Effects of Cooperative Small Group Discussion on Elementary School Students' Argumentation and Attitudes toward Science in Taiwan

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Abstract

112 Words

This study investigated the effects of cooperative small group discussion on improving elementary school students' argumentation and attitudes toward science. One hundred and eleven fifth grade students were randomized into an experimental group to join a 12-week cooperative small group discussion intervention; another 107 sixth grade students were randomized to be the comparison group. All participants completed the Student Questionnaire (SQ) at the beginning and end of this study. Additional observation and interview results were used to triangulate and consolidate the quantitative finding. The finding revealed that intervention presented significant impacts on enhancing experimental group students' argumentation and attitudes toward science than their comparison group counterparts. Implications and research recommendations are presented.

Key words: Cooperative small group discussion; attitudes toward science; argumentation; elementary school student; Taiwan

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Introduction

Student attitudes toward science has been emphasized as one of the important learning outcomes by educational researchers (e.g., Authors, 2008a, 2008b; Author, 2010; Barmby, Kind, & Jones, 2008; George, 2006; Pell and Jarvis, 2001; Reid & Skryabina, 2002) and continuously investigated by international assessments [(i.e., TIMSS 2007 (Martin, Mullis, & Foy, 2008); PISA 2006 (OECD, 2007) as the key indicator for making educational improvement. Surprisingly, the more study years students involved in learning science, the more negative perceptions they have articulated from their science learning experience (Barmby, et al., 2008; Author, 2010). Some researchers suspected that the low percentage of females studying or working in science related fields could be attributed to students' negative attitude toward science (Barmby, et al., 2008; Authors, 2010; Ministry of Education, 2006). On the other hand, previous studies have indicated that positive attitudes toward science is correlated to students' positive commitment to science and might influence their life-long interest and learning in science (George, 2006; Reid et al., 2002). The above literature guides us to focus on promoting elementary school students' attitudes toward science with an early intervention.

Argumentation plays a critical role for the development of healthier societies and democratic communities. For example, individuals should voice their well justified or evidenced-based conclusions and demonstrate logical and rational patterns of reasoning to support their arguments (Venville & Dawson, 2010) on issues such as whether or not to eat genetically-modified food, recycle household waste, or construct a nuclear plant in their own community. Meanwhile, in order to make socially responsible decisions for their own well-being and that of others, citizens should have the necessary understanding to enable them to make informal decisions. Even though argumentation and constructing persuasive arguments are important for typical citizens, previous studies have mainly focused on training those skills in college or high school students (Osborne, Erduran & Simon, 2004; Sadler & Fowler, 2006; Sadler & Zeidler, 2005). Less attention has been given to the investigation of elementary students' argumentation skills. Part of the reason is attributed to the claim that the threshold level of knowledge required for quality argumentation is of college-level (Sadler, et al., 2006). However, some researchers found that secondary school students' argumentation skills benefited from classroom interventions either in small group or whole classroom discussions (Venville et al., 2010). In this study, we further extend the exploration into beginning science learners, elementary school students. Our attempt was mainly inspired by the assumptions of Simon, et al. (2006) which indicated that school education should provide learning opportunities for children to practice argumentation. Although high quality arguments with deep understandings of subject content were not expected from elementary students' learning outcome, it is assumed that students' involvement in relevant real-life argumentation is likely to contribute to the improvement of their skills in constructing quality arguments.

How attitudes toward science can relate to students' learning?

Attitudes can be defined as the feelings that person posses toward an object based on his/her knowledge and belief of that object (Kind, Jones, & Barmby, 2007). Thus, attitudes are best thought as evaluative judgments formed by the person (Ajzen, 2001; Crano & Prislin, 2006). Rajecki (1990) defined attitude to include three components of cognition, affect, and behavior. Osborne, Simon, and Collins (2003) asserted that attitudes of feelings, beliefs and values of an object can be applied to science, which translate to enthusiasm about science, perception of school science, and the contribution of science to society.

Attitude plays a critical role in fostering deep understanding and long-lasting learning. High levels of interest and motivation resulted in significant improvement in high-order learning performance (Kern & Carpenter, 1986). In contrast, low levels of attitudes toward science are likely to result in students' apathy toward science or dropout from advanced level science classes (Nieswandt, 2007). Previous literature indicated that positive attitudes toward science are correlated to students' positive commitment to science and might influence their life-long interest and learning in science (George, 2006; Reid et al., 2000).

The importance of argumentation in elementary school students

In 1991, in the book-*The skills of argument*, Kuhn advocated that a person's argumentation ability is not caused by nature, but through exercises to achieve growth and progress. She concluded that many children and adults are poor in coordinating and constructing a relationship between evidence (data) and theory (claim), which is essential to a valid argument. Along similar lines, Simon, Erduran and Osborne (2006) pointed out that not only should curriculum and instruction in elementary and middle school levels be integrated with some argumentation capacities, but teachers should also improve their argumentation teaching expertise. Thus, schools and teachers should conduct appropriate teaching activities, design a positive learning environment, and provide fine models of argumentation that allow students to foster their argumentation ability. In addition, Hogan and Maglienti (2001) and Zohar and Nemet (2002) also claimed the importance of argumentation in students and teachers. This is emerging as one of the important educational issues in the early 21st century. In many science classrooms, it was shown that teachers frequently present an abundance of scientific facts and problem-solving algorithms in a compressed curriculum to students (Osborne, et al., 2004). Students are often passively engaged. They are taught to focus on completing assignments and solving exam questions. Consequently, students memorize facts without understanding scientific principles and do not apply their knowledge to actual phenomena they encounter (Paris, Yambor & Packard, 1998). Traditional approaches to science instruction can lead to boredom, frustration, and negative perceptions of science. One study found that the more traditional science courses the students attend, the less motivated they are of future science courses or careers (Paris, et al., 1998). Above studies are significant because they highlight the necessity and importance of an argument discourse for children, further demonstrating that it needs to be taught through suitable instruction, task structuring, and modeling.

Ample researches suggested that argumentation is fostered by a context in which student-student interaction is permitted and encouraged (Kuhn, Shaw, & Felton, 1997; Zohar et al. (2002). For instance, Kuhn et al. (1997) found that dyadic interaction significantly increased the quality of argumentative reasoning in both early adolescents and young adults. Whereas, we seldom found studies that focused on elementary school children’s argumentation. As previous studies indicated that elementary children had more positive attitudes toward science than their secondary school counterparts (Barmby et al. 2008; Authors, 2010), it is worthy to foster elementary school students’ quality of argumentation, to promote their individual interest in learning science, and to build their positive attitudes toward science in early stage.

Gender differences in science learning

Gender stereotype is a type of subjective perception of what men and women should be and how they should behave. As children realize their own gender identity, they also acquire sets of beliefs and expectations about boys and girls in general (Martin and Halverson, 1981; Author, 2004; Authors, 2008a, 2008b). A growing body of literature has shown that gender differences in academic performance (Alfieri, Ruble & Higgins, 1996), learning in science (Lawrenz, Hong, Lin, & Huffman, 2003; Authors, 2008a, 2008b; Author, 2010) and characteristics (Martin, 1987; William & Best, 1990; Authors, 2003; Authors, 2011). With regard to gender stereotypes, girls may believe that they are better than boys in reading and writing as a way to compensate for stereotypes that reflect negatively on the performance of girls in math and science. Men are expected to display instrumental traits, whereas women are expected to be expressive (Williams et al., 1990). Data obtained from TIMSS (Martin et al., 2008) revealed that eighth grade boys' outperformed girls in science content areas, whereas at the fourth grade level, the gender differences in achievement in science areas were much less pronounced. In this study, we further explore the gender differences in learning science in an innovational learning environment.

Innovative teaching is necessary in elementary school science classes

In this era of rapid advances in science and technology, we need to promote scientific knowledge and interest for all students in grades K-12 (Paris, et al., 1998). According to the National Research Council (1990), instruction time spent on science should be comparable to the time spent on reading, writing, and mathematics. Moreover, the increased instructional time should include innovative approaches of combining hands-on experience and practical problem solving (American Association for the Advancement of Science, 1993).

In this study, we designed cooperative small group discussions that attempt to improve experimental group students' attitudes toward science and promote their ability of argumentation. Students are involved in a particular science related context which is directly tied to the content of instruction and instructional strategies. The strategies will be explained in detail in the methodology section. Cooperative learning is a technique of learning that many perceive as being preferred over competitive situations. Cohen (1994) found that cooperative learning represents a major change from teacher-fronted instruction and, therefore, raises new issues that educators need to consider, such as combining various models of cooperative learning. Numerous studies found that cooperative learning provided many potential benefits beyond enhanced learning (Johnson & Johnson, 1999; Johnson, Johnson & Stanne, 2000). These benefits included increased self-esteem, greater ties with school, enhanced inter-ethnic ties, and improved complex thinking. Furthermore, cooperative learning offers one small ray of hope that we can move away from the all-too-present unhealthy forms of conflict and competition that plague our world today (Kohn, 1992). Thus, the experimental group students not only encountered mutual interaction with team members, but they also gained psychological supports and encouragements during the intervention.

Three major research questions were: (1) How significant are the differences in attitudes toward science and perception of classroom learning environment between experimental group students and their counterparts? (2) How significant are the differences in argumentation between experimental group male and female students and their comparison? (3) How do target students progress in attitudes toward science and argumentation while participating in cooperative small group discussion?

Method

Participants and setting

First, we randomly selected an elementary school from Kaohsiung city in Taiwan. Continuous discussions and communications with the school principal, classroom teachers and students were made. An agreement from the school administrator was obtained. The participants included 218 students. One hundred and eleven fifth grade students were randomly selected as the cooperative small group discussion intervention; in addition, 107 sixth grade students were randomly selected as the comparison group.

Six fifth-grade boys and 6 girls with the lowest scores on Student Questionnaire (SQ) in the pretest were selected as target students for follow-up interviews and weekly observations. An information letter regarding the aims of the study and a consent form were sent home to families requesting permission for students to participate. There were 218 students and parents who signed the student and parent consent forms. The investigators administrated the SQ to the consenting students. Before administering the survey, the investigators reminded students of the purpose of the study and explained the procedure for completing the questionnaires. Students' understandings of the survey were verified and questions were answered. All of the students were assured that their responses were confidential and not to be compared or identified personally. On average, 218 participants spent 20 to 25 minutes responding to the SQ.

The experimental group boys and girls mean ages are 11.42 (SD = 0.63) and 11.38 (SD = 0.73), respectively. The comparison group boys and girls mean ages are 12.34 (SD =0.77) and 12.30 (SD = 0.54), respectively.

Procedures

A quasi-experimental design was used in this study. All of the students responded to the SQ at the beginning and at the end of this study. All experimental group students attended a12-week cooperative small group discussion intervention To begin in this study, the investigators spent a week to observe these 12 target students at their classrooms to confirm the results of questionnaire responses. Weekly classroom observations and individual interviews after the intervention were conducted with 12 target students (6 boys and 6 girls). During the 25-30 minute interviews, the target students were asked to explain their changes after attending the cooperative small group discussion intervention. Finally, classroom teachers and science teachers were interviewed by the first author at the end of intervention. Comments and feedbacks from interviewers were considered in the interpretation of the quantitative results.

Cooperative small group discussion intervention

In general, Taiwanese elementary school students spend about 8~9 hours a day from 7:30am to 4:30pm in school from Monday to Friday. They attend classes base on a weekly classroom schedule. Most schools allot one and half hours of free time each week. Students can mind their personal task or assignment in their classrooms during this period. Our intervention was conducted on Monday mornings from 7:50 to 9:20am from February 2008 to June 2009 in four classrooms of the participants' school. Three graduate school level investigators majoring in science education and one college senior majoring in math education were trained to teach the four classes. The 90-mintue cooperative small group discussion intervention weekly executed at the students' home classrooms. Experimental group students (including the 12 target students who were blinded during the intervention) engaged in intervention initiated by the investigators. During intervention children were encourage to initiate active engagement. The cooperative learning fostered small group communication, cooperative problem solving, and inter-dependence. We encouraged these target students engagement in learning the materials. In addition, Toulmin's Argument Pattern (TAP, Toulmin, 2003) was integrated into the intervention. For instance, during last 15~20 minutes of intervention, students took turns to present their data, claims, warrants, backing, qualifiers and rebuttal in front of the class, and other students provided questions to them. Students also completed worksheets that organized the activities and provided spaces for them to record their performance. Lastly, the investigators summarized their findings obtained from student presentations and small group discussions. During the intervention period, the comparison group students worked on their home works or personal tasks in their own classrooms.

Experimental group students were involved in discussing, presenting and debating open-ended problems with no definitive, correct answers, and often with a number of possible answers. Sample questions and socio-scientific issues used for small group discussion are as follows. (1) How to protect our living environment**:** each small group reads a scenario explaining that plastic products are commonly used around the world, even though they take more than 100 years for decomposition. After reading the scenario, groups were encouraged to discuss substitute materials to solve this problem; (2) Internet ethics**:** portrays a girl considering making friends through the internet. Groups discuss and provide their position and argumentation toward internet ethics and friendships; (3) Salty soybean milk**:** groups were encouraged to discuss and provide hypothetical methods to make soybean soup thicker; (4) Race and culture: groups read an article about conflict in a restaurant due to the misunderstanding of body language, they were encouraged to provide better ways to decrease culture discrimination; (5) Moral dilemmas: groups read an article talking about a doctor's dilemma in whether or not to tell the truth of the diagnosis to the patient.

Development and Validation of Instrument

Student Questionnaire (SQ). All participants completed an 87-item investigator-developed questionnaire. The SQ includes 4 sections described below: The demographic section of the SQ elicited respondents' background (i.e., student's ID, grades, gender and age).

The second section included 27 items that were derived from the Chinese version of PISA (OECD, 2007). Children response to the 27-item Attitudes toward Science scale (ATS) were analyzed as follows: First, the spread of responses to each item was determined, only those items with a standard deviation greater than 0.70 were retained. The selected items had a high internal consistency (Cronbach' $\alpha = 0.94$, $N= 218$). We then conducted a KMO and Bartlett's Test of Sphericity that presented an extremely high KMO= 0.95 and significant differences of all items (Approximately Chi-Square = 2856.515, df = 351, p<.001) (Tabachnick & Fidell, 2001). Four components were extracted and accounted for 56.42 % of the variance. The first factor (Science self-efficacy) (including 9 items, total score range from 9 ~36) accounted for 41.89% of the variance, sample item is '*I feel that I can express myself better.'*; the second factor (Interest in science) (including 9 items, total score ranged from 9 ~36) accounted for 6.02 %, sample item is '*After finishing my work, I found that science activities are very interesting.'*; the third factor (Contribution toward team members) (including 6 items, total score ranged from 6 ~24) accounted for 4.50%, sample item is '*When I disagree with my classmates, I try to be persuasive instead of offensive.'* ; the fourth factor (involvement) (including 3 item, total score ranged from 3 ~12) accounted for 4.02 % of the variance, sample item is: '*I acted as an executer at science class.'* The items are scored on 4-point Likert scale where '4' represents 'always', and '1' represented 'never'. Reponses were summed; and a higher total score indicated more positive attitudes toward science. Table 1 presented means, standard deviations (SDs), factor loadings, correlations, and Cronbach' α results on the 27-item for assessing participants' attitudes toward science. It can be seen that all items were satisfied with the three indices recommended by Cohen (1988) (i.e., SDs are higher than 0.70; factor loadings are bigger than 0.50; and correlation with total score are greater than 0.40). The above results indicated that the instrument has satisfactory construct validity and internal reliability.

[Insert Table 1 about here]

The third section included 56 items from the Chinese version questionnaire of "What is Happening in the Classroom" (WIHIC) developed by Fraser (1998) which measures students' perceptions of the classroom learning environment. The five-point

Likert-type ranges from 1 representing ‘it never happens’ to 5 representing ‘most of the time’. Sample items are*: I make friendships among students in this class: The teacher takes a personal interest in me.* The WIHIC has demonstrated satisfactory construct validity and internal reliability by a numbers of studies (Aldridge, Fraser, Taylor, and Chen, 2000; Authors, 2008a). In this study, we found it has an extremely high internal consistency (Cronbach’ α = 0.98, N= 218).

The fourth section included three investigator-developed argumentation questions that emphasized on students’ quality of arguments. Sample question would be: ‘ *‘Orange County is famous for its natural lakes. In order to preserve fish resources in lakes, the county government enacted a law requiring any caught fish smaller than 12-centimeter to be released back to the lake. Only the big fishes can be taken home. (a) Do you agree or disagree with this policy? (b)What are your reasons? (c)If you are invited to conduct a scientific experiment to check if this policy benefits the growth of the fish population, how are you going to design your experiment?’* We used Osborne et al. (2004) analytical framework to evaluate the quality of students’ arguments. For instance, level 1 consists of a simple claim; level 2, consisting of claims with either data, warrants or backings but do not contain any rebuttals; level 3, provides a series of claims or counter claims with either data, warrants or backings with the occasional weak rebuttal; level 4, shows a claim with a clearly identifiable rebuttal; level 5, argumentation displays an extended argument with more than one rebuttal. A higher score indicates better argumentation ability. Participants’ response to the three argumentation questions were analyzed as follows: First, the spread of responses to each item was determined, only those items with a standard deviation greater than 0.70 were retained. The remaining items presented a moderate internal consistency (Cronbach’ α =0.69, N= 218). Then we conducted a KMO and Bartlett’s Test of Sphericity that presented an extremely high

KMO= 0.65 and significant differences of all items (Approximately Chi-Square = 126.013, df = 3, p<.001) (Tabachnick et al., 2001). One component was extracted and accounted for 63.07% of the variance. The above results indicated that the instrument has satisfactory construct validity and internal reliability.

Students' observation form. Because students' argumentation and attitudes toward science are internalized values and abilities, they are hard to observe. Thus, we carefully developed a 5-category "Classroom Observation Coding Schedule" based on Pellegrini (1996) observational methods. He asserted that good descriptions meet the criteria of being reliable and valid, which are general techniques for use in either experimental or field settings (p. 7). The form was designed to gather information on the target students' behaviors related to argumentation and attitudes toward science during the intervention. The investigators and classroom teachers coded the behaviors of 12 target students in 10 minutes intervals. Each student was observed 9 times at 10-minute intervals throughout the intervention. The total number of marked behaviors were tallied and averaged for each category. Specifically, the total amount of time spent engaging in each type of behavior was recorded. The inter- and intra-reliability coefficients for coding time profiles between observers ranged from 0.92~0.99. All observation items are derived from the ATS (Authors, 2010). The first category observes students' self-efficacy with five items, the sample item is: *'I feel that I can express myself better.'* The second category observed students' interest in learning science with five items, the sample item is: '*I help my classmates to do their work*.' The third category rates students' contribution toward team members with five items, the sample item is: '*I help my classmates to realize what they should do*.' The fourth category observed students' involvement during the intervention with three items, the sample item is: '*I am a leader in science class*.' The fifth category observed students' argumentation during the intervention with five items, the sample item is: 'I *provide a series of claims or counter claims.*' Higher percentages of marked items indicate better performance on each category.

Student and teacher interviews. Teachers were individually interviewed for 25-30 minutes using a semi-structured interview protocol in June 2009 by the first author. The target students were individually interviewed at the end of the intervention. All interviews were audio taped transcribed. Sample interview question is: '*can you describe for me changes you experienced while attending this intervention?'* Sample interview question of teachers is: '*do you perceive any differences in the target students after they joined the cooperative small group discussion intervention?'*

Data analyses

Firstly, we conducted exploratory factor analysis and internal consistency verification to examine the reliability and validity of instrument; secondary, the t-tests, and analysis of covariance (ANCOVA) assessed the similarity and differences between genders and groups in attitudes toward science and argumentation. Finally, content theme analyses (Patton, 2002) were adopted to analyze the qualitative interview transcript.

Results

How significant are the differences in attitudes toward science and perception of classroom learning environment between experimental group students and their counterparts?

As shown in Table 2, the experimental group students' adjusted posttest total mean score in ATS (84.65) is significantly higher than the comparison group students' adjusted posttest mean (80.31) (F (1, 217) = 3.84*, $p < 0.05$) (effect size = 0.29); and the experimental group students' adjusted posttest total mean score in interest in science (28.91) is significantly higher than the comparison group students' adjusted posttest mean (27.20) (F (1, 217) = 4.58*, $p<0.05$) (effect size =0.31).

As shown in Table 3, the ANCOVA results reveal that the experimental group students' adjusted posttest mean score in degree of *teacher support* on WIHIC (27.87) is significantly higher than the comparison group students' adjusted posttest mean (24.35) (F (1, 217) = 8.47***, p <0.001)(effect size = 0.92); and the experimental group students' adjusted posttest mean score in degree of *cooperation* on WIHIC (30.91) is significantly higher than the comparison group students' mean score (28.79) (F (1, 217) = 4.05*, p<0.05) (effect size =0.58).

[Insert Tables 2 & 3 about here]

How significant are the differences in argumentation between experimental group male and female students and their counterparts?

As shown in Table 4, the experimental group students' adjusted posttest mean score in argumentation (4.83) is significantly higher than the comparison group students' adjusted mean (3.36) (F (1, 217) = 38.74***, p <0.001)(effect size = 0.71). Then, we conducted paired t-tests to exam gender difference within the experimental group. The pre and post test means for the variable are shown in Table 5. The boy's posttest scores are significantly higher than their pretest scores (t = - 4.05***, p <0.001) (effect size = -0.56); the girls' posttest scores are also significantly higher than their pretest scores (t = - 2.34*, p <0.05) (effect size = -0.37).

[Insert Tables 4 & 5 about here]

How do target students progress in argumentation and attitudes toward science while participating in cooperative small group discussion?

The goal of both observations and in-depth interviews is to get a better understanding of social and cultural phenomena and processes rather than to produce objective facts about reality or to make generalizations about populations (Pettigrew, Fidel, & Bruce, 2001).

Observation results

The 12 target students' behaviors were observed for 10 weeks during the cooperative small group discussion intervention. Their behaviors were plotted on Radar Graphs to illustrate behavior changes across time. The marked area stands for student's performance. A bigger marked area signifies better performance. Since students within each group have similar Radar Graphs, three representative graphs are shown for target students' dramatic behavior changes. The radar graphs of Figure 1 presents one of the lowest SQ score girl –Shan's dramatic behavior changes from week 1-5 (shown in the left picture) to week 6-10 (shown in the right picture). Shan gained a low total score on SQ. She enjoyed and loved all activities and made significant progress in all categories. It can be seen in Figure 1 that Shan made dramatic improvements in interest from 43.75 % to 73 %; argumentation from 25 % to 52 %; science self-efficacy from 27.5 % % to 46 %, contribution improved from 27.5 % to 36 %; and involvement from 37.5 % to 46 %.

Chin had low science self-efficacy and low interest in science prior to the intervention. She enjoyed all activities and made significant progress in all five categories. It can be seen in Figure 2 that Chin's science self-efficacy improved from 22.5 % to 47.0%; interest improved from 25 % to 65%; contribution improved from 11.50 % to 27%; involvement improved from 10.75 % to 44 %, and argumentation from 30% to 56%..

Chung was a less interest and involvement boy; he was attracted by all hands-on activities and small group discussion contents, he made significant progress in four out of five categories. It can be seen in Figure 3 that Chung not only made a big enhancement interest from 35 % to 75 %; but also in the self-efficacy from 35 % to 43.75 %; involvement from 33.75 % to 55 % and contribution from 22.5 % to 37.5 %.

[Insert Figures 1 to 3 about here]

Interview results

The follow-up interviews with 12 target students corroborated with the quantitative results. We present the results from the three target students, one classroom teacher, and one science teacher's interviews to demonstrate these target students' improvement in posttest argumentation ability and attitudes toward science. Their self-reported improvements were corroborated by comments from the classroom teacher and science teacher. In analyzing their responses the two recurring themes (Patton, 2002) were argumentation and attitudes toward science.

Argumentation

Shan (a low self-efficacy and less interested girl) said:

> "During the soybean milk experiment, we first added all the seasonings into soybean milk. After discussion among team members identifying the problems, we finally knew how to manipulate the variables and decided which seasonings to be added.….Because the process of cooperative small group discussion intervention was full of challenges. Our team members discussed and found evidenced-base conclusions, and then we presented our claims in front of the whole class. It made me feel like a scientist." (12 June 2009)

Ms. Chen (Chung's science teacher) said:

> "Chung was always a less interested learner in my science class. I found that he enjoyed discussion more and operated more with his peer during regular science class. He seemly enjoyed and involved in the cooperative small group discussion intervention….. I found that Chung raised his hands more often than before and he asked high quality questions about pertaining to science. You know, I was so surprised from of this change. He hesitated to join the

intervention at the beginning of this semester." (28 June 2009)

Attitudes toward science

Chin (a low interest and low science self-efficacy girl)

> "The intervention had tremendous impact on me. I came in the first week without having much of excitement for this new type of learning but left with a sense of pride for myself." (12 June 2009)

Chung (a low interest and less involved boy) said:

> "I thought that my team was every good. We always got our experiments done by working together, and we were very proud of that." (12 June 2009)

Ms. Chen (Classroom teacher) said:

> "I found that not only Chung but also all my students were willing to work together; they learned how to listen to each other. I also noticed that my students were more cooperative and respectful to each other during this semester. I observed that Chung, Chiu, Bo, Ting, You and Shan worked together and provided more evidence-based claims to support their arguments at my class. I am really impressed with their changes." (28 June 2009)

Discussion

Effects of cooperative small group discussion intervention on elementary school students' attitudes toward science and argumentation

The quantitative and qualitative results provided evidence of elementary school students' significant improvement in attitudes toward science and quality of argumentation. In addition, the student-centered, small group, supportive, and cooperative learning environment appeared to have been very effective. Interview results also revealed that almost all target students voiced positive attitude toward, and interest in science while improving their quality in argumentation.

Although this study did not conduct formal investigations of long-term effects, the positive impact in students' attitudes toward science and argumentation were impressive—even right after the study was completed. Many experimental group students have voiced contentment in being involved in science and are even planning do science projects for the next annual science fair when they are in sixth grade. Renninger and Hide (2002) revealed that a person with an individual interest can experience situational interest when given appropriate environmental stimuli; this seems to explain how the current intervention has garnered students' interests.

Part of the reasons why the cooperative small group discussion intervention gained such positive outcomes might be due the interesting topics (i.e., protecting our environment, salty soybean milk etc.), hands-on activities, cooperative learning, small group design, and the TAP model being much more appealing than regular science classes (Eylon & Linn, 1988). These teaching materials and activities have been tested with encouraging outcomes by previous studies (Authors, 2008a, 2008b; Lin, Hung & Hung, 2002; Simon & Richardson, 2009).

The results from the argumentation questions and attitudes toward science scale revealed that fifth grade students (experimental group) had better quality in argumentation and more positive attitudes than the sixth grade students (comparison group), which may indicate either the general enthusiasm of young students or the decreasing motivating in science among older students. Most importantly, we found that experimental group students' attitudes toward science became more positive from pretest to posttest. These included responses to items such as: "I am able to reason more"; "I am able to make more hypotheses"; "I am able to critique more of my own work"; "I find that science activities are very interesting"; "I learn more through cooperating and discussing with my classmates". Clearly, the cooperative small group discussion intervention fostered more positive attitudes about participating in the intervention. In argumentation questions, experimental group students showed significant improvement in answering critique questions, which indicated that they improved their fundamental thinking skills such as hypothetic deductive reasoning, comparative skills, and question generating ability. These cognitive skills were embedded into students' daily learning tasks as they wrote down their conclusion on the weekly study sheets. During the TAP model practices, one group of students presents data, claims, qualifiers and rebuttal in front of the class while other groups ask them questions. As a result, the experimental group students exhibited more enthusiasm; they showed significant progress in their quality of argumentation, and improved their attitudes toward science.

The qualitative reports from target students and teachers substantiated the enthusiasm for the intervention. Students showed that they enjoyed most aspects of the intervention, especially the TAP Model, cooperative learning, small group discussion and hands-on activities (cf. Chin's, Shan's & Chung's interviews). Classroom and science teachers also corroborated the target students' significant improvements. They saw positive responses, increased interests, and active involvement in regular science class in their students. Additionally, they mentioned the experimental group students' improvement in cooperation after the intervention (cf. Ms Lin's & Ms Chen's interviews).

The present finding was partly consistent with the assertion of Simon et al. (2006) who believed not only should curriculum and instruction in elementary and middle school levels integrate some argumentation capacity, but also teacher themselves should improve their argumentation teaching expertise. In this study, we provided a fine teaching model that allowed students to foster their argumentation ability. This result also confirmed Kuhn's (1991) assertion that argumentation ability is not innate, but rather through exercise in order to master. We suspected that concrete experiences through hands-on scientific investigations enabled students to build a better understanding of science. Consequently, positive attitudes toward science were developed. The experimental group students' commitment and enthusiasm in learning science provided additional empirical evidence for the benefits of cooperative small group discussion intervention in students' affective domain in learning science.

Gender differences in argumentation

We found that experimental group boys made significant and greater progress (effect sizes of boys = -0.56) in the quality of argumentation from the pretest to posttest than the girls (effect sizes of girls = -0.37). This seems to elude that if boys are cultivated under effective teaching and have sufficient opportunities to practice; their argumentation ability might develop faster than girls. It showed the cooperative small group discussion intervention had significant effects on those elementary school students' argumentation. The results of this study echo the studies by Johnson et al., (2000) and Author (2010). We believed that elementary school students' attitudes toward science could have been negatively influenced by unsupportive teaching strategies and detrimental learning environments. Whereas, when the students, especially boys attended the cooperative small group discussion intervention, their attitudes and learning motivation were dramatically enhanced. The above findings are consistent with prior research indicating significant gender stereotyped thinking in Taiwan (Authors, 2003; Authors, 2008a, 2008b). Girls are believed that they outperform than boys in reading and writing but who reflect negatively on the performance in math and science (Williams et al., 1990), this study once again demonstrated this phenomenon has existing in current Taiwan elementary school settings . We highly encourage school teachers to provide more support and encouragement for girls to promote their argumentation ability and attitudes toward science.

Limitations and Research Recommendations

In this study we measured participants' attitudinal outcomes. The comparison group students' age was one year older than the experimental group students; otherwise, their background were similar to the experimental group students' demographic variables. Because the treatment effect might have been confounded with the attention effect, we conducted ANCOVAS to adjust scores between the two groups. Readers are reminded that although both experimental and comparison group students were in the same school, and the time spent in class for the two groups were equal, the responses of students from the experimental group may have been influenced by the particular features of the intervention. In other words, because variables assessed in this study are not directly related to the intervention (i. e., focusing on affective domain rather than cognitive ability), potential Hawthorne effects (McCarney, Warner, Iliffe, van Haselen, Griffin, & Fisher, 2007) should be carefully considered.

In conclusion, the cooperative small group discussion was found to have significant benefits in promoting young students attitudes toward science and quality of argumentation. This study showed that elementary school students would benefit from a curriculum with the following features: interesting topics, hands-on activities, cooperative learning, small group design, and the TAP model that enable students to accomplish complex tasks. This study hopes to encourage educators to pay more attention to students' learning environments and multiple teaching strategies which might result in meaningful and effective teaching models for young learners.

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Table 1
MEANS, STANDARD DEVIATIONS, AND FACTOR LOADINGS OF ATTITUDES TOWARD SCIENCE (ATS) ITEMS (N= 218)

Dimensions /Items	*M*	*SD*	Factor loading with total score	Correlations with total score	Alpha if item deleted
Self-efficacy in learning science					
1. I will ask when I don't understand.	3.11	0.77	0.71	0.68	0.952
2. I realize that helping people makes me more competent.	3.18	0.82	0.77	0.74	0.952
3. I feel that I can express myself better.	2.99	0.86	0.75	0.71	0.952
4. I feel that I have better operational skill.	3.07	0.80	0.72	0.68	0.952
5. I have clearer concept.	3.18	0.79	0.79	0.75	0.952
6. I am more able to think.	3.15	0.76	0.72	0.69	0.952
7. I am more able to make hypotheses.	3.06	0.81	0.68	0.65	0.953
8. I am more able to reason and criticize.	2.97	0.84	0.69	0.65	0.953
9. I realize how to communicate with my classmates.	3.21	0.88	0.69	0.65	0.953
Interest in Science					
10. I help my classmates to do their works.	3.16	0.77	0.71	0.68	0.952
11. I provide suggestions to help my group to reach the goal.	3.08	0.81	0.76	0.69	0.952
12. I realize that helping people benefits me.	3.31	0.78	0.74	0.69	0.952
13. After finishing my work, I receive praises from my classmates.	2.91	0.90	0.72	0.62	0.953
14. After finishing my work, I find that science activities are very interesting.	2.97	0.90	0.68	0.56	0.953
15. I think each of my classmates will have his/her jobs done.	3.13	0.87	0.67	0.64	0.953
16. I learn more through cooperating and discussing with my classmates.	3.26	0.83	0.80	0.72	0.952
17. I get to enjoy science class through cooperating and discussing with my classmates.	3.06	0.86	0.67	0.68	0.952
18. Different opinions from classmates help me to think.	3.13	0.90	0.66	0.65	0.953
Contribution toward Team Members					
19. I help my classmates to realize what they should do.	3.14	0.75	0.71	0.68	0.952
20. I try my best to do my job.	3.33	0.74	0.74	0.71	0.952
21. When my group members disagree with each other, I will try to solve the problem.	2.95	0.90	0.69	0.67	0.952
22. I listen carefully to my classmates' speech rather than interrupt them.	3.14	0.81	0.62	0.59	0.953
23. I will care about how others feel.	3.17	0.79	0.61	0.57	0.953
24. When I disagree with my classmates, I try to be persuasive instead of offensive.	2.95	0.88	0.57	0.54	0.954
Involvement					
25. I acted as a leader at science class.	2.62	0.96	0.59	0.57	0.954
26. I acted as an executor at science class.	2.74	0.96	0.55	0.50	0.954
27. I acted as a recorder at science class.	2.51	0.89	0.65	0.40	0.954

Table 2

RESULTS OF ANCOVAS OF STUDENTS' ATTITUDES TOWARD SCIENCE (ATS) SCORES BETWEEN EXPERIMENTAL AND COMPARISON GROUPS

Variables	Group	N	Mean of posttest	SD	Adjusted posttest mean	Adjusted posttest SE	F	Effect size	P
ATS Total [a]	Exp.	111	84.79	14.04	84.65	1.55	**3.84***	0.29	0.05
	Com.	107	80.16	15.84	80.31	1.57			
Science Self-efficacy[b]	Exp[f].	111	28.47	5.57	28.46	.56	2.26	0.22	0.14
	Com[g].	107	27.24	5.50	27.26	.57			
Interest in science[c]	Exp.	111	28.94	5.19	28.91	.56	**4.58***	0.31	0.03
	Com.	107	27.17	5.98	27.20	.56			
Contribution toward team members[d]	Exp.	111	19.10	3.54	19.03	.36	2.73	0.25	0.10
	Com.	107	18.11	3.77	18.13	.36			
Involvement[e]	Exp.	111	8.03	2.45	8.05	.23	2.07	0.20	0.15
	Com.	107	7.60	2.24	7.58	.23			

Note. *p < .05; [a]ATSS total scores ranges from 27 to108, with higher scores indicating positive attitudes toward science; [b] Dimension of science self-efficacy total scores range from 9 to 36; [c]Dimension of interest in science total scores range from 9~36; [d]Dimension of science contribution toward team members total scores range from 6~24; [e] Dimension of involvement total scores range from 3~12; [f] For Cohen's *d* an effect size of 0.2 to 0.3 might be a 'mall' effect, around 0.5 a 'medium' effect and 0.8 to infinity a 'large' effect, large effect size could be larger than 1 (Cohen, 1988).

Table 3

RESULTS OF ANCOVAS OF STUDENTS' WIHIC SCORES BETWEEN EXPERIMENTAL AND COMPARISON GROUPS

Variables	Group	N	Mean of posttest	SD	Adjusted posttest mean	Adjusted posttest SE	F	Effect size	P
WIHIC Total[a]	Exp.	111	207.86	34.44	203.01	4.44	3.69	0.51	0.06
	Com.	107	188.47	37.30	191.82	3.67			
Student Cohesiveness[b]	Exp.	111	30.77	6.53	30.72	.70	0.32	0.08	0.57
	Com.	107	30.11	7.12	30.16	.70			
Teacher Support[c]	Exp.	111	28.19	7.72	27.87	.85	**8.47*** **	0.92	0.00
	Com.	107	24.04	8.61	24.35	.84			
Involvement[d]	Exp.	111	25.78	7.62	24.90	.67	0.39	0.05	0.60
	Com.	107	24.01	7.23	24.05	.89			
Investigation[e]	Exp.	111	25.19	7.43	24.04	.11	2.02	0.42	0.12
	Com.	107	22.89	7.45	23.02	.11			
Task orientation[f]	Exp.	111	31.99	6.44	31.91	.70	3.40	0.46	0.07
	Com.	107	30.02	7.26	30.10	.70			
Cooperation[g]	Exp.	111	30.93	6.94	30.91	.76	**4.05***	0.58	0.05
	Com.	107	28.77	8.26	28.79	.76			
Equity[h]	Exp.	111	31.17	7.08	30.73	.84	2.73	0.34	0.10
	Com.	107	28.38	9.04	28.79	.80			

Note: *p <.05; ***p<.001; [a] WIHIC total scores range from 56 to 280, with higher scores indicating positive classroom learning environment; [b] Dimension of student cohesiveness total scores range from 8 to 40; [c] Dimension of teacher support total scores range from 8 to 40; [d] Dimension of involvement total scores range from 8 to 40; [e]Dimension of investigation total scores range from 8 to 40; [f] Dimension of task orientation total scores range from 8 to 40; [g] Dimension of cooperation total scores range from 8 to 40; [h] Dimension of equity total scores range from 8 to 40.

Table 4

RSULTS OF ANCOVAS OF STUDENTS' ARGUMENTATION SCORES BETWEEN EXPERIMENTAL AND COMPARISON GROUPS

Groups	N	Mean of posttest	SD	Adjusted posttest mean	Adjusted posttest SE	F	Effect size	P
Exp.	111	4.96[a]	2.29	4.83	0.20	**38.74*** **	0.71	0.00
Com.	107	3.27	1.84	3.36	0.18			

Note: ***p <.01; [a] argumentation section includes 3 questions, we conducted Osborne, et al. (2004) analytical framework used in for assessing the quality of argumentation, total scores range from 0 ~15.

Table 5

RESULTS OF PAIRED T-TESTS OF EXPERIMENTAL GROUP BOYS' AND GIRLS' ARGUMENTATION SCORES

Gender	N	Paired	Mean	SD	t	Effect size	p
Boy	56	Pre	3.64 [a]	2.14	**-4.05*****	-0.56	0.00
		Post	4.88	2.32			
Girl	55	Pre	4.02	1.93	**-2.34***	-0.37	0.02
		Post	4.80	2.28			

Note: *p <.05; ***p <.0001

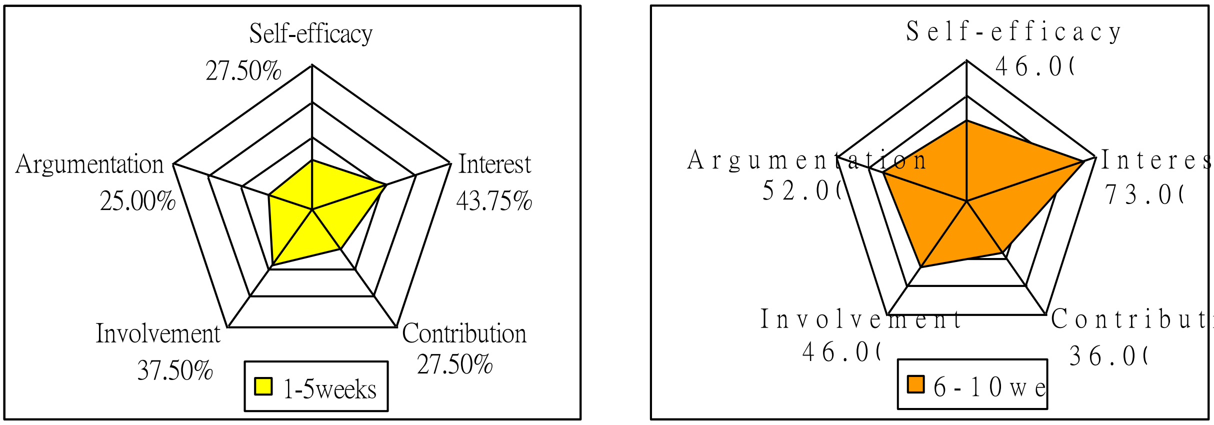

Figure. 1 Shan's (girl) classroom observation result. *Note*. A large radar aera indicates a positive outcome of target category

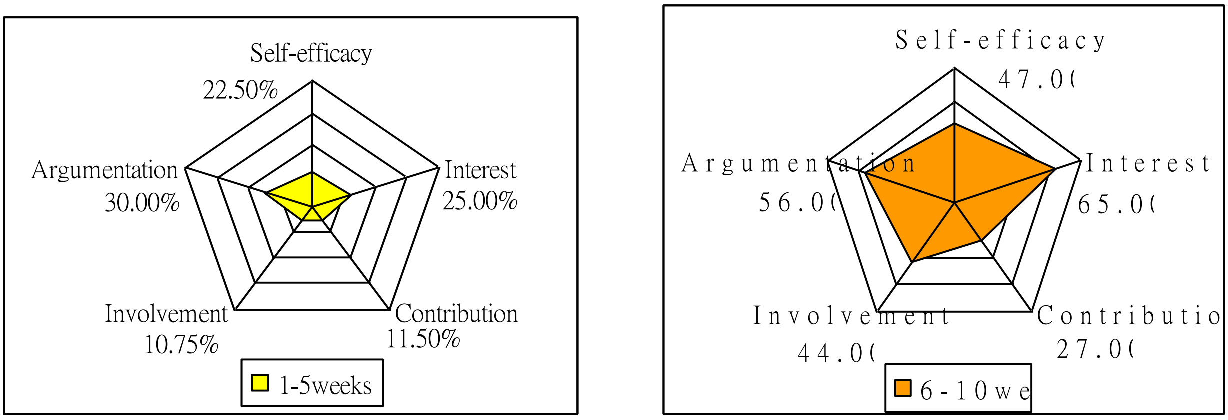

Figure 2 Chin (girl) classroom observation result.

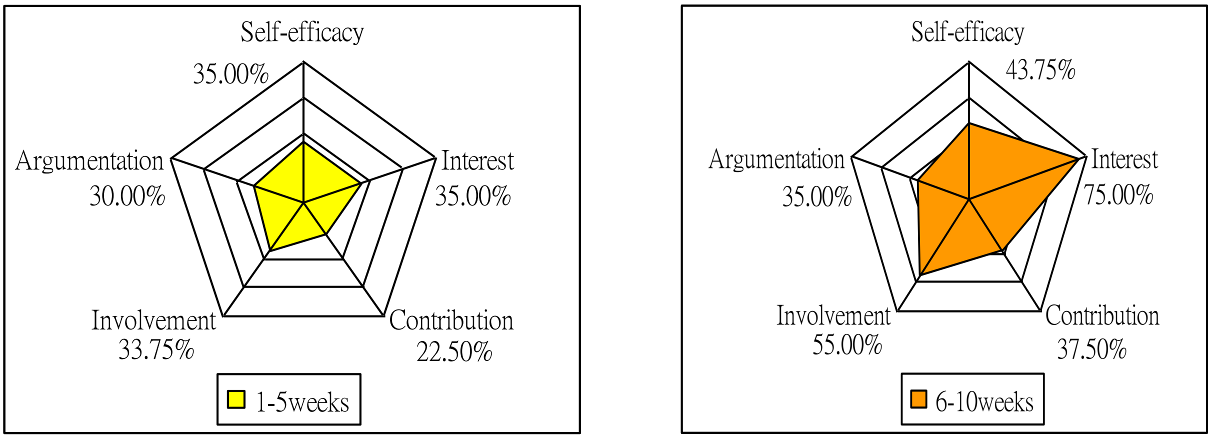

Figure 3 Chung's (boy) classroom observation result.