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The Development and Revising of the LTTS Programs for Lower Elementary Students

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Abstract

The purpose of this study is to develop teaching and learning materials for lower elementary students of Korea. 17 teaching and learning materials and activity sheets for the Korean Education Curriculum were developed according to the cognition accelerating class models. The education programs were made of total of 31 chapters. And this study was to revise and finalize the teaching and learning materials of cognition accelerating science class to improve its effectiveness and to rid of problems that arose during implementation of the original materials. It did so by making four improvements as followed: change of activity materials, elaboration of activities, modification of problem solving methods, and enhancement of activity tools.

Keywords: LTTS program, Elementary student, Korea, Program development, Program modification

INTRODUCTION

Research aim and motivation

In recent, today has been called as a knowledge society where new knowledge and acquisition of information grow into an individual and national competence. The aim of revised Korean Science Education Curriculum aligns with such social theme, and it proposed, "To understand fundamental concepts of science by inquiring natural phenomena and objects with curiosity and interests and to build scientific attitude necessary for creatively and scientifically solving problems in our daily life" [1, 2, 3].

This study aimed to develop a method for developing creativity of elementary students of Korea. It developed and applied teaching and learning materials for cognition accelerating science program based on the metacognition enhancing LTTS [4, 5] program targeting for third graders [6- 9]. We already reported the result on educational effect, c.f. the metacognition, motivation to learn, and scientific attitudes of students which were analyzed in order to investigate the effect of cognition accelerating science class [10]. Furthermore, the study aimed to introduce cognition accelerating science class as a creativity-developing learning and teaching material for teachers who prepare for classroom teachings that increase thinking ability and creativity of students. It also aimed to provide back data on such teaching and learning materials.

In the previous conference presentation, the outline and application results of the developed program [10] were reported. Here, we would like to describe concrete examples of program development and its modification under 7th Korean Science Curriculum.

RESEARCH RANGE

In order to fulfill the aim of this study, the research was carried out as followed:

A. 17 of 33 topics in LTTS level 7&8 and 8&9 closely related to third grade science education curriculum of Korea were obtained [6, 7, 8, 9].

B. Above obtained topics of LTTS were linked with third grade science education curriculum to develop teaching and learning material and activity sheets for cognition accelerating science class according to the cognition accelerating class model [6, 7, 8, 9].

C. As the continued study intends to stimulate more active interactions and to increase effectiveness of the LTTS program on the education curriculum of Korea, the study revised and improved the teaching and learning materials of cognition acceleration science class by fixing and modifying problems found during treatment of the originally developed material.

EXPERIMENT METHOD

1. Analysis of the education curriculum and textbooks

In order to observe the applicability and effect of cognition accelerating LTTS program on lower elementary science classes in Korea, third's grade science education curriculum and teacher's text as well as textbooks were analyzed.

The analysis showed that chapters "1. Matter around us, 2. Playing with magnets, 4. Measuring temperatures, 5. Weather and our daily life" of first semester of third grade and chapters "2. Refraction, reflection, and diffraction of light, 5. Various rocks and soils, 7. Separating mixed particles" of second semester of third grade were closely related with topics from LTTS level 7&8 and 8&9 [4, 5].

2. Method of study research problem and subjects

The LTTS program was developed to increase the concrete thinking ability of lower elementary students with low level of cognitive thinking skills. After analyzing the difficulty level and materials of the LTTS program to predict the effectiveness of LTTS program-based cognition accelerating science class, it could be construed that the program was applicable for students

between third and fourth grade in Korea. Therefore, the subject of this study was determined to be third graders in Korea, and some chapters in National Education Curriculum for third graders were restructured into cognition accelerating science class.

3. Application of development material

To fulfill the purpose of this study, the followings were carried out. To form learning environments encouraging to effective cognition accelerating science class such as the learning method, learning atmosphere, and learning attitude, pre-classes made of six lessons over three weeks were carried out on three common knowledge topics other than the LTTS topics to be used for the actual class.

Teaching and learning materials did not provide by the LTTS program and presentation materials for each lesson were developed in this study for more fluid class session.

Meanwhile, metacognition, motivation to study, and scientific attitudes of students were tested before and after the cognition accelerating science class to observe its effectiveness [10].

4. Modification criteria of teaching and learning materials

Modification criteria of the original teaching and learning materials were determined as followed.

First, does the activity material fit in? – Review if the activity materials of LTTS program developed for classroom environment of Britain fit in with the National Education Curriculum of Korea.

Second, is the activity elaborated enough to induce active interactions? – Review if teacher question and comments are concisely yet carefully formed to induce active student-teacher interaction and student-student interaction. Also review if the activity flows smoothly with the overall learning material in accordance with the cognition accelerating class strategy.

Third, is problem-solving process well thought? – Is the learning process well formed in steps to help students understand the concept more accurately and achieve the learning objective?

Fourth, does the activity tool contribute to the problem solving? – Review if activity tools used during the problem-solving process help students accurately grasp the learning concept. Check if there exists a better tool suited for the job.

5. Literature study

Previous studies related to the LTTS program which was implemented in Korea could be organized as followed.

Choi et al., [11] confirmed that cognition acceleration of the CASE program was especially effective on fifth grade girls who were in their concrete operational period.

Shin and Choi [12] applied two years of the Thinking Science program on fifth grade students to study the effect of the Thinking Science program on the cognition acceleration and development of cognitive functions in elementary students. The results showed that Thinking Science program positively influenced cognitive acceleration and development of cognitive functions in elementary students.

Kim et al., [13] qualitatively analyzed characteristics of mutual interactions among small gender groups by applying five activities of LTTS program on thirteen second grade students divided in small gender groups.

Kim et al., [14] also studied interactions of second grade students according to their cognitive level using the LTTS categorization activities. The study formed a small experimental group of heterogeneous students of one or two students in the transition phase going from preoperational stage to concrete operational stage, one or two students in the beginning of concrete operational stage, and one student in the middle of concrete operational stage. The study then treated three learning topics related to categorization in LTTS program to the experimental group and control group.

Bang [15] analyzed the influence of categorization activities of the LTTS program specifically on the categorization problem solving skills in students.

Jeong [16] developed a cognition accelerating class program to be treated on experimental group and control group of second grade students learning chapter on “Light and Shadow”. The academic understanding of concept of shadows were then compared and analyzed.

There were many previous studies concerning adaptation of the Thinking Science program, which is a middle school level program of the CASE project, and modifications performed in this study were mostly inspired by the study on modification and improvement of the Thinking Science program.

Ryu [17] partially modified and adjusted the original Thinking Science program to fit the class level and state of the current National Science Education Curriculum of Korea in “A Study on Modification of the Thinking Science Program for Local Adaptation”. The study reviewed the original Thinking Science program in the different perspectives.

Gang [18] improved the original Thinking Science program by resolving problems that arose during implementation in order to maximize its effectiveness in classroom environment in “A Study on Modification of the Thinking Science program for Classroom Adaptation”. The original program was improved in the different aspects.

Looking at above previous papers, most studies covered and treated fractional part of topics of the LTTS program and studied its effectiveness, or they implemented only the cognition accelerating strategy on the learning materials. Also, previous studies have their limitations in that they merely translated LTTS program developed for the education curriculum of Britain or added fractional modifications to it. The research period was also as short as eight weeks and only about four months at the longest [11-19].

Therefore, this study aimed to diversely cover various types of scientific thinking suggested in the LTTS program, develop

teaching and learning materials using the LTTS program considering its connection with the lower elementary education curriculum of Korea to promote cognitive development, and implement the developed material in the regular science class hour over long period of time for the sake of stimulation of scientific thinking accordingly to the original purpose of the CASE project and LTTS program, "enhancement of metacognition and scientific thinking".

RESULT AND DISCUSSION

1. Development process of teaching and learning materials

The development process of teaching and learning materials for cognition accelerating science class could be explained in terms of each learning stage using an example topic of "13. Categorization of Rocks" [10].

1.1 Setting up learning objectives

After comparing and analyzing "5. Various Rocks and Soils" from Science Education Curriculum in third grade with "4.1 Rock Categorization" from the LTTS program, it could be constructed that cognition accelerating science class was applicable on chapter 1/6, "Observations and Categorization of Various Rocks" of "5. Various Rocks and Soils" as shown as <Table 1>.

Generally, teaching and learning process in Korea begins by explicitly introducing the learning problem according to the learning objective of each chapter. Because this study aims to apply cognition accelerating science classroom suitable to education curriculum of Korea, the teaching and learning material development process of each topic will begin by setting up learning objectives. This stage was placed before the five stages of cognition accelerating class model.

According to the teaching guide of second semester science education curriculum of third grade, the lesson theme of chapter 1/6 of "5. Various Rocks and Soils" is "observing and categorizing various rocks" and the lesson theme for "Rock Categorization" is "categorizing different rocks by their attributes".

The learning objective was formed to be "observe and categorize various rocks by their attributes", combining two lesson themes.

Table 1. Learning objective of a cognition accelerating science class, "Rock Categorization"

Type	Third grade National Science Education Curriculum	LTTS program
Topic title	5. Various Rocks and Soils	4.1 Rock Categorization (Level 7&8)
Lesson theme	Observing and categorizing various rocks	Categorizing different rocks by their attributes
Learning objective	Observe and categorize various rocks by their attributes	

1.2 Lesson plan

The main theme of chapter 1/6 of "5. Various Rocks and Soils" in the first semester education curriculum of third grade is "observing and categorizing various rocks". The teaching guide instructs to motivate students by asking them to gather various rocks from their surroundings, and then moves onto the "learning objective" after the rocks are gathered by each group in one place.

On the other hand, "Rock Categorization" of LTTS starts off the class by asking students to share their feelings on the rock and to describe the shape and features of the rock. It does not explicitly state the "learning objective".

During the stage of lesson planning, "learning objective" was prepared for each lesson material, and inquiry questions were also added in the lesson for fluidity. With such background, student teacher interactions during the stage of lesson planning were formed as seen in <Table 2>.

Table 2. Lesson planning stage of a cognition accelerating class on "Rock Categorization"

Learning stage	Learning format	Student-teacher interaction	Time (min)	Prep materials and caveats
Lesson planning	Class study	▣ Collecting various rocks ∘Where can we find rocks? - A mountain, valley, beach, and river bank ∘Categorize the rocks you collected into different groups ▣ Sharing students' feelings on the collected rocks ∘ Hold each rock and carefully try to feel the rock. Close your eyes and try to express your feeling of the rock in your mind. ▣ Share your expressions with each	10′	- Make sure students do not try to taste the rock, and guide them to wash their hands after making observations - Give students enough time to think Collected rock or lab environment rock specimen - Lead students to discover various rock attributes on their own

		other ∘Present to class of your feeling on the rock ▣ Go over the learning objective ∘What can we learn based on the feelings we shared today? Let's observe and categorize different rocks by their attributes.		

1.3 Cognition conflict and constructive activities stage I

According to the teaching guide, chapter 1/6 of "5. Various Rocks and Soils" is made of activities of "observing and categorizing various rocks" where students categorize rocks into their own developed categories after observing each rock's attributes such as size, shape, texture, pattern, holes, gloss, mass, and particle size. In other words, the activity is summarized to be "Observe → Define categories → Categorize" in the listed order.

On the other hand, in "Rock Categorization" of the LTTS, students first define different rock categories after observing different attributes of various rocks, and categorize those rocks. Students, then, question the categorization process and compare the categorization with other groups. Hence, the activity is summarized to be "Observe and define categories → Compare with other groups → Categorize → Reflect upon the categorization process" in the listed order.

The two different learning sets were combined to form the student teacher interaction of cognition conflict and constructive activities stage I as, "Observe → Define categories → Categorize → Compare with other groups → Reflect upon the categorization process".

1.4 Metacognition stage I

The part on metacognition in cognition accelerating science class was taken directly from the metacognition stimulating questions used in the LTTS topic on "Rock Categorization". Such metacognition stimulating questions help students form their own cognition and build their own cognition tool that can be reused for answering new questions and ideas as shown as <Table 3>.

Table 3. Metacognition stage I of a cognition accelerating class on "Rock Categorization"

Learning stage	Learning format	Student-teacher interaction	Time (min)	Prep materials and caveats
Metacognition stage I	Class study	▣ Reflective thinking ∘What was the toughest challenge in categorizing rocks? ∘What have you done to tackle such challenge? ※Students struggle when they find a rock that belongs to more than one category. Guide students to overcome such struggle on their own.	5′	

1.5 Cognition conflict and constructive activities stage II

In this stage, students is induced another cognition conflict from searching for new rock categories which did not used during the first stage, and students will resolve such conflicts through active interactions with each other and teachers. Such interactions help students overcome their limits and develop higher-level thinking. <Table 4> shows the process of stimulating active interactions among the students and between students and teachers while inducing cognition conflict by searching for new categories.

Table 4. Cognition conflict and constructive activities stage II of a cognition accelerating class on "Rock Categorization"

Learning stage	Learning format	Student-teacher interaction	Time (min)	Prep materials and caveats
Cognition conflict and constructive activities stage II	Group studies	▣ Use different methods to categorize rocks. ∘ Are there different ways to categorize rocks? ▣ First set of categorizations, second set of categorizations, third set of categorizations ∘ Look up page 40 of the experiment observation ∘ First, categorize rocks 1~9 by their shape. ∘ Categorize the already categorized rocks by their color ∘ Categorize the already categorized rocks by their texture ※ Guide students to further categorize (second and third) already categorized rocks	20′	- Help students understand that there are multiple ways of categorizing rocks, and challenge them cognitively. Some students will experience cognition conflict from different categorization methods. - Encourage students who define categories with appropriate reasoning.

1.6 Metacognition stage II

Because teachers act as mediators who can effectively stimulate metacognition of the students, the metacognition stage II was filled with questions that reflected upon the cognition conflict and constructive activities stage II as shown in <Table 5>.

Table 5. Metacognition stage II of a cognition accelerating class on "Rock Categorization"

Learning stage	Learning format	Student-teacher interaction	Time (min)	Prep materials and caveats
Metacognition II	Class study	▣ Reflective thinking ∘ Can you explain how you categorized multiple stones? ∘ How did you come up with such method of categorization?	5′	- Guide students to critically reflect upon developed categorization methods

1.7 Cognition conflict and constructive activities stage III

Students were able to understand that there are multiple ways in categorizing rocks through cognition conflict and constructive activities stage I and II. Next, cognition conflict and constructive activities stage III was formed to challenge students beyond the acquired knowledge. Through this stage, students will be able to develop higher-level deductive reasoning skills, and such deductive thinking will accelerate cognitive development as shown in <Table 6>.

Table 6. Cognition conflict and constructive activities stage III of a cognition accelerating class on "Rock Categorization"

Learning stage	Learning format	Student-teacher interaction	Time (min)	Prep materials and caveats
Cognition conflict and constructive activities stage III	Group studies	▣ Defining categories with constraints ◦Think of a method to categorize rocks into two groups this time ※ Some students will find that categorizing into three or four groups is actually easier, and constraining rock groups to two will challenge and stimulate these students. ◦How many methods of categorization are there? ◦Do you understand the presented method of "grouping"? Do you have any other question?	10′	- List various methods of categorizations suggested by different students groups on the board where everyone can see

1.8 Metacognition stage III and beyond

Students can self-cognize their own thinking process during the whole learning process through reflective thinking, and they can also be expected to develop more comprehensive and concrete thinking skills during the expansive stage where they get to apply the obtained problem-solving strategies on different situations as shown in <Table 7>.

Table 7. Metacognition stage III of a cognition accelerating class on "Rock Categorization"

Learning stage	Learning format	Student-teacher interaction	Time (min)	Prep materials and caveats
Metacognition stage III and beyond	Class study	▣ Reflective thinking ◦Can you recall the time when someone else provided a categorization method that you were not able to think of? ◦What idea was it? ◦What have you learned about rocks from today's lesson? ◦Do you have any other question about rocks? ▣ Expansion ◦If you were a owner of store selling rocks, how would you like to display your products? ◦Why do you want to display your products in such layout?	10′	- ※Instruct students to think of three or more questions, and try to answer them on their own until next class. - Come up with an interesting real-life situation to apply the rock categorization methods.

This summarizes the process of developing learning and teaching materials and activity sheets for cognition accelerating science class on the topic of "Rock Categorization". The teaching and learning materials for other sixteen topics were developed using a similar process.

2. Modifications and improvements

After implementing the teaching and learning materials developed for cognition accelerating class to regular science class hours, it has been found the teaching and learning materials need to be modified and improved considering classroom environment, its relationship with the National Science Education Curriculum, student's cognitive thinking

level, and student's interests in order to increase its classroom adaptability and usability.

Therefore, this study revised and finalized the teaching and learning materials and activity sheets in four different categories: change of activity materials, elaboration of activities, modification of problem solving methods, and enhancement of activity tools. The specifics of the modification are as followed as.

2.1. Change of activity materials

The activity materials were changed in the modified learning material as seen in <Table 8>.

Table 8. An example of activity material change in the newly modified material

Activity title	Activities	Comparison before and after the change of activity materials	
		The original activity material	The newly modified activity material
How Hot is It?	Matching temperatures to different situations Discuss regarding student's choices	Match temperature cards (12) to situation cards (12). Healthy person (37°C) Boiling water (100°C) Piece of ice (0°C) Person who has cold (41°C) Tap water (9°C) Pond in July (20°C) Mid-day in classroom during May (25°C) Mid-day in classroom during October (17°C) Mid-day in classroom during November (17°C) Outside temperature during mid-day of August (32°C) A lemonade just taken out from a refrigerator (2.5°C) Playground on a snowy day in winter (17°C)	Remove situation cards regarding classroom temperatures of different months Classroom temperature in May Add situation cards for hot water, cold water, ice water, coffee, rice in rice cooker, and blowing wind of a hairdryer Match temperature cards (14) to situation cards (14) Instruct how to measure temperatures of various objects Give out assignments of measuring temperatures of various objects on their own
I Like Hot Soups	Discuss on methods that can keep hot soups warm	Inquire for best methods on maintaining the temperature of a hot soup	Look for examples found in our daily life where temperature is constantly maintained Inquire how insulated tumblers and rice cookers maintain their temperatures

Of two topics that underwent activity material change, the modification process of activity material change of the topic, "How Hot is It?" is as followed.

2.1.1 Problems which was found during the implementation of the original material

The problems had been found during the implementation of the original material on the chapter of "Measuring Temperatures" were lack of student-student interactions and lack of student-teacher interactions. The problem was explained using two following reasons.

First, students had trouble imagining the "mid-day classroom temperature of May, October, and November". Students pointed out that it was difficult because the climates of May, October, and November were not as distinct as that of summer and winter, and also because classroom temperature always changed as school used air conditioner or heaters to control the room temperature.

Second, measuring the actual temperature after predicting the temperature of an object or situation increased the effectiveness of the class. Objects and situations with accessible temperature measurements such as the body temperature of a healthy person, mid-day classroom temperature in May, tap water temperature, and boiling water temperature were selected. Making predictions and checking the predictions in groups helped students build better understanding of the learning objective and kept them motivated. Instructions on properly measuring object's temperature were also necessary.

2.1.2 Modified material

First, part on predicting mid-day classroom temperatures for different months were removed except for May as the activity takes place in May. This part was removed because students were yet to learn about the seasonal climate change. Weather and climates are covered in the chapter, "5. Weather and Our Daily Life" which follows the chapter "4. Measuring Temperatures".

Second, an activity was added for students to make temperature measurements on various objects and situations on their own after making predictions and discussing the predicted temperatures. Temperature measurements on objects not accessible in classroom such as a rice in rice cooker were assigned as homework. Instructions on properly measuring temperatures depending on the state of object were also provided.

2.2. Elaboration of activities

Elaboration of activities refers to adjustment of difficulty level of the problem and modifying measurement methods for the activity to more fluidly take place [17]. An example of activity elaboration is as seen in <Table 9>.

Table 9. An example of activity elaboration in the newly modified material

Activity title	Comparison before and after the elaboration	
	Original material	Newly modified material
Making a Shadow Puppet	Learn the concept of a shadow Understand why and how shadows are formed Understand making a shadow puppet is different from making a regular puppet (Inquire relationships between transparency, half-transparency, opacity, outline, color, and delicacy)	Added an activity of making differently colored shadow puppet other than the black colored shadow puppet using OHP film and permanent markers
A Shadow Stick	Investigate the position and length of a shadow Inquire relationship between the Sun position and shadow Understand the Sun path during the day	Subdivided and made questions more succinct Increased shadow measurement reps to eight times Measure the length of the shadow Added an inquiry section on the Sun position and the relationship between the shadow direction and Sun direction
Rock Categorization	Categorize rocks by their attributes (color, shape, size, and texture) Determine categorization criteria Discuss about different categorization criteria	Reordered the learning process Observe → Determine categorization criteria → Categorize → Compare with other groups → Reflect upon the categorization process
Soil Constituents	Mix water with soil, and observe the change Observe humus	Compare the amount of humus to learn the attributes of a fertile soil Compare water permeability of sand and soil
I Like Hot Soups	Inquire for methods that keep soups warm	Come up with examples where temperatures are well maintained Discuss on necessary devices for maintaining a temperature Think why it is important to maintain a temperature
Where Does it Belong?	Categorize various substances under certain rules Categorize into liquid and solids	Prepare the actual substance beyond simple cards with name of substances on it Powder substances such as flour, sugar, and salt were excluded for the sake of lesson plan as they are covered in the next chapter
Cannot Find Sugar	Inquire for methods to separate sugar from sugar solution Inquire for methods that separate sand from sand and water mixture	Separation of sand and iron filings Separation of sand and gravel Evaporation of a sugar solution Separate sand and water using sieves (Can be linked with "5. Water Carrying Soil" and "Water Permeability Experiment")
Separating Mixtures	Inquire for methods to separate various mixtures Understand that separating methods are different depending on the attributes and traits of the substance	Include iron filings Need to provide intentionally prepared mixtures to help students inquire the order of separation of a mixture. Give students opportunities to freely mix their own mixtures and inquire different separating methods

Of the eight topics of original learning and teaching material that underwent elaboration, the elaboration process of "A Shadow Stick" was explained as followed.

2.2.1 Problems which was found during the implementation of the original material

Problems have been found during the implementation of the original material on "A Shadow Stick" in classrooms are as followed.

First, the expansive and comprehensive teacher questions of the LTTS program needed to be subdivided. Because teacher questions in "A Shadow Stick" of LTTS were expansive and comprehensive, students had trouble understanding the question and providing answers expected by the teacher. This prevented from student-teacher interactions actively taking place. Therefore, the teacher questions need to be elaborated more specifically yet concisely and be subdivided logically.

Second, measurement rep on a stick's shadow needed to be increased for obtaining sufficient inquiry data. In "A Shadow Stick" of the LTTS, the shadow of a stick was measured twice before noon, and students were asked to predict the shadow of a stick in the afternoon. However, mere two reps of measurements before noon were not considered sufficient data for making accurate predictions, and so the original learning and teaching material was designed to measure the shadow of a stick four times at 9:30 am, 10:30 am, 11:30 am, and 12:30 pm for making predictions on the shadow in the afternoon. Still, undeniable number of students struggled to accurately predict the direction and length of the shadow of a stick in the afternoon with four times of measurements before noon.

Therefore, in the modified material, the measurement of the shadow of a stick was made eight times during the day starting from 9 in the morning until 5 in the afternoon at a one-hour interval. Based on such measurement students were able to understand more accurately the relationship between the direction and length of the shadow of a stick and the position of the Sun.

2.2.2 Modified material

The modified material that resolved problems found during the implementation of the original material are as followed.

First, the teacher questions were more elaborated and specified. This helps students to better understand the teacher questions and to answer the intent of the question. The process of

formulating an answer stimulates cognitive thinking in students, and this will certainly push for more active interactions of student-teachers and student-students.

Second, scientific thinking of making predictions can be more effectively formed when there are sufficient inquiry data for making predictions. So, increasing number of measurements on the shadow of a stick to eight times will help students think in terms of cause-and-effect as well as stimulating the cognitive thinking in students.

2.3 Modification of problem solving methods

The following table is an example of a modification of problem solving method in the newly modified material as seen in <Table 10>.

Table 10. An example of modification of problem solving method in newly modified material

Activity title	Comparison before and after the modification	
	Original material	Newly modified material
Inquiry of Magnetic Poles	<Lesson plan> Experiment with the magnetic attraction between the iron and magnet ↓ Experiment with the magnetic field ↓ Experiment with the magnetic attraction and repulsion between two magnets	Change of order in the <Lesson plan> Experiment with the magnetic attraction and repulsion between two magnets ↓ Experiment with the magnetic attraction between the iron and magnet ↓ Experiment with the magnetic field

2.3.1 Problems which was found during the implementation of the original material

Problems have been found during the implementation of the original material on "Inquiry of Magnetic Poles" were as followed.

First, the "Cognition conflict and constructive activities stage I" in "Experiment of magnetic attraction between a magnetic substance (a paper clip) and magnet" was able to stimulate student interests, but it required previous knowledge on magnetic attraction for active discussion of experiment results to take place. However, because learning on magnetic attraction and repulsion is covered in the "Cognition conflict and constructive activities stage III", the lesson plan had to be reordered. The lesson plan was reordered to enable students to learn about magnetic attraction and repulsion in the "Cognition conflict and constructive activities stage I".

Second, in the "Cognition conflict and constructive activities stage II" of "Experiment with the magnetic field", students observed that the further a paper clip is from a bar magnet the weaker the magnetic attraction. Inquiring reasoning behind such phenomenon enabled students to understand the concept of magnetic field. However, because the concept of magnetic field is preceded by concept of magnetic force, or magnetic attraction and repulsion, the learning of "Cognition conflict and constructive activities stage III" needs to take place first.

2.3.2 Modified material

The lesson plan in the original material was modified from "1. Experiment with the magnetic attraction between the iron and magnet → 2. Experiment with the magnetic field → 3. Experiment with the magnetic attraction and repulsion between two magnets" to "1. Experiment with the magnetic attraction and repulsion between two magnets → 2. Experiment with the magnetic attraction between the iron and magnet → 3. Experiment with the magnetic field"

2.4 Enhancement of activity tools

An example of enhancement of activity tools in newly modified material is as seen in <Table 11>.

Table 11. An example of enhancement of activity tools in newly modified material

Activity title	Activities	Comparison before and after the enhancement	
		Original material	Newly modified material
Potatoes	Inquiry of relationship between the mass of potato and stretched length of the rubber band	Rubber band	Spring

The tool used in the activity "Potatoes" is a rubber band. A rubber band is an elastic body that stretches when an object pulls on it with its weight. The weight of different objects can be compared using this property. In revision of National Science Education Curriculum of Korea, there is a chapter on "6. Stretching a Spring" and "3/5. Length of a Spring and Number of Masses" in second semester curriculum of fourth grade that utilizes an elastic body for measuring weight of an object. Because the LTTS program utilizes a rubber band that can be easily found in our daily life and because the LTTS program stimulates cognition acceleration with various scientific thinking types, "Potatoes" of the LTTS program encouraging scientific thinking of "variable relationships" was applied to third grade students in Korea.

The process of modifying such material can be explained using an example of enhancing the activity tool of the original material in the chapter, "Potatoes".

2.4.1 Problems which was found during the implementation of the original material

Problems have been found during the implementation of the original learning material of "Potato" were as followed.

First, there was a need for better activity tool than a rubber band to more precisely show the relationship between the object

mass and the change in length of an elastic body. The activity tool used in the "Potatoes" was a rubber band, and at the end of the rubber band was a plastic bag hanging to be filled with variously weighing potatoes. Students compared the variously stretched length of the rubber band to spot the heaviest potato.

However, a general, off-the-shelf rubber band tends to be short and thin, not sufficing as an experiment tool. A longer-length rubber band tends to have weak elasticity and does not react sensitively enough to changing masses. The cotton elastic band often used in clothing also has a very short range of elastic zone, and therefore it was difficult to formulate accurate experimental results using a rubber band as an activity tool in the activity, "Potatoes".

Second, potatoes used in the experiment needed to be carefully selected. The weight of normal, round shaped potatoes was distinguishable solely by their size, and therefore did not induce much of cognition conflict in students.

Third, a motivational background was necessary to attract student interests and participation. In order to stimulate and maintain student motivation on this learning session, a "Story of Deserted Island" was added as part of the last stage of cognition accelerating class model, "expansion".

2.4.2 Modified material

The newly modified material resolving problems of implementation of the original material are as followed.

First, a spring instead of rubber band was used as an activity tool. A spring was easier to be fixed on a stand, was easier to hang a plastic bag, and was easier to make comparisons on the stretched lengths when potatoes with various masses were placed in the plastic bag.

Second, selecting potatoes with various shapes instead of sizes were proven more effective in inducing cognition conflicts. Selecting similarly shaped potatoes resulted in students spotting the heaviest potato only by direct observation without the need for an experiment using the elastic body. Therefore, potatoes with various shapes should be selected to make it harder for students to guess the weight of a potato from direct observation of its size, and hence increasing the effectiveness of the class.

Third, for stimulating and maintain student motivations in the class, a "Story of Deserted Island" was added in as part of the last stage of cognition accelerating class model, "expansion".

CONCLUSIONS

1. Conclusion

The purpose of this study was to develop teaching and learning materials to be used in cognition accelerating science class targeting for third grade students of Korea. The study was carried out as followed as.

Third grade's science education curriculum was restructured to fit in cognition accelerating science class, which is a teaching and learning method that can increase metacognition and scientific thinking abilities of third grade elementary students of Korea. The teaching and learning materials and activity sheets of each topic were developed according to the cognition accelerating class model applied in the restructured education curriculum.

In order to increase the adaptability and interactive of the LTTS program in classrooms in Korea, the original learning and teaching materials were modified to resolve problems found during the implementation of the original material. The modifications were change of activity materials, elaboration of the activities, modification of problem solving methods, and enhancement of activity tools. The modified teaching and learning materials encouraged active interactions between student-teacher and student-students during its implementation in classrooms.

2. Proposals

The possible influences of this study on elementary science education and possible future studies are proposed as followed as.

First, because this study was carried out on only part of the third-grade science education curriculum, future studies that intend to utilize the teaching and learning materials of this study should analyze the overall structure and learning topics of the revised national science education curriculum.

Second, during the process of implementing the teaching and learning materials developed in this study into classrooms, the effect of applied teaching and learning materials will need to be compared by selecting and treating experimental group and control group in order to increase objectivity and credibility of the developed materials' treatment effect on class.

Third, because the teaching and learning materials were developed optimally for small population of a single class year, it should be modified and improved before being applied to different classroom environment or to students with different cognitive levels.

Fourth, although this study was done under the previous curriculum, the 'reflective thinking' activities emphasized by LTTS and CASE are well suited to the learning-oriented lessons that are becoming a trend of current Korean education. For example, the lecturer in class or the question method in Havruta's education emphasizes discussions and discussions, and constantly engages in dialogue and presentation to create a continuous interaction. Therefore, further investigation is needed from this point of view.

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