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Ameliorating Gender Differences in Attitudes about Science: A Cross-National Study[1]

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The outcomes of two studies reported here indicate that the teacher inservice workshops, combined with activity-based science lessons, affected students' attitudes and perceptions about electricity. Australian and U.S. studies produced different patterns explored and explained in the paper.

KEY WORDS: Gender differences; sex differences; attitudes toward science; cross-national.

BACKGROUND

For over two decades researchers have attempted to elucidate factors affecting the confidence and competence of girls to do scientific and technological subjects. In addition, over a decade of intervention projects have attempted to ameliorate any differences between girls' and boys' interest and achievement levels in science and technology.

Recently, research has identified interesting contrasts between girls' and boys' attitudinal, interest, and self-confidence patterns toward science. For example, both achievement and attitude show increasing gender differences from age 9. In the third grade both girls (67%) and boys (66%) respond that they think what they learn in science class is useful in everyday life. In seventh grade, both boys' and girls' responses continue to be fairly high (54% and 57%). However, boys retain that positive attitude through senior high school while girls' perceptions of the utility of science fall by 11% during those years (HRI, 1989). Data from the most recent National Assessment of Educational Progress (NAEP) show that 81% of boys, compared to 78% of fourth-grade girls, respond that they like science. However, by grade 8 a gender gap has occurred with 72% of boys, compared to 64% of girls, responding positively. By senior year in high school, girls' positive responses have fallen another 7% to 57%, while affirmative answers by boys are risen by 2% to 74% (Jones *et al.,* 1992).

The deterioration in attitudes about and interest in science by girls is paralleled by a decline in their performance. It may be documented that girls simply stop doing science, particularly physical science, sometime during upper elementary school. For example, between ages 9 and 13 the number of girls who have "tried to fix something mechanical" declines, while the number of boys doing those activities rises dramatically (Mullis and Jenkins, 1988). In the NAEP survey of science, 9-year-old boys and girls score approximately the same at all four proficiency levels, but by age 13, girls fall behind boys at the upper two levels (ability to analyze scientific procedures and data; ability to integrate specialized scientific information), and they continue to lag behind boys through high school (Mullis and Jenkins, 1988). According to the most recent science assessment, twice as many twelfth grade boys (13%) as girls

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(6%) are able "to integrate scientific information" (Jones *et al.,* 1992).

Using data from NAEP, two secondary analyses teased out explanations for the achievement and attitudinal differences. First, Kahle and Lakes (1983) showed that 9-year-old girls expressed desires similar to those of boys when they were queried about what science activities they would like to do. However, when asked what science they had done, responses showed that boys, compared with girls, had had more opportunities to use scientific equipment, to perform science experiments, and to take science-related field trips. In the second study, Linn and others analyzed the response patterns for achievement items and found that at all age levels tested (9, 13, and 17 years), girls significantly more often than boys selected the "I don't know" response (Linn *et al.,* 1987). Whereas boys were willing to risk guessing, girls were less willing to take a chance. That difference in selection pattern accounted for a considerable amount of the achievement difference between girls and boys.

Recently, projects and research have focused on elementary schools where the decline in girls', compared to boys', attitudes and confidence levels begins. Researchers have related the formation of students' interest in science to the amount and kind of science taught in the elementary school (Kelly, 1982; Ormerod and Wood, 1983). It has become evident that performance in science interacts with students' out-of-school science-related experiences, particularly those in physical science (Johnson, 1987; Kahle and Lakes, 1983).

Furthermore, the role of the teacher in influencing students' perceptions about and confidence in doing science has been noted ((McMillan and May, 1979; Simpson, 1987). Harlen (1985) has drawn attention to the need for equitable teaching strategies and science experiences in the elementary schools if girls are to participate equally in science. (Equitable teaching strategies refer to those for which girls and boys indicate similar preferences. Generally, they result in fewer discrepancies between girls' and boys' attitudes, confidence, or achievement levels in science.) Research has also shown that certain instructional techniques are more likely to be equitable (Galton, 1981; Johnson and Johnson, 1987; Kahle, 1985). Briefly those techniques involve the use of cooperative learning groups, laboratories, and discussions. Of equal importance may be an increase in the time girls spend manipulating equipment and in doing experiments, activities that will augment their lack of out-of-school science experiences (Kahle and Meece, 1992). In addition, active participation in science is motivational for most students (NRC, 1990).

There are, however, substantial institutional and structural barriers to activity-based instruction. First of all, elementary teachers have had little, if any, experience with the processes of science in university science classes (NRC, 1990). Second, the prerequisite supplies and equipment for teaching process science are unavailable in many elementary schools. Third, space for teaching elementary science is a concern. Recent data show an increase in the number of elementary classrooms without science facilities. Science is most often taught in self-contained classrooms with portable science materials (56% of K–3 and 53% of 4–6 classrooms) (HRI, 1989). Therefore, materials may not be available when questions arise, or consumables, used by another class, may not be replaced in a timely manner. Furthermore, objects and/or equipment cannot be retained in a classroom in order to allow students to make prolonged observations and measurements. Last, elementary teachers are uncomfortable with a process approach to science, and inadequate teacher backgrounds in science often result in an overreliance on texts and lectures.

PURPOSE

This paper describes a project, originally done in Australia and reproduced in the United States, that attempted to identify school-related factors that affected children's confidence and interest in science. Considerable literature had led the researchers to the conclusion that teachers' and students' attitudes could be affected by teachers' lack of knowledge and skills in science and/or by the lack of information about and practice of equitable teaching strategies.

The two studies (Kahle *et al.,* 1992; Rennie *et al.,* 1985) implemented teacher-intervention programs designed to enhance teachers' skills in teaching a science and technology topic in an equitable way. Both studies provided workshops focused on skills and/or equity in science teaching at the elementary level. Their purpose was to test the efficacy of workshops to provide teachers with attitudes and skills to teach science in an equitable way. The success of the workshops was judged in terms of the change in teacher reports about their own skills and attitudes but, more importantly, in the equality of outcomes in terms of students' enjoyment and perceived self-competence in doing science. The specific purpose of this paper is to compare and contrast American and Australian male and female students' interests and self-confidence levels in science before and after the teacher workshops. The questions answered in this paper are: What patterns of interest do 9-year-old boys and girls have in science in general and in electricity in particular? What attitudes and perceptions about electricity do students have after instruction in this topic? Are students' attitudes and perceptions related to the kind of workshop attended by their teacher.

DESIGN OF THE STUDIES

The Australian study was conducted with 18 fifth-grade teachers and their students in a metropolitan school district. Ten teachers (five male and five female) participated in a two-day workshop designed to enhance their ability to teach electricity in a gender-equitable way (skills/equity). Eight matched teachers (four males and four females) formed a control group and received only that section of the workshop (one half day) that focused on the skills of teaching electricity (skills). The science and technology topic of electricity was chosen because the teachers indicated less experience and confidence with teaching it, compared to other topics (plants, animals, and matter). Pretest and posttest questionnaires for both teachers and students, together with classroom observations of the teaching of the electricity topic, were used to assess the impact of the inservice workshops. The project and its results are fully reported by Rennie *et al.* (1985).

The United States study was carried out with 23 fourth- and fifth-grade teachers in a metropolitan area in the Midwest. Their classes were mixed Caucasian (52%) and African-American (48%) students, in contrast with the Caucasian Australian sample. The United States study both replicated and extended the Australian study by using three types of workshops: science skills, science skills and equitable teaching strategies, and equitable teaching methods only. All workshops were a full day and were followed by a second half day of instruction. The U.S. sample consisted of eight teachers in the skills group, eight teachers in the skills/equity group, and seven teachers in the equity group. The impact of the workshops was evaluated using methods similar to those of the Australian study. More details of the study's design and implementation are given by Kahle *et al.* (1992).

The skills/equity workshop in the U.S. study closely paralleled the one provided to the Australian teachers. However, supplemental information and activities were included in the other two workshops in order to provide all groups of teachers with the same amount of instructional time. In both countries the skills/equity workshop included an introduction to gender issues by an international expert. In addition, teachers were introduced to research concerning teacher–student interaction patterns, wait time, and cooperative learning. Using video tapes, they practiced simple observational procedures that would allow them to identify any gender differences in their own teaching. In addition, they spent a half day doing the electricity activities. Teachers in the skills group also spent a half day practicing with the electricity activities (similar to the Australian study); U.S. teachers also participated in a unit on teaching classification in biology. The equity group, an additional treatment group in the U.S., had the same equity instruction as the skills/equity group as well as an additional half-day during which gender differences in spatial abilities, role models, and career information were discussed.

DATA COLLECTION

In both studies, students' attitudes and perceptions about science and, in particular, electricity, were investigated using questionnaires. The initial questionnaire was given prior to the teaching of electricity and the final questionnaire was given within two weeks of its completion.

Initial Questionnaire

The major purpose of the initial questionnaire was to establish baseline information about students' interests in science, in general, and in electricity, in particular. The first part of the questionnaire contained a general science interest scale of 16 items with a rating scale response format. The scale was developed for the Australian study after consideration of the kinds of science-related hobbies likely to be engaged in 9- and 10-year-old students and an examination of the science curriculum. There were four items relating to each of the topics, animals, plants, matter, and energy, which were the four con-

Table I. Mean Responses to General Science Items on Children's Initial Questionnaire, Australian and U.S. Studies[a]

	Males		Females		
	Mean	SD	Mean	SD	*t*
How much would you like to find out					
1. how iron ore is made into steel (Aus.)	2.87	1.02	2.45	0.99	5.77**[b]
(*U.S.*)	*2.74*	*1.05*	*2.67*	*1.07*	*0.84*
2. how electricity makes the television work	3.45	0.80	3.13	0.90	5.15**
	3.22	*0.99*	*3.19*	*1.00*	*0.38*
3. how compost helps plants to grow better	2.33	1.08	2.64	1.00	−4.13**
	2.27	*1.07*	*2.58*	*1.11*	*−3.58***
4. how germs make you sick	2.95	1.10	3.25	0.98	−3.96**
	2.92	*1.15*	*3.32*	*1.00*	*−4.77***
How much do you like to do					
5. experiments with earthworms	2.70	1.08	2.44	1.12	3.36**
	2.83	*1.20*	*2.31*	*1.23*	*5.49***
6. experiments with shadows	2.40	1.04	2.55	1.04	−2.10*
experiments with gravity	*3.61*	*0.78*	*3.27*	*0.97*	*4.96***
7. experiments with seeds	2.53	1.08	2.98	0.94	−6.20**
	2.48	*1.10*	*2.86*	*1.02*	*−4.61***
8. experiments with water	3.19	0.96	3.25	0.89	−0.88
	3.06	*1.06*	*3.23*	*0.97*	*−2.21**
How much do you like to do science work					
9. about the weather	2.55	1.06	2.47	0.94	1.11
	2.69	*1.11*	*2.81*	*1.06*	*−1.44*
10. about moths, butterflies and caterpillars	2.60	1.11	3.06	0.97	−6.07**
	2.82	*1.14*	*3.13*	*1.03*	*−3.60***
11. about wheels and motors	3.55	0.81	1.91	1.01	24.83**
	3.27	*1.00*	*2.17*	*1.12*	*13.23***
12. about mushrooms and toadstools	2.19	1.11	2.65	1.08	−5.77**
	2.17	*1.14*	*2.26*	*1.13*	*−1.11*
How much would you like to					
13. collect rocks and minerals	3.07	1.02	2.85	1.07	2.94**
	2.83	*1.12*	*2.90*	*1.11*	*−0.80*
14. make working models from Lego or other kits	3.74	0.64	3.03	1.03	11.63**
	3.50	*0.88*	*3.30*	*0.98*	*2.76***
15. grow your own vegetable or flower garden	2.73	1.07	3.52	0.74	−11.81**
	2.62	*1.18*	*3.42*	*0.88*	*−9.93***
16. look after mice or goldfish as pets	3.38	0.90	3.64	0.70	−4.48**
	2.77	*1.13*	*2.92*	*1.13*	*−1.48*

[a]Key: 1, not at all; to 4, a lot.
[b]$^{*}p < 0.05$; $^{**}p < 0.01$.

tent areas of the local science curriculum. Each item asked students how much they would like to do a certain activity and the four-point response format ranged from "not at all" to "a lot."

The second part of the initial questionnaire concerned the electricity unit. Five items asked students how much they would like to do certain activities that would be covered in the unit. The response format was the same as that used in the general science part. The third and final section of the initial questionnaire asked students whether, if they wanted to, they could be a scientist when they grew up. They were asked to write a reason for their response. The details of the development and pretesting of the scale are reported by Rennie *et al.* (1985).

The U.S. study used the same initial questionnaire with minor changes in wording to reflect local idiom; for example, the word flashlight was substituted for the word torch. In addition, item 6 was changed from "How much would you like to do experiments with shadows?" to "How much would you like to do experiments with gravity?" as this was more suited to the local curriculum.

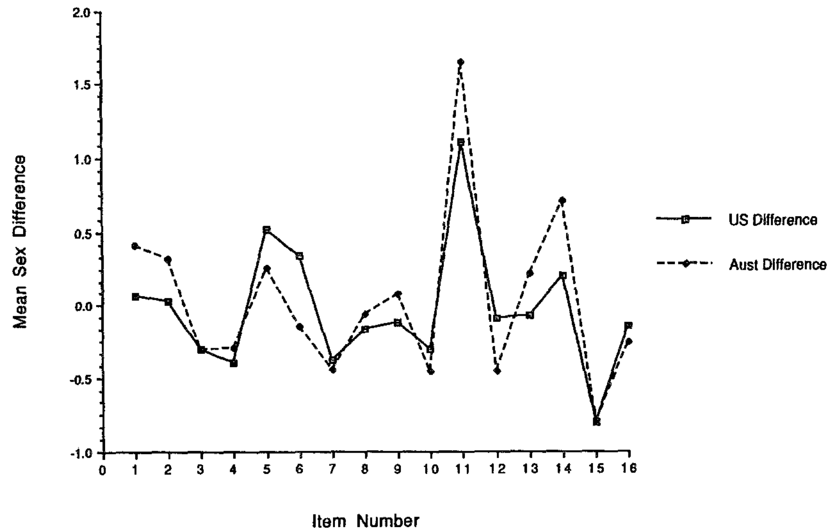

Fig. 1. Differences between boys' and girls' mean scores on the general science items for the Australian and U.S. studies.

The Development of the Final Questionnaire

The final questionnaire served to measure students' responses to, and perceptions about, the electricity unit. The first four items of the final questionnaire asked how much students enjoyed particular activities that were experienced during that unit. Three of these items were also on the initial questionnaire, and the response format was the same for both questionnaires. The next three items asked students to rate how good were "most boys," "most girls," and "you" at working with the electrical equipment. The four response choices ranged from "hopeless" to "really good." Two questions asked students how much they enjoyed the electricity topic and how hard they found it. The final two questions asked whether students thought that women could learn to become electricians and whether "you" could learn to be an electrician if you wanted to. The same final questionnaire was used in the U.S. study, again with small changes in wording.

RESULTS

Analysis of Initial Questionnaire

The initial questionnaire was completed by 394 boys and 373 girls in fifth grade in the Australian study, and by 354 boys and 314 girls in fourth and fifth grades in the U.S. study. The initial questionnaire was analyzed on an individual item basis, because it was desired to obtain information about a range of interests of boy and girl students (Rennie and Parker, 1987). In both studies, students were found to have a high interest in science, averaging at just below three on the four-point scale. Item means and standard deviations for the two data sets are reported in Table I together with the results of repeated t tests to determine the extent of sex differences. For the Australian data, the overall item means for boys and girls, respectively, were 2.98 and 2.86. The matching figures for the U.S. data were 2.86 and 2.90. It can be seen that boys and girls, overall, have very similar levels of interest in science but, as Table I shows, the patterns of science interest are different.

Figure 1 charts the differences between the means of boys and girls in the two studies. Three points can be made. First, the disparities between boys and girls are generally smaller in the data from the U.S. study. In particular, item 14 which referred to the building of models from Lego or other kits has a smaller sex difference. The Australian data are seven years older than the U.S. data, and Lego is much more common now than it was then, and it is possible this gap has since narrowed in Australia. Second, the items concerning motors and gardens (items 11 and 15) are the two with the greatest differences, and it is tempting to invoke the dichotomy of physical and biological sciences to explain this pattern of sex differences. However, and this is the third point of interest on the graph, there are many items where there are no significant sex differences, and these include items describing activities concerning water, weather, rocks and minerals, and mice and goldfish.

The second part of the initial questionnaire contained five items referring to electricity and resulted in students expressing high levels of interest in the activities described. Table II reports the means, standard deviations and the results of t tests for the two studies. In each data set, boys expressed more interest than did girls in the five activities, but these differences did not always reach statistical significance in the U.S. study.

In response to the final question of the initial questionnaire, more boys than girls expressed the belief that they could be a scientist if they wanted to. In the Australian study, the percentages of boys and girls responding "yes" were 54.8% and 48.2%, respectively, and the corresponding percentages for the U.S. study were 73.5% and 58.6%, considerably higher figures. The reasons given by the students were varied, but similar, between the two sets of results. Positive responses tended to reflect students' interest in science and their belief that they could do it, while negative responses were attributed to a lack of interest in science or a belief that it was too difficult. A number of students claimed that they had already chosen a different career. In general terms, the reasons given by boys were similar to those given by girls, but boys were more likely to say they were good at science, while girls were more likely to say they did not know much about science or assumed they would not be good at it.

The analyses reported above used the individual student as the unit of analysis. This is appropriate because a composite description of students' interests was required, and students were mixed in the sample as they were in the population. However, in the analysis of the final questionnaire, comparisons needed to be made between a smaller number of classes taught by teachers in the different treatment groups, comparisons for which the class might be a more appropriate unit of analysis. Students in the same class would have had some similarity in their background science experiences, especially those that occur in connection with the school science program. Consequently, analyses of variance were used to determine whether there were systematic differences between the nature of students' responses to the initial questionnaire and their class membership and the sex of their teacher. In both sets of data, no systematic significant differences were found in students' interests that were related to the sex of their teacher, nor was there interaction between students' sex and the sex of their teacher. However, there were significant differences associated with class on nearly every item in the Australian data and most items in the U.S. data. Interaction effects were not significant. Overall, these results suggest that class membership is a variable that should be taken into account when analyzing childrens' attitudes about science.

Table II. Mean Responses to Electricity Items on Children's Initial Questionnaire, Australian and U.S. Studies[a]

How much would you like to		Males Mean	Males SD	Females Mean	Females SD	t
1. Work out ways to make a	(Aus.)	3.28	0.92	2.74	0.94	8.03**[b]
flashlight bulb light up?	(*U.S.*)	*3.22*	*1.04*	*2.83*	*1.10*	*4.64***
2. Test things to see if electricity		3.38	0.90	2.90	1.00	7.01**
passes through them?		*3.38*	*0.96*	*3.01*	*1.10*	*4.67***
3. Cut up a battery and flashlight		3.46	0.86	3.12	1.03	4.94**
to see what's inside it?		*3.31*	*1.00*	*3.24*	*1.05*	*.87*
4. Make your own switch to turn a		3.58	0.79	3.25	0.94	5.21**
light on and off?		*3.23*	*1.06*	*3.25*	*0.98*	*–.26*
5. Do an experiment to see how		2.85	1.02	2.58	0.98	3.82**
brightly a flashlight can shine?		*2.99*	*1.10*	*2.92*	*1.09*	*.81*

[a]Key: 1, not at all; to 4, a lot.
[b]**$p < 0.01$.

Analysis of the Final Questionnaire

The data from the final questionnaire provided the basis for making comparisons between boys and girls in terms of their attitudes about the electricity topic, and from those results, inferences could be made about the treatment effects. All analyses were based on the class as the unit of analysis because of the class-related differences found in the analysis of the initial questionnaire. (Although there is a loss of degrees of freedom, and hence power of the F test, the means are associated with smaller standard errors because they are calculated from aggregated data. Also, the treatment groups cannot be assumed to be statistically equivalent. In the Australian study, the research classes were chosen and assigned randomly to treatment groups, but the loss of two classes from the skills-only group invalidated the assumption of equivalence. In the U.S. study, it was not possible to assign classes randomly to treatment groups, so in this data set also, it cannot be assumed that groups are equivalent.) Because the treatment groups were not equivalent, item mean scores were not a valid means of comparing among treatment groups. However, if differences between the scores of boys and girls were the basis of comparison between groups, then the extent of this difference would suggest where more equitable teaching strategies had been applied successfully. This strategy also offered a way of making comparisons between the results of the Australian and U.S. studies.

The differences in scores between girls and boys were analyzed by subtracting the girls' mean score from the boys' mean score for each class and using these difference scores as the criterion measure. In the Australian study, two-way fixed-effects analysis of variance was then used to test for effects associated with treatment group and sex of teacher. Sex of teacher was not a factor that could be considered in design of the U.S. study because the number of male teachers was small and it was not possible to assign male teachers to each treatment group. Hence, one-way analyses of variance searching for treatment effects were used.

Students' Enjoyment of the Electricity Topic

The first four items of the final questionnaire asked students how much they enjoyed particular activities experienced during the electricity topic. Each item was scored 1–4. The items were summed to form a short activities scale, measuring enjoyment of electrical activities. Table III reports the mean item score on this scale, together with the mean scores for item 8, which asked students whether they enjoyed working with the electrical equipment "less," "as much," or "more" than they thought they would. This item was scored 1–3.

Table III. Mean Item Scores for Students' Enjoyment of Activities During the Electricity Topic[a]

	Australian study		U.S. study	
Treatment group	Males	Females	Males	Females
Activities scale				
Skills	3.43	3.13	3.45	3.27
Skills/equity	3.36	3.34	3.34	3.48
Equity			3.47	3.49
Enjoyment (item 8)				
Skills	2.59	2.35	2.56	2.50
Skills/equity	2.45	2.51	2.47	2.62
Equity			2.59	2.61

[a]Key: Activities scale items—1, not at all; to 4, a lot. Enjoyment item—1, less; to 3, more.

Whether or not the students enjoyed the topic can be judged from two sources of data. First, the means in Table III for both studies indicate that students scored over 3 (on the four-point scale) on the items of the activity scale and well over the midpoint of 2 on item 8. There is a tendency for boys to have scored higher than girls in the skills-only group for both studies, but clearly all students enjoyed the topic. The second source of data comes from comparison with the results from the initial questionnaire. Some of the items in the final questionnaire (items 1, 2 and 4 in the Australian study and items 1 and 2 in the U.S. study) were also included in the initial questionnaire, where they were presented as "How much would you like to . . .?" rather than "How much did you enjoy . . .?" In both studies, the results from the initial questionnaire revealed significant differences in favor of boys (see Table II), but these differences are not significant for the final questionnaire. Girls enjoyed these specific activities more than they anticipated at the time of the initial questionnaire. In contrast, boys' enjoyment was about the same or even less than anticipated.

Table IV presents the mean differences between boys' and girls' scores on the common items for the initial questionnaire and the final questionnaire, and it can be seen that the consistent positive differences (that is, male means higher) at the time of the initial questionnaire have disappeared. Positive differences on the final questionnaire are asso-

Table IV. Mean Differences between Males' and Females' Responses to Items Common to the Initial and Final Questionnaires[a]

Item/treatment	Australian study Initial	Australian study Final	U.S. study Initial	U.S. study Final
Flashlight bulb (item 1)				
Skills	0.58	0.52	0.52	−0.04
Skills/equity	0.55	−0.02	0.31	−0.06
Equity			0.61	−0.05
Conductor (item 2)				
Skills	0.71	0.23	0.45	0.31
Skills/equity	0.50	−0.04	0.36	−0.20
Equity			0.33	−0.04
Switches (item 4)				
Skills	0.49	0.20	[b]	
Skills/equity	0.35	0.08		
Equity				

[a]Negative score indicates higher female mean.
[b]This item was not matched in the U.S. data.

ciated with the classes whose teachers received only skill training. The data in Table IV show that the experience of doing the electricity activities brought the scores of girls and boys much closer together in each group. In fact, the girls enjoyed the work more than the boys in a number of classes (those of teachers participating in the equity training), resulting in a negative difference (in favor of girls). Clearly, the actual experience of working with the electrical equipment was enjoyable, and one the girls did not expect to enjoy as much as they did.

Differences among the treatment groups in students' enjoyment of the electricity topic were examined using the differences between male and female scores on the activities scale. Analysis of the Australian data revealed a statistically significant treatment effect ($F = 9.88, p < 0.01$), but in the U.S. data the effect was not significant ($F = 1.84$). Figure 2 shows the results for the two studies. In both, the skills-only group is the only one in which boys outscore the girls. The skills/equity group in the Australian study and the equity-only group in the U.S. study have negligible differences between the girls and boys. In fact, girls in the skills/equity group in the U.S. study appear to have particularly enjoyed the topic.

Somewhat similar results are obtained for item 8, which asked about anticipated enjoyment of the topic. In the Australian study, the analysis resulted in a significant treatment effect ($F = 4.23, p < 0.10$), but the treatment effect was not significant in the U.S. data ($F = 0.96$). The graph of the mean difference scores in Fig. 3 shows again that only in the skills group did boys enjoy the electricity topic more than girls did. Taken together, the results for these items suggest that teachers with some equity training, compared to those with only skills training, were able to teach the electricity unit in a manner that appealed to both girls and boys.

Perceptions about the Electricity Topic

Four items tapped students' self-confidence in doing electricity and their perceptions of its difficulty. Items 5, 6, and 7 asked students how good

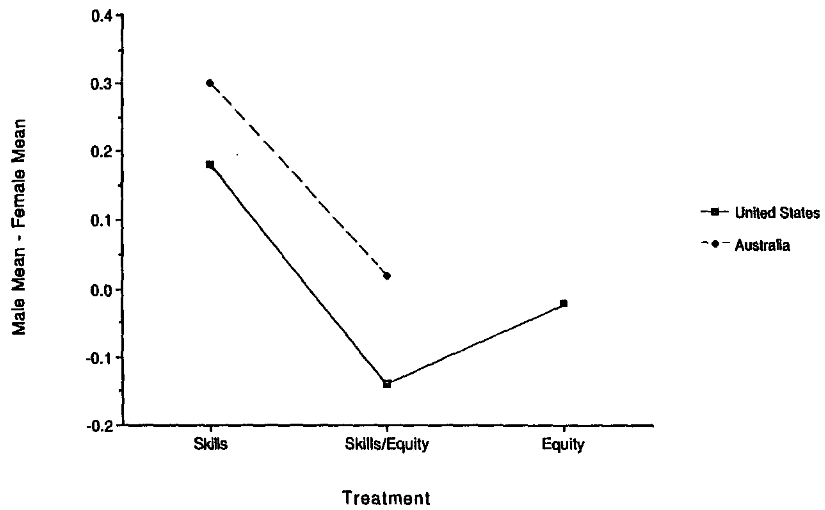

Fig. 2. Differences between boys' and girls' mean scores on the activities scale for the Australian and U.S. studies.

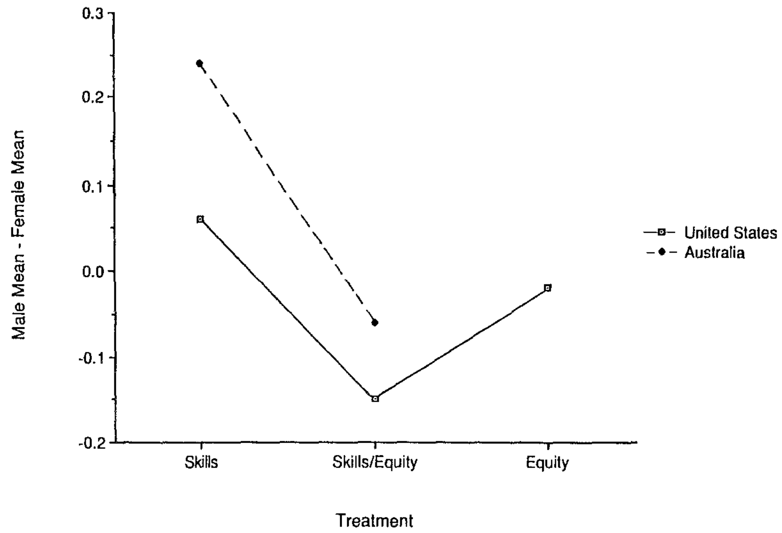

Fig. 3. Differences between boys' and girls' mean scores on item 8 (How much did you enjoy..?) for the Australian and U.S. studies.

they thought "most boys," "most girls," and "you" were at working with bulbs, wires, and batteries. These three items were scored 1–4 and the mean scores are reported in Table V. Item 9 asked how hard students found the electricity work and the item was scored 1–5 on a scale from "always hard" to "always easy."

The responses have a different pattern for the two studies. For the Australian data, the mean scores for items 5 and 6, reported in Table V, show that boys perceive "most boys" to be good at working with the equipment but consider "most girls" to be less able than "most boys" with it. In contrast, girls thought that "most girls" were about as good as "most boys" at working with the equipment. The results for the U.S. study were more extreme. In each treatment group, students thought that most of their own sex were good at working with the equipment but were negative about the ability of the opposite sex. The results for item 7 indicate that boys perceived themselves to be nearly as good as "most boys" at working with the equipment, but girls saw themselves as less able than "most girls." This suggests a lack of confidence in girls who, on average, perceive themselves to be less able than other girls.

There are no significant differences associated with treatment for items 5, 6, or 7 in either study. However, there are significant differences associated with students' sex. For item 5, significantly more males than females think that boys are good at working with bulbs, wire, and batteries ($F = 7.00$, $P < 0.05$ in the Australian study and $F = 112.02$, $P < 0.01$ in the U.S. study). The opposite is true for item 6. Girls have a much higher estimation than boys do of the ability of girls to work with the equipment ($F = 36.36$, $P < 0.001$ in the Australian study and $F = 162.21$, $P < 0.001$ in the U.S. study). Analysis of the mean differences between boys' and girls' mean scores on item 7 reveal that a significant sex difference exists in both data sets, with boys more confident of their own ability than are girls $F = 38.39$, $P < 0.001$ in the Australian study and $F =$

Table V. Mean Scores for Students' Perceptions about the Difficulty of the Electricity Topic[a]

Item/treatment group	Australian study Males	Australian study Females	U.S. study Males	U.S. study Females
Most boys (item 5)				
Skills	3.59	3.26	3.59	2.56
Skills/equity	3.40	3.24	3.69	2.75
Equity			3.77	2.35
Most girls (item 6)				
Skills	2.57	3.11	2.42	3.74
Skills/equity	2.72	3.20	2.29	3.67
Equity			2.12	3.77
How good are you (item 7)				
Skills	3.29	2.87	3.44	3.34
Skills/equity	3.23	2.90	3.67	3.46
Equity			3.70	3.57
How easy (item 9)				
Skills	3.69	3.32	3.67	3.35
Skills/equity	3.67	3.49	3.89	3.58
Equity			3.97	3.46

[a]Key: items 5, 6, 7 = 1, hopeless; to 4, really good. Item 9 = 1, always hard; to 5, always easy.

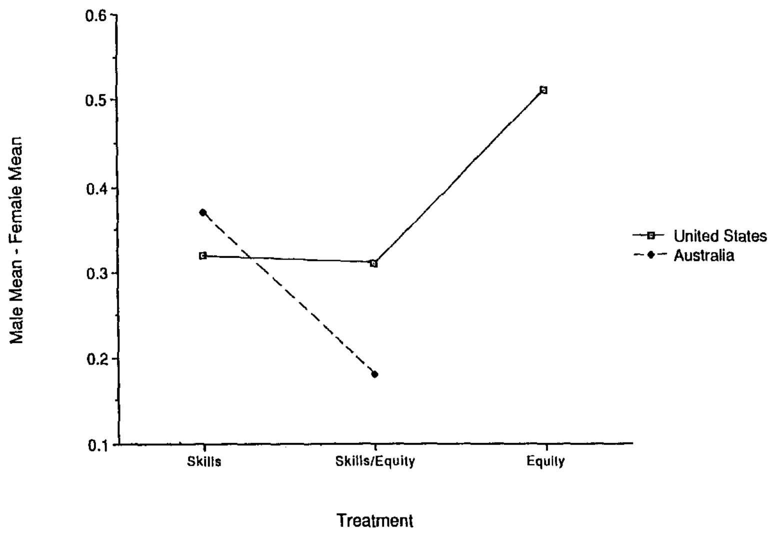

Fig. 4. Differences between boys' and girls' mean scores on item 9 (How easy . . .?) for the Australian and U.S. studies.

4.45, $P < 0.05$ in the U.S. study). However, these sex differences were much less than those on items 5 and 6. Interestingly, boys and girls in the U.S. study appeared to be more confident of their own ability than their Australian counterparts.

Item 9 asked students how easy or hard they found the work in electricity. The mean scores in Table V show that, on average, and in both studies, boys' means are higher than girls' means, but that all are between the "sometimes easy" and "mostly easy" response choice. The mean difference score between males and females are graphed in Fig. 4 and show that the differences between boys and girls are variable but tend to be larger in the U.S. classes taught by teachers with only equity training. However, on average, both U.S. and Australian boys found the electricity topic easier than did the girls ($F = 14.16$, $P < 0.01$ in the Australian study and $F = 14.58$, $P < 0.001$ in the U.S. study).

The last two items of the final questionnaire referred to the career of electrician. Item 10 asked students whether they thought women could learn to become electricians, and item 11 asked whether they themselves could learn to become an electrician if they wanted to. The results of these last two items are recorded in Table VI as the percentage responding "yes" to each item. In both studies, there was no treatment effect for item 10, but as the graph in Fig. 5 shows, fewer boys than girls thought that women could become electricians. The mean difference between boys and girls was significant in both studies ($F = 13.49$, $P < 0.01$ in the Australian study and $F = 25.4$, $P < 0.001$ in the U.S. study).

Item 11 asked students whether they thought they could learn to become an electrician if they wanted to. The mean difference scores are graphed in Fig. 6. There is a treatment effect present in the Australian data ($F = 3.90$, $P < 0.10$) but not in the U.S. data. In each study it is noticeable that the difference between the percentage of boys and girls responding "yes" to this question is smaller for the treatment groups whose teachers received the equity or skills/equity training. The results in Table VI show that in all groups, around 90% of boys thought they could become electricians. In the Australian data an average of 85% of girls in the skills/equity group said "yes" to this question, but only 70% of

Table VI. Percentages of Students Responding "Yes" to Electrician as a Career

Item/treatment group	Percentage			
	Australian study		U.S. study	
	Males	Females	Males	Females
Women electricians (item 10)				
Skills	84	93	86	97
Skills/equity	77	94	75	99
Equity			74	96
You an electrician (item 11)				
Skills	88	70	95	85
Skills/equity	91	86	94	91
Equity			89	91

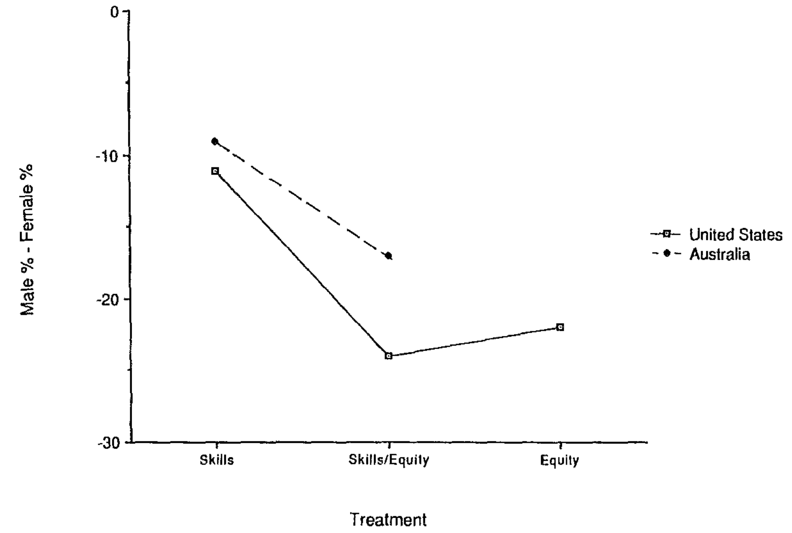

Fig. 5. Differences between boys' and girls' mean scores on item 10 (Could women be electricians?) for the Australian and U.S. studies.

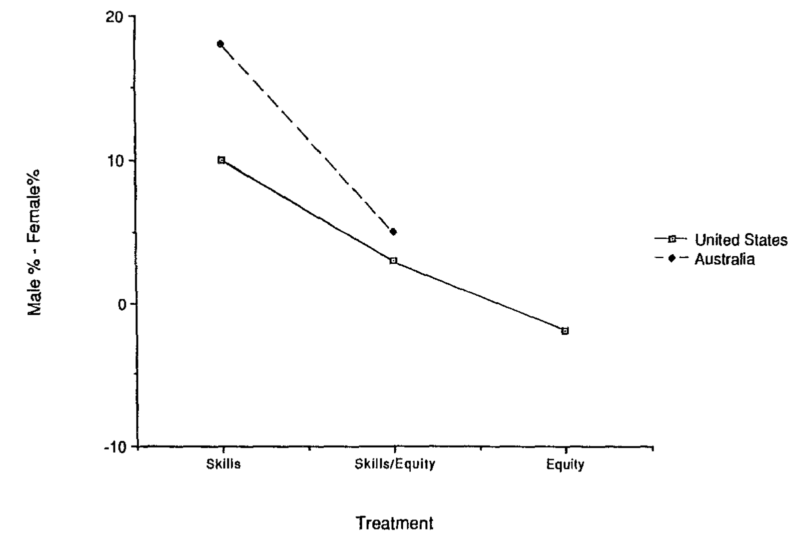

Fig. 6. Differences between between boys' and girls' mean scores on item 11 (Could you be an electrician?) for the Australian and U.S. studies.

girls in the skills-only group responded "yes." The pattern of responses in the U.S. study is similar, but is not as marked. Although many girls thought women could become electricians, they did not think that they themselves could become electricians, an indication of a low level of self-confidence, particularly among girls in the skills-only groups in both Australia and the U.S.

DISCUSSION

The results of both studies indicate that preexisting gender differences in enjoyment of physical science activities can be ameliorated by girls having opportunities to do such activities. Regardless of the type of teacher workshop, boys and, to a greater extent, girls enjoyed the activities more than they thought they would. In addition, in both countries, gender differences disappeared for students in the skills/equity and equity groups, whose teachers had received training about the importance of active participation for both girls and boys. However, in the classes of teachers with only equity training, the largest difference between boys and girls was found on the item asking how easy students found the topic. Although girls in that group enjoyed the activities, they felt that the science experiments were difficult.

These results reinforce other findings that indicate that girls' interest in, attitudes about, and enjoyment of science are restricted by the type and kind of science they have experienced. Differential experiences of girls and boys in science were noted by Kahle and Lakes in 1983 and have been confirmed in a recent AAUW report, "How Schools Shortchange Girls" (WCCRW, 1992). It notes that "Girls are more apt to be exposed to biology-related activities and less apt to engage in mechanical or electrical activities" (p. 28). Furthermore, differences occur early and continue throughout school. According to one study, by third grade, 51% of the boys, compared to 37% of the girls, surveyed had used microscopes. By eleventh grade, 49% of the boys, contrasted with 17% of the girls, had used an electricity meter (WCCRW, 1992). Parker (1985) has noted that unless girls have opportunities to do a variety of science activities, their expressed interest or anticipated enjoyment of them is based upon ignorance, not knowledge. She cautions that developing science curriculum based on girls' expressed interests may further disadvantage them.

Results in both countries showed that boys are more confident of their own and others boys' ability to do electricity activities than girls are of their own or of others girls' ability to do them. However, differences between girls' and boys' self-confidence ratings were more extreme in the U.S., with boys ranking themselves equal to other boys, but with girls ranking themselves as less able than girls in general. Girls' lack of self-confidence has been demonstrated to affect enrollment patterns in mathematics (Eccles, 1989). As the AAUW study reports, "Gender differences in confidence are strongly correlated with continuation in math and science classes . . .. Females, more than males, have been found to doubt their confidence in math" (WCCRW, 1992, p. 28). Although similar analyses have not been done in science, it is reasonable to expect a similar correlation.

One difference between the U.S. and Australian responses was found in the higher level of self-confidence expressed by American boys and girls. The higher U.S. level supports findings from other studies, which indicate that American students, compared to Chinese and Japanese students, express more confidence in their ability to do mathematics, regardless of their grades in that subject (Stevenson and Stigler, 1992). Stevenson and Stigler argue that American education is structured to build student self-confidence and the phenomenon may have caused the difference found between Australian and American students.

Generally, the results of both studies support the need for equity training for teachers as well as the importance of hands-on science experiences, especially in the physical sciences, for girls. Girls come to school with fewer experiences in the physical sciences, and, without equity education, many elementary teachers allow them to avoid such activities in school. Again, recent NAEP data (U.S. only) show that in both fourth and eighth grades, about equal numbers of girls and boys indicate that they have done experiments and projects (either at home or in school) for the following topics: plants and animals, chemistry, rocks and minerals, telescopes, thermometers and barometers. However, 14% more boys than girls report doing experiments and projects with electricity in fourth grade, and the difference grows by eighth grade, when 21% more boys than girls respond that they have done electrical activities (Jones *et al.,* 1992).

CONCLUSION

Despite the difference in countries and the seven-year time lapse between the two studies, the results of the initial questionnaire indicate that the extent and pattern of girls' and boys' interest in and attitudes about science are remarkably similar. However, the differences between boys and girls are smaller in the more recent U.S. data. Although this could be due to the different educational environments (Stevenson and Stigler, 1992), an alternative explanation is that gender differences are narrowing over time. Consistent with this explanation is the smaller number of significant differences between girls' and boys' responses on the electricity items of the initial questionnaire as well as U.S. girls', compared to Australian girls', more positive response to the item on the final questionnaire about becoming an electrician.

In general terms, the outcomes of both studies indicated that the teacher inservice workshops, combined with activity-based science lessons, affected students' attitudes and perceptions about electricity. In the Australian study, there was a consistent pattern of results suggesting that teachers who received both skills and equity training were more able than teachers who received only skills training in creating an environment in which girls enjoyed the topic, found it easy, and were confident of their own ability to do the activities. The U.S. data produced similar trends. The addition of an equity-only workshop in the U.S. study resulted in classes where girls generally enjoyed the activities as much as boys did. They had more confidence in their own ability than did girls in the classes of teachers who received only skills training.

A reviewer of the U.S. proposal for this study remarked that positive results from the equity component in two of the three workshops would indicate that all teacher inservice programs should include short equity training. Although the results are not positive enough to support that premise, they indicate that equity training for teachers, combined with activity-based science for students, can raise girls' enjoyment of and confidence in physical science to equal that of boys. That is a first step in bringing equality to the teaching and learning of science and technology.

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