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ABSTRACT

To investigate factors which could explain the unequal participation and performance of males and females in science, the limited opportunity for females to acquire scientific literacy from their male peers in school was examined. It was assumed that males are more scientifically literate than females (even at elementary school age), that most peer learning results from same-sex as opposed to cross-sex interaction, and that cross-sex group work for science projects would increase female scientific literacy. Fourth- and fifth-grade students from 29 classrooms in California and Connecticut completed three pretests in the fall of 1980: classroom sociometric, attitude survey, and problem solving task completed once individually and once by a four person mixed-sex group. Posttests were administered the following spring. Researchers observed each classroom eight times, focusing each time on three boys and three girls randomly selected. Test results and observations were used to assess classroom organization, extent of cross-sex cooperation, willingness to participate in cross-sex interaction, and sex bias/sex stereotyping. Findings indicated that opportunities for peer learning in general and cross-sex peer learning in particular were few, students were not receptive to cross-sex grouping, and that more peer learning opportunities existed in collaborative than in non-collaborative classrooms. (DC)

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1. Introduction

Much of the research that has sought to explain the unequal participation and performance of women and men in science has focused on sex differences in interests and abilities, on the one hand, and overt sex discrimination on the other hand. With laws prohibiting sex discrimination reducing the barriers against women in science, and empirical investigations of scientific reasoning ability finding fewer and fewer sex differences, it is important to consider other factors that may limit females' participation and performance in science. Our paper today addresses one such factor: the limited opportunity for females to acquire scientific literacy from their male peers in school.

The argument in this paper is based upon two assumptions that we wish to make explicit at this point: First, we assume that males are more scientifically literate--to use Marcia Linn's term--than are females, that this difference can be observed as early as elementary school and that it is largely due to socialization. Second, we assume that a great deal of peer learning occurs in school, that peer learning typically occurs through same-sex rather than cross-sex interaction, and that teachers' use of cross-sex collaborative groups for instruction will facilitate cross-sex peer learning. Third, we assume that teachers' use of cross-sex collaborative groups for science instruction--where such use is particularly appropriate due to the collaborative nature of scientific tasks--will increase female scientific literacy.

In this paper, we pose three questions: 1) are elementary school classrooms now structured in such a way as to encourage cross-sex peer learning, particularly in science? 2) are elementary school students willing to engage in cross-sex collaboration in science? and 3) what is the relationship between willingness to engage in cross-sex collaboration in science and the structure of the classroom?

3. Data

Data reported in this paper are drawn from the first year of an ongoing study of classroom interaction, student cooperation and leadership (Lockheed, Amarel, Finkelstein, Harris, Flores, Holland, McDonald, Nemceff, & Stone, 1981).

3.1 Sample. For the school year 1980-81, twenty-nine fourth- and fifth-grade volunteer teachers were recruited in two school districts, one located in California and one in Connecticut. During the fall of 1980, the students of all participating teachers were administered three pretests: 1) a classroom sociometric, in which students could indicate their interest in working on a science project with each other member of his or her class, 2) a survey of attitudes, experiences and self perceptions, and 3) a problem solving task completed once individually and once by a four person mixed-sex group. During the fall and spring, all classrooms were observed on eight separate occasions, for the entire instructional day. In the spring, posttests were administered to the students.

3.2 Classroom organization measures. The organization of the classroom was measured through direct observation and by the survey administered to the children.

3.2.1 Observation. Classroom observations were conducted by trained observers using the Anecdotal Processing to Promote the Learning Process (APPLE) system (Lambert, Hartsough, Caffrey, & Urbansky, 1976) as adapted for the larger project (Lockheed et al., 1981). For each observation day, three boys and three girls chosen at random from the class lists were designated as target students to be observed; observers were provided guidelines for sampling and recording the behavior of these students. The context of instruction was coded on site, while the student behavior and related student and teacher interactions were recorded verbatim, and coded subsequently by trained encoders. One of the four instructional context codes indicated the working relationship of the student being observed to others in the class. Five categories of such relationships were recorded: the student was working by himself or herself, the student was working in an all-girl group, the student was working in an all-boy group, the student was working in a mixed-sex group, or the students were working as a class unit. Groups were defined as students working together, sharing information and helping each other. Opportunities for peer learning were operationalized as instructional contexts in which students worked in groups.

3.2.2. Student report. The student posttest contained five items designed to measure the extent of cross-sex cooperation a child had experienced in class under the guidance of the teacher. The items were of the type, "Did the teacher who taught you science yesterday or today ask you to work at the same table or on a project with other students?" The response alternatives described different possible groups, including mixed-sex groups. Responses indicating a cross-sex experience were coded "1" and all others were coded "0." The items were summed to form a single index with a possible range of 0-5, with the higher value representing more cooperative experience.

3.3. Willingness for cross-sex interaction in science. This measure was derived from the student science project sociometric, that provided each child a computer-generated list of all the children in his or her homeroom class--the group with whom he or she had science. Next to each name were three choices about how he or she "would feel about working with this person on a science project." The children were instructed to:

> "go down this list of student names and for each name circle the statement that is most like how you would feel about working together on a science project. If you would really like to work with this student on a science project, circle the words 'would really like to work with.' If you wouldn't mind working with this student, circle the words in the second column, 'wouldn't mind working with.' If you would mind working together on a science project, circle the words in column three 'would mind working with.'"

For each child, the mean rating given to boys and the mean rating given to girls in his or her class was computed; omits were not included in calculating this mean rating. In every class, ratings of same-sex classmates were higher than ratings of cross-sex classmates for both the pretest and the posttest. Sex differences for either same-sex or cross-sex ratings were not found. Classroom level cross-sex ratings were computed by summing the mean male cross-sex rating with the mean female cross-sex ratings and dividing by the total number of students in the classroom.

3.4. Student attitude. Measures of sex bias in student perceptions of the academic competence of his or her classmates, of sex bias in student attitudes towards cooperation, and of gender stereotypes were contained in the survey.

3.4.1. Student competence scale. The purpose of this scale was to measure student beliefs regarding the relative competence of boys and girls at school-related tasks. The scale contained eight items of the type, "Think of the best science student in your class. Is this person a boy or a girl?" The possible range for the scale was 0-8 with the higher value representing a belief of greater female competence and the lower value representing a belief in greater male competence.

3.4.2. Attitude toward cooperation scale. The purpose of this scale was to measure attitudes towards cross-sex interaction in the classroom. The scale, which was adapted from the Attitudes Toward Cross-Sex Interaction subscale of the Lockheed-Harris Sex Role, Cross-Sex Interaction and Female Leadership Scale (Parks, Bogart, Reynolds, Hamilton, & Findley, 1979), contains six items of the type "Think of three people in your class that you would choose to do school work with. Are they all boys, all girls or both boys and girls?" Cross-sex and mixed-sex responses were coded "1" and same-sex responses were coded "0." All six items were summed to form a single scale having a possible range of 0-6, with the higher value representing a more positive attitude toward cross-sex cooperation.

3.4.3. Gender stereotypes scale. The purpose of this scale was to measure gender stereotypes other than those related to competence. The scale contains eight items of the type, "Do you think girls and boys are interested in the same things?" The less stereotyped response was coded "1" and the more stereotyped response was coded "0." All eight items were combined into a single scale having a possible range of 0-8, with the higher score representing less stereotyped attitude.

4. Results

4.1. Classroom organization. Our first question was: Does the structure of elementary school classrooms provide opportunities for peer learning, particularly cross-sex peer learning, in science? Classroom observation and student reports were inspected for evidence of these opportunities.

4.1.1. Observations. The opportunity for peer learning was operationalized as instructional context codes that indicated any form of grouping--all male groups, all female groups or cross-sex groups. A total of 23,590 cleaned observation records were available for analysis from these 29 classrooms; of these, 2371 (10.05%) indicated any form of grouping. The percentage of group instructional contexts, by classroom, is presented in the first column of Table 1. This percentage ranged from a high of 1.7% of instructional contexts for Teacher 7 to a low of 1.8% of instructional contexts for Teacher 9; in 20 of the 29 classrooms, groups of any type constituted fewer than 15% of the recorded instructional contexts.

The opportunity for cross-sex peer learning was operationalized as instructional context codes that indicated cross-sex grouping; 1681 such contexts were recorded, or 14.3% of all instructional recorded contexts. The percentage of such instructional contexts, by classroom, is presented in the second column of Table 1. This percentage ranged from a high of 21.9% of coded instructional contexts for Teacher 7 to a low of 0.4% of instructional contexts for Teacher 9; in 26 of the 29 classrooms, cross-sex groups constituted fewer than 15% of the recorded instructional contexts.

Observation records collected in science classes were examined separately for evidence of opportunities for peer learning. Out of 910 instructional contexts recorded in science classes, 77 (8.5%) indicated any form of grouping, and 42 (4.6%) indicated cross-sex grouping. Instructional groups of any kind were recorded for science classes in only six of the 29 classrooms.

4.1.2. Student report. Responses from students regarding their own participation in teacher directed cross-sex collaborative experiences further indicates a low level of cross-sex collaboration in these classrooms. The mean number of teacher directed cross-sex collaborative experiences reported on the posttest by the students in these classrooms was 0.94, or less than one experience in any class during the week preceding the survey administration.

4.2. Classroom willingness to engage in cross-sex collaboration in science. Classroom willingness to engage in cross-sex collaboration in science was operationalized as the mean of the cross-sex sociometric ratings within classrooms. Table 2 presents these ratings, by class, for all 29 classes in our study. The classroom mean ranged from 1.36 in the homeroom class of Teacher 3 to 2.02 in the homeroom class of Teacher 64, with a classroom mean of 1.67. These ratings indicated a very low mean classroom willingness to engage in cross-sex collaboration for a science project.

4.3. Relationship between willingness to engage in cross sex scientific collaboration and classroom organization. Because students in all classrooms reported a general unwillingness to engage in cross-sex collaboration for a science project, and because the overall level of opportunities for collaboration of any kind were so limited in these classrooms and were virtually non-existent in science, we decided to explore the relationship between organization and cross-sex collaboration using classrooms at the extremes of the latter distribution. From Table 2 we identified the two classrooms exhibiting the greatest willingness to engage in cross-sex collaboration for a science project and the two classrooms exhibiting the least willingness to engage in cross sex collaborations. Differences between the mean cross-sex rating for the more collaborative classes, 2.01 for the pretest and 2.02 for the posttest, and the mean cross-sex rating for the less collaborative classes, 1.42 for the pretest and 1.37 for the posttest, were statistically significant, $t = 7.51$, $p < .001$ and $t = 8.92$, $p < .001$, respectively.

4.3.1. Observation. A total of 2,547 clean observation records were available for analysis from the four classrooms; 1,528 in the two more collaborative classrooms and 1,019 in the two less collaborative classrooms. The five types of instructional context codes, indicating the relationship of the target student to other students, were collapsed into three categories of group work (all male, all female and cross-sex) and a residual category indicating individual or whole class instruction. Table 3 presents a cross-tabulation of opportunities for peer learning by more or less collaborative classrooms. Opportunities for peer learning occurred in 18.1% of the more collaborative classrooms and in 7.9% of the less collaborative classrooms, a statistically significant difference, X^2 (3) = 69.66, $p < .001$. All types of peer learning opportunities were observed more frequently in more collaborative classrooms than expected, and less frequently than expected in less collaborative classrooms.

4.3.2. Student report. Student reports of cross-sex collaborative experiences support the observation records. On a five-point index of teacher directed cross-sex interaction, students from more collaborative classrooms reported an average of 1.0 experiences compared to an average of 0.18 experiences reported by students from less collaborative classes; these differences were statistically significant, $t = 5.15$, $p < .001$.

4.3.3. Student attitudes. Student attitudes on the posttest reflect these differences, with students from more collaborative classes being less sex biased in their perceptions of student competence, more positive toward cross-sex collaboration and less sex-stereotyped overall than students from less collaborative classes. These differences are reported in Table 4.

5. Conclusions

The observation records that we have collected in these 29 classrooms--as well as the student reports--demonstrate how limited are the formal opportunities for girls to acquire scientific literacy from their male classmates. Teachers rarely organize instruction in such a way as to encourage peer learning, even in science, a subject matter particularly suited to collaboration. Perhaps as a consequence of limited opportunities for cross-sex collaboration, both girls and boys express little interest in cross-sex collaboration in science. Thus, a cycle is created in which the students' predispositions toward same-sex interactions, left unchallenged by instructional contexts designed to encourage cross-sex interaction, are free to continue to generate same-sex interactions, and the opportunities for cross-sex learning are lost.

References

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Table 1

Opportunities for Peer Learning in 29 Fourth and Fifth Grade Classrooms in California and Connecticut, as a Percentage of Total Observed Instructional Contexts

Classroom I.D.	Total instructional contexts coded	Percent group contexts[a]	Percent cross-sex group contexts
1	516	22.5	11.4
2	561	15.2	10.5
3	565	12.7	12.3
4	514	12.5	11.1
6	629	11.9	10.5
7	562	31.7	21.9
8	725	8.0	5.5
9	454	1.8	0.4
10	734	25.2	18.8
11	683	8.2	4.8
12	464	11.6	4.1
13	489	23.7	15.3
14	527	15.6	11.0
15	627	17.4	13.6
16	795	8.7	7.4
51	1164	7.8	7.0
52	1055	2.3	0.9
53	945	1.9	1.6
54	982	7.9	6.5
55	1027	9.2	1.2
56	919	5.4	2.5
57	1148	3.7	0.7
58	1134	8.6	5.5
59	936	9.8	9.2
60	1319	7.8	2.9
61	932	8.5	5.9
62	1027	13.1	11.2
63	1118	7.5	7.0
64	1039	15.4	9.7

[a] includes cross-sex group contexts

Table 2

Mean Willingness to Engage in Cross-sex Collaborative Work in Science, by Student Sex Within Classroom on Posttest Sociometric

Classroom I.D.	Mean male cross-sex rating	Mean female cross-sex rating	Weighted mean cross-sex rating
1	2.09	1.82	1.94
2	1.45	1.56	1.49
3	1.29	1.43	1.36
4	1.65	1.56	1.60
6	1.50	1.49	1.49
7	1.52	1.57	1.54
8	1.31	1.44	1.38
9	1.69	1.66	1.67
10	1.57	1.89	1.71
11	1.72	1.75	1.73
12	2.14	1.89	2.01
13	1.81	1.64	1.73
14	1.90	2.00	1.95
15	1.69	1.64	1.66
16	1.80	1.50	1.64
51	1.62	1.45	1.66
52	1.69	1.78	1.74
53	1.90	1.60	1.74
54	1.90	1.75	1.85
55	1.81	1.61	1.73
56	1.67	1.41	1.56
57	1.34	1.41	1.38
58	1.62	1.52	1.57
59	1.74	1.73	1.73
60	1.51	1.51	1.51
61	1.68	1.76	1.71
62	1.90	1.62	1.76
63	1.79	1.47	1.61
64	2.12	1.93	2.02

Table 3

Crosstabulation of Opportunities for Peer Learning

by More and Less Collaborative Classrooms (N=4)

Classroom type	Instructional context: All male groups	All female groups	Cross-sex groups	Not groups
More collaborative (N=2)	14(0.92%)	86(5.63%)	176(11.52%)	1252(81.94%)
Less collaborative (N=2)	4(0.39%)	4(0.39%)	72(7.07%)	939(92.15%)

$\chi^2_{(3)} = 69.66$, $p < .001$

Table 4

Student Attitudes in Two More Collaborative
and Two Less Collaborative Classrooms

Variable	More collaborative classroom $\bar{X}$	More collaborative classroom N	Less collaborative classroom $\bar{X}$	Less collaborative classroom N	t-stat
Perception of classmates' competence (0 = male bias; 8 = female bias)	5.76	38	3.06	49	5.10***
Attitude toward cross-sex collaboration (0 = preference for same sex group; 6 = preference for cross-sex group)	3.38	40	1.87	47	4.34***
Gender stereotypes (0 = sex stereotyped, 1 = nonstereotyped)	6.00	40	4.70	44	3.42***

*** $p < .001$