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Do Students Really Notice? A Study of the Impact of a Local Systemic Reform.

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ABSTRACT

This paper describes a major reform effort of an elementary science curriculum called the Science: Parents, Activities, and Literature (Science PALs) Project. The goal of the project was to move teachers towards an interactive-constructivist model of teaching and learning that assumes a middle-of-the-road interpretation of constructivism where hands-on activities are used selectively and purposefully to challenge students' ideas, promote deep processing, and achieve conceptual change. The program also enriches the cross-curricular connections of the science units and promotes meaningful parental involvement. A broad question was raised as to whether or not students really notice. This study explored elementary school students' perceptions of and attitudes toward interactive-constructivist science teaching and learning occurring in classrooms of teachers who were or were not participating in the Science PALs project. The sample consisted of 664 females and 651 males in Grades 1 through 6. Students' perceptions and attitudes were generally higher for science teaching and learning in classrooms of teachers with two or more years of Science PALs experience than in the classrooms of teachers with little to no experience with PALs. A survey of parent participants in the project revealed overwhelming support. An appendix contains descriptive statistics and summary analysis of variance tables. (Contains 12 references.)(PVD)

Do Students Really Notice?
A Study of the Impact of a Local Systemic Reform

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Introduction

This paper is about a school district's effort to effect a major reform of its elementary science curriculum. The district, the Iowa City Community School District, had an extensive hands-on, kit-based elementary school science curriculum in place. This kit-based curriculum was supported by a district science supervisor and a material distribution center. The kits contained exemplary National Science Foundation (NSF) supported materials, such as FOSS (Full Option Science System), NSRC/STC (National Science Resource Center/Science and Technology for Children), and the INSIGHTS series (Educational Development Center). The kits were delivered to the teacher on a rotating basis with minimal professional development focused mainly on mechanics and activity deployment. While the students enjoyed the kits and curriculum, there

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was a strong sense among the teachers and curriculum supervisors that students were not developing meaningful science understandings from the experience. A primary reason for this belief was that the typical elementary schoolteacher in the district had little understanding of the science concepts the kits explored and was uncomfortable teaching science.

The Science: Parents, Activities, and Literature (Science PALs) Project was launched in 1994 to reform the district's elementary science program. It was determined that, in order for teachers to become more effective, this comprehensive professional development program needed to increase science content knowledge and science content-pedagogical knowledge, to enrich the cross-curricular connections of the science units, and to promote meaningful parental involvement. It was also decided that these intentions needed to be addressed in a professional development context that provided teachers with first-hand experience with interactive-constructivist learning and a problem-centered, inquiry approach. Undertaken by the Science Education Center at the University of Iowa and the Iowa City Community School District, and funded by the National Science Foundation and the Howard Hughes Medical Foundation, the project's overarching goal was to increase elementary school teachers' content-pedagogical knowledge and move teachers towards an interactive-constructive model of teaching and learning assuming a middle-of-the-road interpretation of constructivism (Shymansky, Yore, Dunkhase, & Hand, 1998).

Problem

Science PALs stressed the importance of children's ideas about science, strategies for challenging children's prior knowledge to stimulate conceptual growth and change, connections to other content disciplines in the children's school day, and parents as partners in their children's science education. Since all these elements ultimately play out in the classroom — how they impact the children — it was decided that the children's reactions to and impressions of the reform efforts should be the first barometer of the project's success. Do students really notice?

This study explored elementary school students' perceptions of and attitudes toward interactive-constructivist science teaching and science learning occurring in classrooms of teachers who were or were not participating in Science PALs. Students' perceptions of science teaching and attitudes toward science learning were examined as a function of the teacher's years of experience in the Science PALs project (0, 1, 2+), the student's gender (female, male), and the students' grade level (1-2, 3-4, 5-6). The following research questions focused the study:

- Are students' perceptions and attitudes influenced by their teacher's years of experience in Science PALs, the student's grade level, and the student's gender?
- Are there experience, gender, and grade level interaction effects evident in students' perceptions and attitudes?

Background

Science teaching, science learning, and science teacher education research has enjoyed increasing popularity in recent years with the publication of the *National Research Council's National Science Education Standards* (NRC, 1996), the *National Board for Professional Teaching Standards* (NBPTS, 1994), and the *Report of the National Commission on Teaching and America's Future* (Darling-Hammond, 1996). These reform documents reaffirm the importance of teachers, teaching, and hands-on/minds-on learning as primary influences on students' thinking, achievement, and science literacy. Collectively, the document provides a vision of what we should teach, how we should teach, and how we should teach teachers to teach. Furthermore, an analysis of the reform documents for language arts, mathematics, science, social studies, and technology all reveal a common focus on "all" students, common learning outcomes of literacy and critical thinking, and common instructional intentions regarding constructivism and authentic assessment (Ford, Yore, & Anthony, 1997). Unfortunately, little attention has been given to developing a concise, clear definition of constructivism and of associated classroom practices. The National Science Teachers Association (1997) has encouraged teachers to increase their professional awareness of the science standards for teaching, professional development, assessment, content, program, and education system. Clearly, the current science reform believes it is not enough to specify learning outcomes without emphasizing the quality of learning experience, the authenticity of the evaluation, and the availability of learning opportunities.

Henriques (1997) established a comparative framework for four faces of constructivism — information processing, social constructivist, radical constructivist, and interactive-constructivist. She provided parallel descriptions of the approaches and their implications for teaching elementary school science:

1. **Information processing** utilizes a computer metaphor to illustrate learning in which a series of micro-processes generates ideas and analyzes errors, which lead to closer and closer approximations of the right answer. Learning is a process of identifying causal relationships between antecedents and outcome, establishing critical (essential, necessary, and sufficient) attributes of a concept, and acquiring accurate understanding of fixed entities and relationships that exist independent of human activity.
2. **Social constructivism** utilizes a context metaphor to illustrate learning in which group dynamics lead to multiple interpretations that are resolved by social negotiations resulting in consensus and common understanding at the group level. Knowledge is perceived as a social artifact, not as a representation of reality.
3. **Radical constructivism** utilizes an organism metaphor to illustrate learning in which intrapersonal deliberations and inner speech lead to equally valid unique interpretations that are internally assessed for personal consistency. Knowledge is perceived as an individualistic snapshot of a multiple reality.
4. The **interactive-constructive model** utilizes an ecology metaphor to illustrate learning in which dynamic interactions of prior knowledge, concurrent sensory experiences, belief systems, and other people in a sociocultural context lead to multiple interpretations that are

verified against evidence and privately integrated (assimilated or accommodated) into the person's knowledge network. Knowledge is perceived as individualistic conceptions that have been verified by the epistemic traditions of a community of learners.

The vision described in the *National Science Education Standards* (NRC, 1996) is of science teaching that engages all students in a quest for science literacy involving the abilities, critical thinking, and habits-of-mind to construct understanding of the big ideas and unifying concepts of science and the communications to share with and persuade other people about these ideas (Ford, et al., 1997). The science teaching standards envision changes in emphasis (NRC, 1996, p. 52):

Less Emphasis on	**More Emphasis on**
Treating all students alike and responding to the group as a whole	Understanding and responding to individual students' interests, strengths, experiences, and needs
Rigidly following curriculum	Selecting and adapting curriculum
Focusing on student acquisition o in formation	Focusing on student understanding and use of scientific knowledge, ideas, and inquiry processes
Presenting scientific knowledge through lecture, text, and demonstration	Guiding students in active and extended scientific inquiry
Asking for recitation of acquired knowledge	Providing opportunities for scientific discussion and debate among students
Testing students for factual information at the end of the unit or chapter	Continuously assessing student understanding
Maintaining responsibility and authority	Sharing responsibility for learning with students
Supporting competition	Supporting a classroom community with cooperation, shared responsibility, and respect
Working alone	Working with other teachers to enhance the science program

When these changing emphases in teaching (children's attributes, rigidity of curriculum, relevant learning outcomes, active questioning, alternative assessment, locus of control, and collaboration) are considered in the context of science and technology standards (science as inquiry and technology as design) and the epistemology described by the nature of scientific knowledge standards ("Science distinguishes itself from other ways of knowing and from other bodies of knowledge through the use of empirical standards, logical arguments, and skepticism, as scientists strive for best possible explanations about the natural world"), it becomes apparent that an interactive-constructivist perspective is supported by the *National Science Education Standards* (NRC, 1996, p. 201).

Science PALs

The first year (1994-95) of the Science PALs Project began with 16 elementary school teachers designated as science advocates — one from each elementary school in the district. These teachers were selected in part for their willingness to serve as science leaders in their schools as well as their interest in participating in the teacher enhancement project. Around these common attributes, the science advocates had diverse demographics, teaching experiences, and academic backgrounds (Henriques, 1997).

The science advocates began the project by attending a special, problem-centered summer workshop similar to the Focus on Children's Ideas in Science project (FOCIS) (Shymansky, Woodworth, Norman, Dunkhase, Matthews, & Liu, 1993). The FOCIS project utilized middle school science teachers' interest in children's misconceptions and their sincere desire to promote conceptual change in their students as an authentic problem focus for the summer workshop and multiyear collaboration with a science content mentor. The focus on children's ideas served as the "straw man" in the FOCIS project, since enhancement of the teachers' science content knowledge and content-pedagogical knowledge were the actual goals of the project. The FOCIS project was effective in achieving meaningful science and science pedagogical learning among the middle schoolteachers on science topics of their choice.

The Science PALs workshop was designed to help participants explore selected curriculum units (NSF-supported versions), and activities using students' ideas again as the "straw man". The workshop matched science content consultants with small groups of science advocates to explore the science concepts in specific units the group selected and to promote interactive-constructivist teaching strategies among the teachers. The Science PALs activities attempted "to create optimal, collaborative learning situations in which the best sources of expertise are linked with the experiences and current needs of the teachers" (NRC, 1996, p. 58). In the workshop and the ensuing school year inservice sessions, various strategies were employed to have the science advocates articulate their alternative frameworks for the science concepts related to the school district's science units, and additional extension activities to challenge these understandings were implemented. The ultimate objective was to address the teachers' personal misconceptions and have them rethink their understandings to develop more accurate scientific conceptions critical to teaching the unit. These science advocates then supplemented the specific FOSS, INSIGHTS, and NSRC units with understandings of the science reforms, misconception literature, additional science activities, children's literature, and interdisciplinary connections to produce teacher resource binders (TRBs) for each science unit.

They field-tested the enriched units (field-test versions) in their own classrooms in the fall and attended three one-day workshops during and after teaching the units. The field-test experiences were shared with colleagues and science content consultants to further clarify science understandings and explore other activities to challenge additional student misconceptions they had uncovered while teaching the unit. These insights were used to revise the TRBs for each science unit (final version) and to develop home science activity bags. The activity bags consisted of a children's literature selection related to the central science topic of the unit, simple science equipment, and a parent interview and activity guide. The activity bags were used by parents to assess their children's prior science conceptions and to provide this information to their children's teachers. Parents and children read the story together and explored various science challenges in the story as they occurred, using the activity guide and equipment provided in the activity bags. The feedback from parents was used to make adjustments to the science instruction that more accurately reflected their students' prior knowledge. Parent orientation meetings were developed to introduce parents to the Science PALs project and activity bags. A Science PALs project newsletter was published to keep the community informed about the project's progress and to maintain contact with students' families.

The cascading leadership design of Science PALs involves a progression of participating teachers and an evolution of their specific leadership roles. April 1994-April 1995 focused on recruiting and working with the 16 science advocates. Fourteen of these original advocates remained active in the project during the 1995-96 cycle. Thirteen of the original advocates continue to serve in the advocate capacity, while one is active in the project but no longer as an advocate and two have left the school district. April 1995-May 1996 activities focused on recruiting and working with 24 lead teachers to complement and share leadership responsibilities with the advocates in a school. Eighteen of the original lead teachers remained active as of December 1996; four are still affiliated with the project but are not actively teaching Science PALs units during the 1996-97 school year and two have left the project. May 1996-April 1997 activities focused on 37 additional teachers recruited as Year 3 (1996-97) cohort teachers to increase the cadre of Science PALs teachers in each school. One hundred forty teachers were recruited as the Year 4 (May 1997-June 1998) cohort, but these teachers are not considered as part of this study.

The summer workshop with follow-up inservice cycle was repeated in subsequent years with approximately 40 teachers in the second year (1995-96), 80 teachers in the third (1996-97), and 140 teachers in the fourth year (1997-98). The inservice cycle focused on authentic problems using activities to challenge teachers' ideas and social interaction and private reflections to get the teachers to rethink their ideas. A similar cycle was then used by the teachers to challenge the students' ideas and to promote concept growth and change in science. About 70% of the elementary teachers in the school district and about 90% of those that taught science on a regular basis participated in Science PALs over the four years. The cascading leadership model used meant that the advocates and lead teachers progressively assumed greater responsibility for the summer workshop, professional development activities, and science decisions.

One professional development activity worthy of specific note is the collaborative development of the Professional Development System (PDS). This activity was critical in defining the science teaching model associated with the Science PALs project. Science advocates, project staff, and external consultants progressively refined the fundamental dimensions of the project (planning, implementation, leadership), the artifacts (points of evidence) used to inform each dimension, and the four categorical examples for each dimension. This system provided the definition and catalyst for much of the inservice activities (Shymansky, Henriques, Chidsey, Dunkhase, Jorgensen, & Yore, 1997). The categorical examples for each dimension served as analytical scoring rubrics for any point of evidence (lesson plans, field notes, videotapes, teacher journals, peer interactions, students' work, etc.) used to inform the dimension.

The Prototypical Science PALs Teacher

The prototypical Science PALs teacher was defined by Henriques (1997) as one who has a working knowledge about inquiry, the nature of science, and science topics in elementary school science. The teacher's content knowledge is married with age-appropriate and topic-specific pedagogical knowledge (content-pedagogical knowledge) that informs instructional planning, classroom teaching, and assessment. "Learning science thus involves being initiated into the ideas and practices of the scientific community and making these ideas and practices meaningful at the individual level" (Driver, Asoko, Leach, Mortimer, & Scott, 1994, p. 6). Science PALs teachers, as more experienced members of the scientific learning community, collaborate with the less experienced members (students, others teachers) to seek problems, ask questions, set tasks, structure experiences, and scaffold performances such that the less experienced persons can internalize and assume control of the processes. Science PALs teachers, as interlocutor, constantly seek to understand what the students know; to support, stimulate, question, and monitor conceptual growth and changes; and to provide just-in-time expertise. The interlocutor role involves a balancing act of being a co-investigator at times and a mentor who demonstrates, guides, and directs at other times. They are encouraged to be spontaneous, flexible, and anticipate learners' interests, questions, and problems. They use holistic teaching strategies that emphasize contextual learning and well-defined concept goals. They plan interactions with literature, activities, and prior experiences (including misconceptions) in a sociocultural context in which learners are encouraged to talk science, share alternative interpretations and rationales, and negotiate clarity. They focus on the value of children's ideas and how to utilize those ideas to plan, modify, and design concrete experiences to help children consolidate and integrate new ideas with prior knowledge structures. They involve parents in assessing their children's science ideas, promoting science education, and supporting classroom learning as an instructional resource. Finally, the prototypical Science PALs teacher is a professional who is responsible for their continued growth as a teacher of children and science.

Design

The broad question, "Do students really notice?", was addressed using a comparative groups design that utilized participating and non-participating teachers to define comparison groups of students exposure to different science teaching. Female and male students from Grades 1-2, 3-4, and 5-6 classrooms with teachers having varying levels of Science PALs experience (0, 1, 2+ years) were given surveys to assess their perceptions of science teaching and attitudes toward science learning. The sample (N = 1315) consisted of 664 females and 651 males from Grades 1-2 (N = 299), Grades 3-4 (N = 456), and Grades 5-6 (N = 560). Science advocates (3 years of experience) and lead teachers (2 years of experience) were combined into the 2+ years of experience group to produce reasonable sample sizes for Grades 1-2 and 3-4 and to reflect the advocate training phase in year 1 of the project.

Instrument

Student responses to three forms of a special instrument, the "Student Perceptions Of Constructivist Climates" (SPOCC), produced data for the study. The instruments contained Likert items designed to assess students' agreement, absence of opinion, or disagreement on a three-position response scale to statements describing aspects of the Science PALs elements and statements describing students attitudes about science and their performance in science. The original Grades 1-2 survey had 86 items, while the original Grades 3-4 and 5-6 surveys had 191 items. These surveys were administered during the spring of 1996 in three settings (20-40 minutes) to 3400 students; 2552 student responses from Grades 1-2 (N = 831), Grades 3-4 (N = 722), and Grades 5-6 (N = 999) were usable.

Ten conceptually unified factors were established using factor analyses techniques. Original items were scored as disagree (1), do not know (2), and agree (3) and were assigned to factors using a varimax approach with minimum loading weights of 0.30. Items not meeting this condition were deleted, resulting in a final Grades 1-2 survey of 35 items, Grades 3-4 survey of 79 items, and Grades 5-6 survey of 75 items. Internal consistencies ranged from marginal (0.45-0.60) to reasonable (0.61-0.87). Generally, the instruments have reasonable face validity and reliability for exploratory research. Further verification utilizing the science advocates' students' responses from the 1996 study were used to explore construct and predictive validity (Yore, Shymansky, Henriques, Hand, Dunkhase, & Lewis, 1998). These explorations revealed that five dimensions demonstrated satisfactory correlation with expert ratings of the science advocates' implementation of Science PALs and detected appropriate differences between the four most successful and four least successful implementators of Science PALs. Based on the collective information on reliability and validity, the following dimensions were used in this study: students' perception of the constructivist approach, students' perception of parental interest, students' perception of the use of literature in science, students' attitudes toward school science, and students' attitudes toward careers in science (Table 1).

Data Analyses and Results

The research focus of this study was to explore the impact of the Science PALs reform effort on students' perceptions of science teaching and attitudes toward science learning. The analyses provide descriptive data for male and female students in Grades 1-2, Grades 3-4, and Grades 5-6

Table 1: Internal Consistencies of and Number of Items in the Likert Item Factors used to Assess Students' Perceptions and Attitudes (1996 data, 1997 data, N = 1315).

Scale and Factors	Grade-Level Groupings					
	1-2		3-4		5-6	
	1996 (N=831)	1997 (N=299)	1996 (N=722)	1997 (N=456)	1996 (N=999)	1997 (N=560)
Perceptions of Science Teaching						
Constructivist Approach	0.67(8)	0.69(8)	0.81(21)	0.79(21)	0.85(17)	0.87(17)
Parental Interest	0.70(6)	0.69(6)	0.68(5)	0.61(5)	0.72(7)	0.70(7)
Use of Literature in Science	0.52(3)	0.45(3)	0.49(3)	0.40(3)	0.61(5)	0.59(5)
Attitudes toward Science Learning						
Attitude toward School Science	0.58(6)	0.73(6)	0.74(5)	0.74(5)	0.81(21)	0.80(21)
Careers in Science	0.68(4)	0.68(4)	0.72(3)	0.69(3)	0.79(4)	0.73(4)

classrooms in which the classroom teachers have not been involved in Science PALs project (0, 1, or 2+ years). Since the perceptions and attitudes were assessed by different but similar items, the average perception and attitude for each factor was used to allow cross-grade comparisons. Differences in perceptions and attitudes were tested using 3-way Analyses of Variance (ANOVA). Tables 2, 3, and 4 provide descriptive statistics for the treatment effects and the two significant interaction effects. A more comprehensive set of descriptive statistics and summary ANOVA results are provided in Appendix A.

The students' perceptions and attitudes were generally higher for science teaching and science learning in classrooms of teachers with 2+ years of Science PALs experience than in classrooms of teachers with 0 or 1 year of Science PALs experience. Three dimensions of students' perceptions and attitudes (Constructivist Approach, School Science, and Careers in Science) were lower in classrooms of teachers with 1 year of Science PALs experience than in classrooms of teachers with no Science PALs experience. None of the perceptions or attitudes reached the desired prototypical levels (2.8+), and none of the treatment effects were significant ($p \leq 0.05$). Exploratory pair-wise t-tests revealed only the difference in the students' perceptions

Table 2: Descriptive Statistics (Mean, Standard Deviation and Cell Size) for Years of Experience in Science PALs

Perceptions and Attitudes	**Teacher Years of Science PALs Experience**		
	0 (N=343)	**1 (N=341)**	**2+ (N=631)**
<u>Students' Perceptions of Science Teaching</u>			
Constructivist Approach	2.61, 0.32	2.52, 0.40	2.63, 0.36
Parental Interest	2.08,0.52	2.12, 0.55	2.18, 0.52
Use of Literature in Science	2.09, 0.64	2.22, 0.62	2.23, 0.61
<u>Students' Attitudes toward Science Learning</u>			
Attitude toward School Science	2.32, 0.53	2.28, 0.57	2.34, 0.56
Careers in Science	2.04, 0.67	2.03, 0.67	2.09, 0.62

Table 3: Descriptive Statistics (Mean, Standard Deviation, Cell Size) for Students' Perception of Constructivist Approach for Specific Grade Level and Years of Science PALs Experiences

	Grade Level		
Years of Science PALs	**1 - 2**	**3 - 4**	**5 - 6**
0	2.60, 0.34 (N=68)	2.47, 0.31 (N=120)	2.71, 0.27 (N=155)
1	2.82, 0.27 (N=59)	2.52,0.30 (N=191)	2.34, 0.52 (N=91)
2+	2.73, 0.31 (N=172)	2.52, 0.36 (N=145)	2.62, 0.37 (N=314)

Table 4: Descriptive Statistics (Mean, Standard Deviation, Cell Size) for Students' Perception of Parental Interest for Specific Grade Level and Years of Science PALs Experience

	Grade Level		
Years of Science PALs	**1 - 2**	**3 - 4**	**5 - 6**
0	2`.10, 0.49 (N=68)	2.07, 0.60 (N=120)	2.07, 0.47 (N=155)
1	2.45,0.49 (N=59)	2.10, 0.54 (N=191)	1.95, 0.51 (N=91)
2+	2.23, 0.52 (N=172)	2.27, 0.56 (N=145)	2.11, 0.49 (N=314)

of parental interest between 0 years and 2+ years of Science PALs experience was significant ($p \leq 0.05$).

All grade-level effects, except students' perceptions of parental interest, were significant ($p \leq 0.05$), while none of the gender effects were significant. The grade level results were supportive of other research indicating less positive perceptions of science teaching and attitudes toward science learning with increased years of schooling. The lack of gender effects rebuts the general trend where females' perceptions of and attitudes toward science teaching and learning are lower than those of males. Inspection of the 5 pairs of females' and males' means indicates that 2 comparisons favored females and 3 comparisons favored males.

Two significant ($p \leq 0.05$) treatments by grade-level interactions were found for students' perceptions of the constructivist approach and parental involvement. Generally, Science PALs appears to be more positively perceived by students in the lower grades (1-2) than by students in the upper grades (5-6). These interactions appear to be influenced by the sharply lower student perceptions and attitudes in classrooms with Science PALs teachers just starting to change their science teaching approach. The effects of this uncertainty may be compounded by the fact that the Grade 5-6 students may be experiencing constructivist science learning for the first time.

Discussion

The Science PALs reform effort was successful in many ways in the Iowa City Community School District: elementary school science teachers moved toward an interactive-constructive approach; parents positively responded to their new roles as partners; and most importantly, students saw a change in their science instruction and developed a more positive attitude about science and their performance in science. Science PALs teachers utilize students' ideas to plan instruction; they challenge these ideas with activities and questions; they use a variety of assessment techniques; they connect science to other areas of the elementary school curriculum; and they involve parents in meaningful ways (Shymansky, et al., 1998).

A survey of parent participants in the Science PALs project revealed overwhelming support (>70% agree to strongly agree) from the 186 respondents for the Science PALs experience, activity bags, literature as springboards into science inquiry, parent-child involvement, parent orientation meetings, and transferability to other subject areas (Shymansky, et al., 1998). The response patterns were consistent except for the usefulness of parent orientation meetings (likely caused by the fact that 34% of the respondents had not attended the scheduled meetings). Written comments indicated that parents had concerns about time requirements, advance notice, and lead time; that activity bags were more effective with younger children; that some literature selections were not explicitly connected to science ideas; and clarity and value of parent directions and training sessions. Several parents expressed a willingness to help develop activity bags, orient new parents, and participate in workshops for new teachers.

There is evidence to suggest two or more years of experience are required to implement constructivist practices that students will detect. But reform efforts are not always uniform in their effects. In the upper elementary grades (5-6) where students are more accustomed to traditional "telling techniques" of instruction (even when hands-on materials are used), perceptions and attitudes might even dip in the early stages of implementation when interactive-constructivist approaches are first used. Students may be negatively influenced by the unexpected changes. This effect should disappear with increased teacher experience and student exposure to interactive-constructivist learning.

The interaction effects support a trend found in the early stages of the Science PALs effort that the interactive-constructive approaches were (a) more fully accepted and effectively used by teachers and (b) judged more positively by students in the lower grades than the upper grades (Dunkhase, Hand, Shymansky, & Yore, 1997; Shymansky, et al., 1998). Again, this is not surprising since use of children's ideas, use of children's literature, and parental involvement are normal practice in the primary school culture.

References

Darling-Hammond, L. (1996). *What matters most: Teaching for America's future (Summary Report).* New York: The National Commission on Teaching & America's Future.

Driver, R., Asoko, H., Leach, J. Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher*, 23(7), 5-12.

Dunkhase, J.A., Hand, B., Shymansky, J.A., &Yore, L.D. (1997). The effect of a teacher enhancement project designed to promote interactive-constructive teaching strategies in elementary school science on students' perceptions and attitudes. Paper presented at the Annual School Science and Mathematics Association Conference, Milwaukee, WI, November 13-15.

Ford, C., Yore, L.D. & Anthony, R.J. (1997). Reforms, visions, and standards: A cross-cultural curricular view from an elementary school perspective. Paper presented at the Annual Meeting of the National Association of Research in Science Teaching, Oak Brook, IL, March 21.

Henriques, L. (1997). A study to define and verify a model of interactive-constructive elementary school science teaching. Unpublished Ph.D. dissertation, Iowa City, IA: The University of Iowa.

National Board for Professional Teaching Standards (1994). *What teachers should know and be able to do*. Detroit, MI: National Board for Professional Teaching Standards.

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

National Science Teachers Association (1997). Awareness hit for the National Science Education Standards. Washington, DC: NSTA.

Shymansky, J.A., Henriques, L., Chidsey, J., Dunkhase, J.A., Jorgensen, M., & Yore, L.D. (1997). A professional development system as a catalyst for changing science teachers. *Journal of Science Teacher Education, 8,* 29-42.

Shymansky, J.A., Woodworth, G., Norman, O., Dunkhase, J., Matthews, C., & Liu, C.T. (1993). A study of changes in middle school teachers' understanding of selected ideas in science as a function of an inservice program focusing on student preconceptions. *Journal of Research in Science Teaching, 30*, 737-755.

Shymansky, J.A., Yore, L.D., Dunkhase, J.A., & Hand, B.M. (1998). Science, parents, activities, and literature: Overview, results, and reflections. Paper presented at the International Meeting of the Association for the Education of Teachers in Science, Minneapolis, MN, January 8-11.

Yore, L.D., Shymansky, J.A., Henriques, L., Hand, B.M., Dunkhase, J.A., Lewis, J.O. (1998). Students' perceptions of science teaching and attitudes toward science learning and teachers' self-report of using children's ideas, applications of science, and use of print resources as indicators of interactive-constructivist teaching in elementary schools. Paper presented at the International conference of the Association for the Education of Teachers in Science, Minneapolis, MN, January 8-11.

Appendix A

Descriptive Statistics and Summary ANOVA Tables 1A-10A

Table A1. Descriptive Statistics (mean, standard deviation, sample size) for Students' Perceptions of Constructivist Approach.

Teacher Experience	Level 1/2		Level 3/4		Level 5/6		Total
	F	M	F	M	F	M	
Non-Science PALs (0)	2.57, 0.36 N = 43	2.66, 0.29 N = 25	2.50, 0.29 N = 58	2.45, 0.33 N = 62	2.73, 0.26 N = 72	2.70, 0.28 N = 83	2.61, 0.32 N = 343
Total	2.60, 0.34 N = 68		2.47, 0.31 N = 120		2.71, 0.27 N = 155		
Science PALs (1)	2.82, 0.26 N = 28	2.82, 0.28 N = 31	2.51, 0.28 N = 96	2.52, 0.32 N = 95	2.39, 0.52 N = 51	2.27, 0.53 N = 40	2.52, 0.40 N = 341
Total	2.82, 0.27 N = 59		2.52, 0.30 N = 191		2.34, 0.52 N = 91		
Science PALs (2+)	2.76, 0.29 N = 85	2.71, 0.33 N = 87	2.53, 0.35 N = 76	2.50, 0.37 N = 69	2.60, 0.41 N = 155	2.64, 0.33 N = 159	2.63, 0.36 N = 631
Total	2.73, 0.31 N = 172		2.52, 0.36 N = 145		2.62, 0.37 N = 314		

Table A2. 3-Way ANOVA results for Teacher Experience, Grade Level, and Gender for Students' Perceptions of Constructivist Approach.

	Df	F ratio	p-value
Teacher Experience	2	0.68	0.512
Grade Level	2	6.98	0.002
Gender	1	0.82	0.366
Teacher Experience * Grade Level	4	2.78	0.036
Teacher Experience * Gender	2	0.22	0.806
Grade Level * Gender	2	0.68	0.509
Teacher Experience * Grade Level * Gender	4	1.00	0.406

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Table A3. Descriptive Statistics (mean, standard deviation, sample size) for Students' Perceptions of Parental Interest.

Teacher Experience	Level 1/2 F	Level 1/2 M	Level 3/4 F	Level 3/4 M	Level 5/6 F	Level 5/6 M	Total
Non-Science PALs (0)	2.06,0.48 N = 43	2.17, 0.49 N = 25	2.10, 0.61 N = 58	2.05, 0.59 N = 62	2.03, 0.47 N = 72	2.11, 0.46 N = 83	2.08, 0.52 N = 343
Total	2.10, 0.49 N = 68		2.07,0.60 N = 120		2.07,0.47 N = 155		
Science PALs (1)	2.47, 0.52 N = 28	2.42, 0.47 N = 31	2.10, 0.56 N = 96	2.10, 0.56 N = 95	2.01, 0.52 N = 51	1.86, 0.48 N = 40	2.12, 0.55 N = 341
Total	2.45, 0.49 N = 59		2.10,0.54 N = 191		1.95,0.51 N = 91		
Science PALs (2+)	2.32, 0.46 N = 85	2.14, 0.56 N = 87	2.35, 0.53 N = 76	2.19, 0.59 N = 69	2.08, 0.47 N = 155	2.14, 0.51 N = 159	2.18, 0.52 N = 631
Total	2.23, 0.52 N = 172		2.27,0.56 N = 145		2.11,0.49 N = 314		

Table A4. 3-Way ANOVA results for Teacher Experience, Grade Level, and Gender for Students' Perceptions of Parental Interest.

	Df	F ratio	p-value
Teacher Experience	2	2.56	0.088
Grade Level	2	6.39	0.003
Gender	1	1.98	0.159
Teacher Experience * Grade Level	4	2.72	0.040
Teacher Experience * Gender	2	1.61	0.201
Grade Level * Gender	2	0.56	0.571
Teacher Experience * Grade Level * Gender	4	1.65	0.160

Table A5. Descriptive Statistics (mean, standard deviation, sample size) for Students' Perceptions of Use of Literature in Science.

Teacher Experience	Level 1/2 F	Level 1/2 M	Level 3/4 F	Level 3/4 M	Level 5/6 F	Level 5/6 M	Total
Non-Science PALs (0)	2.65,0.42 N = 43	2.64, 0.41 N = 25	2.12, 0.67 N = 58	2.21, 0.64 N = 62	1.69, 0.44 N = 72	1.87, 0.59 N = 83	2.09, 0.64 N = 343
Total	2.65, 0.41 N = 68		2.17,0.65 N = 120		1.79,0.53 N = 155		
Science PALs (1)	2.90, 0.22 N = 28	2.76, 0.44 N = 31	2.15, 0.67 N = 96	2.09, 0.58 N = 95	2.02, 0.53 N = 51	2.04, 0.45 N = 40	2.22, 0.62 N = 341
Total	2.83, 0.36 N = 59		2.12,0.63 N = 191		2.03,0.50 N = 91		
Science PALs (2+)	2.73, 0.40 N = 85	2.72, 0.39 N = 87	2.19, 0.59 N = 76	2.28, 0.58 N = 69	1.92, 0.54 N = 155	1.99, 0.56 N = 159	2.23, 0.61 N = 631
Total	2.72, 0.40 N = 172		2.23,0.59 N = 145		1.96,0.55 N = 314		

Table A6. 3-Way ANOVA results for Teacher Experience, Grade Level, and Gender for Students' Perceptions of Use Of Literature in Science.

	Df	F ratio	p-value
Teacher Experience	2	1.67	0.200
Grade Level	2	48.16	0.001
Gender	1	0.44	0.507
Teacher Experience * Grade Level	4	0.96	0.438
Teacher Experience * Gender	2	1.12	0.327
Grade Level * Gender	2	1.33	0.266
Teacher Experience * Grade Level * Gender	4	0.15	0.961

Table A7. Descriptive Statistics (mean, standard deviation, sample size) for Students' Attitudes towards School Science.

Teacher Experience	Level 1/2 F	Level 1/2 M	Level 3/4 F	Level 3/4 M	Level 5/6 F	Level 5/6 M	Total
Non-Science PALs (0)	2.42,0.45 N = 43	2.48, 0.41 N = 25	2.29, 0.53 N = 58	2.29, 0.69 N = 62	2.22, 0.47 N = 72	2.35, 0.49 N = 83	2.32, 0.53 N = 343
Total	2.44, 0.43 N = 68		2.29,0.62 N = 120		2.29,0.49 N = 155		
Science PALs (1)	2.75, 0.23 N = 28	2.55, 0.45 N = 31	2.14, 0.62 N = 96	2.31, 0.56 N = 95	2.18, 0.57 N = 51	2.15, 0.53 N = 40	2.28, 0.57 N = 341
Total	2.65, 0.37 N = 59		2.22,0.59 N = 191		2.16,0.55 N = 91		
Science PALs (2+)	2.60, 0.43 N = 85	2.45, 0.57 N = 87	2.32, 0.66 N = 76	2.28, 0.61 N = 69	2.23, 0.52 N = 155	2.28, 0.54 N = 159	2.34, 0.56 N = 631
Total	2.52, 0.51 N = 172		2.30,0.63 N = 145		2.25,0.53 N = 314		

Table A8. 3-Way ANOVA results for Teacher Experience, grade Level, and Gender for Students' Attitudes towards School Science.

	Df	F ratio	p-value
Teacher Experience	2	0.09	0.915
Grade Level	2	0.68	0.612
Gender	1	0.59	0.552
Teacher Experience * Grade Level	4	0.00	0.998
Teacher Experience * Gender	2	0.59	0.552
Grade Level * Gender	2	1.82	0.163
Teacher Experience * Grade Level * Gender	4	1.39	0.236

Table A9. Descriptive Statistics (mean, standard deviation, sample size) for Students' Attitudes towards Careers in Science.

Teacher Experience	Level 1/2 F	Level 1/2 M	Level 3/4 F	Level 3/4 M	Level 5/6 F	Level 5/6 M	Total
Non-Science PALs (0)	2.13, 0.55 N = 43	2.33, 0.51 N = 25	1.98, 0.68 N = 58	1.94, 0.80 N = 62	1.90, 0.62 N = 72	2.14, 0.64 N = 83	2.04, 0.67 N = 343
Total	2.21, 0.54 N = 68		1.96, 0.74 N = 120		2.03, 0.64 N = 155		
Science PALs (1)	2.42, 0.39 N = 28	2.48, 0.54 N = 31	1.89, 0.66 N = 96	2.04, 0.68 N = 95	1.89, 0.69 N = 51	1.92, 0.69 N = 40	2.03, 0.67 N = 341
Total	2.45, 0.47 N = 59		1.96, 0.67 N = 191		1.90, 0.68 N = 91		
Science PALs (2^+)	2.24, 0.51 N = 85	2.17, 0.62 N = 87	2.00, 0.65 N = 76	2.06, 0.68 N = 69	2.11, 0.60 N = 155	2.01, 0.65 N = 159	2.09, 0.62 N = 631
Total	2.20, 0.57 N = 172		2.03, 0.66 N = 145		2.06, 0.63 N = 314		

Table A10. 3-Way ANOVA results for Teacher Experience, Grade Level, and Gender for Students' Attitudes towards Careers in Science.

	Df	F ratio	p-value
Teacher Experience	2	0.06	0.939
Grade Level	2	12.26	0.001
Gender	1	2.25	0.134
Teacher Experience * Grade Level	4	1.55	0.201
Teacher Experience * Gender	2	1.95	0.143
Grade Level * Gender	2	0.01	0.988
Teacher Experience * Grade Level * Gender	4	1.48	0.206

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