The Influence of Embedded Argumentation Teaching and Explicit Argumentation Teaching on Tenth Grader Students’ Scientific Argumentation Abilities and Conceptual Understanding

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The purpose of this study is to compare the influence of embedded argumentation teaching and explicit argumentation teaching on Grade 10 students’ scientific argumentation abilities and conceptual understanding. A non-equivalent group pre- and post-test design was employed in the study and three classes of Grade 10 students used as subjects, dividing into the experiment group 1 (36 persons), the experiment group 2 (35 persons), and the control group (35 persons). Group 1 accepted embedded argumentation teaching, Group 2 accepted explicit argumentation teaching, and the control group accepted traditional lecture teaching. Teaching contents include Chapter 2 “Motion and Force” (10-hour class) and Chapter 3 “Heat” (eight-hour class) of “Basic Physics” in Grade 10. After the end of teaching, scientific argumentation post-test and “Motion & Force-Heat” argumentation post-test were tested. This study adopted scientific argumentation pre-test before teaching as covariance to conduct one-way analysis of covariance (ANCOVA), so as to eliminate the influence of students’ argumentation abilities before teaching on their argumentation performances after teaching. Additionally, in order to explore students’ conceptual understanding of “Motion and Force” and “Heat,” the test was used after the end of two chapters to make a comparison with one-way analysis of variance (ANOVA). According to research findings, Grade 10 students’ scientific argumentation abilities, “Motion & Force-Heat” argumentation abilities, and scientific conceptual understanding in embedded argumentation teaching and explicit argumentation teaching could be improved better than those in traditional lecture teaching ($p < 0.05$). However, there is no difference in the improvement of argumentation abilities and scientific conceptual understanding between embedded argumentation teaching and explicit argumentation teaching ($p > 0.05$). Experiment effect size (ES) fell within medium to large range.

Keywords: conceptual understanding, embedded argumentation teaching, explicit argumentation teaching, scientific argumentation abilities
Introduction

The current scientific education focuses on cultivating students’ scientific argumentation abilities (Kenyon, Kuhn, & Reiser, 2006; Simon, Erduran, & Osborne, 2006; von Aufschnaiter, Erduran, Osborne, & Simon, 2008). In the research of argumentation teaching, one important difference is the distinction between explicit argumentation teaching and embedded argumentation teaching. Some scholars adopted explicit teaching by officially introducing composition, structure, and quality criteria to promote students’ argumentation abilities (Kelly & Takao, 2002; Kenyon, Kuhn, & Reiser, 2006; Kuhn & Reiser, 2007; Osborne, Erduran, & Simon, 2004; Sandoval & Reiser, 2004; Simon, Erduran, & Osborne, 2006; Zohar, 2004). Some scholars adopted embedded teaching by designing a learning environment of argumentative discourse, to embed argumentation activities in classroom culture and learning homework, to justify their own claims, and to promote their argumentation abilities (Eichinger, Anderson, Palincsar, & David, 1991; Jiménez-Aleixandre & Pereiro-Munhoz, 2002, 2005; Jiménez-Aleixandre & Reigosa, 2006; Jiménez-Aleixandre, Bugallo-Rodríguez, & Duschl, 2000; Jiménez-Aleixandre, López-Rodríguez, & Erduran, 2005; Kelly, Drucker, & Chen, 1998; López-Rodríguez & Jiménez-Aleixandre, 2002; Mason, 1996, 1998; Mork, 2005). However, which one of teaching orientations has better effect to promote students’ argumentation abilities remains an open-ended question in the literature?

Literature Review

Although there are two different orientations on the research of argumentation teaching, some common discoveries were showed on both research results:

1. Argumentation abilities are required to cultivate in long-term teaching activities (Kelly & Takao, 2002; Kenyon, Kuhn, & Reiser, 2006; Kortland, 1996; Kuhn & Reiser, 2007; Osborne, Erduran, & Simon, 2004; Zohar & Nemet, 2002);
2. Scaffold built by teachers plays key roles (Kenyon, Kuhn, & Reiser, 2006; Kortland, 2001);
3. Argumentation teaching is always backed by activity design, teachers’ strategy, classroom atmosphere, etc. (Kuhn & Reiser, 2007; Zohar & Nemet, 2002);
4. Students are encouraged to rethink the change of their own comprehensions, ideas, and positions (Jiménez-Aleixandre & Pereiro-Munhoz, 2002; Mason, 1996).

It can be understood from these common discoveries that the factor of a learning environment for the promotion of argumentation abilities is not only the key point of embedded argumentation teaching, but also an influence factor of explicit argumentation teaching.

Nevertheless, students are not good at using argumentation to back their claims or rebut different claims (Jiménez-Aleixandre, Bugallo-Rodríguez, & Duschl, 2000; Richmond & Striley, 1996; Sampson & Clark, 2008; Zohar, 2008). A good learning environment must be given to students to solve this difficult problem, including the selection of appropriate teaching material, cooperation with proper teaching strategy, and the process of suitable teaching activity, so that students would have opportunities to participate in argumentative discourse for lifting their argumentation abilities (Duschl & Osborne, 2002). In this context, the scaffold-assisted students in learning argumentation can be used as follows:

1. Explanation of the relevant epistemic goals related with argumentation that are simple but profound can assist students in recognizing the meaning of argumentation, the way of constructing, assessing, or rebutting the argumentation as well as debate, etc. (Simon, Erduran, & Osborne, 2006).
2. Claim is clarified as the initial period of argumentative discourse, as it is an argumentation element easier for students to understand. The relation between justification and claim can be further explained, illustrated, and discussed after the claim being clarified (Zohar, 2004).

3. Instruction, demonstration, and judgment are given to students to construct and assess the argumentation and the constituent elements of argumentation (Osborne, Erduran, & Simon, 2004; Sandoval & Reiser, 2004). Regarding the argumentation criteria, a good argumentation includes true, reliable, and multiple justifications, which involve backing and rebuttal of another argument (Zohar & Nemet, 2002). Regarding the evidence, an appropriate evidence is specific, which is from data instead of personal opinion (Kenyon, Kuhn, & Reiser, 2006).

4. Open-ended questions are asked to lead to students’ explanation or justification (Jiménez-Aleixandre, López-Rodríguez, & Erduran, 2005; Simon, Erduran, & Osborne. 2006). For example, Why do you think so? What do you have any evidence to back? or How do you convince others?

5. Students’ ideas are challenged to point out limitations or inconsistency of their arguments (Mason, 1996; Mork, 2005).

6. Students are encouraged to rethink how to change their positions and reasons for changes (Jiménez-Aleixandre & Pereiro-Munhoz, 2005; Simon, Erduran, & Osborne, 2006).

7. It is considered that students should put prior knowledge as required into the argumentation, because prior knowledge of subject is the key factor for students (Crossa, Taasoobshirazib, Hendricksc, & Hickeya, 2008; Koslowski, 1996; von Aufschnaiter, Erduran, Osborne, & Simon, 2008).

In accordance with the aforesaid literature review, the purpose of this study aimed at the establishment of learning environment to promote students’ argumentative discourse to explore and compare the influence of explicit argumentation teaching and embedded argumentation teaching on Grade 10 students’ scientific argumentation abilities and conceptual understanding.

**Research Design**

A non-equivalent group pre- and post-test design was adopted by this study, which Group 1 accepted embedded argumentation teaching, Group 2 accepted explicit argumentation teaching, and the control group accepted traditional lecture teaching. Instruments include scientific argumentation pre- and post-test, “Motion & Force-Heat” argumentation post-test, “Motion and Force” conceptual understanding post-test, and “Heat” conceptual understanding post-test. The teaching starts at the beginning of a semester, two-hour class per week in total nine weeks, i.e., 18-hour class teaching activity and teaching hours in experiment groups is in consistent with those in the control group. Teaching contents are Chapter 2 “Motion and Force” (10-hour class) and Chapter 3 “Heat” (eight-hour class) of “Basic Physics” in Grade 10. To prevent students’ argumentation abilities before teaching from affecting the test of their argumentation performances after teaching, this study adopted scientific argumentation pre-test before teaching as covariance to conduct analysis of covariance (ANCOVA). So, it can eliminate the influence of students’ argumentation abilities before teaching on their argumentation performances after teaching. Additionally, in order to explore students’ conceptual understanding of “Motion and Force” and “Heat,” the test was used after the end of two chapters to make a comparison with analysis of variance (ANOVA).
Subject

Three classes of Grade 10 students in a certain national senior high school, Kaohsiung were used as subjects, including the experiment Group 1 (36 persons), the experiment Group 2 (35 persons), and the control group (35 persons), respectively. Entrance examination results were used for S-type normal classes grouping in this school, causing that study quality for students in three classes became similar distributed. The teacher of Group 1 was the same as that of Group 2, who was qualified for Ph.D. candidate of scientific education with teaching seniority for 14 years and experienced in argumentation teaching for two years. Another teacher taught the control group, who had a master’s degree in physics with teaching seniority for 13 years.

Treatment

As students in Group 1 and Group 2 had no classroom learning experience in argumentative discourse before teaching, they did not understand the meaning of “argumentation” as well as the language and structure of argumentation, and why they should make and how to make the argumentation. Under such circumstances, a learning environment was a necessary approach through the promotion of argumentative discourse, which can be divided into two parts in this study, i.e., selection of teaching material and teaching strategy.

Regarding selection of teaching material, there are two sources: 1. Students’ alternative conceptions are used as issues to induce students’ argumentation; and 2. The opposite issues are used as competition theory to motivate students’ argumentative discourse. The following four key points should be considered in the selection of teaching material:

1. The contents of learning unit should be used to introduce as an example of argumentative discourse;
2. Students’ prior knowledge should be connected;
3. It is connected with the important concepts of the learning unit;
4. Two or several alternative explanations or claims should be presented in basic structure of teaching material.

Point 1 is concerned with language of argumentation, including words and phrases for evidence, reason, claim, theory, idea, argument, conclusion, because of, warrant, therefore, hypothesis, concept, and investigation, in line with, verification, judgment, inference, backing, trust, confirmation, no backing, and rebuttal. Points 2 and 3 that lay emphasis on argumentative learning should consider students’ prior knowledge based on students and consider important conceptual learning of science based on subjects. The final point emphasizes the format of competition theory and the design of argumentation teaching material, so as to arise the motivation of students’ argumentative discourse.

Regarding teaching strategy, the following four strategies are adopted in a learning environment for the promotion of argumentative discourse:

1. Teachers’ demonstrations and instructions are used to direct students to make reasonable argumentation;
2. Open-ended questions are asked to trigger students’ proposals of in-depth explanation, justification, and reflection;
3. Dialogue argumentation is driven by means of “group discussion” and “whole-class discussion” to justify backed theories or rebut other theories;
4. At the end of argumentative discourse, teachers clarify, rebuild, and comment each argument to assist students in rethinking argumentation process to achieve in-depth conceptual understanding of science.
Regarding the last teaching strategy, students are beginners of argumentative discourse. They could have flaws in the process of their dialogue argumentation and may not reach a consensus, even have misconceptions. Therefore, teachers should assist in clarifying the conceptions, commenting advantages and disadvantages of dialogue argumentation, and rebuilding reasonable argumentation in each team, and teachers should also allow students to rethink and learn there from. The following three key points should be noticed when using these teaching strategies:

1. Students are guided to generate a lot of dialogues favorable to forming argumentation process;
2. Students’ ideas are challenged to cause that students could reflect the limitations or inconsistencies of their evidences or reasons;
3. Students should possess basic knowledge of learning unit in favor of the process of their argumentative discourse.

Point 1 is that teachers could play the role of inductor to help students to see the difference among different arguments for creating confrontation. The open-ended questions (e.g., Are there evidences to back your ideas? Why this evidence can back your ideas? and How do you convince others to believe in your ideas?) can be used to promote argumentative discourse of team and class. Point 2 explains that teachers could play the role of challenger to purposely put forward rebuttal questions to challenge students and motivate students to reflect on the argument. Point 3 mainly emphasizes that argumentative discourse needs the basis of subject knowledge, so that teachers should firstly cultivate students’ basic knowledge, and then, guide students to carry on argumentative discourse.

The aforesaid learning environment for the promotion of argumentative discourse, namely, is embedded teaching in Group 1, while explicit teaching in Group 2 combines another three teaching strategies:

1. The language and structure based on Toulmin’s (1958) argumentation pattern are used to demonstrate the argumentation;
2. Guide students to know the meaning of argumentation and how to construct the argumentation with evidences and reasons;
3. Reminder and judgment are provided for students to construct and assess argumentation and elements of argumentation.

Point 1 enables students to understand what the argumentation is. Point 2 enables students to understand why and how the argumentation should be made. Point 3 is to explain an essential judgment for a convincible argumentation to students.

Instrument


Scientific Argumentation Pre-Test

There are four contextualized test units for scientific argumentation pre-test in total 32 points, including the test of “earthquake forecast system,” “plant development,” “the flies’ tendencies,” and “planting of morning glories,” respectively. Referred to the question format of programme for international student assessment (PISA) 2006 (Organisation for Economic Cooperation and Development [OECD], 2003), these tests were presented by situational questions with figures or tables to design from the elements of Toulmin’s (1958) argumentation
pattern. Students must use data provided by figures or tables to raise claims and explain which evidences can back their claims and why. In addition, rebuttal of others’ arguments should be offered according to evidences.

The test of “earthquake forecast system.” It referred to the book *Education for Thinking* written by Kuhn (2005), which seven operating results of earthquake forecast systems were presented with tables. Students should analyze data to form a conclusion, giving reasons for conclusion from evidences and thinking how to rebut others’ arguments with evidences.

The test unit of “plant development.” It referred to the book *Assessing Student Understanding in Science* written by Enger and Yager (2001), which lots of experimental data were presented with tables. Students could analyze data to compare the biggest factor that affected plant growth rate, providing further evidences and reasons for backing their own arguments and offering rebuttal of other listed irrelevant factors in accordance with evidences and reasons.

The test of “the flies’ tendencies.” It referred to scientific reasoning test of Lawson (1978), which the distribution of flies in test tubes under variable factors was presented with graphical representation. Students should analyze the key influence factor from the figure to make reasonable conclusions and explain evidences and reasons, including rebuttal of others’ arguments in accordance with evidences and reasons.

The test of “planting of morning glories.” It also referred to scientific reasoning test of Lawson (1978). Students should judge whether various fertilizers would have influence on morning glories in blossom by listing data as evidences for their own claims, explaining evidences, and reasons to reasonably rebut others’ arguments.

Scientific Argumentation Post-Test

There are four contextualized test units for scientific argumentation post-test in total 33 points, including the tests of “the cat’s learning,” “Salmon’s returning home,” “drug effectiveness,” and “respiratory rate of fish.” The design of the test questions was the same as the scientific argumentation pre-test.

The test of “the cat’s learning.” It referred to an example from the book *How People Learn: Brain, Mind, Experience, and School* written by Bransford et al. (2000) and was adapted for an argumentative test. The relation between the cat’s exercise times and times taken for escape was provided for students to draw a line chart. Students should use data as evidences to make conclusions and give reasons. In addition, they should use data to think about counter argument existed against their own arguments for further rebuttal.

The test of “Salmon’s returning home.” It referred to the book *Biology: A Critical Thinking Approach* written by Lawson (1994), which two tables were used to show migratory quantity of salmons in the experiment group (fish nose was covered) and the control group (fish nose was not covered). Students should analyze data to form reasonable conclusions and give reasons for them from evidential reasoning. Students should think anomalies existed in data and counter arguments existed against their own arguments for further rebuttals.

The test of “drug effectiveness.” It referred to the article entitled “Developing reason” written by Kuhn and Dean (2004), which was designed with table to show the effect of three drugs on acquired immune deficiency syndrome (AIDS) treatment. Students should have gained some understanding of control, independent, and dependent variables before analyzing data and comparing results to form correct conclusions and find out key drugs that could affect infection rate of AIDS patients, so as to rebut and explain others’ erroneous arguments.
The test of “respiratory rate of fish.” It was designed by researcher. Students should analyze and compare the influence of water temperature on respiratory rate of fish from data, which was used as evidence for further reasons and conclusions. Additionally, students should think any unsettled matter in the experimental design causing the existence of counter argument and propose the improvement of experimental design to strengthen their own arguments.

“Motion & Force-Heat” Argumentation Post-Test

Post-test of argumentation for “Motion & Force-Heat” was based on the contents of basic physics in Grade 10, which open-ended questions were designed in accordance with two units “Motion and Force” and “Heat,” respectively, from the elements of Toulmin’s (1958) argumentation pattern. Besides, Richmond and Striley (1996) claimed that students should collect and use data in consistent with scientific and acceptable mode, in which the ability of problem identification, conception of testable hypothesis, design of experiment, and understanding of the possible impact on the results should be included. In this test, students should not only offer claims from experimental data and explain the reasons, but also put forward an testable hypothesis by describing the design of experiment, and finally, infer what possible supported hypotheses and what the reasons were.

There are four contextualized test units in this test, Tests 1 and 2 were part of “Motion and Force” and Tests 3 and 4 were part of “Heat” in total 26 points, including the tests of “simple pendulum motion,” “inertia law,” “heat and temperature difference,” and “natural cooling of hot water.”

The test of “simple pendulum motion.” It was designed by researcher, which was to explore what variables affected pendulum period. The experimental data was presented with tables. Students should have gained some understanding of control, independent, and dependent variables before selecting appropriate experiment group for analysis and comparison, and then, made argumentation on which one of three hypotheses designed is correct.

The test of “inertia law.” It was designed by researcher, which the situation of scientific concept involved in sloshing water in the bucket while walking is Newton’s first law of motion (inertia law):

An object in motion continues in motion with the same speed and in the same direction (every object will remain at rest or in uniform motion in a straight line) unless acted upon by an external force (or by external force but resultant force is zero). On the contrary, if resultant force applied to the object is not zero, the object will start motion.

Therefore, sloshing water in the bucket while walking, because a resultant force acted upon the bucket is not zero. In this test, students should select one of three guesses (hypotheses) and also propose their own hypotheses to design experiments for the verification, so as to speculate which experimental result would back which hypothesis and give the reasons of speculation.

The test of “heat & temperature difference.” It was designed by researcher, which the situation was to explore what variables (e.g., heating time, specific heat of substance, and so on) would affect the rise of temperature upon absorption of heat with different substances. The design of the test recorded experimental results in different conditions with table. Consequently, students could analyze and compare different experiment groups in accordance with data to use the argumentation of the relations among substance types, mass of object, heating time, and temperature difference.

The test of “natural cooling of hot water.” It was designed by researcher, which scientific concept involved in different water quality in the process of natural cooling of hot water into cold water would affect
fast and slow of temperature decreasing. An object in different temperature placed in room temperature would reach the same final temperature. This test was designed to show student A’s misconception, allowing students to think if they backed student A’s idea and gave reasons for backing or no backing. If not, students were asked to draw a reasonable relation curve on time-temperature figure.

The scientific argumentation pre- and post- test and “Motion & Force-Heat” argumentation post-test reviewed by two scientific education experts were used as theoretical basis to judge if it met the design of test questions and appropriateness of question contents. Three Grade 10 students in non-experiment and non-control group were selected to answer the questions, and then, interviewed to confirm if comprehensibility and appropriateness were offered to Grade 10 students by words and phrases of test questions. After testing and scoring, test papers of 18 students were randomly selected from the experiment group and the control group and taken up by another two scorers for scoring in accordance with marking criterion of each test question. Pearson product-moment correlation was adopted to calculate consistency reliability between scorers for results of scoring, showing correlation coefficients of 0.94, 0.94, and 0.96 for scientific argumentation pre-test ($p < 0.05$), correlation coefficients of 0.97, 0.97, and 0.97 for scientific argumentation post-test ($p < 0.05$), and correlation coefficients of 0.97, 0.97, and 0.99 for “Motion & Force-Heat” argumentation post-test with good scorer reliability.

“Motion and Force” Conceptual Understanding Post-Test

This study adopted the translation of “Force concept inventory” by Cheng (2002) from the development of Hestenes, Wells, and Swackhammer (1992) to assess students’ comprehension of the concept of force and motion after learning the unit “Motion and Force.” This assessment was mainly used to measure students’ qualitative understanding of mechanical concept, excluding the calculation of all test questions. In this study, internal consistency reliability Cronbach $\alpha = 0.84$ ($N = 106$).

“Heat” Conceptual Understanding Post-Test

This study adopted “Comprehension test of the concept of temperature and heat” developed by Lin (2003), so as to assess students’ comprehension after learning the unit “Heat.” There were 20 questions in this test used to build content validity with two-item detail table and reviewed by four experts to build expert validity. Sixty-one Grade 8 students in a certain junior high school, Taipei accepted the test to obtain internal consistency reliability Cronbach $\alpha = 0.80$. In this study, internal consistency reliability Cronbach $\alpha = 0.79$ ($N = 106$).

Data Analyses

In order to compare the influence of embedded argumentation teaching in the experiment group 1, explicit argumentation teaching in the experiment group 2, and traditional lecture teaching in the control group on Grade 10 students’ scientific argumentation abilities, this study adopted scientific argumentation pre-test before teaching as covariance to conduct ANCOVA in accordance with dependent variables based on students’ performances of scientific argumentation post-test as well as “Motion & Force-Heat” argumentation post-test, respectively. It can eliminate the influence of scientific argumentation post-test before teaching on the performances of scientific argumentation post-test as well as “Motion & Force-Heat” argumentation post-test. The ANOVA was adopted in this study to compare the influence of embedded argumentation teaching in the experiment group 1, explicit argumentation teaching in the experiment group 2, and traditional lecture teaching
in the control group on Grade 10 students’ conceptual understanding of “Motion and Force” as well as “Heat.” If the aforesaid statistical analyses reached significance level, least significant difference (LSD) method would be further used for pos-hoc comparison. Moreover, significance level of various statistical tests in this study was set for $\alpha = 0.05$. Additionally, the index $\eta^2$ of ANOVA experimental effect proposed by Cohen (1988; 1992) was adopted in the study, which 0.14, 0.06, and 0.01, respectively, indicated large, medium, and small value of experimental effect.

Findings and Discussions

The Students’ Performances of Scientific and “Motion & Force-Heat” Argumentation

Where scientific argumentation pre-test before teaching was used as covariance and the students’ performance for scientific argumentation post-test as dependent variable, ANCOVA was conducted. Test result of regression coefficient homogeneity in the group showed $F(2, 106) = 1.51; p = 0.227, p > 0.05$, but was not at a significance level. It represented that the relation between covariance and dependent variable would not be different depending on different processing level in each independent variable. The ANCOVA could be continued once it met the hypothesis of regression coefficient homogeneity in the group. The result of ANCOVA showed $F(2, 106) = 7.37, p < 0.05$ as in Table 1, meaning that students in three groups had different performances for scientific argumentation post-test and reached statistical significance level after the influence of scores on scientific argumentation pre-test were excluded. For further post-hoc comparison by LSD method, the results showed as in Tables 1 and 2 that embedded argumentation teaching (average score of scientific argumentation post-test was 19.05) could improve students’ scientific argumentation ability better than traditional lecture teaching (average score of scientific argumentation post-test was 15.67). Explicit argumentation teaching (average score of scientific argumentation post-test was 20.08) also could improve students’ scientific argumentation ability better than traditional lecture teaching (average score of scientific argumentation post-test was 15.67). However, the improvement of students’ scientific argumentation ability had no difference between embedded argumentation teaching and explicit argumentation teaching. Besides, experimental effect size (ES) $\eta^2 = 0.13$ showed large value.

Table 1

<table>
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<tr>
<th>Source of variable</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>Post-hoc comparison</th>
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<td>1</td>
<td>63.07</td>
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<td>0.001*</td>
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Note. * $p < 0.05$.

Table 2

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<td>Explicit argumentation teaching</td>
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<tr>
<td>Traditional lecture teaching</td>
<td>15.71</td>
<td>5.27</td>
<td>15.67</td>
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Where scientific argumentation pre-test before teaching was used as covariance and the students’ performance for post-test of “Motion & Force-Heat” argumentation as dependent variable, ANCOVA was conducted. Test result of regression coefficient homogeneity in the group showed $F(2, 106) = 2.83; p = 0.064$, $p > 0.05$, but was not at a significance level. It represented that the relation between covariance and dependent variable would not be different depending on different processing level in each independent variable. The ANCOVA could be continued once it met the hypothesis of regression coefficient homogeneity in the group. The result of ANCOVA showed $F(2, 106) = 67.23, p < 0.05$ as in Table 3, meaning that students in three groups had different performances for “Motion & Force-Heat” argumentation post-test and reached statistical significance level after the influence of scores on scientific argumentation pre-test were excluded. For further post-hoc comparison by LSD method, the results showed as in Tables 3 and 4 that embedded argumentation teaching (average score of “Motion & Force-Heat” argumentation post-test was 17.56) could improve students’ scientific argumentation ability better than traditional lecture teaching (average score of “Motion & Force-Heat” argumentation post-test was 15.46). Explicit argumentation teaching (average score of “Motion & Force-Heat” argumentation post-test was 18.06) also could improve students’ scientific argumentation ability better than traditional lecture teaching (average score of “Motion & Force-Heat” argumentation post-test was 15.46). However, the improvement of students’ “Motion & Force-Heat” argumentation ability had no difference between embedded argumentation teaching and explicit argumentation teaching. Besides, experimental ES $\eta^2 = 0.09$ showed mid-upper value.

Table 3

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<th>$p$</th>
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<td>Traditional lecture teaching</td>
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Note. * $p < 0.05$.

Table 4

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<td>Explicit argumentation teaching</td>
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<td>Traditional lecture teaching</td>
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</table>

The Students’ Performances for Conceptual Understanding of “Motion and Force” and “Heat”

Where students’ performances of “Motion and Force” conceptual understanding post-test and “Heat” were used as dependent variables, ANOVA was conducted in three groups, showing the results as in Tables 5 and 6. According to Table 6, “Motion and Force” conceptual understanding post-test for three groups of students showed $F(2, 105) = 11.15, p < 0.05$, meaning they had different performances and achieved statistical significance level. For further post-hoc comparison by LSD method, the results showed as in Table 6 that embedded argumentation teaching (average score of “Motion and Force” conceptual understanding post-test was 18.86) could improve students’ conceptual understanding of “Motion and Force” better than traditional lecture teaching (average score of “Motion and Force” conceptual understanding post-test was 13.29). Explicit
argumentation teaching (average score of “Motion and Force” conceptual understanding post-test was 17.02) also could improve students’ scientific argumentation ability better than traditional lecture teaching (average score of “Force & Motion” conceptual understanding post-test was 13.29). However, the improvement of students’ conceptual understanding of “Force & Motion” had no difference between embedded argumentation teaching and explicit argumentation teaching. Besides, experimental ES $\eta^2 = 0.18$ showed large value.

Table 5

<table>
<thead>
<tr>
<th>Test</th>
<th>Group</th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept of “Motion and Force”</td>
<td>Embedded argumentation teaching</td>
<td>36</td>
<td>18.86</td>
<td>3.83</td>
</tr>
<tr>
<td></td>
<td>Explicit argumentation teaching</td>
<td>35</td>
<td>17.20</td>
<td>4.21</td>
</tr>
<tr>
<td></td>
<td>Traditional lecture teaching</td>
<td>35</td>
<td>13.29</td>
<td>6.78</td>
</tr>
<tr>
<td>Concept of “Heat”</td>
<td>Embedded argumentation teaching</td>
<td>36</td>
<td>17.75</td>
<td>2.10</td>
</tr>
<tr>
<td></td>
<td>Explicit argumentation teaching</td>
<td>35</td>
<td>17.00</td>
<td>3.52</td>
</tr>
<tr>
<td></td>
<td>Traditional lecture teaching</td>
<td>35</td>
<td>15.63</td>
<td>4.49</td>
</tr>
</tbody>
</table>

Table 6

<table>
<thead>
<tr>
<th>Test</th>
<th>Source of variable</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>Post-hoc comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept of “Motion and Force”</td>
<td>Between group</td>
<td>579.37</td>
<td>2</td>
<td>289.68</td>
<td>11.15</td>
<td>0.000*</td>
<td>Embedded argumentation teaching &gt; Traditional lecture teaching</td>
</tr>
<tr>
<td></td>
<td>Within group</td>
<td>2,677.05</td>
<td>103</td>
<td>25.99</td>
<td>11.15</td>
<td>0.000*</td>
<td>Explicit argumentation teaching &gt; Traditional lecture teaching</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3,256.42</td>
<td>105</td>
<td>25.99</td>
<td>11.15</td>
<td>0.000*</td>
<td>Embedded argumentation teaching &gt; Traditional lecture teaching</td>
</tr>
<tr>
<td>Concept of “Heat”</td>
<td>Between group</td>
<td>81.92</td>
<td>2</td>
<td>40.96</td>
<td>3.35</td>
<td>0.039*</td>
<td>Embedded argumentation teaching &gt; Traditional lecture teaching</td>
</tr>
<tr>
<td></td>
<td>Within group</td>
<td>1,260.92</td>
<td>103</td>
<td>12.24</td>
<td>3.35</td>
<td>0.039*</td>
<td>Explicit argumentation teaching &gt; Traditional lecture teaching</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1,342.84</td>
<td>105</td>
<td>12.24</td>
<td>3.35</td>
<td>0.039*</td>
<td>Embedded argumentation teaching &gt; Traditional lecture teaching</td>
</tr>
</tbody>
</table>

Note. * $p < 0.05$.

According to Table 6, “Heat” conceptual understanding post-test for three groups of students showed $F(2, 105) = 3.35, p < 0.05$, meaning they had different performances and reached statistical significance level. For further post-hoc comparison by LSD method, the results showed as in Table 6 that embedded argumentation teaching (average score of “Heat” conceptual understanding post-test was 17.75) could improve students’ conceptual understanding of “Motion and Force” better than traditional lecture teaching (average score of “Heat” conceptual understanding post-test was 15.63). Explicit argumentation teaching (average score of “Heat” conceptual understanding post-test was 17.70) also could improve students’ scientific argumentation ability better than traditional lecture teaching (average score of “Heat” conceptual understanding post-test was 15.63). However, the improvement of students’ conceptual understanding of “Heat” had no difference between embedded argumentation teaching and explicit argumentation teaching. Besides, experimental ES $\eta^2 = 0.06$ showed medium value.

General Discussion

As the above-mentioned analyses result, it could be found that total 18-hour class teaching activity, including Chapter 2 “Motion and Force” (10-hour class) and Chapter 3 “Heat” (eight-hour class) of “Basic Physics” in Grade 10 had no difference between embedded argumentation teaching and explicit argumentation teaching on the improvement of students’ scientific argumentation abilities and “Motion & Force-Heat” argumentation abilities. Two types of argumentation teaching could improve students’ scientific and “Motion &
Force-Heat” argumentation ability better than traditional lecture teaching, including large experimental effect on the improvement of scientific argumentation ability and mid-upper experimental effect on the improvement of “Motion & Force-Heat” argumentation ability. The results were in consistent with claim of Duschl and Osborne (2002). They thought that students should be given a good learning environment and opportunities to participate in argumentative discourse for lifting their argumentation abilities, including the selection of appropriate teaching material, cooperation with proper teaching strategy, and the process of suitable teaching activity.

The results also reflected the propositions of Jiménez-Aleixandre, Bugallo-Rodríguez, and Duschl (2000), Richmond and Striley (1996), Sampson and Clark (2008), and Zohar (2008). They discovered that students were not good at backing or rebuttal of their claims with argumentation in traditional teaching situation. The improvement of students’ scientific and “Motion & Force-Heat” argumentation abilities had no difference between embedded and explicit argumentation teaching.

There are similarities and differences between the results and two schools of scholars, in which one party argued about the adoption of embedded teaching to design a learning environment of backing argumentative discourse. Argumentation activities could be embedded in classroom culture and learning practice to promote students’ argumentation abilities (e.g., Eichinger, Anderson, Palincsar, & David, 1991; Jiménez-Aleixandre & Pereiro-Munhoz, 2002, 2005; Jiménez-Aleixandre & Reigosa, 2006; Jiménez-Aleixandre, Bugallo-Rodríguez, & Duschl, 2000; Jiménez-Aleixandre, López-Rodríguez, & Erduran, 2005; Kelly, Druker, & Chen, 1998; López-Rodríguez & Jiménez-Aleixandre, 2002; Mason, 1996, 1998; Mork, 2005). The other party argued about the adoption of explicit teaching to officially introduce the composition, structure, and quality standard of argumentation, so as to promote students’ argumentation abilities (e.g., Kelly & Takao, 2002; Kenyon, Kuhn, & Reiser., 2006; Kuhn & Reiser, 2007; Osborne, Erduran, & Simon., 2004; Sandoval & Reiser, 2004; Simon, Erduran, & Osborne, 2006; Zohar, 2004).

Similarities showed that either type of teaching was effective in improving students’ argumentation abilities and differences showed that both types of teaching were effective in improving students’ argumentation abilities without any difference. Whether the results may produce diverse outcomes caused by junior high school students (compared to senior high school students) or students with high and low academic achievement should be studied further. Moreover, as the instruments used to measure argumentation ability designed by this study may result in effective but no difference outcome in both teaching, it is worthy of further study.

For the improvement of students’ conceptual understanding of “Motion and Force,” there is no difference between embedded argumentation teaching and explicit argumentation teaching. Both types of argumentation teaching could improve of students’ conceptual understanding of “Motion and Force” better than traditional lecture teaching and had large experimental effect. For the improvement of students’ conceptual understanding of “Heat,” embedded argumentation teaching was better than traditional lecture teaching and had mid-upper experimental effect. For the improvement of students’ conceptual understanding of “Heat,” there is no difference between explicit argumentation teaching and traditional lecture teaching, and no difference between explicit argumentation teaching and embedded argumentation teaching. This result showed embedded argumentation teaching and explicit argumentation teaching could improve students’ scientific conceptual understanding better than traditional lecture teaching and students’ scientific conceptual understanding had no difference between embedded argumentation teaching and explicit argumentation teaching.
Newton, Driver, and Osborne (1999) stated that any learner had opportunity to express the reasons of backing specific conceptual understand in dialogue argumentation and intended to justify their own viewpoints, rebutting others’ challenge or proposing alternative ideas to result in clearer conceptual understanding. Von Aufschnaiter, Erduran, Osborne, and Simon (2008) deemed viewpoints from constructivism that argumentation teaching orientation enabled students to more likely to actively involve in scientific learning, and thus, students’ conceptual understanding could be reasonably expected to improve. They also indicated that argumentation teaching would back the improvement of students’ thoughts, causing faster development opportunity of specific concepts in learning and the assistance of students for connection in different situations. These may explain why students’ performances were better than those in general teaching. According to researches from Jiménez-Aleixandre, Bugallo-Rodríguez, and Duschl (2000), Jiménez-Aleixandre and Pereiro-Munhoz (2002), Leach (1999), Mason (1996), and Zohar and Nemet (2002), it could discover that students involved in argumentation learning may improve their conceptual understanding. However, there is no conclusion in the literature showing which type of argumentation teaching has better effect in the promotion of students’ scientific conceptual understanding.

Conclusions and Implications

From analysis and discussion of literature, this study concluded that a learning environment for the promotion of argumentative discourse, including selection of teaching material and considerations, teaching strategies and notices, constituted embedded argumentation teaching, and then, explicit argumentation teaching in accordance with explicit teaching. Upon research validation of quasi-experimental design, it discovered that embedded argumentation teaching and explicit argumentation teaching could improve Grade 10 students’ scientific argumentation abilities, “Motion & Force-Heat” argumentation abilities and scientific conceptual understanding better than traditional lecture teaching, but the improvement of argumentation abilities, and scientific conceptual understanding had no difference between embedded argumentation teaching and explicit argumentation teaching. In consequence, the research results can be used as basis of reference design for teachers’ planning of argumentation teaching and selection of embedded argumentation teaching or explicit argumentation teaching depending on students’ learning conditions.

In future research, further study is needed to explore whether different results could be produced by embedded argumentation teaching or explicit argumentation teaching to different school types and senior high school students with different learning achievements. Next, whether the improvement of difficulty and complexity in instruments for measuring argumentation ability would cause the difference for improving students’ argumentation abilities and conceptual understand between embedded argumentation teaching and explicit argumentation teaching. It is also an issue worthy of further study.

References


EMBEDDED ARGUMENTATION AND EXPLICIT ARGUMENTATION TEACHING


