한국과학교육학회지, 29권 7호, pp. 783-791(2009. 11)   J Korea Assoc. Sci. Edu, Vol. 29, No. 7, pp. 783-791(2009. 11)

Students' Salivary Cortisol level and Emotional intensity vary by teacher's teaching style in Secondary School Science Class

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Abstract: This study was conducted to examine my hypothesis that how teacher's teaching style influences emotional and physiological states of students in the secondary school science classroom. Sixty healthy secondary school students were participated in this study and divided into two groups: manipulation and non-manipulation. Each group underwent different styles of teaching on the scientific hypothesis-generating of corn starch experiment. Before and after the class, the strength of emotion was measured using adjective emoticon check lists and they extracted their saliva sample for salivary hormone analysis. Here are the results of this study. First, the intensity of positive emotions in the manipulation group was significantly stronger than the one in the non-manipulation group, whereas the intensity of negative emotions in the non-manipulation group was significantly stronger than the one in the manipulation group. Second, the cortisol level, an indicator of stress, was decreased in the manipulation group whereas it was increased in non-manipulation group. Third, the quality of scientific hypotheses which is generated by students during the class had no connection with types of instructions. Fourth, this study found significantly negative correlation between students' emotional intensity of interest and concentration changes of salivary cortisol. Therefore, the different teaching styles have influence upon students' attitude and interest in science.

Key words: salivary cortisol, teaching style, emotional intensity, manipulation, non-manipulation

I. Introduction

Science is a key area of education, but many secondary students view it as an unattractive. It is such a notable and disconcerting reversal in that this attitude differ from the one of primary schooler who tend to regard science as one of the most enjoyable subjects (Kwak *et al.*, 2006). By the age of fourteen to nineteen, interest has waned, to be replaced by an abiding dislike of such topics as the Krebs cycle, periodic table and electromagnetic induction (Hadden & Johnstone, 1983; Kwak *et al.*, 2006). If it is so, why do they lose interest in science during secondary school despite it was their most favorite subject during primary school?

The science interested all over the world have made a ceaseless effort to change students' negative attitudes towards science and boost their interest in it. According to large-scale comparative studies like the IEA's TIMSS (Trends in International Mathematics and Science Study) or OECD's PISA (Programme for International Students Assessments), Korea and Japan tend to be ranked high in most international tests on students' achievement in science and mathematics. However, paradoxically, in spite of high scores on achievement testing, TIMSS and PISA data also indicate that Korean and Japanese students have more negative attitudes towards both science and mathematics than in any other (of the nearly 50) countries (Martin et al., 2008; OECD, 2007). Why does the ironical phenomenon happen? Why is it difficult to implant positive attitude and interest in students when we have provided inquiry-based science curricula and seen great improvement at achievement in science?

Major differences between primary and secondary science classes are 'learning by actual doing' and 'direct interaction with authentic environments.' One of the good examples is the traditional wet-experiment to which scientists do all the tasks by themselves (Bredderman, 1983; Pyatt & Sims, 2007). Most curricula of science

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**Received on 2 October 2009, Accepted on 23 October 2009

classes in the primary consist of 'hands-on and manipulative' inquiry science activities. Students participate them actively, and they are usually at the student-centered level. When they enter a secondary school, however, the majority of sciences classes turn into teacher's demonstration or simulation typed instructions such as an indirect and non-manipulaitive teaching style based on Information & Communication Technology (ICT), the virtual laboratory using movie clips or flash animations which are conducted in the online interface in a great part of science classes (MEST & KERIS, 2008). This is an inquiry-based science learning nevertheless participating just a mental way (Kwak *et al.*, 2005).

If it were true that the differences of students' attitudes and emotions towards science mentioned above are caused by their teachers' teaching styles in science classes after all, it would be a plausible explanation. Considering there is an interactive feedback loop system between emotional and physiological state changes, it would make the assumption even more reasonable (LeDoux, 1996; Rosenzweig *et al.*, 2005).

In the null hypothesis test, it was found that there exists no difference between the students' emotional intensity and their stress level associated with their teacher's teaching style in science classroom. Therefore, it is hypothesized that students' attitudes and interest in science might be associated with their teacher's teaching style in science classroom.

If this hypothesis is correct, the stress levels of students will be decreased after they perform experiments directly using their hands by themselves because their cortisol secretion was decreased. However, the stress levels of students will be increased after they undergo experiment indirectly using simulation type instruction (they DO NOT use their hands and perform only thought experiment) because their cortisol secretion was increased. After all, all these things will bring students either positive or negative emotions about learning subjects. Therefore, it has an influence upon students' attitudes and interest in science and academic achievements. The purpose of this study is to examine our hypothesis about students' emotions and stress related to teachers' teaching styles in science classroom by a physiological method.

Ⅱ. Methods and Procedure

1. Participants

Sixty healthy secondary school students (27 males and 33 females; mean age 16.83, range 16-17; 9-10th grades) were participated in this study. No participant had any history of neuro-physiological, psychiatric or other major medical illness. The participants and their parents gave informed consent to their participation in the study, which was approved by the Ethics Committee of KNUE (Korea National Univ. of Education). Participants were divided into two groups; the manipulation group and the non-manipulation group. Each group consisted of thirty persons. In this study, experiments were done by raters blind to the experimental-control status of participants. Also, to prevent Hawthorne effect (Adair, 1984), the participants blind to their group status. The two groups were even in terms of age and the scientific hypothesis generation ability of their participants (assessed by a questionnaire and HQ equation, Kwon *et al.*, 2007), and the participants were randomly assigned to one of two groups after the preliminary hypothesis-generating test. As such, this study found no significant difference regarding the participants' ability of hypothesis generation between the two groups, the manipulation group and the non-manipulation group ($p = 0.245$).

2. Two types of teaching styles as a classroom instruction

The inquiry based instruction focused on the scientific hypothesis-generating was performed in both classes. Students should generate their own hypothesis on the questioning phenomenon during instruction and fill out the activity worksheets. The instruction procedure and the worksheet form followed Kwon *et al.* (2006, 2009): It consisted of six steps: 1) observing a situation, 2) generating a causal question, 3) analyzing the question, 4) representing experienced phenomena, 5) causing representation and 6) constructing hypothesis. The corn starch experiment was used in this study (Habdas *et al.*, 2006). It is well-known science activity on the material property.

The manipulation group underwent the following teaching style (Kwon *et al.*, 2007): 1) mixing cornstarch and water and distribute samples of mixture in clear plastic cups (about a third to one half full) to groups of 4 to 5 students; 2) allowing enough time for free exploration and recording the observations of physical properties of the mixture by actual manipulation using their hands; 3) hypothesis-generating based upon the observed facts such as the property which looks like liquid and solid. However, the non-manipulation group underwent the following teaching style: 1) watching the video clip on the corn starch experiment (the same content and procedure as the manipulation group); 2) allowing enough time for free exploration and recording the observations of physical properties of the mixture by watching video clip; 3) hypothesis-generating based upon their observed facts such as the property which looks like liquid and solid.

3. Measuring quality of students' scientific hypotheses

Kwon *et al.* (2007)'s HQ equation: $HQ = \Sigma\{LE_n \times \Sigma(DL_n \times TH_n)\}$ was used in this study in order to measure and quantitate the quality of students' scientific hypothesis (abbreviation; HQ: hypothesis explanation quotient, LE: levels of explican, TH: types of hypothesis, DL: explican's degree of likeness, n: n^{th} explican). A more detailed scoring criterion of each term was followed Kwon *et al.* (2007). Then, HQ score was collected from the students' worksheets. A comparison of the HQ scores between two groups, the manipulation group and the non-manipulation group, was made to assess the difference associated with instruction types (teacher's teaching styles in science classroom).

4. Self-rating emotional intensity questionnaire

Before and after the instruction, each participant completed an emotional intensity questionnaire in which they rated the global intensity of seventeen different emotions they felt before and after the instruction, on a 5-point likert scale (0 = "no emotions at all" to 4 = "very intense emotions") (Fig. 1). The questionnaire (adjective emoticon check list) (Han *et al.*, 2004; Lee & Kwon, 2008) consist of 17-items of emotional states: basic emotion (acceptance, fear, expectancy, sadness, surprise, anger, disgust, joy)

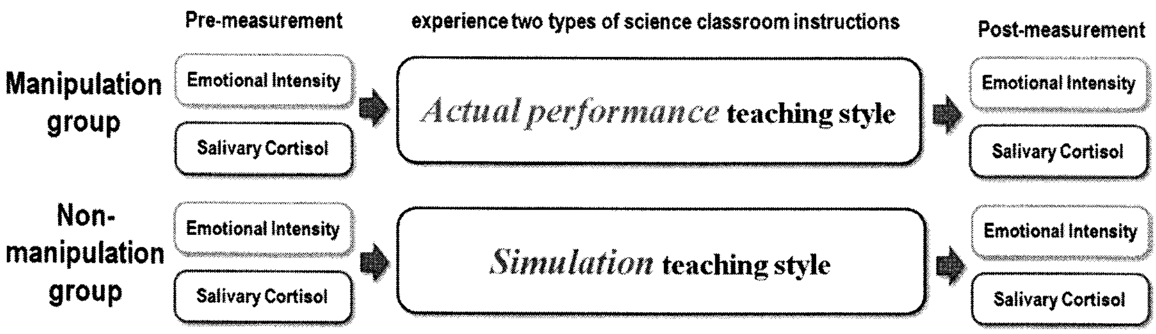

Fig. 1 *The experimental procedure (See text for a complete explanation).*

(Plutchick, 2003), primary dyad (love, astonishment, submission, remorse, contempt, disappointment, aggressiveness, optimism) and the other dyad (interest). Participants rated on a 5-point scale (0 = "not at all" to 4 = "very intense") the extent to which they felt each emotional state before and after the instruction.

5. Saliva collection and hormone determination

Before and after the instruction, salivary cortisol samples were collected twice using salivettes (Salimetrics, PA, USA) (Fig. 1). All materials were mailed to a researcher (unfrozen salivary cortisol samples are expected to be stable under these conditions; Clements & Parker, 1998). The sealed saliva samples were then frozen and delivered to Carlcam Laboratory (CarlCam Phamaceutical Co., Ltd., Seoul, Korea; www.carlcam.co.kr), where they were assayed to duplicate salivary cortisol using an enzyme immunoassay (EIA). Intra-and inter-assay variabilities were each less than 10%.

6. Statistical analysis

The SPSS 12.0 for Windows statistical package (SPSS Inc., Chicago, IL, USA) was used for data (saliva cotisol level, emotional intensity and HQ scores) analysis. Significant differences in saliva cotisol level, emotional intensity and HQ scores were assessed separately using analysis of variance (ANOVA).

Ⅲ. Results

1. Hypothesis explanation quotient

In the results of students' scientific hypotheses quality analysis, all of the participants successfully generated scientific hypotheses. The mean score of the manipulation group was 4.96 (SD = 3.67) whereas the mean score of the non-manipulation group was 5.43 (SD = 3.95). Fig. 2 shows the variation of the means of HQ scores for two groups. Although HQ scores of the non-manipulation group were higher than the manipulation group, there was no significant difference between two groups in quality of scientific hypotheses (p = 0.458).

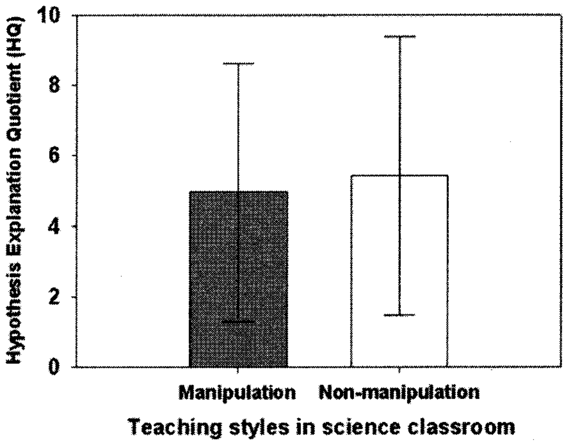

Fig. 2 *Variation of the mean of hypothesis explanation quotient (HQ) for students' hypotheses during the classes. Dark-gray boxes indicate the mean score of 'manipulation group' and white boxes indicate the mean score of 'non-manipulation group'. Values are the mean and standard deviation.*

2. Emotional intensity

The emotional intensity comparison was conducted to two groups between pre and post phases of instruction using an emotional intensity questionnaire. The emotional intensity of most students was significantly changed after the class excluding the 'submission' (Table1). On the post phase, the emotional intensity of positive emotions (acceptance, expectancy, surprise, joy, love, astonishment, optimism) was increased significantly higher in the manipulation group than in the non-manipulation group, and negative emotions (fear, sadness, anger, disgust, submission, remorse, contempt, aggressiveness, disappointment) were vice versa. In contrast, the emotional intensity of positive emotions was decreased significantly lower in the non-manipulation group than in the manipulation group, and negative emotions were vice versa. More details are shown in Table 1.

3. Salivary cortisol level

The salivary cortisol level comparison was conducted to two groups between pre and post phases of the instruction. The salivary cortisol level changes of the manipulation group on the post phase were increased significantly higher than those of the non-manipulation group. After the hypothesis-generating class, the ANOVA results for the salivary cortisol level in the

Table 1

Students' emotional intensity changes after classes

Emotion types	Phase	Group		*F*	*P*
		Manipulation	Non-manipulation		
Acceptance	Pre	2.53±1.01	2.31±1.12	1.269	0.262
	Post	3.02±1.15	1.56±1.08	51.201	0.000
Fear	Pre	1.37±1.11	1.50±1.17	0.374	0.542
	Post	0.56±0.90	1.42±1.33	17.319	0.000
Expectancy	Pre	2.88±1.20	2.71±1.22	0.606	0.438
	Post	2.95±1.25	1.39±1.22	48.349	0.000
Sadness	Pre	0.56±0.94	0.47±0.92	0.269	0.588
	Post	0.42±0.79	1.27±1.99	21.199	0.000
Love	Pre	1.32±1.29	0.94±1.11	3.114	0.080
	Post	1.81±1.56	0.65±0.87	26.243	0.000
Submission	Pre	0.66±1.11	0.58±1.08	0.163	0.687
	Post	0.58±1.09	0.66±1.05	0.191	0.663
Astonishment	Pre	1.15±1.17	1.52±1.51	2.170	0.143
	Post	1.85±1.30	0.95±1.17	16.166	0.000
Disappointment	Pre	0.76±0.95	0.68±0.97	0.237	0.627
	Post	0.51±0.82	1.78±1.42	35.668	0.000
Interest	Pre	2.78±1.10	2.47±0.99	2.701	0.103
	Post	3.41±0.90	1.73±1.38	62.527	0.000
Disgust	Pre	0.83±1.04	1.31±1.15	5.680	0.019
	Post	0.34±0.66	1.92±1.52	54.187	0.000
Anger	Pre	0.44±0.91	0.69±1.05	1.988	0.161
	Post	0.25±0.73	1.08±1.30	18.365	0.000
Surprise	Pre	1.59±1.08	1.37±1.23	1.106	0.295
	Post	2.27±1.41	1.19±1.21	20.346	0.000
Joy	Pre	1.85±1.03	1.87±1.21	0.013	0.909
	Post	3.03±0.96	1.32±1.08	83.963	0.000
Remorse	Pre	0.78±1.07	1.00±1.27	1.064	0.304
	Post	0.75±0.92	1.24±1.56	4.506	0.036
Contempt	Pre	0.38±0.85	0.60±1.05	1.659	0.200
	Post	0.15±0.45	0.71±1.15	12.085	0.001
Aggressiveness	Pre	0.32±0.78	0.63±1.03	3.413	0.067
	Post	0.20±0.58	0.79±1.13	12.668	0.001
Optimism	Pre	2.24±1.17	2.26±1.04	0.011	0.918
	Post	2.83±1.04	1.18±1.05	76.001	0.000

Note. Mean±S.D. (Standard deviation).

manipulation group [F(1, 119) = 0.039, $p < 0.001$] revealed a significant difference between two groups on the post phase as shown in Fig. 3. And, the salivary cortisol level changes of the manipulation group on the post phase were decreased significantly lower than those of the non-manipulation group (p = 0.002; Paired t-test). But, in the case of the non-manipulation group, their salivary cortisol levels were increased significantly higher than those of the non-manipulation group (p = 0.01; Paired t-test).

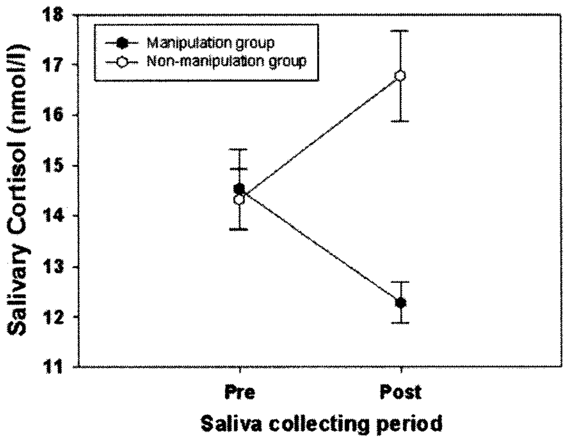

Fig. 3 *Variation of the mean of salivary cortisol level changes during the classes. Black hexagons indicate the mean score of 'manipulation group' and white hexagons indicate the mean score of 'non-manipulation group'. Pre = before instruction, Post = after instruction. Values are the mean and standard error of mean.*

4. Correlations

This study also conducted correlations between the emotional intensity and the salivary cortisol level change (pre – post cortisol level). In this study, we found a significant negative correlation between interestandthesalivarycortisollevelchange (r = −0.45, $p < 0.001$) during the classes. However, other emotions were not significantly correlated with salivary cortisol level changes. Scatter plot of the emotional intensity and concentration changes of salivary cortisol are displayed in Fig. 4.

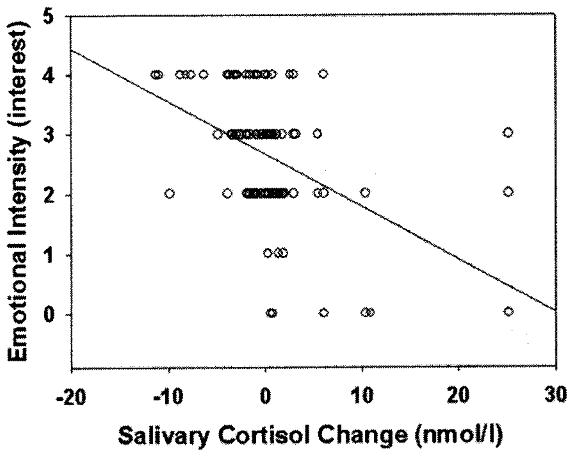

Fig. 4 *Depicted are scatter-plots and trend-lines from the correlations between the emotional intensity of interest and the concentration changes of salivary cortisol from two groups (manipulation and non-manipulation) and two phases (pre and post instruction).*

Ⅳ. Discussion

According to our findings, some significant emotional and physiological changes were found after students underwent the instruction between the manipulation group in which the students performed the experiment directly using their hands by themselves (hands-on activity and wet-experiment during the inquiry) and non-manipulation group in which the students underwent the experiment indirectly using simulation such as moving picture demonstration [thought and dry-experiment only during the inquiry (Galili, 2009)]. But, there was no significant difference between two groups in quality of scientific hypotheses (Fig. 2).

In the manipulation group, positive emotions were increased, and negative emotions were decreased significantly at the post phase (Table 1). The concentration of cortisol which is well-known stress indicating hormone was (Bassett *et al.*, 1987; Kirschbaum & Hellhammer, 1989) decreased significantly, too. However, in the non-manipulation group, negative emotions were increased and positive emotions were decreased significantly at the post phase (Table 1). The concentration of cortisol was increased significantly after they experienced the instruction (Fig 3).

It is consistent to the results of previous studies (Foley & McPhee, 2008; Jaus, 1977; Kwon & Lawson, 1999; Pyatt & Sims, 2007). Particularly, interest was negatively correlated with cortisol level changes which is a stress indicator (Bassett *et al.*, 1987; Kirschbaum & Hellhammer, 1989) out of many positive emotions (Fig. 4). No matter how we try to teach our student by an inquiry-based learning style, indirect teaching style such as simulation and demonstration types of instruction bring about more stress to students. Consequently, experiencing repetitive physical condition like this, students will have more to negative emotions and attitudes towards science. That is why they have lost interest in science during secondary school despite science was their most favorite subject during primary school. In other words, two different types of teaching styles (manipulation and non-manipulation) make no difference in cognitive products such as the quality of scientific hypotheses (i.e. academic achievement). However, they make significant differences in emotional and physiological aspects, and then it has influence upon the students' motivation in the science classroom in the future.

In addition, there are *"fight or flight"* responses in the endocrinology and ethology (LeDoux, 1996). This is the body's response to perceived threat or danger. During this reaction, certain hormones like adrenalin and cortisol are released, speeding the heart rate, slowing digestion, shunting blood flow to major muscle groups, and changing various other autonomic nervous functions, and giving the body a burst of energy and strength. Originally named for its ability to enable us to physically fight or run away (flight) when faced with danger, it's now activated in situations where neither response is appropriate, like in traffic or during a stressful day at work. When the perceived threat is gone, systems are designed to return to normal function via the relaxation response, but in our times of chronic stress, this often doesn't happen enough, causing damage to the body (Cannon,1914). Therefore, continuous and too much concentration of cortisol secretions will be students act on the *'flight'* response in the next time. In other words, they become disgusted with science.

Nowadays, IT innovation lets students meet ICT-based tutorial (named cyber or *e*-learning) in any subject (MEST & KERIS, 2008) more frequently. Teachers' demonstration is also conducting on behalf of the whole students in the class students owing to temporal limits and too many students per teacher in secondary schools' science class (Pyatt & Sims, 2007). The results of this study suggested that students who have been continuously experienced these types of teaching style will lose their interest in science and show negative attitudes towards it. Therefore, students' actual manipulation experiences, *'Learning by doing'* as John Dewey has said once (Bot *et al.*, 2005; Dewey, 1910/1964), is the most important thing to make more interesting science classes.

V. Conclusion and Implications

This study was conducted to examine our hypothesis that how teacher's teaching style influences emotional and physiological states of students in the secondary school science classroom (inquiry part). The following is the conclusion we could get across this study.

First, after they underwent the instruction, the intensity of positive emotions was significantly stronger than the non-manipulation group in the manipulation group, whereas intensity of negative emotions was significantly stronger than the manipulation group in the non-manipulation group.

Second, after students underwent the instruction, the cortisol level an indicator of stress, was decreased in the manipulation group whereas it was increased in the non-manipulation group.

Third, the quality of scientific hypotheses which is generated by students during the class has no connection with instruction types. Of course, there are significant differences between a student-centered knowledge generating (inquiry) type instruction and a teacher-centered traditional expository instruction in the quality of students' generated scientific knowledge. However, in this study, both classes were student-centered, and the instruction form was inquiry-based. Therefore, there was no significant difference between two groups in quality of scientific hypotheses.

Fourth, this study found a significant negative correlation between students' emotional intensity of interest and concentration changes of salivary cortisol. It means that a physiological state change of students has influence upon their emotional state and intensity.

How should we educate students in order to inspire them to have more interest in science and to be passionative scientists in the future? In this context, we should take mouses, keyboards, and beam projectors away from them and increase more classical inquiry classes based upon students' actual manipulation such as hands-on activities in the future science classroom rather than simulation and demonstration based classes.

References

Adair, G. (1984). The Hawthorne effect: A reconsideration of the methodological artifact. Journal of Applied Psychology, 20, 334-345.

Bassett, J. R., Marshall, P. M., & Spillane, R. (1987). The physiological measurement of acute stress (public speaking) in bank employees. International Journal of Psychobiology, 5, 265 73.

Bot, L., Gossiaux, P. B., Rauch, C. P., & Tabiou, S. (2005). 'Learning by doing': A teaching method for active learning in scientific graduate education. European Journal of Engineering Education, 30(1), 105-119.

Bredderman, T. (1983). Effect of activity-based elementary science on student outcomes: A quantitative synthesis. Review of Educational Research, 53, 499-518.

Cannon, W. B. (1914). The emergency function of the adrenal medulla in pain and the major emotions. American Journal of Physiology, 33, 356-372.

Clements, A. D., & Parker, C. R. (1998). The relationship between salivary cortisol concentrations in frozen versus mailed samples. Psychoneuroendocrinology, 23, 613-616.

Dewey, J. (1910/1964). Science as subject matter and as method. In R. D. Archambault (Ed.) John Dewey on Education. Chicago: University of Chicago press, 182-192.

Foley, B. J., & McPhee, C. (2008). Students' attitudes towards science in classes using hands-on or textbook based curriculum. Paper presented at AERA 2008, NewYork, NY

Galili, I. (2009). Thought experiments: Determining their meaning. Science & Education, 18,1-23.

Habdas, P., Weeks, E. R. & Lynn, G. D. (2006). Squishy materials. The Physics Teacher, 44(5), 276-279.

Hadden, R. A., & Johnstone, A. H. (1983). Secondary school pupil's attitudes to science: the years of erosion. European Journal of science education, 5, 309-318.

Han, H., Shin, D., Lee, H. & Kwon, Y. (2004). The Development of an analysis tool on emotion words for Measuring of Scientific Emotion. A paper presented at the ASERA 2004 35th Annual Conference, Armidale, New South Wales, 7th-10th, July.

Jaus, H. H. (1977). Activity-oriented science: Is it really that good? Science and Children, 14(7), 26-27.

Kirschbaum, C., & Hellhammer, D. H. (1989). Salivary cortisol in psychobiological research: an overview. Neuropsychobiology, 22, 150 69.

Kwak, Y., Kim, C. J., Lee, Y. R., & Jeong, D. S. (2006). Investigation on elementary and secondary students' interest in science. Journal of Korean Earth Science Society, 27(3), 260-268.

Kwon, Y. J., & Lawson, A. E. (1999). Why do most science educators encourage to teach school science through lab-based instruction?: A neurological explanation. Journal of Korean Association for Research in Science Education, 19(1), 29-40.

Kwon, Y. J., Jeong, J. S., & Park, Y. B. (2006). Roles of abductive reasoning and prior belief in children's generation of hypotheses about pendulum motion. Science & Education, 15, 643-656.

Kwon, Y. J., Lee, J. K., & Jeong, J. S. (2007). Explanation patterns of biological hypotheses generated by science high school students in starch experiments. Secondary Education Research, 55, 275-298.

Kwon, Y. J., Lee, J. K., Shin, D. H., & Jeong, J. S. (2009). Changes in brain activation induced by the training of hypothesis generation skills: An fMRI study. Brain and Cognition, 69, 391-397.

LeDoux, J. E. (1996). The emotional brain: the mysterious underpinning of emotional life. NY: Touchstone.

Lee, J. K., & Kwon, Y. J. (2008). Types of emotion during the hypothesis-generating and hypothesis-understanding process on the biological phenomena. Secondary Education Research, 56(3), 1-36.

Martin, M. O., Mullis, I. V. S., and Foy, P. (2008). TIMSS 2007 International Science Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades. Chestnut Hill, MA: Boston College.

MEST, & KERIS (2008). Adapting Education to the Information Age: White Paper. Seoul: KERIS.

OECD (2007). Programme for International Student Assessment (PISA) 2006 Science Competencies for Tomorrow's World, Vol. 1. Organization for Economic Co-operation Development: Paris, FR.

Pine, J. Aschbacher, P., Roth, E., Jones, M., McPhee, C., Martin, C., Phelps, S., Kyle, T. & Foley, B. (2006). Fifth graders' science inquiry abilities: A comparative study of students in hands-on and textbook curricula. Journal of Research in Science Teaching, 43(5), 467-484.

Plutchik, R. (2003). Emotions and Life: Perspectives from psychology, Biology, and Evolution. American Psychological Association. Washington, DC.

Pyatt, K., & Sims, R. (2007). Learner performance and attitudes in traditional versus simulated laboratory experiences. In ICT: Providing choices for learners and learning. Proceedings ascilite Singapore 2007.

Rosenzweig, M. R., Breedlove, S. M. & Watson, N. V. (2005). Biological psychology: an introduction to behavioral and cognitive neuroscience, 4th Ed, Sinauer associate, Inc.

Shon, M. (2001). Demonstrations of lessons: Teaching authentic inquiry in science lessons. Asia Pacific Education Review, 2(2), 35-44.