한국과학교육학회지, 32권 8호, pp. 1367~1377(2012. 10)　　J Korea Assoc. Sci. Edu, Vol. 32, No. 8, pp. 1367~1377(2012. 10)

Analysis of Inquiry Activities in High School Biology Textbooks Used in China and Korea

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Abstract: Inquiry activity is a major source of student investigation which both of the national curriculum standards strongly emphasize for achieving scientific literacy. The purpose of this study was to examine inquiry activities incorporated in high school biology textbooks used in China and Korea. The inquiry activities were examined with regard to inquiry level and science process skills. Bell's and a modification of Padilla's framework were used in these analyses. Results show that the Korean textbooks were more exclusively occupied by simple inquiry activities - None of them provided activity more complex than level 2 inquiry. In addition, the Korean textbooks had uniformly basic science process skills, whereas their Chinese counterparts gave students some challenges for higher level process skills. Therefore, it cannot be guaranteed that the activities in the Korean textbooks are helpful in guiding students toward a gradual progression to high-level inquiry. Implications for inquiry-based science education were suggested based on the results of the study.

Key words: school science, biology textbook, inquiry activity, China

Introduction

China and Korea, as East Asian neighbors, have increased their exchange in many areas, especially in economy and culture. Their cooperation in academic research has also expanded recently. In this mood, better understanding of the other side's science education will contribute to facilitating collaboration between science educators. In addition, too many different conditions from target country may be barrier to have implications through comparative study. China, however, has lots of educational factors in common with Korea, for example, school year system, highly centralized curriculum system, and eastern cultural background that favors social and emotional support and consensus building, rather tan logical arguments and criticism required to educate science (Lee, 1997). Therefore, this study will help to aware their own weakness that can be overcome and to strengthen their strong points.

This study focused on inquiry activity in high school. Science educators continue to suggest that engaging students in processes of investigation and inquiry can be an important opportunity for instruction of central conceptual and procedural knowledge and skills in science (Hofstein and Lunetta, 2004). Both the Chinese 8th National Biology Curriculum Standards for High School (CBCS) and the Korean 7th National Science Curriculum Standards (KSCS) strongly promote the use of an inquiry-oriented approach in biology instruction which emphasizes problem solving and critical thinking in a real-world context. They both advocate “inquiry” in order for all students to foster scientific literacy (MOEC, 2003; MOEK, 1997). In this context, it is important to investigate inquiry activities in their textbooks, because science textbooks continue to be a major component of science instruction throughout nation, and are used frequently in science classrooms (Hams and Yager, 1981).

Our approach to analyze inquiry activity incorporated in high school biology textbooks used in China and Korea was to examine their levels of inquiry activities, and investigate science process skills they covered. Defining

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**Received on 31 July 2012, Accepted on 29 September 2012

inquiry and assessing how much inquiry is supported by a particular inquiry activity can be difficult and confusing (Bell *et al.*, 2005). The concept of different levels of inquiry was first described by Schwab (1962). Recently, Bell, Smetana, and Binns presented a modified framework to assess the level of inquiry, based on the amount of information provided to the student. Science process skills are the sequence of events that are engaged by researchers while taking part in a scientific investigation. Science educators hold the belief that the acquisition of these skills will better enable students to solve problems, to learn on their own, and to appreciate science (Chiappetta, 1997). The process skills are classified into basic process skills and integrated process skills. The former are the prerequisites to the latter, and they provide the intellectual groundwork in scientific inquiry. The integrated skills are the terminal skills for solving problems or doing science experiments (Beautmont-Walters & Soyibi, 2001).

This investigation sought to answer the following questions:

1. Can the students of both nations be expected to progress gradually from lower to higher level inquiry investigations over their years of high school?
2. Can the inquiry activities of both nations help students develop science process skills to conduct higher level inquiries?

Description of Chinese Science Curriculum

The Chinese government pushed drastic reform in the education curriculum in 2001. This includes the changes in the system, structure and content of the curriculum to fulfill the needs of compulsory education of China. The designers of the 8th national curriculum reform came to a common understanding on the need for constructing an 'integrative learner-oriented curriculum', and advocated the education for all students, not just for future experts and leaders, to prepare qualified future citizens.

The Ministry of Education issued biology curriculum standards for high school (CBCS) in 2003. It is composed of core and elective courses. The three core courses are for all students: Biology 1 (molecule & cell), Biology 2 (genetics & evolution), and Biology 3 (homeostasis & environment). The three elective courses are mainly about biotechnology. The Ministry of Education specifies overall curriculum organization and the timetable arrangement for school subjects, but local governments and schools have more discretion than before. Therefore, there are slight differences in operating the curriculum depending on regions.

Inquiry is a critical component in CBCS. It is likely that one of the main purposes for promoting inquiry-based science instruction is for students to understand scientific concepts: "Inquiry is one of the effective methods for students to understand the world of life and to learn biology". Another purpose of the curriculum designers may be for students to develop the skills and the disposition to use them which is necessary to become independent inquirers about the world: "…learn the method through which the knowledge is acquired so that students can improve problem solving ability" (MOEC, 2003).

Methods

Data Sources

Four textbooks were used in this study. All of their inquiry activities were provided within textbooks, without a companion laboratory manual. Science 9, despite being a textbook for middle school, was also included because it is the only subject provides Mendelian genetics in the secondary education of Korea.

Five topics in the four textbooks were selected for this study, because they not only were regarded as fundamental concepts in high school biology, but also were determined to be

Title	Author	Publisher	Year	Code
Chinese textbooks				
Biology 1-3	朱正威/ 趙占良	People's Education Press	2007	Renmin
Biology 1-3	吳相鈺/ 劉恩山	浙江科學技術出版社	2005	Zhejiang
Korean textbooks				
Science 9	Lee *et al*.	Kumsung Publishing Co	2008	Kumsung
Science 9	Lee *et al*.	Jihak Publishing Co.	2008	Jihak
Biology II	Park *et al*.	Kumsung Publishing Co.	2009	Kumsung
Biology II	Lee *et al*.	Jihak Publishing Co.	2010	Jihak

The textbooks selected for analysis were those widely used in each country.

important by high school biology teachers (Stewart, 1982).

- Photosynthesis
- Cellular respiration
- Mendelian genetics
- Cell division
- DNA

Analysis of Inquiry Levels

Invitations to inquiry exist in varying degrees. Different levels of inquiry, the concept of which was first described by Schwab (1962), can be classified depending on the level of openness (Bell *et al*. 2005; McComas 2005; NRC 2000). An instrument, revised by Bell *et al*., describes a simple model that includes four inquiry levels varying in the amount of information provided to the student. The lowest level is defined by strongly teacher-directed instructions given to the student. At the highest level, all stages of inquiry remain "open" - Student must pose an inquiry question, choose methods, and find a solution. Table 1 shows the four levels of inquiry

Table 1

Four-level model of inquiry produced by Bell et al.

Level of inquiry	Question	Methods	Solution
1 (confirmation)	O	O	O
2 (structured)	O	O	
3 (guided)	O		
4 (open)			

Note. The O marks what is provided by the teacher

are: confirmation inquiry, structured inquiry, guided inquiry, and open inquiry (Bell *et al*., 2005). We used this framework for evaluating inquiry activities.

The character of inquiry activity can be classified into two types; wet labs in which students use materials and equipment, the opposite of them are dry labs, also called paper and pencil activities (Germann *et al*., 1996). Because the major form of dry labs in the textbooks of the two nations is somewhat simple; a set of data with a graph or a table and some related questions, they are not suited for Bell's analysis framework. Therefore, the analysis of inquiry level was confined to the wet labs in this study.

Analysis of Science Process Skills

Most commonly cited science process skills are observing, classifying, space/time relations, using numbers, measuring, inferring, predicting, defining operationally, formulating models, controlling variables, interpreting data, hypothesizing, and experimenting (Chiappetta et al., 1998). However, the above components could not cover all of the process skills provided in the four textbooks of the two countries, so we modified them for a detailed and "customized" analysis. Table 2 presents a list of science process skills examined in this study. Not only wet labs but also dry labs were examined in this analysis.

Table 2
Science process skills

<table>
<tr><th>Process Skill</th><th>Definition and Sample</th></tr>
<tr><td>Observing</td><td>–noting the properties of objects and situations using the five senses</td></tr>
<tr><td>Classifying</td><td>–relating objects and events according to their properties or attributes</td></tr>
<tr><td>Measuring</td><td>–expressing the amount of an object in quantitative terms</td></tr>
<tr><td>Calculating</td><td>–using quantitative relationships</td></tr>
<tr><td>Inferring</td><td>–giving an explanation for a particular object or event
· "What is the relationship between the number of cells observed in each mitotic stage and duration of each stage?" (Jihak, p103)</td></tr>
<tr><td>Predicting</td><td>–forecasting a future occurrence based on past observation or the extension of data</td></tr>
<tr><td>Judging about experiment*</td><td>–interpreting/explaining/making a decision about experimental technique
· "Why was a container of water placed between the light source and the water plant?" (Jihak, p61)</td></tr>
<tr><td>Recording results</td><td>–recording, describing or drawing results verbally, in writing, or by drawing pictures, filling out blank cells from table
· "Record your observations in this data table." (Jihak, p61)
<table>
<tr><td>Distance(cm)</td><td>50</td><td>40</td><td>30</td><td>20</td><td>10</td></tr>
<tr><td>Number of bubbles</td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>Manipulating apparatus*</td><td>–selecting appropriate materials for the experiment to be done and set up the experimental apparatus accordingly.
· "Add water to test tube and a pinch of baking soda." (Jihak, p61)</td></tr>
<tr><td>Transforming data*</td><td>–transforming data into graphs and tables</td></tr>
<tr><td>Interpreting data</td><td>–arriving at explanations, inferences, or hypotheses from data, interpreting data statistically, identifying human mistakes and experimental errors
· "If Mendel had performed statistical analysis using data of just 10 pea plants at that time, could he have understood the law of segregation correctly?" (Renmin, Bioloy 2, p6)</td></tr>
<tr><td>Identifying/ Posing questions*</td><td>–identifying questions to be answered or problems to be solved</td></tr>
<tr><td>Formulating hypothesis</td><td>–stating a tentative generalization of observations or inferences that may be used to explain a relatively larger number of events</td></tr>
<tr><td>Identifying/ Controlling variables</td><td>–determining all the variables in an experiment</td></tr>
<tr><td>Designing an experiment*</td><td>–designing an experiment by identifying materials and describing appropriate steps in a procedure to test a hypothesis
· "What are possible environmental factors that affect photosynthesis? Select one and design experiment to see if it affects photosynthesis." (Renmin, Biology 1 p105)</td></tr>
<tr><td>Drawing conclusions*</td><td>–formulating conclusions</td></tr>
</table>

Process Skill	Definition and Example
Formulating models	–constructing images, objects, or mathematical formulas to explain ideas
Reporting/ Arguing*	–communicating to share their observations with someone else, try to convince someone by laying out a logical basis · "Using clear and scientific terms, report about your group's result and conclusion to your whole class." (Renmin, Biology 1 p92)
Evaluating*	–evaluating experimental design, recommending further testing where necessary · "What is the brilliant part of Engelmann's experiment?" (Renmin, Biology 1 p100)
Experimenting	–carrying out an experiment without any directions about method · "Conduct an investigation using procedures your group designed" (Zhejiang, Biology 1 p95)

* appended in this study

Results

Overview of Inquiry activities

Examining of the inquiry activities shows that there is a distinct difference between the two nations. Table 3 depicts the distribution of wet and dry labs. The most outstanding feature is that the Korean textbooks offered more dry labs (i.e., paper and pencil tasks) than wet labs. In contrast, the Renmin contained 69% wet labs, and the Zhejiang designed most of their inquiry activities in the form of wet labs. One of the reasons why Korean textbooks have higher percentage of dry labs, in other words, reducing the number of wet labs which require much time, might be that wet labs can be burdensome for both students and teachers, because the main target students of Biology II are those of science stream and they usually take the course in their last year of high school, when they have to prepare for university entrance examination.

However, more time-consuming is not likely to be a conceivable reason for many dry labs of the Korean textbooks, because the topic of Mendelian genetics which students learn in the third year of middle school, regardless of publisher, also had more dry labs. A more convincing explanation for the high frequency of dry labs in the Korean textbooks is as follows. Most textbook publishers are not free from pages limits, although "inquiry" is extremely stressed in their curriculum, so they reorganized the knowledge contents, which are usually in the form of descriptive explanations in the Chinese textbooks, into the format of dry labs under the

Table 3
The distribution of wet and dry labs

Textbook	Number of inquiry activity		
	Wet lab	Dry lab	Total
Renmin	9	4	13
Zhejiang	9	1	10
Kumsung	4	13	17
Jihak	8	12	20

title of "Inquiry". The dry labs, in many cases, covered many famous experiments throughout the history of biology, where students were asked to answer about the experiment by predicting the result, interpreting data, and drawing conclusion. Students were expected to develop their inquiry skills by participating in the process of experiments scientists conducted in the past. Benefits of the form of dry labs in the Korean textbooks can work in two ways: on the one hand, publishers can align their textbooks with national standards that emphasize "inquiry". On the other hand, scientific facts and ideas are subject to become boring, by processing them into inquiry format instead of lengthy explanation, students can get motivated to learn science.

Analysis of Inquiry Levels

Table 4 shows the inquiry levels of the wet labs in the five topics. The findings indicate that majority of the activities invited students to participate in low levels of inquiry: Most of them were either level 1 confirmation or level 2 where students were given step by step procedures to

Table 4

Evaluation of levels of inquiry for wet labs presented in the five topics

	Levels of inquiry			
Topics of inquiry activity	Ren-min	Zhe-jiang	Kum-sung	Ji-hak
Cellular respiration				
Alcoholic fermentation in yeast		(De)	2	
Cellular respiration in yeast	3*			
Measuring respiration rate				2
Photosynthesis				
Separating leaf pigments	2	2		2
Effect of light intensity on photosynthesis				2
Effect of environmental factors on photosynthesis	3*	3		
Mendelian Genetics				
Simulation of monohybrid cross	1	1	1, 1[c]	1
Simulation of dihybrid cross		2		
Simulation of dihybrid test cross		1		
Cell Division				
Investigating the limits of cell growth	2			
Observing mitosis	1	2[a],1[b]	2	2
Observing meiosis	1			2
Simulating chromosome behavior in meiosis	2	2		
DNA				
DNA extraction				2
Constructing a model of DNA	N/A	N/A		1

Demonstration; [a] observing permanent slides of mitosis; [b] making a temporary mount of onion root tip for mitosis; [c] Computer-based; * attached level 2 as an guiding example to level 3 activity; N/A refers to activity not appropriate to be classified: What is open to students in constructing a model of DNA is only procedure, while question and the answer are already provided.

follow and defined problems to investigate. Neither Kumsung nor Jihak provided more than level 3 inquiry. It means that there was no opportunity for students to design their own procedures and to choose their own problem to investigate. In contrast, students, although not very often, are allowed to have greater responsibility in Renmin and Zhejiang: a few inquiry activities were determined at level 3. But unlike Zhejiang, the level 3 activities of Renmin attached a couple of examples of designing an experiment including its procedures as references by which students can be guided, therefore it is likely that the activities is bound to drop to level 2 in actual classroom practice, rather than level 3 which is probably the original intent of the textbook author.

The level 3 inquiries in the Chinese textbooks organized students' investigation in small groups. Different groups of students began with a testable question which was posed by author. They approached the question by testing different independent variables, for example, each group was asked to investigate different factors affecting the rate of photosynthesis, formulate hypothesis, and then design their own procedures. Students need to share their findings with peers when they have class presentation. Students can develop teamwork skills through such a small group activity: foster collaboration as well as competition; develop students' confidence and active participation in learning; lead to creative and innovative solutions to problems; give students a chance to perform a number of different roles.

Analysis of Science Process Skills

Figure 1 presents the frequency of the science process skills. The process skill ranked at number one, if we leave the skill of manipulating apparatus out of consideration, is different

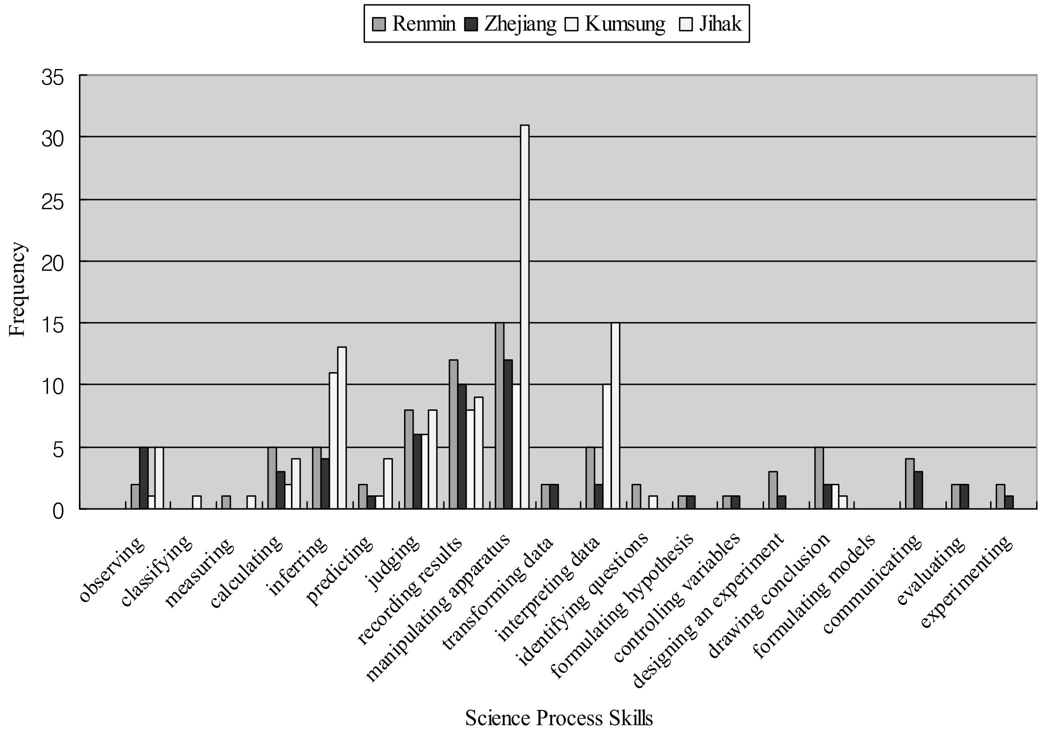

Fig. 1 *The distribution of science process skills*

between the two nations, and this is a natural consequence caused by the difference of their main type of inquiry activity. The major form in dry labs which are frequently seen in the Korean textbooks is that students are given a set of data with a graph or a table first and then asked to answer cause and effect relationship, to make prediction or inference based upon the data. The process skill that is most often found, therefore, was analyzing/interpreting data. On the other hand, Chinese textbooks with more wet labs ask students if they understand the results of the experiment, so it is natural that the process skill "recording/describing/drawing results" took the first place. Although the skill of analyzing/interpreting data were found in both nations, the Korean textbooks offered it in easier ways, in other words, they asked students to use lower order analysis skills (e.g., determining qualitative and quantitative relationships within the data), while Renmin provided higher level skills (e.g., interpreting data statistically, identifying experimental errors).

Judging about experiment, the process skill usually used in wet labs, was not uncommon, because the absolute number of wet labs was similar between the two, except for Kumsung. Without the skill, students would not have had chance to be asked to perform inferring, explaining and making a decision about experimental technique or procedures, thereby they just follow directions without any understanding of why they are done. It is fortunate that the frequency of this process skill was not low in that it will help to reduce the risk that school science classes may degenerate into "cookbook labs".

Although the KSCS emphasizes team work skills and communication in inquiry activity, none of the Korean textbooks examined in this study reflected their curricular objectives, whereas these skills were not neglected in their Chinese counterparts. Renmin asked students brief discussion about results of experiments, and some argumentation while designing an experiment in their level 3 inquiry activities as well as dry labs. Zhejiang also offered the communication skills: Students needed to express what they learned after their experiment and report to their classes in the activity of constructing a model of DNA by using his/her own materials.

The integrated process skills such as formulating hypotheses, controlling variables, designing experiment, and experimenting were extremely rare in the Chinese textbooks, and almost zero in the Korean textbooks. The process skill of formulating models could not be found anywhere in the textbooks of the two nations.

Discussion

As the result of the analysis of inquiry levels have shown, most of the inquiry activities of the four textbooks are at lower levels of inquiry. Although those activities examined in this study are only a small part of the whole, they are not insufficient to notice the textbook's trend. Most science educators would agree that school-based science inquiry has broad purposes, and one of them is deep understanding of the knowledge of science. Guided inquiry (i.e., lower level activity) can best focus learning on the development of particular facts and concepts of science, while more open inquiry will afford the best opportunities for cognitive development and scientific reasoning (NRC, 2000). Both the CBCS and KSCS consider the understanding of scientific knowledge as a great merit of inquiry learning, rather than cognitive development and scientific reasoning, as noted in the analysis of the two national standards (Kim, 2011). Therefore, it is not surprising that they had so many level 1 and level 2 inquiry activities. The authors of the four textbooks, in this sense, faithfully reflected their curriculum intent.

However, the learning about nature of science and scientific inquiry is also the crucial objective of school science activity (Germann *et al.*, 1996).

Science educators are continually searching for innovative ways to encourage students to conceptualize the dynamic and ever-changing nature of the scientific process, via a complex, ill-structured inquiry learning process, that is, open inquiry (Sadeh & Zion, 2009). The problems and procedures given in lower level inquiries, which were very common type of inquiry activities in the Korean textbooks, may surround students with a sense of certainty that does not always exist in science. In this context, the lack of higher level inquiries should be recognized as a serious problem in that it may lead to students' misunderstanding of nature of science and scientific inquiry. Therefore, the fact that none of inquiry activities were more than level 3 in Kumsung or Jihak might be partly due to the lack of emphasis on this point in the KSCS.

The Korean revised curriculum which is a modification of the KSCS has just begun to be implemented in the 1st grade of high school in 2011. It placed special emphasis on "creativity", which is the feature discriminated the revised curriculum from those curricula before. A creative individual is not afraid of failing, takes risks, and seeks the unknown. Creativity involves a novel approaches to problems. In this respect, inquiry activities exclusively with lower level inquiries where all students conduct an experiment with the same design and same procedures, and their experimental results are predictable and clear might be ill-prepared for cultivating students' creativity. Therefore, students need to be guided to the high-level inquiry investigations after having participated in low level activities.

The fact that the Korean textbooks, for training the skill of analyzing/interpreting data, assigned students monotonous tasks is problematic. They required students to determine qualitative or quantitative relationships within the data repeatedly. Students are and will be living in a flood of experimental data in everyday life: they read and hear biology related news, such as health and environment. For better informed consumers of scientific information, science educators need to help them develop more diverse process skills about data interpretation, for example, identifying human mistakes and experimental errors, understanding the difference between a statistical correlation and a genuine causal link, recognizing data and its limitations, and so on.

The KSCS places emphasis on "discussion" for democratic citizenship (Kim, 2011). This aspect is also important in the understanding of the nature of science: scientific rationality is grounded not only in procedures of inquiry but also in debate and argumentation within scientific communities (Knain, 2001). However, the Korean textbooks did not reflect this objective for students' scientific literacy as future citizens. The lack of communication/argumentation skill could be caused by lower level inquiries which make up the majority of inquiry activities in the two Korean textbooks. The lower level activity is highly teacher directed, that is, a large amount of information is provided to the student, for this reason, there is no room for students' discussion or argumentation. As we have seen in the cases of the Chinese textbooks, giving students an opportunity to design their own experiment in small groups may be a suitable way to enhance the skills of communicating/reporting/argumentation, because they have to meet and discuss their design, report results in front of whole class, and if necessary, argue for relative merits of their design.

Renmin and Zhejiang directed students to practice integrated process skills, such as, formulating hypothesis and controlling variables, but only in the level 3 activities. Unless students have had enough training to develop these skills through the other inquiry activities like paper and pencil tasks before, it may be difficult for them to perform those higher process skills. Science educators in Korea have been pointed out that many of their textbooks that fall short of higher order process skills are a big problem. The integrated science process skills are crucial skills for solving problems or doing science experiments. One of those skills, formulating hypothesis is very important in scientific inquiry because it enables us to create useful representations of real world objects, resolve anomalies, and develop new theories (cited in Oh, 2010). By forming hypotheses about natural phenomena, the ideas students have that influence how they learn are exposed, making the correction of their misconceptions feasible (cited in Mitchell, 2007). Another integrated process skill, controlling variables, the ability to correctly use it is central to scientific reasoning in planning experiments or in interpreting their results because the basis of it is the understanding that good experimental design relies on changing only one variable at a time, while the other variables are kept constant in order to identify cause and effect (Babai and Dori, 2009).

None of the inquiry activities in Kumsung and Jihak directed students to challenge the integrated process skills might raise concerns about the effectiveness of "free inquiry" included in the revised curriculum which was just implemented from 2011. So-called "free inquiry" is an open inquiry activity in which students design their own procedure to carry out the investigation on their own topics. It is adopted in the hope of developing students' interest in science and enhancing their creativity (MOEK, 2007). However, it is unlikely that underprepared students can properly perform such a high level of inquiry.

In short, some discrepancies between curriculum objectives and their textbooks in terms of inquiry can be seriously taken into consideration by science educators of the two nations. There is no question that the inquiry activities should give students opportunities to perform higher level inquiry, to challenge higher order process skills as they go to higher grades. Therefore, inquiry activities in the textbooks should be organized systematically considering the degree of difficulty, start with teacher directed activity and then move on to student centered one progressively.

Conclusion and Recommendation

The Chinese textbooks encouraged students to challenge level 3 activities. The two Korean textbooks, however, were held at low-level activities. The exclusion of higher levels might make Korean students to have difficulty in improving levels of inquiry over their years of high school. With regard to science process skills, the Chinese textbooks offered them a little more diversely not only in the kinds of skills but also in the range of their complexity level. However, a lack of integrated process skills like formulating hypotheses, controlling variables in the textbooks, which is the problem the two nations have in common, cannot meet the expectation that students will be well prepared for conducting higher level inquiry.

If they expect students to become independent inquirers about the natural world, it is necessary to help them try higher level inquiry and train integrated science process skills necessary for conducting it. The problem that Korean textbooks included only low level inquiry activities may be alleviated through some extra-curricular activities, for example, students may conduct level 3 activity under the guidance of teacher in after-school classes. This kind of inquiry activities has the potential to take student engagement and ownership of the lab to a new level.

The 2011 Korean revised curriculum, a modification of the 7th KSCS, has implemented in high school, and students began to learn life science, a new subject name of biology, in 2012. The new curriculum placed special emphasis on "creativity", which is the feature discriminated it from those before. Cultivating creativity in science education cannot be divorced from inquiry learning. As a subsequent study in this line, it might be meaningful to investigate if the spirits of new curriculum were reflected in the inquiry activities of their new textbooks.

References

Babai, R., & Dori, L. T. (2009). Several case lessons can improve students' control of variables reasoning scheme ability. *Sci Educ Technol* 18, 439-446.

Beautmont-Walters, Y., & Soyibi, K. (2001). An analysis of high school students' performance on five integrated science process skills. *Research in Science and Technology education*. 19(12), 133-145.

Bell, L.R., Smetana, L., & Binns, I. (2005). Simplifying inquiry instruction: assessing the inquiry level of classroom activities. *The Science Teacher* 72(7), 30-33.

Chiappetta, E. L. (1997). Inquiry-based science. *The Science Teacher*, 22-26.

Chiappetta, E. L., Koballa, T. R., & Collette, A. T. (1998). Science instruction in the middle and secondary schools. Upper Saddle River, NJ: Merrill/Prentice Hall.

Germann, P. J., Haskins, S., & Auls, S. (1996). Analysis of nine high school biology laboratory manuals: Promoting scientific inquiry. *Journal of Research in Science Teaching*, 33, 475-499.

Hams, N. C. & Yager, R. E. (1981). What research says to the science teacher (Vol.3, No.471-114776). Washington, DC: National Science Teachers Association.

Hofstein A. & Lunetta V. N. (2004). The laboratory in science education: foundation for the 21st century, *Science Education*, 88, 28-54.

Kim, SJ. (2011). Comparative analysis of high school biology curriculum for scientific literacy themes: The cases of China and Korea. dissertation, Beijing: Beijing Normal University.

Knain, E. (2001). Ideologies in school science textbooks. *International Journal of Science Education*, 23(3), 319-329.

McComas W (2005). Laboratory instruction in the service of science teaching and learning. *Science Teacher* 72(7), 24-29.

Miller, R. (2008). Taking scientific literacy seriously as a curriculum aim. *Asia-Pacific Forum on Science Learning and Teaching*, 9(2), 1-18.

Ministry of Education, People's Republic of China [MOEC]. (2003). *The Biology Curriculum Standards of High School*. Beijing: People's Education Press (in Chinese).

Ministry of Education, Republic of Korea [MOEK]. (1997). *The Science Curriculum Standards*. Seoul: Daehan Press (in Korean).

Ministry of Education, Republic of Korea [MOEK]. (2007). *The Revised science curriculum standards*. Seoul: Daehan Press (in Korean).

Mitchell, T. S. (2007). Levels of Inquiry: Content Analysis of the Three Most Commonly Used United States High School Biology Laboratory Manuals. dissertation, University of Southern California.

National Research Council. (2000). Inquiry and the national science education standards: a guide for teaching and learning. National Academy Press, Washington, DC.

Oh, PS. (2010). How can teachers help students formulate scientific hypotheses? Some strategies found in abductive inquiry activities of earth science, *International Journal of Science Education*, 32(4), 541- 560.

Padilla, M. J. (1990). The science process skills. Research Matters - to the Science Teacher. No. 9004.

Sadeh, I., & Zion, M. (2009). The development of dynamic inquiry performances within an open inquiry setting: A comparison to guided inquiry setting. *Journal of Research in Science Teaching*, 46(10), 1137-1160.

Stewart, J. H. (1982). Difficulties experienced by high school students when learning basic Mendelian genetics. *The American Biology Teacher*, 44(2), 80-89.