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An Introduction of Korean Elementary Science Textbook Development Model 'FLOW' and the Feathers of the Textbook

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Abstract: This study introduces the development of elementary science textbooks in Korea. In Korea there has been eight revisions to the National curriculum and the development of nine textbooks. The State of Korea has organized textbook development teams, but this time the State chose the development team through public contest. Researchers suggested the 'FLOW' development model based upon results of studies in creative education and developed the new science textbooks. The 'FLOW' model includes four stages, aimed towards capturing students' interest in science (Fun Science), engaging students in various scientific inquiries and experiences (Lab. Experience), organizing their own knowledge of science (Organizing Knowledge), and to encourage students to become little scientists (Willing to be a Scientist). The textbook is a research-developmental textbook that utilizes various literature and exploration-strategic textbooks. The textbook's basis is formed upon scientists' experiences that assist in the realization of 'inquiry' that is emphasized within the science field.

Key words: science textbook, textbook development, FLOW model, National curriculum, scientific inquiry

Introduction

Textbooks are developed and based on a curriculum forming an outline for national education. Many countries including Korea have their own national curriculum, on which textbooks are based. Despite the restrictions of a national curriculum, textbook developers reconstruct the curriculum and write textbooks according to their knowledge and convictions. (Dios-Jiménez *et al.*, 1997).

In Korea there have been eight revisions to the National curriculum all of which were under government leadership. A change in National curriculum is followed by the development of new textbooks. In it's latest revision (Revised 2007 National Curriculum) the government led textbook development proceeded as usual except for in the areas of Science and Mathematics. The Science and Mathematics textbooks were developed through a nationwide public contest. Hence researchers entered the science textbook development enterprise and developed science textbooks for the 5th and 6th grades.

Science textbooks are primary sources used by science educators throughout the world to guide them in teaching the content and process skills prescribed within a curriculum (Chiappetta *et al.*, 1991; Hubisz, 2003; Leite, 1999; Stoffels, 2005). Admitting that textbooks are mainly used to instruct students, teachers rely heavily on textbooks (Leite, 1999). Textbook developers write textbooks taking into consideration various features and situations of these curriculums and textbooks. This caused researchers to suggest a new strategy for the development of science textbooks in Korea. This study introduces the 'FLOW' Model for developing new textbooks as well as providing a history of Korean science textbook development and helps explain the features of the newly developed textbooks.

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The History of Korean Science Textbook Development

Since 1945, nine science textbooks have been introduced in Korean schools. The first science textbook, 'Natural Science Study', merely presented subject matter and content from natural phenomenon surrounding daily life. The second textbook (1954~1963) named 'Nature Study' consisted of six content areas: 'Life of Living Organism', 'Change of Nature', 'Movements of Heavenly Bodies', 'Healthy Life', 'Work of Machines and Tools' and 'Making Good Use of Nature and Protecting It'. The second textbook followed Bruner's Spiral Curriculum that allowed students to experience content repeatedly and more deeply as they were promoted through subsequent grade levels. Since then, the Spiral Curriculum has been applied within Korea's national curriculum.

The third textbook (1963~1973) was developed utilizing students fundamental learning ability. Sequence and consistency of curriculum along with daily-experiential total teaching was emphasized. The forth textbook (1973~1981) was based upon a discipline-centered curriculum that emphasized knowledge structures, basic concepts, and scientific inquiry methods. The textbooks included questions and instructions for investigating the nature rather than explanations of knowledge surrounding natural phenomenon. Within the fourth textbook there had been strong intention to have the students figure out scientific concepts or rules by engaging in scientific inquiry. The process of scientific inquiry, which is emphasized within the science education field, started to be stressed around this period.

The fifth textbook (1981~1987) was found its basis in both discipline-centered curriculum and humanistic education trend. This allowed greater focus to be placed upon content learned, strengthened fundamental education, and placed an emphasis upon the whole student. Developers of the sixth textbook (1987~1992), adjusted content level and sequence through the addition of real-life scientific problems. This was achieved by accepting criticisms of the former textbooks as being excessively discipline-centered. The seventh textbook (1992~1997) placed emphasis on optimizing content, thus strengthening the scientific inquiry process and improving evaluation methods. This allowed students to learn through the selection of subject matter that aroused their interests.

In the eighth textbook (1998~2007), the basic direction of the curriculum was as follows: (1) to promote self-efficiency and basic abilities to deal with social changes. (2) to reconstruct system of units reasonably and to organize differentiated curriculum. (3) to expand autonomy in organizing and implementing curriculum at school. (4) to optimize the amount of contents.

The latest textbook (2008 ~ present) tried to reduce content learning amount and deepen learning experience for a greater degree of scientific comprehension. Moreover, the textbook was developed to enhance learners' affective characteristics of interest and creativity, which are essential in the era of science and technology. Additionally, the latest text follows the intent of current curriculum by helping 'superior students' achieve sustainable progress (MOE & HRD, 2007).

The contents that should be covered in science textbooks

The goal of science education is to improve the quality of scientists and to provide understanding about science to ordinary people (Harlen, 2000). To achieve this goal, science textbooks need to cover scientific literacy. Scientific literacy is claimed to be the ultimate goal of science education by many science instructors and educators. The goal of science education presented in the Korean national curriculum also shares this view.

To understand the basic concepts of

science while inquiring the natural phenomenon and matters with interests and curiosity, to enhance scientific thinking ability and problem-solving skill, and to cultivate the scientific literacy which is needed for solving daily-life problems creatively and scientifically
-The Goals in Korea Revised National Curriculum in 2007-

Although the definition of scientific literacy differs amongst scholars, it represents the contents of science education curriculum, from the experiences that all students may have to the result, which can be attained in the process, and teaching-learning direction and methods (Trowbridge *et al.*, 2000). Putting various ideas about scientific literacy together, 〈Table 1〉 represents the components of scientific literacy suggested in 「Benchmarks for Science Literacy」 (AAAS, 1993) and 「National Science Education Standard」(NRC, 1996).

Researchers created the 'FLOW' Model as a strategy for developing textbooks to reflect the following, "contents which should be covered in science textbooks".

'FLOW' Model Suggested for Developing Science Textbooks

1. The Direction of Developing Science Textbooks

The Revised National Curriculum in 2007 of Korea emphasizes 'an ability to understand basic scientific concepts', 'scientific inquiry skill and attitude', 'Cognition on STS' and 'rational problem solving ability that is creative'. The textbooks for 5th~6th grade focus on attracting students' interest in science through scientific based inquiry. In addition, the textbooks tried to make it possible for students to actively engage in various scientific based inquiry activities arising from their own interests. The following are concrete directions for developing textbooks:

First, textbooks should be interesting and easy for students to learn from. Many elementary students whose dreams were to be a scientist are considering science to be a very difficult subject and lose interest in science (Butler, 1999). This is occurring because the gap existing between the 6th grade level of elementary school and the 1st grade level of middle school is of great significance. This large gap leads some students to abandon the study of science after entering middle school due to increased levels of difficulty. Moreover, it creates at rend of students' avoiding science and engineering resulting in dimming educational prospects within the sciences. In response researchers adjusted the level, and learning amount of the textbook to attract students' interest and curiosity of science. The adjusted levels and learning amount aided in the reduction of the level gap existing between differing school stages, and helped students learn science easily while being entertained by the subject matter.

Table 1
The components of scientific literacy

AAAS	NRC
The nature of science	Unifying concepts and processes in science
The nature of technology	Science as inquiry
The physical setting	Physical science
The living environment	Life science
Human society	Earth and space science
The designed world	Science and technology
Historical perspectives	Science in personal and social perspective
Common themes	History and nature of science
Habits of mind	

Second, the textbooks should be written for students to enter into the inquiry process as scientists. Existing science textbooks were like a cookbook suggesting experiment orders that left the students to simply follow the prescribed order of the experiment at hand. The act of Learning through experiments suggested in detail does not allow students to think freely and may cause them to lose interest in science. It is possible for students to change their attitudes toward science and to improve their scientific inquiry ability by experiencing the whole inquiring activity process. This process ranges from problem recognition based on actual scientists' thinking all the way through to drawing conclusions. Moreover, students will incur a greater understanding of the nature of science through learning based upon actual scientists' thinking. Within this context, the researchers tried to organize the science textbook by placing increased focus upon inquiry based activity.

Third, the textbook should be written to help students understand basic scientific concepts. As it is written in the elementary Science Curriculum, science is viewed as being both phenomenon and activity-based rather than concept-based. Although there are limits to studying science without acquiring the basic concepts due to the unique features of science, researchers intended that the new science textbooks for 5th and 6th grade students include various activities. Additionally, appropriate teaching models were included to assist students' comprehension and acquisition of basic concepts.

Fourth, the textbook should be written to help students acquire scientific inquiry ability systematically. The acquisition of scientific inquiry ability is as important as the comprehension of the basic concepts of science. Scientific inquiry ability is used to form scientific concepts by students. Scientific concepts can be delivered to students through classes in which teachers model the concept. Student experiments would follow after the teachers' initial instruction offered by their model presented. The scientific inquiry process would help students' mental activities appearing before and after the experiments to be wider and more systematical. Thus, the textbook will contain experiments based upon inquiry skills that enable students to experience both a basic and combined inquiry process aimed towards improving relevant scientific skills.

Fifth, the textbook should help students solve problems of daily life creatively. The researchers tried to help students, through science textbooks, too not only learn scientific knowledge but to apply that knowledge creatively. Within the application of this learned scientific knowledge the students will be encouraged to take into consideration situations of daily life.

Sixth, the textbook should help students' attainment of scientific literacy within the advanced science and technology community. Science textbooks for 5th and 6th grade students will consist of a variety of reading materials and lessons aimed toward the acquisition of scientific literacy. The acquisition of scientific literacy will further the students' interest in advanced scientific culture and the role scientists play with in the world of science and technology.

2. Science textbook development strategy, 'FLOW' model

Motivation is defined as the power, which brings proper actions to achieve the goal and maintains action (Schunk *et al*, 2008). The motivation of learning is the goal of education itself, while it is also a means of achieving other goals. Thus education is closely related to conceptual change (Paik *et al.*, 1999), learning strategies (Jeon & Noh, 1997), and academic achievement within the scientific field (Glynn *et al*, 2007). From this perspective, researchers developing the new textbook have tried to emphasize 'interest in science' as 'a motivation

for science' choosing to discuss flow as discussed by Csiszentmihalyi.

Csiszentmihalyi's (1991) opinion was to let students who learn science with a textbook experience flow. The flow that Csikszentmihalyi (1991) discusses occurs when both the task given to the students is challenging, and their ability to perform is high. He believes this is the most suitable status for creativity and the introduction of new concepts. Also, he insists that enjoyment, does not depend on 'what we do' but 'how we do it.'

On the other hand, although the students' interest toward science is positive, it is becoming lower as they enter into advanced grade levels (Kwak *et al.*, 2006) even though much of the content varies amongst grade levels within a spiral curriculum. Science education should be primarily about inquiry-based activities that emphasize the 'how' over the 'what' of science. Within this perspective, the science textbook should be made to place more stress on the 'how' which brings proper challenges to the students rather than on the 'what,' in hopes of stimulating their curiosity.

The researchers have tried to make the science textbook so that students can flow to become 'a little scientist' or further develop their creativity. For this purpose, the researchers set the development strategy named the 'FLOW' model, in accordance with the direction of textbook development. The 'Flow' model is based on 'motivating interests in science' drawing upon the students to flow, which is shown by Csikszentmihalyi (1991), Reiff *et al.* (2002), and Yang *et al.* (2007) results that studied scientists' inquiry activities. Reiff *et al.* (2002) and Yang *et al.* (2007) claimed that scientists went through a series of processes ranging from starting inquiry based upon scientific curiosity and interests all the way through to the organization of knowledge.

Thus 'FLOW' is an acronym assigning meaning to each letter of the word. First, 'F' represents 'Fun Science,' which helps students feel interested in science. Second, 'L' represents 'Lab Experience,' where the students are exposed to a variety of experiments and scientific experiences. Third, 'O' represents 'Organizing Knowledge', where the students will organize their own scientific knowledge through lab experiences. Finally, 'W' represents 'Willing to be a Scientist,' which is explained by 〈Table 2〉 in detail. Each these four steps consist of suitable activities appropriate for the students' thinking processes.

As mentioned before, the 'FLOW' Model is a strategy developed along with the textbooks to produce Creative Young Scientists. 'FLOW' is designed to draw students' attention and interest allowing them to conduct research as a scientist would. By letting students solve various problems through creative thinking and allowing them to gain scientific knowledge through creative processes, the students' enjoyment of science is further fostered.

The FLOW models design is based upon Csikszentmihalyi's 'Finding Flow' that emphasizes letting the students become immersed in science, experience scientistific inquiry process, and organize scientific knowledge. The 'FLOW' model has four steps and each step has a corresponding Korean name for both the students' and teachers' greater understanding. They are Fun science, Lab. experience, Organizing knowledge, and Willing to be a scientist, abbreviated FLOW. The 'FLOW' model organizes each of the four steps. Below are the features of each step:

■ Step 'F' (Fun Science)

The success of all learning is dependent upon the way instructors draw learners' attention and interest to subject matter. The students' motivation for learning operates as an advance organizer on the concepts that will be learned through learning and the inquiry activity (Ausubel, 1968). The start point of unit 'F' consists of easily comprehensible and interesting content, various thinking and discussion based

Table 2
'FLOW' model

Stage	Contents
Stage F	Fun science This stage encourages students to become immersed in the learning process through the use of easy and interesting materials.
Stage L	Lab. experience This stage encourages students to experience the creation of scientific knowledge through creative inquiry experiences such as observation, experimentation, investigation and discussion.
Stage O	Organizing knowledge This stage encourages students to organize scientific knowledge created in stage L and write inquiry reports.
Stage W	Willing to be a scientist This stage encourages students to solve various problems associated with daily life creatively, using scientific knowledge created in the former stages.

activities, and supports conceptual learning. The students are encouraged to guess and freely discuss the content of the unit they may face during inquiry activities that will be covered within the unit's simple scientific activities.

■ Step 'L' (Lab Experience)

Science in elementary school classrooms should consist of activity-based learning through various types of inquiry activities rather than concept-based learning. This is because according to Piaget students in elementary school are mostly in the concrete operational period. However, basic scientific concepts cannot be ignored since students have to further their studies in the area of science as they mature. To ensure the students experience necessary scientific concepts and inquiry, step 'L' is designed to offer various scientific experiences that allow students to utilize creativity and scientific thinking.

■ Step 'O' (Organizing Knowledge)

Throughout this step, students systematically organize the information and knowledge gathered from the inquiry activities. In the past, science education has been mostly about students' scientific experience, which resulted in the lack of the last step, organizing knowledge scientifically. The new textbook for 5th and 6th grade students has added this step to ensure students will be able to place the outcomes derived from the inquiry step in order, organize knowledge, and draw conclusions. In the end students will give a presentation based upon the results acquired from their own inquiry. Also, 'Scientific writing' that is stressed within the 2007 curriculum has been added to step 'O.' 'Scientific writing' is aimed toward giving students an opportunity to write logically about a topic developed from their own scientific experience and knowledge gained in the same manner as scientists write books to introduce new theories into the greater scientific community. 'Scientific writing' is composed in a way that organizes content covered within a unit, expanding upon it, and or applying the content in a new way.

■ Step 'W' (Willing to be a Scientist)

The purpose of the new textbook for 5th and 6th grade students is to make students' Creative

Young Scientists.' Step, 'W' introduces the scientists' relationship to inquiry activities students have formerly completed in step 'L' and allows the students to experience what real scientists actually do. Additionally, step 'W' contains a variety of problem situations that students can solve creatively via their scientific knowledge established through the previous steps. Thus, through step 'W', the students would have the chance to create themselves in the image of a scientist and become more familiar with their works.

The features of the new science textbook

The newly developed textbook is part of a recent trend that places a greater emphasis upon 'inquiry learning', which is promoted by the 2007 national curriculum. According to the current national curriculum, the science textbook that is based upon the 'FLOW' model is composed of the following features.

First, this textbook was developed after much research and discussion aimed towards the development of direction and organization of scientific systems. Additionally, content selection, and content teaching methods were established through a review of modern scientific trends, inquiry processes, and a wide range of textbooks used by developed countries. Second, under the purpose of forming 'a creative Young scientist,' the textbook is strategy-based, according to the 'FLOW' model. Third, the textbook elicits students' knowledge by motivating them to have fun with science in a lab type setting further helping to organize their learned knowledge to experience activities of a real scientist. Fourth, students are able to learn the basis of scientific inquiry and it's basic functions as well as combining those functions systematically through the utilization of appropriate topics. Since the textbook presents the process of scientific inquiry in a storytelling type manner, it also serves as an inquiry-based textbook. Fifth, this textbook is composed of content found within the students' everyday life making it easily contextualized. This increased level of contextualization assists students to further develop their creative thinking skills. Sixth, this textbook is a model-based textbook. Every class consists of scientific inquiry activities and is based upon the teaching-learning model so that it follows the flow of scientific inquiry and thinking.

Discussion

The science textbooks in Korea were developed by and have conformed to a framework fixed by the government. However, the newly developed science textbook that follows the 2007 Revised National Curriculum, unlike it predecessors, was selected through a contest held throughout Korea. This contest has enabled the textbook to experience increased levels of freedom within its current form while still adhering to the framework fixed by the government. Due to the current circumstance of having only one kind of textbook in Korea, it is difficult for researchers to develop a textbook that ventures beyond the government's current framework. It is of great inspiration that a textbook adopting this new form has been developed. The new science textbook for 5th and 6th grade students is based upon the newly formed 'FLOW' model. The 'FLOW' model is a strategy that considers the stream of scientists' inquiry processes and students' motivation. This model draws upon students' attention and focuses their interest in science. This focus of students' interest in scientific inquiry is followed by the conclusion and organization of their research findings in much the same manner of real scientists. Also, the 'FLOW' model allows students the chance to become 'Creative Young Scientists.' Thus, this new textbook will be a remarkable turning point in science education. The researchers working on this project created the new textbook based upon the results of real scientific inquiry processes.

These inquiries extend beyond the government framework that has hindered former textbooks.

Conclusion

This research introduced the features of the 'FLOW' model. The 'FLOW' model is a strategy used for the development of the Korean elementary school science textbook. This new science textbook, unlike other Korean textbooks, is the result of a series of inquiry activities by scientists sharing curiosity and common interests. The 'FLOW' model encourages students to realize 'Fun Science,' offering them various scientific encounters through 'Lab Experience,' allowing them to 'Organizing Knowledge,' and creates 'Willing to be a Scientists.' Each chapter consists of four steps. The most extraordinary aspect of this new science textbook is that it is the result of previous research (research-developmental textbook) based upon the experience of real scientists (exploration-strategic textbook).

It is the first time the Korean government has attempted to make a new textbook that was open-proposed in form of the project types. The new science textbook is the result of both pedagogists' and teachers' meaningful work. For the first time they have had the opportunity to utilize scientific research to offer their students high-quality textbook.

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