The Effect of Science Writing Heuristic on Concept Formation of Light in 'Mirrors and Lenses' and Scientific Attitudes

Sunggi Kwon* · Su-young Lee[1] · Min-ah Jeong[2]
Daegu National University of Education · [1]Sungbuk Elementary School · [2]Dalsan Elementary School

Abstract: We investigated the effect of Science Writing Heuristic (SWH) on elementary students' concept formation and their retention. Also we explored the interaction effect of those with scientific attitudes. We developed mirrors/lenses lessons incorporating SWH. An experimental group of fifth grade students (n=25) had been instructed with SWH lessons for six periods while a control group (n=25) taught according to the normal science lessons based on the Korean national curriculum using teacher's guides published by the Ministry of Education. Results of pre- and post-test of understanding the concept of mirrors and lenses showed a positive impact of SWH on both male and female students. However, the retention effect after post-test revealed that SWH only had an effect on female students' scientific attitudes. SWH, therefore, could be an effective teaching approach especially on concept formation, retention effects by fostering female students' scientific attitudes.

Key words: science writing, concept formation, retention effect, attitude

Ⅰ. Introduction

Students often form various their own preconceptions about a phenomenon or an object. It usually occurs before they even have a chance to learn or be taught scientifically at school. As concept formation is defined as an active restructuring process based on one's belief or previous knowledge (Jeong & Han, 2006), it is significant for teachers to prepare scientific class that interact students with their own concept to a scientific one in order to inculcate a sense of scientific way of learning. Science class should be designed to give students opportunities to compare and analyze the new information with their own knowledges in order to reorganize their own thoughts and further form scientific concepts. Accordingly, it is important to lead students to get concept formation that can be achieved by allowing them to express their notions in words and create cognitive conflicts to resolve them in order to ultimately complete their scientific way of thinking (O, 2003).

This article has taken the unit of 'Mirrors and lens' for fifth graders, which is often considered difficult in terms of understanding the reflection and refraction of the light. After the completion of the unit, students still tend to find it hard to develop a concept of the subject, even though students are familiar with mirrors and lenses with its usage in their everyday lives. Further, Jeon (2006) has found that students have difficulties in understanding the concept of the light path of concave and convex mirrors and lenses in both terms of reflected and penetrated. Unfortunately, students tend to memorize which lenses concentrate the light or what mirrors magnify such object rather than take the basic notion of it in.

To help students form a scientific concept, teachers can adopt Science Writing Heuristic(SWH) into the class. As a matter of fact, writing is seen as a process where one can array, synthesize and reorganize the whole ideas to reach a scientific thought system rather than as a process of arrange simple languages. Practicing scientific writing-skills may also assist students to ensure such concept

*Corresponding author: Sunggi Kwon(Kwonsg@dnue.ac.kr)
**Received on 11 November 2011, Accepted on 15 May 2012

formation, as it eases students to recognize things they have already known with ones they have not to consequently reach a comprehensive thought formation. Further, writing fairly gives chances on expressing students' own thoughts than speaking does (Jeong *et al.*, 2004). Overall, such a science class employing writing skill improvements can lead students to express a certain concept by easing them to structure a scientific notion system.

Nam *et al.* (2008) has claimed such SHW class has practical effects on middle school students' cognitive development and scientific concept understanding. Bae *et al.* (2009) have reached the conclusion that the male fifth graders' heuristic ability has benefited with a developed science writing teaching method. Lee's research (2007) has found such science writing teaching methods improve students' perseverance, critical mind and curiosity, which are vital to shape scientific attitude. Shin *et al.* (2009) also have asserted that the scientific writing skills beneficially affect on the improvement of students' perseverance of established concept and creativity. However, Bae *et al.* (2009) have not found any relationship between scientific writings and scientific attitudes.

Recently, studies concerning the effects of SWH have been spotlighted. But the results of those studies vary and fail to address certain guidelines, so more researches with practical outcomes are required. Therefore, this research develops scientific writing activities and applies in classes to examine the effects of SWH on scientific concept formation and attitudes in the unit of mirrors and lenses.

Ⅱ. Methods

1. Research Object

This study has randomly selected two classes of fifth-grader in an elementary school in Daegu city, South Korea. Among these classes, students who have participated in both pre- and post-test are taken into the consideration. Classes are divided into two groups of the experimental and control. Both classes are covered with the unit of mirrors and lens. There are twenty-five students in the experimental group, thirteen males and twelve females, and the other group of control has twenty-seven in total, fifteen males and twelve females.

2. Research Design

This research conforms to the quasi-experimental design meanwhile the controlled groups are examined prior to the sciences writing class, once more after the science writing class.

Table 1
Research design

G_1	O_1	X_1	O_2	O_3
G_2	O_1	X_2	O_2	O_3

G_1: Experimental group, G_2: Control group
O_1: Pre-test (concept formation, scientific attitudes)
O_2: Post-test(concept formation, scientific attitudes)
O_3: Delayed Test (retention of conception)
X_1: SWH class, X_2: Normal class

3. Research Procedure

The experimental group is taught the unit of mirrors and lens with SWH while the other control group learned the same unit in the manner of the teachers' guidebook suggested by the Korean Ministry of Education. The study has examined all groups before the SWH class in order to establish homogeneity in terms of forming such a concept of mirrors and lenses along with scientific attitudes. The post-test has also tested both on concept formation and scientific attitudes. As to delayed test, only examination on concept formation is conducted in order to obtain the effects of retention. Both examinations are carried out with the same questions with the changes in order to avoid simple repeats.

Table 2
Research procedure

Basic research	Pilot research	Main research
1. Research design 2. Literature review 3. Curriculum analysis	4. Selecting measurements	5. Developing teaching plan 6. Pre-test 7. Experimental treatment 8. Post-test 9. Delayed test 10. Data analysis

4. Research Developments

This research has modified Bae *et al.* (2009) Science Writing Program as the each class-phase progresses. Initially, the class is to provide students materials to create attentive interests and academic motivations. At the inquiring phase, students are taught scientific concepts as follows with such experiments and observations. Materials that are developed by our researchers are given then at the thought collection phase to assist scientific writing skills individually. With those handouts students are given with time to write and discuss their written works with classmates to have a chance to share their thoughts and to find and correct some errors. At last, students present the complete writings that help them to sum up the scientific concepts.

Every necessity of the learning on the unit is analyzed. Students decide appropriate subjects for writing that help understating of the concept formation. They are also given the different types of writing to assist them to express the subject effectively. Writing questions are prepared with illustrations to promote students' interests. The complete questions are handed out on the thought collection phase of each chapter. The writing subjects and types are shown in Table 3, Table 4 represents complete questions.

5. Measurements

To measure the concept formation, this study has applied Jeon's (2006) questions of mirrors and lenses which is composed with 12 multiple choice questions with predicative reasoning questions. Table 5 shows the content of questions. The face validity of the questions is

Table 3
Subjects and types of SWH in each period

period	Scientific concept	Subject	Type
1	Objects on plane mirror	Mirror-man	Problem-solving
2	Incidence angle & Reflection angle	Two friends' conversation between a wall	Dialog completion
3	Objects on concave & convex mirror	Interview with Dr. mirror	Interviewing
4	Penetrated light refraction on lens	Travels of penetrated light	Writing completion
5	Objects on concave & convex lens	Fun episode from observation	Journaling
6	Characteristics of convex lens	How to make a pinhole camera and result	Writing experimental tools, methods, results

Table 4

Writing questions developed for SWH

period	Questions
1	Junghyun wants to play the 'mirror-man' with her sister. The 'mirror-man' is a game that imitates one to another like a mirror. Imagine you are Junghyun and explain your little sister how to play this game!
2	Dayeon and Seunglee are looking at the wall and talking to each in between. S: Dayeon, you cannot see me because of the wall, can you?D: Yes, I can! You are raising your right hand, right?S: Wow, how do you know?D: Because……Imagine, how this conversation will continue? Relate to the concept that we have learned today.
3	Dayeon asked Dr. Mirror things she has been wondered about the mirror. Below, there are questions that Dayeon has asked. Imagine you are Dr. Mirror and answer Dayeon's questions in the manner of an interview.
4	Following is circumstances which occur when the light penetrates a lens. Think yourself as the light and complete the story.
5	Today, we have observed many objects on both concave and convex lens. Write a journal about the fun and memorable moments.
6	Explain the process of paper-camera making and the looks of objects through the camera simply.

Table 5

Content of questions

Sector	Contents	Subjects
Light reflection	Figure of object	1. figures of an object on a plain mirror 4. figures of an object on a concave mirror 6. figure of an object on a convex mirror
	Direction of light	2. direction of the light on a plain mirror 3. direction of the light on a concave mirror 5. direction of the light on a convex mirror
Light refraction	Distinguishing lenses	11. distinguishing concave lens 12. distinguishing convex lens
	Refracted direction	7.shape of the penetrated light from the concave lens 9. shape of the penetrated light from the convex lens
	Figure of object	8. figures of an object on a concave lens 10. figures of an object on a concave lens

examined by expert science educators. Also, the content validity is tested by three elementary educators certificated with master of arts and item consistency of them is about 80.3%. Students' responses of each question is marked with three elementary educations majored masters. If a student picked a right answer for questions from multiple choices with scientific reasoning gets two points and a student chose a right answer for multiple choices questions without scientific reasoning marks one point. If neither were provided, receives no points.

And for the measurement scientific attitudes we adopted scientific attitudes instruments developed by Kim *et al.* (1998). The value of Cronbach's alpha on the questionnaire is 0.828. It has 21 questions in total with a five step of Likert scale relevant to quantization on statistical analysis. Questionnaire of scientific attitudes is composed of 7 sub-categories. Table 6 represents questions of each sub-category of scientific attitudes.

Data of concept formation and scientific attitudes are analyzed on SPSS 12.0. The study conducted ANCOVA where the covariance is viewed as the pre-test of the concept forming examination, groups are seen as an independent variable and post-test is considered as a dependent variable. Also, counter samples of post- and delayed-test of each group are analyzed using t-test in order to examine the retention of concepts. Then the t-test is also used to prove the attitudes examination of independent samples of sub-categories.

Ⅲ. Results and Discussion

1. The Effects of SWH on Concept Formation

The control group shows higher average scores than the experimental group in pre-test. However in post-test, experimental group presents a better average.

For male students, the average of experimental group has got greater than pre-test at 8.92 where the control group shows 3.6 risen. The average of female experimental students' post-test is greater than control group by showing respectively 17.99 and 14.00. The results of concept formation from post-examination between experimental and control group are shown in Table 7.

The result of a t-test that is conducted to examine the homogeneity of both groups' concept formation on the mirrors and lenses shows heterogeneity on total students. Thus, this research has extended the examination to ANCOVA, which has taken the result of pre-test

Table 6

Questions of sub-category

Sub-category	Questions	Number of Questions
Curiosity	4, 10, 17	3
Open mind	1, 11, 18	3
Critical mind	6, 12, 19	3
Cooperativity	2, 5, 13	3
Voluntariness	3, 7, 14	3
Perseverance	8, 15, 20	3
Creativity	9, 16, 21	3

Table 7

Summary of pre- and post-test

Test	Gender	Group	M	SD	t	*p*
Pre- test	Male	ExperimentalControl	5.23 9.40	1.23 5.43	-2.700	.012*
	Female	Experimental Control	8.00 7.50	2.66 4.53	.330	.745
	Total	Experimental Control	6.56 9.07	2.45 4.73	-2.377	.021*
Post-test	Male	Experimental Control	14.15 13.00	3.84 4.56		
	Female	Experimental Control	17.66 14.00	3.86 3.30	2.497	.021*
	Total	Experimental Control	15.84 13.44	4.18 4.01		

*$p < .05$

as a covariate, groups are as an independent variable and post-test is considered as a dependent variable in order to clarify the countable influences of SWH class.

As both female student groups have shown homogeneity, t-test is conducted. The result of total students is presented in Table 8, male students' in Table 9 and female students' in Table 7. As it is showed in Table 8, by removing the correlation on pre-test of two groups has resulted in a valuable variation ($F=18.569$, $p<.05$). Male students also shows a positive variation after the preliminary test removal in Table 9 ($F=15.729$, $p<.05$). Examination on female groups results a similar variation, shown in Table 7.

The analysis of SWH influences on mirrors and lenses concept formation has proven its beneficial effects on both male and female students. According to Prain and Hand (1999) science writing activities help students to have a better understanding in forming such scientific concept. SWH that helps to collect students' ideas as well as to express them in words can immediately assist students to form a solid conception scientifically.

2. The Effects of SWH on Retention

On the delayed test, the average of experimental groups has been 4.94 greater than the control group on both male and female students. Post- and delayed test of experimental group have not shown a significant difference by showing the averages at respectively 15.08 and 15.84. Reversely, the average of control group has shown a critical change than the other group rating at 10.14 to 13.44. The average and standard deviation between groups of post- and delayed test are shown in Table 10.

Table 8

Results of covariate between groups

Variance	*SS*	*df*	*MS*	*F*	*p*
Covariate	325.804	1	325.804	31.167	.000
Group	194.116	1	194.116	18.569	.000*
Deviation	512.223	49	10.454		

*$p < .05$

Table 9

Results of covariate on male students

Variance	*SS*	*df*	*MS*	*F*	*p*
Covariate	289.389	1	289.389	40.125	.000
Group	113.436	1	113.436	15.729	.001*
Deviation	180.303	25	7.212		

*$p < .05$

Table 10

Average and standard deviation between groups of post- and delayed test

Group	Gender	Post		Delayed	
		M	SD	M	SD
Experimental	Male	14.15	3.84	13.15	4.33
	Female	17.66	3.86	17.16	3.51
	Total	15.84	4.18	15.08	4.18
Control	Male	13.00	4.56	10.93	5.32
	Female	14.00	3.30	9.167	5.89
	Total	13.44	4.01	10.14	5.54

In order to establish a valuation on the durability of SWH, the counter samples between post- and delayed test are analyzed with t-test. The results are explained in Table 11.

Post- and delayed test on the experimental group have not demonstrated significant variations statistically, which may explain a month durability of a formed concept by science writing. On the other hand, the control group has demonstrated significant changes in post- and delayed test. That is, the group has marked a lower score in the delayed test than the post-test as the science writing activities harden and longer the concept that has been established than a simple memorization.

To compare the distinction between genders, the outcome of male students are shown in Table 12 and those of female in Table 13.

As shown in Table 12, differences between post- and delayed test of both experimental and control male groups exhibit statistical validity. Also, both groups have resulted in lower marks in delayed test. In other words, the SWH do not help male students to keep the formed concept durational. For female experimental group, there have not shown significant difference between post- and delayed test whereas the control female group has a slight variation between examinations. It can be interpreted that female students have been enduring the concept of mirrors and lenses formed a month long. Thus, the SWH class is beneficial to female students to last the notion of concept but male students. This can be explained by the fundamental differences in characteristics of male and female such as sensitivity, vocabulary and logical thinking(Joo, 1999) have affected female students better in terms of retention effect.

3. The Effects of SWH on Scientific Attitudes

Table 14 represents the results of t-test conducted pre and post in order to clarify the effects of SWH on scientific attitudes. Values of experimental group on pre-test are almost even, which explain the homogeneity on scientific attitudes. However, the average of post-test of experimental is greater at 3.73 than of the

Table 11

T-test of post- and delayed test

Group	t	*df*	*p*
Experimental	1.978	24	.059
Control	4.358	26	.000*

*$p < .05$

Table 12

T-test of male students post- and delayed test

Group	T	*df*	*p*
Experimental	2.550	12	.025*
Control	2.471	14	.027*

*$p < .05$

Table 13

T-test of female students post- and delayed test

Group	T	*df*	*p*
Experimental	.724	11	.484
Control	3.891	11	.003*

*$p < .05$

control group where the result of t-test of post-test has shown valuable variation. The values of t-test on pre- and post-test by sub-categories (curiosity, open mind, critical mind, cooperativity, voluntariness, perseverance, creativity) scientific attitudes is shown in Table 15.

The averages of post-test on sub-categories have raised compare to the pre-test. Comparing the averages on post-test of both groups, experimental group has shown a greater average

Table 14

Results of pre- and post- test on scientific attitudes

Test	Group	N	M	SD	t	*p*
Pre	Experimental Control	25 27	3.46 3.46	.40 .25	.089	.929
Post	Experimental Control	25 27	3.73 3.52	.38 .36	2.031	.048*

*$p < .05$

Table 15

Pre- and post-test of scientific attitudes on sub-categories

Sub-category	Test	Group	N	M	SD	t	*p*
Curiosity	Pre	Experimental Control	25 27	3.36 3.33	.76 .74	.127	.900
	Post	Experimental Control	25 27	3.66 3.19	.74 .62	2.460	.017*
Open mind	Pre	Experimental Control	25 27	3.58 3.55	.61 .62	.182	.856
	Post	Experimental Control	25 27	3.93 3.56	.60 .59	2.211	.032*
Critical mind	Pre	Experimental Control	25 27	2.81 2.59	.56 .42	1.603	.155
	Post	Experimental Control	25 27	3.45 2.90	.85 .86	2.311	.025*
Co-operativity	Pre	Experimental Control	25 27	3.93 3.90	.57 .65	.187	.852
	Post	Experimental Control	25 27	4.06 4.03	.64 .62	.168	.867
Voluntariness	Pre	Experimental Control	25 27	3.56 3.60	.71 .61	1.60	.808
	Post	Experimental Control	25 27	3.70 3.74	.76 .69	−.244	.867
Perseverance	Pre	Experimental Control	25 27	3.74 3.91	.84 .69	−.168	.439
	Post	Experimental Control	25 27	3.90 3.77	.59 .63	−.780	.455
Creativity	Pre	Experimental Control	25 27	3.28 3.32	.62 .63	.753	.815
	Post	Experimental Control	25 27	3.40 3.43	.87 .77	−.235	.889

*$p < .05$

in terms of curiosity, open mind, and critical mind. Pre-test between groups have not shown significant differences, it can be assumed that the scientific attitudes in terms of sub-category classified as homogenous groups. The results of t-test on the post-test of both groups, category of curiosity has shown a slight change in average where open mind and critical mind result a valuable distinction. However, cooperativity, voluntariness, perseverance and creativity have not shown significance. Therefore, SWH have positive effects only on curiosity, open mind and critical mind. As proven in Lee's research (2007) science writing activities are beneficial in the long-term effectiveness of the outcome, enhancing students' criticism, and encouraging curiosity where this research has added the open mind of embracing such as new knowledge or subjects. This may be due to the activities performed in the SWH class, for example, sharing their written thoughts with their classmates, and correcting errors. By doing so, students can give careful attention to others and be as open as to embrace errors for better understanding of such concept and notion.

In order to check the gender differences, Table 16 reveals the result of male students, and of

Table 16

Pre- and post-test of male students' scientific attitude on sub-categories

Sub-category	Test	Groups	N	M	SD	t	*p*
Curiosity	Pre	Experimental	13	3.12	.79	-1.135	.267
		Control	15	3.44	.67		
	Post	Experimental	13	3.61	.62	1.595	.123
		Control	15	3.22	.67		
Open mind	Pre	Experimental	13	3.43	.67	.322	.750
		Control	15	3.35	.64		
	Post	Experimental	13	3.87	.67	.440	.664
		Control	15	3.77	.44		
Critical mind	Pre	Experimental	13	2.69	.44	.619	.542
		Control	15	2.57	.52		
	Post	Experimental	13	3.17	.95	.803	.429
		Control	15	2.91	.81		
Co-operativity	Pre	Experimental	13	3.71	.54	.513	.612
		Control	15	3.60	.65		
	Post	Experimental	13	3.94	.67	.329	.745
		Control	15	3.86	.63		
Voluntariness	Pre	Experimental	13	3.48	.84	-.633	.533
		Control	15	3.66	.65		
	Post	Experimental	13	3.56	.79	-.983	.335
		Control	15	3.86	.82		
Perseverance	Pre	Experimental	13	3.48	1.02	-1.417	.168
		Control	15	3.93	.61		
	Post	Experimental	13	3.64	.53	-.112	.911
		Control	15	3.66	.65		
Creativity	Pre	Experimental	13	3.30	.95	-.575	.570
		Control	15	3.46	.78		
	Post	Experimental	13	3.51	.74	.072	.943
		Control	15	3.48	.97		

*$p < .05$

female students' in Table 17. The result of pre-test on male students by sub-category between experimental and control groups have not demonstrated any validity, which is these groups can be classified as a homogenous party. The averages of experimental group's post-test on sub-category are greater in five categories except voluntariness and perseverance than the control group.

To confirm the statistical validity, t-test is again conducted and has resulted in no notable variations, which mean the SWH do not influence male students' scientific attitudes.

In Table 17 shows the summary of preliminary test of female students' scientific attitudes by sub-category. Female students can be classified as a homogenous as the experimental and control group has not shown any significant

Table 17

Pre- and post- test of female students' scientific attitudes on sub-categories

Sub-category	Tests	Groups	N	M	SD	t	*p*
Curiosity	Pre	Experimental	12	3.61	.67	1.342	.193
		Control	12	3.19	.83		
	Post	Experimental	12	3.72	.88	1.804	.085
		Control	12	3.16	.59		
Open mind	Pre	Experimental	12	3.75	.51	-.268	.791
		Control	12	3.80	.50		
	Post	Experimental	12	4.00	.53	2.842	.009*
		Control	12	3.30	.65		
Critical mind	Pre	Experimental	12	2.94	.66	1.604	.123
		Control	12	2.61	.27		
	Post	Experimental	12	3.75	.63	2.574	.017*
		Control	12	2.88	.96		
Co-operativity	Pre	Experimental	12	4.16	.54	-.561	.581
		Control	12	4.27	.42		
	Post	Experimental	12	4.19	.61	-.234	.817
		Control	12	4.25	.55		
Voluntariness	Pre	Experimental	12	3.63	.55	.479	.636
		Control	12	3.52	.57		
	Post	Experimental	12	3.86	.73	1.104	.281
		Control	12	3.58	.47		
Perseverance	Pre	Experimental	12	4.02	.50	.506	.618
		Control	12	3.88	.80		
	Post	Experimental	12	4.19	.54	1.186	.248
		Control	12	3.91	.60		
Creativity	Pre	Experimental	12	3.25	.62	.558	.583
		Control	12	3.13	.30		
	Post	Experimental	12	3.27	1.01	-.259	.798
		Control	12	3.36	.45		

*$p < .05$

difference. By analyzing the average of the post-test, except cooperativity and creativity, experimental groups has resulted greater in averages in five other categories. T-test is also progressed to establish the statistical validity. Between categories of open mind and critical mind have shown significant differences; however other categories, curiosity, cooperativity and voluntariness, perseverance and creativity have not shown such differences. Thus, SWH class is positively affecting female students' open mind and critical mind. It also demonstrates that female students are reconstructing their linguistic senses to a better standard of its interaction with other classmates. However, female students scientific attitudes tend to get negative and result in a performance gap compared to males as getting seniors (Kahle & Meece, 1999). Consequently, SWH teaching is the alternative method for enhancing students' performance in terms of concept formation in the class.

Ⅳ. Conclusions, Implications and Further Researches

1. Conclusions

The main points of our research are revealed as following conclusions with implications. First, the SWH class has positive influences on scientific concept formation. As a matter of fact the unit of mirrors and lens is somewhat abstract so that it is difficult for elementary students to understand that concept. The result suggests a strategic learning method to teachers to make an ease of such a subject abstract and demanding. SWH class is to help students to compose the meaning of the subject and to give a chance to express their thoughts in words.

Second, the SWH class has a positive effect on female students especially in enduring the formed concept for the longer time. Females are considered better in vocabulary than males are so they perform greater and solidify the scientific concept by expressing what they have learned in words in the SWH class.

Third, as female students seem to receive a positive attitudinal influence from the SWH class and to have more interests in writings, they have proven a significant impact on scientific attitudes in the sub-category of open mind and critical mind. This may be applied as a teaching method to remain them focused on the SWH class so that they can stay interested in shaping of scientific attitudes. Shaping scientific attitudes also leave them active and progressive in learning and help them forming the scientific concept.

2. Further researches

Our research implies some suggestions for further researches. First, there is a need to develop new materials or programs for male students to retain and to relate the formed concept with the scientific attitude. Second, this study is conducted on fifth graders so it could progress further and vary the object of the study into in-depth groups. Third, as the outcome of SWH class is useful materials to evaluate students' thought process and development of concept formation, it is vital to study on the standards of evaluation.

References

Bae, H. S., Jhun, Y. S. & Hong, J. E. (2009). The development of teaching and learning strategy for improving science process skills with science writing. *Journal of Korean Elementary Science Education*, 28(2), 178-186.

Chung, O. H., Hur, M. & Yeun, B. H. (1994). The development of elementary school chilerens's scale for measuring scientific attitudes. *Journal of the Korean Association for Science Education*, 14(3), 265-271.

Hand, B. M., Wallace, C. & Yang, E. M. (2004). Using a science writing heuristic to enhance learning outcomes from laboratory

activities in seventh-grade science: Quantitative and qualitative aspects. *International Journal of Science Education*, 26(2), 131-149.

Jee, Y. S. (2006). The effects of elementary students' science writing activities on 'Earth and Moon' unit. Unpublished master's dissertation, Gyeongin National University of Education.

Jeong, H., Jeong, Y. J. & Song, J. W. (2004). An analysis of writing by 11th grade students on the theme of light according to the type of task. *Journal of the Korean Association for Science Education*, 24(5), 1008-1017.

Jeong, H. S. & Han, Y. W. (2006). Effects of metacognitive learning strategy on elementary school students' conception acquisition of seasonal change and self-efficacy. *Journal of Korean Elementary Science Education*, 25(1), 39-50.

Jeon, H. J. (2006). Analysis on conception of elementary school students about mirror and lens. Unpublished master's dissertation, Busan National University of Education.

Joo, H. S. (1999). Effects of constructivistic learning strategy applied to concept mapping on biological concept leaning and scientific attitude. Unpublished doctoral dissertation, Chonbuk National University.

Kahle, J. B. & Meece, J. (1999). Research on gender issues in the classroom. In Gabel, D. L., *Handbook of Research on Science Teaching and Learning*. pp.542-557. New York: Macmillan Publishing Company.

Keys, C. W., Hand, B., Prain, V. & Collins, S. (1999). Using the science writing heuristic as a tool for learning from laboratory investigations in secondary science. *Journal of the Korean Association for Science Education*, 36(10), 1065-1084.

Kim, H. N., Chung, W. H. & Jeong, J. W. (1998). National assessment system development of science-related affective domain. *Journal of the Korean Association for Science Education*, 18(3), 357-369.

Lee, K. N. (2007). Effects of constructivistic learning strategy on middle school students' learning of scientific conception learning and scientific attitudes: focused on science writing. Unpublished doctoral dissertation, Chonbuk national university.

Nam, J. H., Kwak, K. H., Jang, K. H. & Hand, B. (2008). The implementation of argumentation using science writing heuristic(SWH) in middle school science. *Journal of the Korean Association for Science Education*, 28(8), 922-936.

O, W. G. (2003). Student's conceptions and constructivistic science education. *Bulletin of Science Education*, 19(1), 1-18. Science Education Center of Chungbuk National University.

Prain, V. & Hand, B. (1999). Students perceptions of writing for learning in secondary school science. *Science Education*, 83(2), 151-162.

Shin, Y. J., Hwang, H. O. & Park, H. W. (2009). Effect of the scientific writing through logical thinking development on science inquiry process skills and scientific attitude of elementary school students. *The Korean Journal of Biology Education*, 37(1), 151-161.