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Effects of a Women-in-Sciences/ Men-in-Humanities Intervention on Taiwanese Adolescents' Attitudes Towards Learning Science

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A pretest-posttest control group design was used to investigate the effects of an intervention that focused on the acknowledgement of women in sciences and men in humanities, awareness of academic gender stereotypes, and development of unique selves on student attitudes (interest, confidence, and value) towards learning science. The research participants were 247 Grade-8 students (123 girls) from eight classes (randomly assigned to experimental and control conditions) in a Taiwanese junior high school. Similar to the results of most past studies, girls had a more negative attitude towards learning science than boys as a whole. However, there was an effect of interaction between the experiment and gender, which showed that the gender gap in attitudes towards learning science, especially the value of learning science, diminished after the intervention. This finding suggests that academic gender stereotypes can at least partly intervene in the process of the formation of attitudes towards learning science for both girls and boys.

Keywords: science learning attitudes; gender differences; academic gender stereotypes

An ideal society should give full support to the development of a gender-equal society, in which individuals can develop their capacities and careers based on their unique characteristics such as learning attitudes, rather than be driven by academic gender stereotypes such as the conception that women are humanities-goers and men are sciences-goers. There is, however, a long-lasting and prevalent phenomenon that women have more negative attitudes towards learning science and lower participation in science learning activities and careers than men (Dawson, 2000). The phenomenon is so prevalent, strong, and consistent worldwide, people are very likely to attribute the phenomenon to gender differences by nature (Bornholt, Goodnow, & Cooney, 1994), rather than gender stereotypes by nurture. Research has indicated that gender gaps in mathematics diminish in gender-equal societies (Guiso, Monte, Sapienza, & Zingales, 2008), which implies that nurture may at least partly explain gender gaps favoring males in the diverse aspects of science learning.

To think of the reasons for gender gaps in science learning in a reverse way: Will our learning attitude change if there are more women in sciences and more men in humanities in our world? If we cannot create a world with more women in sciences and more men in humanities at the moment, perhaps we can create a mini-world where women in sciences and men in humanities are highly valued and the misconception of academic gender stereotypes in the real world is emphasized.

The purpose of the present study, therefore, is to create this mini-world by conducting an experimental intervention in real educational settings and to see whether adolescents' attitudes towards learning science will change. If attitudes towards learning science can be changed by an intervention focusing on women in sciences, men in humanities, awareness of academic gender stereotypes, and development of unique selves, then we are likely to infer that academic gender stereotypes at least partly intervene in the process of the formation of science-learning attitudes. In addition, improving female students' attitudes toward learning is an important issue in real educational settings and for a gender-equal society, as there is a much stronger relationship between attitudes towards learning science and both science achievement and participation in science studies and careers for females than there is for males (Gillibrand, 1999; Glynn, Taasoobshirazi, & Brickman, 2007; Zeldin & Pajares, 2000). Further, it is the learning attitudes in relation to science that determine participation in science-related studies or careers rather than achievements, abilities and ambitions in science for females (Frome, Corinne, Eccles, & Barber, 2006). Researchers therefore appeal for interventions focusing on learning attitudes and experiences for females because female students' performance is much more vulnerable to beliefs, attitudes, and experiences than is males' (Quaiser-Pohl & Lehmann, 2002).

Numbers of women in sciences and men in humanities in Taiwan and the world

Women in sciences and men in humanities are minorities in Taiwan, which is also a prevalent phenomenon in the world. In 2006, there were only 38.89% science majors and 13.18% engineering majors that were female in Taiwan, and 38.02% female science majors and 24.16% engineering majors in the countries of the Organization for Economic Co-operation and Development (OECD), as indicated by an official report made by the Ministry of Education in Taiwan (2009). On the other hand, 73.98% of the students studying humanities and 63.96% of those studying social sciences in Taiwan were female, while 64.52% studying humanities and 57.71% studying social sciences were female for the OECD countries. The gender gaps appear to be larger in Taiwan than those in the OECD countries in 2006.

A comparison is made between the 1999 and 2009 gender ratios of college majors in Taiwan in order to understand the long-term trend of gender gaps in careers. The trend shows that gender gaps favoring males appear to become larger in the traditional masculine fields: The ratio of female science majors decreased from 44.50% in 1999 to 34.96% in 2009 (-9.54%) and that of female engineering majors decreased from 15.62% in 1999 to 13.36% in 2009 (-2.27%). There is also a trend that gender gaps favoring females become smaller in traditional feminine fields, with a decreasing ratio of female humanities majors from 72.84% in 1999 to 70.31% in 2009 (-2.53%) and that of female social science majors from 66.93% in 1999 to 59.47% in 2009 (-7.46%) (Ministry of Education in Taiwan, 2010). This trend is not desirable in terms of a gender-equal society.

Gender differences in attitudes towards learning science in Taiwan and the world

Among the diverse attitudes towards learning science, interest, confidence (self-concept), and value are three constructs included in most surveys in relation to learning science, e.g., the student questionnaire used in the Program for International Student Assessment (PISA) of 2006 conducted by the OECD (2007), the student questionnaire used in the Trends in International Mathematics and Science Study (TIMSS) conducted by the International Association for the Evaluation of Educational Achievement (IEA) (Olson, Martin, & Mullis, 2008), and student questionnaires developed and used by Dalgety, Coll, and Jones (2003), Siegel and Ranney (2003), and Tuan, Chin, and Shieh (2005).

The results of the PISA 2006 study revealed that boys indicated higher interest, confidence, and value in relation to learning science than girls, with effect sizes of -.02, -.27, and -.13 for interest, confidence, and value, respectively on average for the OECD countries. The gender gaps favoring boys appeared to be much stronger in Taiwan, with effect sizes of -.29, -.53, and -.16 for interest, confidence and value, respectively (OECD (2007, pp. 90-91). The results of the TIMSS 2007 study revealed a similar finding that boys had significantly larger percentages than girls in high and medium confidence, and boys had a significantly smaller percentage than girls in low confidence (Martin, Mullis, & Foy, 2008).

Results of small-scale studies also indicate significant gender gaps in attitudes towards learning science. Girls have less confidence, interest, and future-orientation towards learning science than boys, except for the finding that girls show more interest in health sciences and biology, as indicated by studies carried out on students from diverse cultures, including Greece, Japan, Taiwan, and the US (Christidou, 2006;

DeBacker & Nelson, 2000; Evans, Schweingruber, & Stevenson, 2002; Jones, Howe, & Rua, 2000; Meece, Glienke, & Burg, 2006; Miller, Slawinski Blessing, & Schwartz, 2006; Trusty, Robinson, Plata, & Ng, 2000). Moreover, gender gaps in attitudes towards learning science may become larger for college students (Lips, 2004).

Interventions in relation to academic gender stereotypes

Women who specialize in the field of sciences and men who specialize in the field of humanities are more likely to experience threats of academic gender stereotypes than women in the field of humanities and men in the field of sciences. Psychologists generally use laboratory experiments to investigate the immediate effects of primed stereotypic threats on research participants' responses, e.g., performance on specific tasks and self-reported emotional reactions. The results of Thoman, White, Yamawaki, and Koishi's (2008) study revealed that female college students experiencing an ability component of gender-mathematics stereotypes had lower mathematics achievements than those experiencing an effort stereotype. In addition, there was a positive relationship between confidence and achievement for females experiencing an ability stereotype, but not for those experiencing an effort stereotype. Ambady, Shih, Kim, and Pittinsky's (2001) study showed that activation of gender identity will increase boys' performance in mathematics but reduce girls', and increasing opportunities to see female leaders in the society could decrease female students' gender stereotypic attitudes (Dasgupta & Asgari, 2004).

Educators use field experiments in an attempt to reduce academic gender stereotypes and to raise desirable learning outcomes. Häussler and Hoffmann (2002) and Hoffman (2002) succeeded in diminishing Grade-7 students' gender gaps in interest, self-concept, and achievement in physics by establishing interventions in real physics classrooms focusing on making physics interesting for girls, training teachers to effectively deal with gender-stereotypic behavior in classrooms, and to conduct half single-sex teaching. Effective educational experiments for raising female students' mathematics achievements have included interventions that have focused on the perspective of malleable intelligence, the attribution of learning difficulties to external environments, and the nullification of gender stereotypes (Good, Aronson, & Harder, 2008; Good, Aronson, & Inzlicht, 2003). Engaging students in structured free recall activities could reduce the gender biases of those students who tend to evaluate female professors as less accurate and less desirable (Bauer & Baltes, 2002). After an extracurricular intervention focusing on the use of cooperative learning and hands-on activities to teach science, girls increased their involvement in learning and in asking questions, but boys still had a greater sexist attitude than girls (Hong, Lin, & Veach, 2008).

The present study

The aim of the present study was to investigate the effects of an experimental intervention that focused on the acknowledgement of women in sciences and men in humanities, awareness of gender stereotype, and development of uniqueness on students' attitudes towards learning science, which included interest in learning science, confidence (self-concept) in learning science, and value of learning science. The intervention was based on the assumption that women were stereotyped as humanities-goers and that men were stereotyped as sciences-goers in our society. A pretest-posttest control group design was used to answer three research questions. Research Question 1 explored the major effect of the experiment, Research Question 2 the major effect of gender, and Research Question 3 the interactive effect of experiment and gender.

1. What is the difference in attitudes towards learning science between students who experience the intervention (the experimental group) and those who do not experience the intervention (the control group)?
2. What is the gender difference in attitudes towards learning science?
3. What is the differential effect of the intervention on attitudes towards learning science between girls and boys?

METHOD

Participants

The research participants were 247 Grade-8 students from eight classes in a public junior high school in Taipei City, Taiwan. The school was situated in a middle-class residential area. The classes were mixed and equally distributed in student ability based on school achievement test results, which was conducted when the students entered the school after primary education. Each class was randomly assigned to either the experimental or the control conditions, which resulted in four classes as the experimental group and the other four classes as the control group. There were 27-34 students in each class and around half were girls within each class. There were 122 students (61 girls) in the experimental group and 125 students (62 girls) in the control group. Tables 2-4 show a detailed description of the numbers of the participants in each condition.

Procedure

A pretest-posttest control group design was used in the present study. Both the experimental and control groups experienced a pretest, a posttest, and a teaching program on career development, except that the experimental group experienced an intervention focusing on the acknowledgement of women in sciences and men in humanities, awareness of academic gender stereotypes, and development of unique selves. The same test content was administered one week before and after the teaching program respectively as the pretest and posttest. The teaching program lasted for five weeks. The lessons were scheduled within regular class periods as career development is part of the national curriculum in Taiwan, in which gender issues are encouraged to be included in the teaching of each subject. Each class was taught once for one sub-topic per week. Each lesson took 45 minutes. Table 1 shows the research design.

The content of the intervention was developed by a research team, which included a college teacher, a school teacher (who taught all the lessons for the eight classes of the experimental and control groups), and five research assistants, who were all education majors. The content of the intervention and the research design were reviewed by four experts in the field of education, and necessary revisions were made according to their suggestions.

Intervention

The intervention included five experimental lessons. Each lesson had a distinct sub-topic: gender and academic/vocational interest, gender and academic/vocational self-concept, gender and academic/vocational aspiration, gender and academic/vocational value for individuals, and gender and academic/vocational value for the society. The categories of academic subjects were school subjects, including Chinese, English, mathematics, sciences, social sciences, arts, and physical education. The categories of vocations used in the intervention (the experimental lessons) were based on Holland's theory (Feldman, Smart, & Ethington, 2008), which is one of the major theories used in most career development lessons in Taiwan's secondary education, and was used in the lessons for the control group.

Holland's theory maintained that there are six vocational/interest types (realistic, investigative, artistic, social, enterprising, and conventional) and parallel environmental arrangements, e.g., departments in universities and vocations in society (Deng, Armstrong, & Rounds, 2007). The first experimental lesson (gender and academic/vocational interest) of the present intervention formally drew on Holland's theory in order to provide a wide spectrum of vocation-related activities/interests in the society, e.g., "manipulate with hands" as realistic, "think about problem-solving methods" as investigative, "dance" as artistic, "care

Table 1
The Research Design

	Pretest	Teaching (5 Lessons/Weeks)	Posttest
Control group	X[a]	Y1[b]	X
Experimental group	X	Y2[c]	X

[a] The same measures are used during the pretest and posttest for the control and experimental groups.
[b] The teaching for the students in the control group focuses on career development.
[c] The teaching for the students in the experimental group focuses on gender and career development.

about others" as social, "lead others" as enterprising, and "categorize data" as conventional activities/ interests. In the lesson, students provided their reasons for why they mostly disagreed with which activities/ interests (among 30) that were highly gender-stereotyped in the society, based on the students' personal awareness.

The procedure for each lesson of the intervention included three phases, each focusing on one kind of activity. The following description of the three phases mainly used the sub-topic of "interest" as an example.

The preparation activity (around 5 minutes). The teacher introduced the topic, provided some examples (real role models in Taiwan and the world) of women in sciences and men in humanities, partially with some other minorities (e.g., women in sports), and raised the issue of academic gender stereotypes.

The development activity (around 35 minutes). Students engaged in activities initiated by the teacher. The activities included: (A) Students completed questionnaires concerning their own interests and their awareness of gender stereotypes in relation to their interests. (B) Students engaged in cooperative games in which they identified daily language use, pictures, or practices in relation to academic gender stereotypes. (C) Students made comparisons between the interests of males and females. (D) Students discussed in groups the differences between their own interests and gender-stereotypic interests. (E) Students discussed the questions posed by the teacher that challenged students' academic gender stereotypes. (F) Students presented to the class and participated in whole-class discussions based on their findings obtained from the group discussions. During the activities, students also completed worksheets that organized the activities and provided spaces for students to record their performance. Lastly, the teacher summarized the findings obtained from student presentations and class discussion, provided students with additional examples of women in sciences, men in humanities, and other minorities, and encouraged students to develop themselves based on their unique characteristics rather than gender stereotypes.

The synthesis activity (around 5 minutes). The teacher summarized all the activities and major findings from the lesson and collected the worksheets completed in the lesson. At last, if necessary, the teacher prepared students for the next lesson. For instance, the students interviewed their parents for their views on the value of their present jobs, their dreams in relation to jobs at the students' age (Grade 8 or around 14 years old), and their reasons for choosing their present jobs.

As revealed by the content of the intervention, the issue of academic gender stereotypes was addressed by social cognitive approaches. If academic gender stereotypes are built through learning by social messages, then the new concept of developing selves based on personal uniqueness rather than gender stereotypes needs to be rebuilt by vicarious learning, verbal persuasion, affective arousal, and active action (Bandura, 1977; Hampton & Mason, 2003). Multiple teaching strategies were used to motivate students, such as strategies that included lectures, cooperative games (Street, Hoppe, Kingsbury, & Ma, 2004), cooperative learning (Cheung & Slavin, 2005; Slavin & Lake, 2009), and hands-on activities. Teaching materials, e.g., the vignettes of the examples of women in sciences and men in humanities, were delivered by lectures, worksheets, and PowerPoint.

Measures

Students filled in the same three measures in relation to their attitudes towards learning science for the pretest and posttest. The items of the three measures were obtained from the student questionnaire in the PISA of 2006 (OECD, 2007). Students were asked to rate each of the items of the measures on a four-point Likert-type scale, ranging from 1 = *strongly agree* to 4 = *strongly disagree*. Student responses were reverse coded in the present study so that a larger number represented a more positive response on the three measures.

Interest in learning science: The measure investigated students' general interest in learning science, and included five items (PISA variables st16q01-05).

Confidence (or self-concept) in learning science: The measure examined students' perceptions of their capacities to learn science well. There were six items on this measure (PISA variables st37q01-06).

Value of learning science: The measure included five items, asking students whether learning science was of benefit to their personal lives (PISA variables st18q03, 05, 07, 08, and 10).

RESULTS

Tables 2-4 present the descriptive statistics of 2 tests (pretest and posttest) x 2 groups (control and experimental groups) x 2 genders (girls and boys) for the three measures of attitudes towards learning science, i.e., interest, confidence, and value, respectively. The present research followed a repeated measures design, in which groups and genders were the between-subject effects and tests were the

Table 2
Descriptive Statistics of test × group × gender for the Measure of Interest in Learning Science

Group	Gender	N	Pretest Mean (SD)	Mean Difference (Girl – Boy)	Posttest Mean (SD)	Mean Difference (Girl – Boy)
Control	Girl	62	2.48 (.60)	-.51	2.37 (.62)	-.60
	Boy	63	2.99 (.64)		2.97 (.71)	
Experimental	Girl	61	2.41 (.59)	-.53	2.47 (.60)	-.39
	Boy	61	2.94 (.74)		2.86 (.82)	
Total	Girl	123	2.44 (.60)	-.53	2.42 (.61)	-.49
	Boy	124	2.97 (.69)		2.91 (.77)	

Table 3
Descriptive Statistics of test × group × gender for the Measure of Confidence in Learning Science

Group	Gender	N	Pretest Mean (SD)	Mean Difference (Girl – Boy)	Posttest Mean (SD)	Mean Difference (Girl – Boy)
Control	Girl	62	2.12 (.55)	-.65	2.07 (.58)	-.77
	Boy	63	2.77 (.61)		2.84 (.76)	
Experimental	Girl	61	2.11 (.56)	-.55	2.17 (.62)	-.42
	Boy	61	2.66 (.74)		2.59 (.84)	
Total	Girl	123	2.11 (.56)	-.61	2.12 (.60)	-.60
	Boy	124	2.72 (.68)		2.72 (.81)	

Table 4
Descriptive Statistics of test × group × gender for the Measure of Value of Learning Science

Group	Gender	N	Pretest Mean (SD)	Mean Difference (Girl – Boy)	Posttest Mean (SD)	Mean Difference (Girl – Boy)
Control	Girl	62	2.57 (.61)	-.42	2.71 (.53)	-.40
	Boy	63	2.99 (.54)		3.11 (.60)	
Experimental	Girl	61	2.70 (.68)	-.17	2.94 (.57)	.07
	Boy	61	2.87 (.67)		2.87 (.77)	
Total	Girl	123	2.64 (.65)	-.29	2.82 (.56)	-.17
	Boy	124	2.93 (.61)		2.99 (.69)	

within-subject effect. The students provided their answers on the same three measures at the pretest and posttest. The repeated measures design, a special case of multivariate analysis of variance (MANOVA), aims to control for individual-level differences in the within-group variance (Hair, Black, Babin, & Anderson, 2010). After controlling for the individual-level differences, a decreased within-group variance is likely to be obtained, which increases the opportunity to obtain a significant between-group effect.

The results of multivariate tests provided initial answers to the three research questions. For the between-subject effects, the results showed that (1) there was no significant difference in attitudes towards learning science between students who experienced the intervention (the experimental group) and those who did not (the control group) (Wilks' Lambda = 1.00; $F_{(3, 241)} = .37$, $p > .05$, $\eta^2 = .00$); (2) there was a significant and large gender difference in attitudes towards learning science (Wilks' Lambda = .78; $F_{(3, 241)} = 22.13$, $p < .001$, $\eta^2 = .22$); and (3) there were significantly differential effects of the intervention on girls' and boys' attitudes towards learning science (Wilks' Lambda = .96; $F_{(3, 241)} = 3.33$, $p < .05$, $\eta^2 = .04$). For the within-subject effect, the results showed that the interactive effects between test (pretest and posttest) and (1) experiment, (2) gender and (3) experiment by gender, respectively, were not significant (Table 5).

The focus of the present study was on the between-subject effects (i.e., the answers to the three research questions). We may also be interested to know the results in relation to each of the three measures of attitudes towards learning science.

***Differences in attitudes towards learning science between students who experienced the intervention and those who did not* (Research Question 1)**

A comparison was made between students in the experimental group and those in the control group on the mean posttest scores of the three measures of attitudes towards learning science (interest, confidence, and value), controlling for pretest scores. There were no significant differences in the three measures between the experimental and control groups. (Please find the test results presented in Lines 2-4 of Table 6 for the effect of groups. The values of the mean and standard deviation of the three measures for the control and experimental groups are presented in Tables 2-4.)

The reasons for the non-significant result may be interpreted by qualitative data provided by the students in the experimental group. In a class activity for the experimental group, the teacher asked students to indicate the activities that most people in our society viewed as typical female or male activities but the students themselves strongly disagreed with. Most girls indicated their concerns over gender stereotype in society in relation to science-related activities, as revealed by the following three girls' statements in their worksheets.

- The activity with which I strongly disagree is 'think about problem-solving methods' because girls can also think about mathematics- and science-related problems and try to figure out and research (the problems) by themselves.
- I disagree that only boys like to 'manipulate with hands' because many girls also like to knit and repair things.

Table 5
Results for Multivariate Tests with Groups and Genders as the Independent Variables (Effects) and Tests as the Repeated (Pretest and posttest) Dependent Variable

Effect		Wilks' Lambda	Hypothesis df	Error df	F	p	η^2
Between	Groups	1.00	3	241	.37	.77	.00
Subjects	Genders	.78	3	241	22.13	.00	.22
	Groups × Genders	.96	3	241	3.33	.02	.04
Within	Tests × Groups	.99	3	241	.55	.65	.01
Subjects	Tests × Genders	.99	3	241	1.08	.36	.01
	Tests × Groups × Genders	.98	3	241	1.92	.13	.02

Note: df = degree of freedom. Small effect size: .01 < η^2 (partial eta squared) < .06; medium effect size: .06 < η^2 < .14; large effect size: η^2 > .14 (Cohen, 1988, p. 283).

- (The activity with which I strongly disagree is) 'do science experiments' because girls also like to try out interesting things. Boys in fact are usually quarrelling while doing experiments. Only girls can actually realize and understand the delights of doing experiments.

The girls highlighted their ability in science-related activities, with an emphasis on individuals and independence, not relying on others. On the other hand, most boys were concerned about humanities-related activities with an emphasis on others and interdependence, as the following three boys stated in their worksheets.

- The activity with which I disagree most is that 'caring about others' is categorized as girls' (activity). Boys can also care about others.
- Everyone has friends. Friends will care about each other.
- I disagree mostly with the notion that girls resolve conflicts because girls dare not persuade others to stop fights. In addition, boys are not necessarily able to lead others because the girls in my class are fiercer (than boys).

The excerpts revealed that there appeared to be differential effects of the intervention on girls and boys. The intervention seemed to attract girls' attention to science and might raise girls' attitudes towards learning science, and to attract boys' attention to humanities, which, however, might or might not influence boys' science-learning attitudes. The result that the experimental and control groups were not significantly different in attitudes towards science suggested that the intervention is not an effective way to raise 'all' students' attitudes towards learning science. However, based on the qualitative data, it was highly expected to see differential effects of the intervention on girls and boys, which is the main focus of the present study. The result is presented in the section of "Differential effects of the Intervention on Girls' and Boys' Attitudes towards Learning Science (Research Question 3)".

Gender differences in attitudes towards learning science (Research Question 2)

There were significant gender differences in interest, confidence, and value towards learning science for all the participating students as a whole. In addition, all the gender gaps favored boys. (The first

Table 6

Results for Tests of Between-subject Effects with Groups and Genders as the Independent Variables (Effect) and the Three Measures of Tests (Interest, Confidence, and Value) as the Dependent Variables

Effect	Measure	Sum of Squares	df	Mean Square	F	p	η^2
Groups	Interest	.12	1	.12	.15	.70	.00
	Confidence	.54	1	.54	.71	.40	.00
	Value	.00	1	.00	.00	.96	.00
Genders	Interest	31.81	1	31.81	40.98	.00	.14
	Confidence	43.89	1	43.89	57.69	.00	.19
	Value	6.60	1	6.60	10.44	.00	.04
Groups × Genders	Interest	.25	1	.25	.32	.57	.00
	Confidence	1.57	1	1.57	2.06	.15	.01
	Value	4.11	1	4.11	6.50	.01	.03
Error	Interest	188.61	243	.78			
	Confidence	184.89	243	.76			
	Value	153.58	243	.63			

Note: df = degree of freedom. Small effect size: $.01 < \eta^2$ (partial eta squared) $< .06$; medium effect size: $.06 < \eta^2 < .14$; large effect size: $\eta^2 > .14$ (Cohen, 1988, p. 283).

5-7 lines of Table 6 show the test results, and the last 2-3 lines of Tables 2-4 show the means and standard deviations of the three measures for girls and boys in total.)

Differential effects of the intervention on girls' and boys' attitudes towards learning science (Research Question 3)

There was a significant interactive effect of experiment and gender on the value of learning science (Line 10 of Table 6). Table 5 shows the means and standard deviations of test × group × gender for the measure of value. On the other hand, the interactive effects of experiment and gender on interest and confidence in learning science, respectively, were not significant (Tables 2-3 for descriptive statistics and Table 6 for test results).

Despite the two non-significant results for interest and confidence, there were similar trends in the interactive effect of experiment and gender among the three measures of attitudes towards learning science. The trend was that there was a smaller gender gap for the students in the experimental group and a larger gender gap for those in the control group in the three measures of attitudes towards learning science in the posttest (Interest: Mean Difference (girl-boy) for the experimental group (MDE) = -.39 > Mean Difference (girl-boy) for the control group (MDC) = -.60. Confidence: MDE = -.42 > MDC = -.77. Value: MDE = .07 > MDC = -.40. Tables 2-4). Compared to the situation in the pretest, the gender gaps in interest and confidence scores were very similar between the students in the experimental group and those in the control group (Interest: MDE = -.53, MDC = -.51. Confidence: MDE = -.55, MDC = -.65). The most dramatic change happened in the value of learning science, in which the gender gap favored boys in the pretest phase for both the experimental and control groups (MDE = -.17, MDC = -.42), while the gender gap favored girls in the posttest phase for the experimental group (MDE = .07) but not for the control group (MDC = -.40), which made the interactive effect of experiment and gender significant (Table 6).

To state in terms of changes from the pretest to the posttest, the gender gaps from the pretest to posttest phases for students in the control group revealed a disappointing trend: with interest from -.51 to -.60 (increased gender gap favoring boys), confidence from -.65 to -.77 (increased gender gap favoring boys), and value from -.42 to -.40 (slightly decreased gender gap but still favoring boys). On the other hand, the gender gaps from the pretest to posttest phases for students in the experimental group showed a desirable trend, with interest from -.53 to -.39 (decreased gender gap favoring boys), confidence from -.55 to -.42 (decreased gender gap favoring boys), and value from -.17 to .07

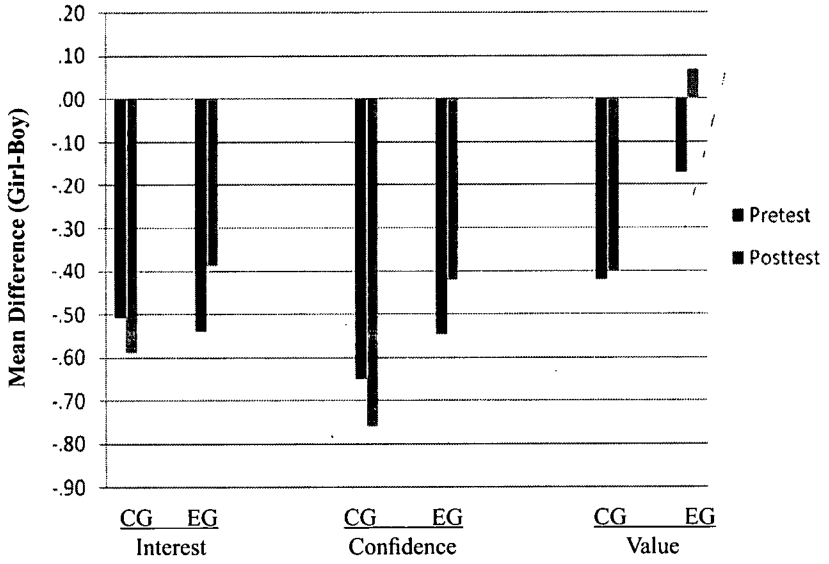

Figure 1. *Gender differences in the mean scores of interest, confidence, and value, respectively, by test (pretest and posttest) and experiment (the control and experimental groups). CG = the control group; EG = the experimental group.*

(decreased gender gap and a change from favoring boys to favoring girls). Figure 1 shows the gender gaps in the three measures during the pretest and posttest for the control and experimental groups

DISCUSSION

These predictions were generally supported by the present results as answers to the three research questions: (1) non-significant effects of the experiment, (2) significant effects of gender, and (3) significant effects of interactions between the experiment and gender on student attitudes towards learning science. The major focus of the present study was on the interactive effect of experiment and gender, i.e., differential effects of the intervention on attitudes between girls and boys, which implies the effectiveness of the intervention. The non-significant effect of the experiment is a byproduct of the interactive effect. The significant gender differences replicate most past research results and imply a strong effect of academic gender stereotypes and the notion that further action needs to be taken.

Academic gender stereotypes intervening in the formation of attitudes towards learning science

The primary intention of the present intervention is to increase girls' positive attitudes towards learning science by valuing women in sciences. The present results showing an upward trend in female attitudes towards learning science fits the intention of the intervention. The most salient effect occurs in the value of learning science. The result echoes Zohar and Sela's (2003) finding that girls need deep understanding or connected knowledge in learning physics. An intervention focusing on valuing women in sciences may increase girls' associations of personal and daily lives with science learning through vivid same-sex role models. The gains of the experimental effect on interest and confidence are also positive but not so salient. Large gender gaps favoring boys in interest and confidence are likely to be one of the major reasons for this undesirable result.

On the other hand, the emphasis of men in humanities is a reasonable operation in the intervention because the present study was conducted in real co-education settings, and an equal-gender intervention is an ethical practice of teaching. In other words, valuing men in humanities is a reasonable intervention for male minorities in terms of academic aptitudes, although the initial intention of the intervention was not to reduce boys' positive attitudes towards learning science. The present finding, however, shows that compared with boys in the control group, boys in the experimental group slightly decreased their attitudes towards learning science after the intervention, although the decrease was not statistically significant. Perhaps we may need to conjecture the possibility that females and males contain the characteristics of both genders and have the drive towards both sciences and humanities (Gilbert & Calvert, 2003). Ideally, we may wish to see that boys and girls have similar attitudes towards learning science in a gender-equal society.

The findings regarding the slightly increasing trend of attitudes toward learning science for girls and the slightly decreasing trend for boys after the women-in-sciences/men-in-humanities intervention may suggest that academic gender stereotypes at least partly intervene in the process of the formation of attitudes towards learning science for both girls and boys. In other words, academic gender stereotypes introduced by nurture are likely to be part of the reasons for gender gaps in attitudes towards learning science. We suspect the phenomenon that boys have more positive attitudes towards learning science than girls or that girls have more negative attitudes towards learning science than boys is partially influenced by academic gender stereotypes. Furthermore, the high relationship between attitudes towards learning science and achievement in science may strengthen the illusive cycle that we create a world in which what we expect (e.g., women are humanities-goers and men are sciences-goers) becomes what we have now (e.g., there are more women in humanities and men in sciences).

Breaking the illusive cycle in relation to academic gender stereotypes is an important issue for educational practice. We are more likely to have girls going to humanities and boys going to sciences not because of their unique characteristics but because of academic gender stereotypes. A gender-equal society or education needs to raise student and teacher awareness of academic gender stereotypes, to encourage development based on personal uniqueness, to value minorities in our society, e.g., women in sciences and men in humanities, and to celebrate the diversity of our society.

Strong gender gaps favoring boys in attitudes towards learning science

Girls have more negative attitudes towards learning science than boys, a present finding that replicates most past research results. The finding is undesirable as the gender gaps favor boys, although the gender gap in the value of learning science non-significantly favored girls after the intervention. Research has indicated that there are significant relationships between attitudes towards learning science and achievements in science (Chang & Cheng, 2008) and the relationships are much stronger for girls than for boys (Weinbergh, 1995). Girls experience more negative learning attitudes and psychological distress than boys, despite their academic achievements (Marsh & Yeung, 1998; Pomerantz, Altermatt, & Saxon, 2002).

Socio-cultural tradition in Taiwan may also play a role in the gender gap favoring boys in attitudes towards learning science. Taiwan maintains a Confucian tradition, which distinguishes the differences in economic functions between men and women: Men master the exterior (jobs) and women master the interior (family), is a popular saying in Taiwan. As such, caring about family/others and being humble have become feminine characteristics highly praised by the society (Zhang, 2006). On the other hand, men are obligated to earn money to raise their families through working aggressively. Mathematical or physical science careers appear to correspond to the typical image of masculine careers because science-related jobs, e.g., scientists and engineers, are perceived as less personal and with higher pay and status by both genders (Morgan, Isaac, & Sansone, 2001). This traditional ideology appears to be rooted in the society, transmitted by mass media, textbooks, and even teachers, which is likely to be part of the reasons for the gender gap favoring boys in science careers and attitudes in Taiwan.

Diminishing the gender gap in attitudes towards learning science is of paramount importance for educators in science, especially in Taiwan. It is suggested that pre-service and in-service teacher education programs need to include the topic of academic gender stereotypes. Teachers are encouraged to include this issue in their daily practices in teaching any school subjects, such as science, mathematics, and language, given the desirable effect of the intervention on a diminished gender gap and limited time allocated for formal inclusion of the academic gender stereotypes issues in real educational settings. Teachers need to be reminded not to increase academic gender stereotypes in their teaching. Teachers also need to provide more support for students who are minorities in terms of academic gender stereotypes, e.g., girls who are interested in sciences and boys who are interested in humanities. The minorities who do not fit the academic gender stereotypes are very likely to experience discrimination threats, adapt themselves to academic gender stereotypes, and go for a field or career that fails to satisfy their own uniqueness.

Limitations of the present study and implications for future research

The present study uses a quasi-experimental design, which can adapt interventions into real educational settings and increase the ecological validity of experimental effects. Findings based on quasi-experiments, however, should still be explained as relationships between the intervention and the studied variables, rather than cause and effect. The relatively short duration of the intervention (five 45-minute lessons) may account for the few significant results (one significant interaction effect) of the present study. Future research can collect more qualitative data, e.g., student interviews and classroom observations, along with the process of the quasi-experiment to elaborate research findings mainly based on quantitative data, e.g., student responses to questionnaires.

The present intervention focuses on three major sub-interventions: providing examples of women in sciences and men in humanities, raising awareness of academic gender stereotypes, and encouraging the development of unique selves. The intervention including three sub-interventions was designed to fit the real educational settings, and the effect obtained from the intervention needs to be viewed as a combined effect from the three sub-interventions as a whole. Further research can conduct experiments focusing on specific topics to validate the separate effects of the three sub-interventions.

The studied variables of the present study are attitudes towards "learning science" (interest, confidence, and value) because the present interventions focus on science learning and partially on career development. Future research focusing on interventions that highlight the contributions of science-related vocations may need to examine the variables of student attitudes towards 'science', e.g., values of science in human history, modern lives, and future society.

The present study was conducted for a sample of students from a specific culture. Rural school students may have different gender attitudes and responses to the intervention from urban school students. Further research can examine the differential effect of similar interventions between more and less gender-equal countries, and between Eastern and Western cultures.

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