMT and other subject areas and learners' interests and experiences	Frequently connects SMT experiences with other subject areas and with learners' interests and experiences	Consistently connects SMT experiences with other subject areas and with learners' interests and experiences
Selection of learning materials	Recognizes need to select SMT materials that align with and support the children's diverse backgrounds	Occasionally selects and uses relevant SMT materials to match and support children's diversity	Selects and uses relevant SMT materials to match and support children's diverse backgrounds	Frequently selects, analyzes, and uses relevant SMT materials to match and support children's diverse backgrounds	Consistently selects, analyzes, and uses relevant SMT materials to match and support children's diverse backgrounds
Home-school communi-cations	May communicate with parents only at regularly scheduled times	Communicates with parents at all regularly scheduled times	Communicates with parents at regularly scheduled times and may initiate additional contacts	Frequently communicates both positive and negative information to parents using a variety of approaches	Consistently communicates both positive and negative information to parents using a variety of approaches
Interpersonal and human relations	Acknowledges need for effective interpersonal and human relations skills, but does not demonstrate them	Develops some interpersonal and human relations skills	Demonstrates some effective interpersonal and human relations skills in working with students	Frequently demonstrates effective interpersonal and human relations skills in working with students, families, and colleagues	Consistently demonstrates interpersonal and human relations skills in working with students, families, and colleagues

Table 3 (continued)

Community as educational resource	Recognizes value of the community as a SMT resource, but is not certain how to use it to support SMT teaching and learning	Develops knowledge of the community to create SMT resources for teaching and learning	Uses knowledge of the community to create some SMT resources for teaching and learning	Frequently uses knowledge of the community to create a network of SMT resources for teaching and learning	Consistently uses knowledge of the community to create a network of SMT resources for teaching and learning
Parental and community involvement in school	Recognizes value of involving parents and community in SMT literacy efforts but is not certain how to do it	May involve some parents in work with SMT classroom activities	Occasionally involves parents in working with SMT classroom activities	Frequently involves parents and community members to work in SMT classroom activities and some other out-of-school SMT activities	Consistently involves parents and community members to work in SMT classroom and many other out-of-school SMT activities
Family-school rapport	Recognizes importance of establishing productive relationships with families, but has not yet done so	Establishes productive relationships with some families	Establishes productive relationships with some families and may use them to develop an understanding of the culture of a family and its expectations	Frequently establishes productive relationships with families and uses them the develop an understanding of the culture of the family and its expectations	Consistently establishes productive relationships with families and uses them to develop an understanding of the culture of the family and its expectations

The Science PALs Project successfully demonstrates that family involvement can be achieved by designing meaningful, time-efficient, and worthwhile take-home science activities. The activity bags provide a natural, safe problem context by using science-related literature to establish a challenge from which the parent can obtain worthwhile preassessment information to

help the teacher, gain insights into how their children think, and demonstrate their honest interest in their children's learning. Children do not see these activities with their parents as "work", rather they truly enjoy the opportunity to demonstrate their knowledge and skills. Teachers also view this parent involvement as a chance to establish working relationships and lines of communication with parents. The educational village starts with home and school. These must be well integrated before seeking community-wide involvement.

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