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The Effect of a Teacher Enhancement Project Designed To Promote Interactive-Constructivist Teaching Strategies in Elementary School Science on Students' Perceptions and Attitudes.

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ABSTRACT

This study takes place within the context of the Science: Parents, Activities, and Literature (Science PALS) project and examines elementary school students' reactions to instruction implemented by teachers participating in this special problem-centered professional development program. The study focuses on student perceptions of their science instruction and student attitudes toward science learning as a function of their exposure to interactive, constructivist teaching strategies designed to focus on student ideas, utilization of literature connections, and incorporation of parents as partners. Using student perceptions and attitudes as dependent variables, teacher participation as the main independent variable, and grade levels and student gender as blocking factors, questions were answered pertaining to variations in attitudes and perceptions between students in Science PALS and non-Science PALS classrooms, grade level variations in attitudes and perceptions, and variations by gender in attitudes and perceptions. Results indicate that the Science PALs appeared to be more influential at the grade 3-6 level than at the grade 1-2 level. Results also indicate that the strategies used in Science PALs are similar to those used by most grade 1-2 teachers (i.e., using literature-based instruction, listening to children's ideas, using small-groups discussion, etc.) but different from the standard approaches in grades 3-6. The gender differences favored the female students for all perceptions of science teaching, while the differences favored the male students for all attitudes toward science learning (except "nature of science"). It is concluded that the impact of the Science PALs approach will not be fully realized until the compound effects are explored as children have multiple exposures to the treatment over their elementary school years. Twenty-one data tables are appended. Contains 13 references. (DDR)

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Research Questions

This study examined elementary school students' reactions to instruction implemented by teachers participating in a special problem-centered professional development program--Science: Parents, Activities and Literature (Science PALs). Specifically, the study focused on student perceptions of their science instruction and student attitudes toward science learning as a function of their exposure to interactive-constructivist teaching strategies designed to focus on student ideas, utilization of literature connections, and incorporation of parents as partners. Using student perceptions and attitudes as dependent variables, teacher participation (i.e., Science PALs vs. no-Science PALs) as the main independent variable and grade levels (grade 1-2, 3-4, 5-6) and student gender (female, male) as blocking factors, the following research questions were analyzed:

- Do perceptions and attitudes differ between students in Science PALs and non-Science PALs classrooms?
- Are there grade level by Science PALs interactions for student perceptions and attitudes?
- Are there gender by Science PALs interactions for student perceptions and attitudes?

This study took place within the context of the Science PALs Project. Science PALs was a four-year systemic reform effort collaboratively undertaken by the Science Education Center at the University of Iowa and a local school district. The overarching goal of the project was to move teachers towards an interactive constructivist model of teaching and learning. This study assumed a middle-of-the-road interpretation of constructivism, sometimes referred to as soft-constructivism. It differs from the extreme interpretations of social constructivism, which assumes understanding is constructed at the group level and radical constructivism which assumes all ideas are of equal veracity. As many of the teachers in the project had little or no experience with constructivist classrooms, the project leaders sought to promote teaching strategies consistent with interactive-constructivist views of learning by modeling these strategies in the teacher inservice project.

Background

Constructivism, an epistemic theory (not an instructional theory), has many interpretations (faces) in education (Phillips, 1995). The faces of constructivism provide a "range of accounts of the processes by which knowledge construction takes place. Some clarification of these distinct perspectives and how they may interrelate" is needed as this epistemic theory is used to construct compatible teaching and assessment approaches (Driver, Asoko, Leach, Mortimer, & Scott, 1994,

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p. 5). Without such clarification teachers and researchers have little anticipatory potential, do not know what to observe and measure, and nearly any form of instruction can be justified under the fuzzy definition of constructivism.

The individual faces do have some common assumptions (basics) and important differences (world view, view of scientific knowledge, locus of mental activity, locus of structure/control, discourse, etc.). Accounts of the various interpretations of constructivism agree that understanding is actively made out of, invented from or imposed on personal experiences. The construction processes and the resulting constructs are influenced by the learners' prior knowledge, memory, cognitive abilities, metacognition, interpretative framework, and socioculture context. Each interpretation encourages meaningful learning of integrated knowledge networks through active deliberation, resolution, debate and reflection of cognitive conflicts and each has discounted rote learning, isolated skills and drill-practice. Furthermore, each interpretation agrees that people have alternative ideas within their prior knowledge and that these alternative ideas are not indications of stupidity; are found across age groupings, content areas, cultures and national boundaries; and are resistant to change. Replacement of an existing set of ideas with a different set requires that the new set be sensible, rational, usable and powerful.

Basic constructivist theory is founded in a collection of philosophical and psychological theories, models and ideas including cognitive equilibrium, zone of proximal development, semiotic interactions, capacity of working memory, etc. (Fosnot, 1996). Different faces of constructivism emerge when the basic assumptions begin to emphasize different philosophical and/or psychological perspectives. Four such faces can be recognized from these assumptions: information processing, interactive-constructivist, social constructivist and radical constructivist (Henriques, 1997).

Yore and Shymansky (1997) analyzed these four faces and their embedded philosophical, psychological and epistemic assumptions. Information processing utilizes a computer metaphor to illustrate learning in which a series of sub-routines or micro-processes generate ideas and analyze errors which lead to closer and closer approximations of the truth or the right answer. The interactive-constructive model utilizes a hybrid ecological metaphor (organism, environment, and machine) 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 of Nature and privately integrated (assimilated or accommodated) into the person's knowledge network within the limited capacity of working memory and stored in long-term memory (Shymansky, Yore, Treagust, Thiele, Harrison, Waldrip, Stocklmayer, & Venville, 1997). 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. 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.

These four faces of constructivism have unique philosophical, psychological, epistemic and pedagogical profiles (Table 1, Yore & Shymansky, 1997). World view involves ways of thinking about how the world works--mechanistic, organismic, contextualistic and some combination of these. Mechanistic views stress the important role of antecedent events as influence on behavior. Contextualistic views stress the importance of situation and environment. The meaning of an act may undergo changes as it unfolds in a dynamic environment, and the pattern of events in a sociocultural context have low predictability. Organismic views stress the importance of the organism as a whole. Reality is only what the organism subjectively perceives, knowing is an individualistic event. A combination, hybrid views stresses the importance of interactions with the physical world as well as the sociocultural context, recognizes that interpretations reflect lived experience and cultural beliefs of the knowers, but requires all interpretations to be judged against evidence grounded in Nature.

Epistemic views of science represent the structure of knowledge and ways of knowing--absolutist (a single right answer is proven), evaluative (multiple interpretations are tested and supported or disconfirmed), and relativist (multiple interpretations are equally valid). Locus of mental activity represents the beliefs about where understanding is created--privately within the mind and brain of the individual (i.e., activity flows from periphery to core where irrelevant stimuli are discarded leaving abstract representations of critical and essential information or activity focuses on subjective experiences, extracting internal coherence and where rightness is seen as the fit with personally established order), publicly within the dynamics of the group (i.e., activity is on the interface between the individual and the environment where the collective wisdom of the group and craft knowledge of the group construct understanding), and publicly and privately in which possibilities are exposed, clarified and narrowed by group negotiations but actual meaning is made privately by individuals reflecting on these possibilities. Locus of structure/control represents a pedagogical feature and the pragmatics of classroom teaching dealing with who sets the agenda for study--teachers, students or shared. Discourse represents the combined psychological-pedagogical feature of type and purpose of interpersonal communications in the classroom--one-way communications of expert to novice, one-way communications of person to self (inner speech being the language tool of thinking and spontaneous conception) and two-way communications among people to negotiate clarity or consensus.

Treatment

A special teacher enhancement project Science PALs served to create two subgroups of elementary school teachers in a midwestern school district--teachers who received professional development in Science PALs and teachers who did not. At the beginning of the Science PALs Project, the school district in the project/study, had an extensive hands-on kit-based elementary science curriculum in place. This kit-based curriculum was supported by a district science coordinator and a material distribution center. The kits contained exemplary 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 little or no professional development in their use. While the kits and curriculum were highly regarded, there was a strong sense among the teachers that, even though the students enjoyed doing the interesting hands-on activities, they were not developing meaningful science understandings from the experience. A primary reason for this was that the typical elementary teacher in the district had little understanding of the science concepts the kits explored and most were uncomfortable teaching science. It was determined that in order for these teachers to become more effective, a comprehensive professional development program to increase their science content knowledge and science content-pedagogical knowledge was needed.

The first year of the Science PALs Project began with 16 elementary school teachers designated as science advocates--one from each of the 16 elementary schools in the district. These science advocates began the project by attending a summer workshop. The workshop (similar to the Focus on Children's Ideas in Science project [FOCIS, Shymansky, Woodworth, Norman, Dunkhase, Matthews, & Liu, 1993]), was designed to explore the curriculum units, activity by activity using an interactive-constructive approach in the workshop to promote interactive-constructivist teaching strategies among the teachers. In the workshop and 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 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. They then field-tested the enriched units in their own classrooms in the fall and attended three one-day workshops during and after teaching the units. Classroom experiences were shared with colleagues and science content consultants to further clarity science understandings and explore possible challenge activities to additional student misconceptions uncovered during the actual teaching of the unit. Feedback from parents who used literature-based take-home activity bags to assess their children's prior science knowledge was used to make adjustments to the science instruction that more accurately reflected children's prior knowledge.

This workshop with follow-up inservice format was repeated in subsequent years with approximately 40 teachers in the second year, 80 teachers in the third, and 140 teachers in the fourth year, numbers representing about 70% of all the elementary teachers in the school district and about 90% of those that teach science on a regular basis. Parent orientation meetings were developed to introduce parents to the Science PALs Project and book bags.

In summary, the prototypical Science PALs teacher had a working knowledge about inquiry, the nature of science, and science topics in elementary school science. For the Science PALs teacher, "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, et al., 1994, p. 6). Their content knowledge was married with age-appropriate and topic-specific pedagogical knowledge (content-pedagogical knowledge) that informed instructional planning, classroom teaching, and assessment. Science PALs teachers were encouraged to be spontaneous, flexible, and anticipate learners' interests, questions, and problems. Science PALs teachers were also instructed in holistic teaching strategies that emphasized contextual learning and well-defined concept goals. Science PALs teachers planned interactions with literature, activities, and prior experiences (including misconceptions) in a sociocultural context in which learners were encouraged to talk science, share alternative interpretations, and negotiate clarity. Science PALs inservice activities focused 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. Science PALs teachers were also instructed in ways to involve parents in assessing their children's science ideas, promoting science education and supporting classroom learning as an instructional resource.

Dependent Measures

As in all instructional reform efforts, impact on students is the ultimate determinant of success. The teacher enhancement activities in Science PALs with its focus on curriculum enrichment, interactive-constructive teaching strategies, and parental involvement were all designed to improve elementary school students' science literacy. In this learning environment science was presented to children as an evaluative epistemology in which their ideas are first articulated, then tested or verified against evidence and reality, and finally reconstructed. With this focus on shared control and interaction with other students, teachers, outside experts, and expert resources in this articulation/investigation/deconstruction/reconstruction process, a process new to most students, it stands to reason that student perceptions of the process would be used to measure the degree to which Science PALs teachers had implemented interactive-constructive strategies in their classrooms.

The use of instruments to measure students' perceptions of the effectiveness of constructivist teaching/learning environments is not new. Fraser (1989) reviewed sixty studies of student perceptions on constructivist teaching environments. He argued that the advantages of using student perceptual measures rather than observational measures include: student perceptions are based on many lessons or classes, while peer/expert observations are based on restricted or limited numbers of observations; the information obtained is the pooled judgment of all the students as opposed to the single view of an observer; and student perceptions are based on the teacher's real behavior and therefore more important than inferred behavior based on observer judgment. Wilkinson (1989, p. 123) suggested that analysis of "student ratings of their teachers appeared to be as reliable as those undertaken by more experienced raters". In summarizing the argument for using student perceptions data Wagenaar (1995, p. 68) put forward the argument that students "are best at detecting consumers' perspectives on those teaching behaviors most noticeable to students".

Much of the recent work on student perceptions has been at the secondary level with elementary schooling being overlooked (Goh & Fraser, 1995). Instruments developed at the secondary level such as the Constructivist Learning Environment Survey (Chen, Taylor & Aldridge, 1997), have used such factors as personal relevance, uncertainty, student negotiation, shared control and critical voice to determine the level of student perception of the constructivist environment. Such factors are focused on the students' beliefs that the teacher encourages them to negotiate meaning, they have some control of the learning and the study of science is more than the authoritarian view put forward by the textbook (an absolutist view of science). Goh and Fraser's (1995) study of elementary school science classrooms used the factors of leadership, helping/friendliness, understanding, student responsibility/freedom, uncertainty, dissatisfied, admonishing and strictness to measure students' perceptions of the learning environment. These factors focused on teacher behavior but not all of these appear to be reflective of a constructivist environment. When preservice elementary teachers were asked to judge the success of constructivist teaching approaches, they chose two primary factors; "students' learning and the children's attitudes toward science" (Stofflett & Stefanon, 1996, p.15). This would indicate that instruments designed to measure elementary students' perceptions of their teacher's implementation of constructivist approaches, should incorporate these factors and the specific face of constructivism desired.

Design

The research questions were addressed using a survey approach. Students from classrooms with teachers having one-two years of Science PALs experience (1+) and students from classrooms with teachers having no Science PALs experience (0) were given surveys constructed expressly for this project to assess their perceptions of and attitudes toward specific dimensions within each of two domains: science teaching and science learning. The Likert items were designed to assess students' disagreement or absence of opinion or agreement with descriptive statements using a three-position response scale. The original Grade 1-2 survey had 86 items, while the original Grade 3-4 and 5-6 surveys had 191 items. These surveys were administered in three settings (20-40 minutes) yielding 2552 student responses from Grades 1-2 (N = 831), Grades 3-4 (N = 722), and Grades 5-6 (N = 999).

Instrument

Students' perceptions of science teaching was composed of: (1) view of constructivist approach, (2) parents' interest, (3) teacher's use of children's literature in science, and (4) relevance of science. Students' attitudes toward science learning was composed of: (1) attitudes towards school science, (2) self confidence, (3) nature of science, and (4) science careers. These eight 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 or items not fitting the factor were deleted. This screening process resulted in a final Grade 1-2 survey of 37 items, a Grade 3-4 survey of 57 items, and a Grade 5-6 survey of 72 items. The 8 factors were clustered into two super-scales: Perception of Science Teaching and Attitude toward Science Learning. Table 1 provides the number of items in each factor and the internal consistency based on data collected for Grades 1-2, 3-4, and 5-6 in the spring of 1996. Internal consistencies ranged from marginal (0.45-0.60) on 9 data sets to reasonable (0.61-0.88) on 21 data sets. Generally, the instruments have reasonable validities and reliabilities for exploratory research, but further verification from this study are planned to explore construct and predictive validities.

Data Analyses and Results

The research focus of this study was to explore the influence of Science PALs teacher enhancement activities 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 classrooms in which the classroom teachers were or were not involved in the Science PALs project (0 or 1+ 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 a 3-way Analyses of Variance (ANOVA). Tables 3-22 provide descriptive statistics and summary ANOVAs for each dimension.

Results and Discussion

The treatment effects generally favored the Science PALs teachers over the non-Science PALs teachers for perceptions of science teaching (with "using literature in science" being significant at the 0.05 level) and for attitudes toward science learning (except "attitude toward school science" and "careers in science"). The Science PALs approach appeared to be more influential at the grade 3-4 and grade 5-6 levels than at the grade 1-2 level, but only the treatment by grade level interaction for "using literature in science" was significant, and this interaction was opposite to the general trend. These results appear to indicate that the strategies utilized in Science PALs are similar to those used by most grade 1-2 teachers, (i.e., using literature-based instruction, listening to children's ideas, using small-groups discussion, promoting self-directed inquiries, etc.) but different from the standard approaches in grades 3-6.

The students' perceptions of science teaching, except "relevance in science," were significantly less positive with increased grade level; while students' attitudes toward science learning, (except "attitudes toward school science" and "careers in science") were significantly more positive with increased grade level for both treatments. Children's perceptions of and attitudes toward school generally and science specifically normally became less positive with increased years of schooling. [Therefore, the Iowa City Community Schools' result for "attitudes toward science learning" were pleasing.] Examination of the grade level effects within the Science PALs treatment do not appear to be as negative for the decreased perceptions and attitudes and appear to be more positive for the increased perception and attitudes across the grade levels.

The gender differences favored the female students for all perceptions of science teaching (significant for three of the five factors), while the differences (all were not significant) favored the male students for all attitudes toward science learning (except "nature of science"). Normally the differences between females and males become noticeable about the end of the primary grades (K-3) and widen favoring males with additional schooling. These results regarding perceptions of science teaching and attitudes toward the "nature of science" contradict this trend. The treatment by gender interactions were not significant, but an examination of the gender differences within the Science PALs treatment revealed a 50-50 split on perceptions and attitudes. This results appears to indicate that the Science PALs approach is equally effective for females and males with the females being positive about the teaching delivery approach and the males being positive about the content message.

The impact of the Science PALs approach will not be fully realized until the compound effects are explored as children have multiple exposures to the treatment over their elementary school years. Furthermore, the Science PALs approach involves the common basis of constructivism and the unique feature of the interactive-constructive approach--using literature in science, parental involvement, shared control, critically positioned teacher interventions, etc. It is likely that these unique features will become more influential with repeated use. These issues will be addressed as the 1997 and 1998 data are analyzed.

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Table 1: Philosophical, Psychological, Epistemic and Pedagogical Features of Information Processing, Interactive-Constructivist, Social Constructivist and Radical Constructivist Approaches (Yore & Shymansky, 1997)

Feature	Information Processing	Interactive-Constructive	Social Constructivist	Radical Constructivist
World View	Machine	Hybrid	Context	Organism
Epistemic View	Absolutist (Traditional) Nature as Judge	Evaluative (Modern) Nature as Judge	Evaluative (Postmodern) Social Agreement as Judge	Relativist (Postmodern) Self as Judge
Locus of Mental Activity	Private	Public and Private	Public	Private
Locus of Structure/Control	Teacher	Shared: Teacher and Individuals	Group	Individual
Discourse	One-Way: Teacher to Student	Two-Way: Negotiations to Surface Alternatives and to Clarify	Two-Way: Negotiations Leading to Consensus	One-Way: Individual to Self (Inner Speech)

Table 2: Internal Consistencies of and Number of Items in the Likert Item Factors used to Assess Students' Perceptions and Attitudes (1996 data).

Scale and Factors	Grade-Level Groupings		
	1-2	3-4	5-6
Perception of Science Teaching	0.83(20)	0.85(34)	0.88(35)
Constructivist Approach	0.67(8)	0.81(21)	0.85(17)
Parental Interest	0.70(6)	0.68(5)	0.72(7)
Use of Literature in Science	0.52(3)	0.49(3)	0.61(5)
Relevance of Science	0.50(3)	0.56(5)	0.74(6)
Attitude toward Science Learning	0.71(17)	0.79(23)	0.84(37)
Attitudes toward School Science	0.58(6)	0.74(5)	0.81(21)
Self-concept	0.54(3)	0.64(6)	0.63(6)
Nature of Science	0.60(4)	0.53(9)	0.51(7)
Careers in Science	0.68(4)	0.72(3)	0.79(4)

Table 3: Descriptive statistics (mean, standard deviation, sample size) for Perception of Science Teaching.

Teacher Experience	Level 1/2		Level 3/4		Level 5/6		Total
	F	M	F	M	F	M	
Non Science PALS	2.48, 0.34 N = 259	2.44, 0.37 N = 294	2.50, 0.31 N = 239	2.44, 0. 31 N = 249	2.36, 0.39 N = 168	2.29, 0.36 N = 174	2.43, 0.34 N = 1383
Total	2.46, 0.36 N = 553		2.47, 0.31 N = 488		2.33, 0.34 N = 342		
Science PALS	2.46, 0.34 N = 130	2.43, 0.37 N = 148	2.56, 0.27 N = 124	2.53, 0.33 N = 110	2.42, 0.29 N = 327	2.37, 0.35 N = 330	2.44, 0.33 N = 1169
Total	2.45, 0.35 N = 278		2.55, 0.30 N = 234		2.40, 0.32 N = 657		

Table 4: 3-Way ANOVA results for teacher experience, grade level and gender for Perception of Science Teaching.

	df	F ratio	p-value
Teacher Experience	1	2.33	0.131
Grade Level	2	5.52	0.006
Gender	1	13.23	0.001
Teacher Experience * Grade Level	2	1.07	0.347
Teacher Experience * Gender	1	0.09	0.765
Grade Level * Gender	2	0.40	0.673
Teacher Experience * Grade Level * Gender	2	0.04	0.963

Table 5: Descriptive statistics (mean, standard deviation, sample size) for Students' View of Constructivist Approach.

Teacher Experience	Level 1/2		Level 3/4		Level 5/6		Total
	F	M	F	M	F	M	
Non Science PALS	2.72, 0.31 N = 259	2.70, 0.31 N = 294	2.59, 0.32 N = 239	2.54, 0.33 N = 249	2.54, 0.40 N = 168	2.44, 0.43 N = 174	2.61, 0.36 N = 1383
Total	2.71, 0.31 N= 553		2.57, 0.32 N= 488		2.50, 0.42 N= 342		
Science PALS	2.67, 0.35 N = 130	2.66, 0.34 N = 148	2.62, 0.28 N = 124	2.61, 0.31 N = 110	2.64, 0.32 N = 327	2.55, 0.41 N = 330	2.62, 0.35 N = 1169
Total	2.66, 0.35 N = 278		2.61, 0.30 N = 234		2.60, 0.37 N = 657		

Table 6: 3-Way ANOVA results for teacher experience, grade level and gender for View of Constructivist Approach.

	df	F ratio	p-value
Teacher Experience	1	1.46	0.231
Grade Level	2	7.69	0.001
Gender	1	13.02	0.001
Teacher Experience * Grade Level	2	2.18	0.120
Teacher Experience * Gender	1	0.24	0.621
Grade Level * Gender	2	3.09	0.046
Teacher Experience * Grade Level * Gender	2	0.26	0.777

Table 7: Descriptive statistics (mean, standard deviation, sample size) for Parent 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	2.28, 0.51 N = 259	2.20, 0.56 N = 294	2.26, 0.56 N = 239	2.12, 0.64 N = 249	2.02, 0.49 N = 168	1.99, 0.48 N = 174	2.16, 0.56 N = 1383
Total	2.4, 0.54 N = 553		2.19, 0.61 N = 488		2.01, 0.48 N = 342		
Science PALS	2.25, 0.50 N = 130	2.22, 0.55 N = 148	2.37, 0.52 N = 124	2.27, 0.63 N = 110	2.08, 0.47 N = 327	2.03, 0.52 N = 330	2.15, 0.53 N = 1169
Total	2.23, 0.53 N = 278		2.32, 0.58 N = 234		2.06, 0.49 N = 657		

Table 8: 3-Way ANOVA results for teacher experience, grade level and gender for Parent Interest

	df	F ratio	p-value
Teacher Experience	1	2.50	0.118
Grade Level	2	9.83	0.001
Gender	1	10.75	0.001
Teacher Experience * Grade Level	2	0.95	0.389
Teacher Experience * Gender	1	0.00	0.960
Grade Level * Gender	2	1.05	0.350
Teacher Experience * Grade Level * Gender	2	0.15	0.860

Table 9: Descriptive statistics (mean, standard deviation, sample size) for Using 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	2.69, 0.45 N = 259	2.65, 0.47 N = 294	2.08, 0.66 N = 239	2.05, 0.64 N = 249	1.78, 0.51 N = 168	1.80, 0.51 N = 174	2.24, 0.66 N = 1383
Total	2.67, 0.47 N = 553		2.07, 0.65 N = 488		1.79, 0.51 N = 342		
Science PALS	2.76, 0.34 N = 130	2.66, 0.48 N = 148	2.44, 0.52 N = 124	2.38, 0.56 N = 110	1.78, 0.55 N = 327	1.84, 0.59 N = 330	2.31, 0.66 N = 1169
Total	2.71, 0.42 N = 278		2.41, 0.54 N = 234		1.81, 0.57 N = 657		

Table 10: 3-Way ANOVA results for teacher experience, grade level and gender for Using Literature in Science

	df	F ratio	p-value
Teacher Experience	1	7.30	0.008
Grade Level	2	104.04	0.001
Gender	1	0.45	0.501
Teacher Experience * Grade Level	2	3.54	0.033
Teacher Experience * Gender	1	0.07	0.793
Grade Level * Gender	2	2.70	0.067
Teacher Expereience * Grade Level * Gender	2	0.39	0.675

Table 11: Descriptive statistics (mean, standard deviation, sample size) for Relevance of Science

Teacher Experience	Level 1/2		Level 3/4		Level 5/6		Total
	F	M	F	M	F	M	
Non Science PALS	2.04, 0.63 N = 259	2.03, 0.65 N = 294	2.58, 0.44 N = 239	2.60, 0.42 N = 249	2.68, 0.41 N = 168	2.57, 0.53 N = 174	2.38, 0.60 N = 1383
Total	2.04, 0.64 N = 553		2.59, 0.43 N = 488		2.63, 0.48 N = 342		
Science PALS	2.04, 0.62 N = 130	2.04, 0.61 N = 148	2.60, 0.36 N = 124	2.55, 0.44 N = 110	2.69, 0.42 N = 327	2.64, 0.46 N = 330	2.50, 0.54 N = 1169
Total	2.04, 0.61 N = 278		2.58, 0.40 N =234		2.66, 0.44 N = 657		

Table 12: 3-Way ANOVA results for teacher experience, grade level and gender for Relevance of Science

	df	F ratio	p-value
Teacher Experience	1	0.25	0.616
Grade Level	2	66.18	0.001
Gender	1	2.74	0.098
Teacher Experience * Grade Level	2	0.02	0.976
Teacher Experience * Gender	1	0.00	0.946
Grade Level * Gender	2	1.57	0.209
Teacher Expereience * Grade Level * Gender	2	0.62	0.536

Table 13: Descriptive statistics (mean, standard deviation, sample size) for Attitude toward Science Learning

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	2.27, 0.32 N = 259	2.30, 0.32 N = 294	2.48, 0.33 N = 239	2.49, 0.30 N = 249	2.35, 0.35 N = 168	2.37, 0.34 N = 174	2.38, 0.34 N = 1383
Total	2.29, 0.32 N = 553		2.49, 0.32 N = 488		2.36, 0.35 N = 342		
Science PALS	2.26, 0.29 N = 130	2.25, 0.34 N = 148	2.50, 0.29 N = 124	2.54, 0.29 N = 110	2.41, 0.33 N = 327	2.42, 0.33 N = 330	2.40, 0.33 N = 1169
Total	2.26, 0.32 N = 278		2.52, 0.29 N = 234		2.42, 0.33 N = 657		

Table 14: 3-Way ANOVA results for teacher experience, grade level and gender for Attitude toward Science Learning.

	df	F ratio	p-value
Teacher Experience	1	0.59	0.443
Grade Level	2	21.80	0.001
Gender	1	1.36	0.244
Teacher Experience * Grade Level	2	1.50	0.228
Teacher Experience * Gender	1	0.05	0.829
Grade Level * Gender	2	0.10	0.905
Teacher Experience * Grade Level * Gender	2	0.61	0.545

Table 15: Descriptive statistics (mean, standard deviation, sample size) for Attitude toward School Science

Teacher Experience	Level 1/2		Level 3/4		Level 5/6		Total
	F	M	F	M	F	M	
Non Science PALS	2.52, 0.43 N = 259	2.51, 0.45 N = 294	2.39, 0.57 N = 239	2.38, 0.58 N = 249	2.12, 0.56 N = 168	2.15, 0.54 N = 174	2.37, 0.54 N = 1383
Total	2.51, 0.44 N = 553		2.39, 0.58 N = 488		2.13, 0.55 N = 342		
Science PALS	2.54, 0.37 N = 130	2.49, 0.41 N = 148	2.33, 0.58 N = 124	2.43, 0.56 N = 110	2.21, 0.52 N = 327	2.22, 0.54 N = 330	2.32, 0.53 N = 1169
Total	2.51, 0.39 N = 278		2.38, 0.57 N = 234		2.22, 0.53 N = 657		

Table 16: 3 Way ANOVA results for teacher experience, grade level and gender for Attitude toward School Science.

	df	F ratio	p-value
Teacher Experience	1	0.33	0.568
Grade Level	2	15.83	0.001
Gender	1	0.08	0.781
Teacher Experience * Grade Level	2	0.64	0.529
Teacher Experience * Gender	1	0.05	0.829
Grade Level * Gender	2	1.10	0.334
Teacher Experience * Grade Level * Gender	2	0.76	0.468

Table 17: Descriptive statistics (mean, standard deviation, sample size) for Student Self Concept

Teacher Experience	Level 1/2		Level 3/4		Level 5/6		Total
	F	M	F	M	F	M	
Non Science PALS	2.55, 0.48 N = 259	2.54, 0.50 N = 294	2.60, 0.45 N = 239	2.63, 0.41 N = 249	2.63, 0.40 N = 168	2.63, 0.39 N = 174	2.59, 0.45 N = 1383
Total	2.55, 0.49 N = 553		2.61, 0.43 N = 488		2.63, 0.39 N = 342		
Science PALS	2.49, 0.51 N = 130	2.49, 0.54 N = 148	2.66, 0.42 N = 124	2.72, 0.35 N = 110	2.65, 0.41 N = 327	2.66, 0.40 N = 330	2.62, 0.44 N = 1169
Total	2.49, 0.52 N = 278		2.69, 0.39 N = 234		2.65, 0.40 N = 657		

Table 18: 3-Way ANOVA results for teacher experience, grade level and gender for Student Self Concept

	df	F ratio	p-value
Teacher Experience	1	0.19	0.668
Grade Level	2	7.66	0.001
Gender	1	0.45	0.503
Teacher Experience * Grade Level	2	1.78	0.176
Teacher Experience * Gender	1	0.25	0.617
Grade Level * Gender	2	0.64	0.527
Teacher Experience * Grade Level * Gender	2	0.06	0.943

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Table 19: Descriptive statistics (mean, standard deviation, sample size) for Student View of the Nature of 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	1.65, 0.54 N = 259	1.71, 0.57 N = 294	2.59, 0.30 N = 239	2.61, 0.28 N = 249	2.60, 0.31 N = 168	2.58, 0.35 N = 174	2.23, 0.62 N = 1383
Total	1.68, 0.56 N = 553		2.60, 0.29 N = 488		2.59, 0.33 N = 342		
Science PALS	1.61, 0.49 N = 130	1.65, 0.54 N = 148	2.62, 0.30 N = 124	2.65, 0.30 N = 110	2.64, 0.31 N = 327	2.63, 0.32 N = 330	2.40, 0.56 N = 1169
Total	1.63, 0.51 N = 278		2.63, 0.30 N = 234		2.64, 0.31 N = 657		

Table 20: 3-Way ANOVA results for teacher experience, grade level and gender for Student View of the Nature of Science

	df	F ratio	p-value
Teacher Experience	1	0.07	0.794
Grade Level	2	239.96	0.001
Gender	1	0.44	0.505
Teacher Experience * Grade Level	2	1.10	0.339
Teacher Experience * Gender	1	0.16	0.693
Grade Level * Gender	2	1.05	0.352
Teacher Experience * Grade Level * Gender	2	0.17	0.840

Table 21: Descriptive statistics (mean, standard deviation, sample size) for Student View of Careers in Science

Teacher Experience	Level 1/2		Level 3/4		Level 5/6		Total
	F	M	F	M	F	M	
Non Science PALS	2.31, 0.59 N = 259	2.41, 0.54 N = 294	2.08, 0.72 N = 239	2.06, 0.70 N = 249	1.94, 0.67 N = 168	2.02, 0.64 N = 174	2.16, 0.66 N = 1383
Total	2.36, 0.56 N = 553		2.07, 0.71 N = 488		1.98, 0.65 N = 342		
Science PALS	2.30, 0.51 N = 130	2.33, 0.58 N = 148	2.07, 0.69 N = 124	2.09, 0.71 N = 110	2.04, 0.65 N = 327	2.10, 0.66 N = 330	2.13, 0.65 N = 1169
Total	2.32, 0.55 N = 278		2.08, 0.70 N = 234		2.07, 0.65 N = 657		

Table 22: 3-Way ANOVA results for teacher experience, grade level and gender for Student View of Careers in Science

	df	F ratio	p-value
Teacher Experience	1	0.19	0.662
Grade Level	2	20.64	0.001
Gender	1	2.32	0.128
Teacher Experience * Grade Level	2	0.81	0.448
Teacher Experience * Gender	1	0.19	0.666
Grade Level * Gender	2	1.17	0.310
Teacher Experience * Grade Level * Gender	2	0.51	0.603

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