



The Development of 'Water strider' Inquiry Learning Program for Improving Scientific Inquiry Learning Ability in the Chapter 'the Little Creatures World' of the Korea Elementary School 5th Grade Science Textbook

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ABSTRACT

The purpose of this study was to develop a 'Water strider' Inquiry Learning Program for improved inquiry learning, and to analyze the validity of the 'Water strider.' The Inquiry Learning Program's goal was to create an application for finding out an on-site applicability for the 'Water strider' Inquiry Learning Program through the Elementary school teachers' workshop. The following are the summarizations of the main issues of study. First, the 'Water strider' Inquiry Learning Program, (or W.S.I.L.P. for short) consisted of five subjects: comprehension of surface tension, collecting and raising water striders, the secret of water striders' body, the condition of floating water striders, and making the model of water striders. There were 10 small group activities which were organized by themes including Prediction, Observation, Explanation, Reflection, and an Additional questions stage. Using these, the students could then comprehend the water strider's structural features and the scientific principles. Secondly, in the assessment of on-site applicability, which elementary school teachers directly implemented, each activity consisted of immediate manipulation activities to help increase the students' interest. They were not only able to easily comprehend the scientific inquiry ability, but also the inquiry ability of the W.S.I.L.P. The 'Water strider' Inquiry Learning Program can also be useful for science club activities in addition to the regular curriculum time because of the integrative lessons that will be available by using the 'Water strider' Inquiry Learning Program.

Keywords: water strider, inquiry learning program, elementary school teachers, scientific inquiry ability

INTRODUCTION

Science should be based on inquiry and should provide students with real world experience where students can ask questions and find their own answers. Providing students with science experience based on inquiry could give students the opportunity to observe and think

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State of the literature

- In elementary school science, a systematic inquiry learning program is needed for students to collect insects in person and observe their behaviors and morphological features in connection with scientific principles.
- An inquiry learning program is needed for elementary school students to improve their science inquiry skills. In this light, the W.S.I.L.P will help elementary school students improve their inquiry skills.
- All the science inquiry learning programs should help students approach science concepts integrally.

Contribution of this paper to the literature

- This study suggests a direction of inquiry learning program development for elementary school students to enhance their curiosity about small organisms and science inquiry skills.
- Through this W.S.I.L.P, this study suggests a plan that elementary school students can approach science concepts integrally, have scientific knowledge and build a creative thinking ability.
- Through teacher workshops, this study suggests how to improve science inquiry learning programs by collecting requests from teachers at the chalkface.

all by themselves. W.S.I.L.P. could be a strategy of a teaching & a learning method and assessment for teachers (Mesa et al, 2008). Due to these characteristics, science education enables students to learn through inquiry-based programs, design verifiable hypotheses, collect test result, analyze the interpretation, and communicate and reconstruct their own knowledge (National Research Council, 1996). In addition, science educators proved that learning based on inquiry improved students' attitudes towards science, science achievement, and science knowledge (Supovitz & Turner, 2000; Wilke, & Straits, 2005).

The purpose of science education in Korea shifted from knowledge delivery to improving the ability to construct the students' own knowledge (Shin, 2010). As inquiry in the Korean Elementary school curriculum enabled students to solve real life problems, it was an effective teaching method for students to be citizens of scientific knowledge. Moreover, science inquiry for the lower grade levels consisted of Basic Science Process Skill to increase the inquiry ability through scientific inquiry activities (Kim *et al.*, 2005). Science inquiry for the higher grades focused on comprehending science by doing science through Integrated Science Process Skill and emphasizing the function of said skills. In this educational context, the Ministry of Education, Science, and Technology in Korea recently planned to insure substantiality. They decided to distribute the new teaching and learning method assessment techniques for interested science classes. These techniques were developed by scientists who provided various programs that were developed by mass media including newspapers and broadcasting for science classes (Shin *et al.*, 2009).

The Korean curriculum of science recently emphasized that a students' understanding of scientific concepts would be improved through the integration of various academic fields

(MOE, 2015). An approach with integrated scientific concepts was needed for students to have interest in science, develop scientific literacy well enough to solve science-related problems in their daily lives, and even build a creative thinking ability required for science (Kim *et al.*, 2014).

However, integrated learning materials were lacking in suggesting problem situations for improving the students' inquiry ability and helping the students learn inquiry skill by relating with their own problem-solving processes (Kim *et al.*, 2005). By developing integrated inquiry learning programs, students will become interested in the science of biology and will enjoy themselves.

Studying science education proven processes or nature experience was effective in learning through a student's own existing knowledge by incorporating new information (Bransford *et al.*, 1999; Driver *et al.*, 1994). Using insects in science class sparked students interest in science and learning experience based on inquiry as a good alternative of increasing inquiry education by recognizing the necessity of improving professionalism (Golik *et al.*, 2010).

In addition to this, the chapter, 'the little creature's world' of Elementary the school's 5th grade science curriculum put an emphasis on immediately raising and observing various insects by suggesting various insects' pictures for Biodiversity education.

Yet, since modern society led to rapid urbanization and industrialization, the environmental pollution has been getting worse. It was difficult to directly collect and observe various insects. In many schools, many students should learn through some pictures of various insects and electronic media instead of collecting insects (Lee & Hong, 2008). In the case of some students' previously wrong concepts of insects, they could not develop scientific concepts and continuously had invalid concepts as they learned without direct observation.

However, insects were interesting enough that the elementary school students were curious about them and a great life model that could teach the biological process and have a great effect on elementary school students'. Moreover, insect raising activities had positive effects on elementary school students. To increase students' interest in the environment, eco-friendly actions were related and the students had to be willing to do something (Jeon *et al.*, 2011). The activities of creating a hypothesis on insect behavior, look and evolution, and verification of a hypothesis could provide an opportunity of infinite and immense development for inquiry to students (Matthews *et al.*, 1997).

Therefore, it was essential that the inquiry program should be developed to directly collect and observe various insects' behavior and structural features related to scientific principles for scientific concepts in elementary school.

Most of all, before an inquiry program can be applied to students, it is imperative to have the usefulness of the program verified by teachers who will use the program. This process will prevent students from having misconceptions while using the inquiry program and even

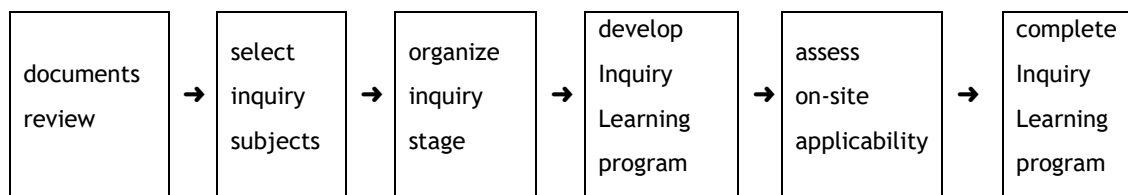


Figure 1. Inquiry process

help them to make an advanced inquiry program that can provide students with more information. In other words, through the teachers' workshop, they can make opinions or requests about inquiry program activities, and by reflecting them, they can find out possible problems by verifying the validity. We can improve the inquiry program and in turn make it that much better.

In this study, the W.S.I.L.P. was developed to increase the elementary school students' curiosity of little creatures with scientific inquiry. This thesis aimed to analyze and seek how elementary school science assessed the on-site applicability of 'Water strider' Inquiry Learning Program which teachers directly implemented and developed.

METHOD

To set the direction of Inquiry Learning Program, documents related with water striders were reviewed and researched for science inquiry function factors. To select and concretize inquiry subjects by considering science inquiry function factors, subordinate activities were organized. In addition, to effectively achieve the goals of activities, inquiry activity processes were suitably selected and organized. Subsequently, the assessment of on-site applicability was directly implemented through elementary school teachers' workshop, and 'Water strider' Inquiry Learning Program was finally developed and completed (Figure 1).

Curriculum related with 'Water strider' Inquiry Learning Program for extending science inquiry ability

The chapter 'the little creature's world' of the 5th grade science book in the Korean Elementary schools dealt with the content of the little creatures' characteristics. The animals' world in the 3rd grade and the plant's world in the 4th grade books didn't deal with the little creatures' environment and the relationship between the world and the little creatures was difficult to relate, so the chapter, 'the little creature's world' was organized for biodiversity education and bioscience inquiry ability (MEST, 2011).

This chapter consisted of 'the little creature's look and features', 'small creatures' world due to the way of life', 'the difference and similarity of small creatures', and 'our lives affected by little creatures.' Especially, 'water strider' Inquiry Learning Program was organized for increasing elementary school students' curiosity of the little creatures and scientific inquiry by observing the little creatures, looking at features such as a water strider, a diving beetle, water

Table 1. The organization of 'Water strider' Inquiry Learning Program

Inquiry subjects	Activity contents	Inquiry process
Comprehending the scientific principle of surface tension	[Activity1] The water in cups doesn't overflow. [Activity2] Clips floating in the water [Activity3] Sinking the baking powder	prediction, recognizing the problem, observation, measurement, inference, communication
Collecting and raising water striders	[Activity4] collecting Water Striders [Activity5] Raising Water Striders	prediction, observation, measurement
The secret of the Water Striders' body	[Activity6] The secret in the Water Striders' body	prediction, measurement, observation, data conversion, communication
The condition that Water Striders float on the water	[Activity7] Observing Water Striders' floating on water [Activity8] Strange shadow [Activity9] Are water striders looking at the same place?	prediction, observation, inference, Setting up a hypothesis, Recognizing the problem, measurement, control of factors, communication, deducing the conclusion
Making the Water Striders' model	[Activity10] Making up Water Striders' model	prediction, setting up a hypothesis, communication, model composition, generalization

scorpion, whirligig beetle, a water stick, water fly, and a dayfly. The chapter, 'the little creature's world' aimed to help students comprehend the various little creatures' phenomena and recognize the importance of life in the diverse environment.

The organization of 'Water strider' Inquiry Learning Program for extending science inquiry ability

Teachers should avoid the illusion that every student can successfully carry out inquiry. Many students were incapable of carrying out the scientific inquiry process even at the simplest level (Wilke, & Straits, 2005). Therefore, the comprehension of the inquiry process through systematic inquiry learning programs was essential. Systematic inquiry learning programs enabled students to practice the inquiry process and provide the various opportunity for skilled abilities, and was useful to carry out the more improved inquiry functions.

Leach et al. (1992) indicated while lower grades of elementary school students classified living creatures according to biological features and organisms, higher grades of elementary school students classified living creatures according to observable features (structure). Furthermore, Shepardson (2002) organized programs relating with structural features through direct observation and activities through personal experience considering the students' knowledge was limited in their daily life experiences (Table 1).

The 'Water strider' Inquiry Learning Program was composed of five subjects. Above all, the activities of comprehending the scientific principle of surface tension related to water strider was implemented, and then the activities of directly collecting, raising water striders,

Table 2. The strategy of ‘Water strider’ Inquiry Learning Program

Steps	Strategy
Prediction	.What is predicted about the inquiry subject? .Students predict what will happen, and explain their predictions. .Students will make a proper and logical prediction relating with the inquiry subject and make use of concrete contents in their previous knowledge.
observation	.What and how should students observe to confirm their prediction? .Students observe precisely and measure with accuracy. .Students design the experiments and sum up the results of their observation. .Students present concrete results of observation target’s characteristics and sum up conspicuously the results of their observation.
Explanation	.What is the difference between students’ prediction and observation results and what is the new discovery for students to newly find out? .Students assess their prediction and make use of the evidence for explanation of their observation.
Reflection	.What is the problem of control of factors in observation? .Students devise alternative methods for their observation. .Students estimate the approach used for the result. .Students evaluate the method for pulling together the results, and suggest their pertinent thoughts for how to improve it.
Additional Question	.What do students want to know more? .Teachers and students suggest the additional questions for the next lesson content. - Students’ additional questions - Teachers’ additional questions .In order to solve their doubts, think of new questions and approach.

and observing water striders’ structural features was connected to the activity of exploring the secret in water striders’ body. After observing the features of their appearance, the condition of water striders floating on the water was studied. Based on the results of the quest, the activity of making up water striders’ model allowed students to comprehend the hidden scientific principle relating to water striders.

The inquiry stage of ‘Water strider’ Inquiry Learning Program was based on White & Gunstone (1992)’s POE (prediction-observation-explanation) strategy. POE (prediction-observation-explanation) strategy is where the students are predicting the experiment results and describing what happens through their direct observation, and finally adjust the conflict between predictions and observations (Wu & Tsai, 2005).

While POE strategies was used to focus on three step inquiry-oriented science instruction, the W.S.I.L.P. was composed of a five-step program including prediction, observation, explanation, reflection, and an additional question stage for high dimensional self-examination (prediction) and students’ motivation to learn more (Additional Question) (**Table 2**).

In the prediction step, students made a proper and logical prediction by relating the inquiry subject and making use of concrete contents with their previous knowledge. In

constructivism theory, learning the lesson is the active and continuous process to take information from the environment, and to consist of personal comprehension and meaning from learners' prior knowledge and experience (Driver & Bell 1986; Roth, 1990). Therefore, students questioned hypothetical issues based on the given information before entering the earnest inquiry activity, and suggested a solution to the problem of water strider. They also answered controversial questions of their predictions or indicated their experiment processes of prediction.

In the observation step, students analyzed photos, data, graphs, and information from a simple experiment for answering the issues or questions based on their prediction and record the results of their observation. Students present concrete results of observation target characteristics and sum up conspicuously the results of their observations. This step leads students to participation and understanding of inquiry contents and process.

In the 'Explanation' step, teachers assisted students in removing disagreement between predictions and observations. Moreover, teachers encouraged students to explain the results of new observations, and share their own interpretations through discussion (Wu & Tsai, 2005).

During the 'Reflection' step, students are provided the opportunity to reflect on what they had learned and to receive feedback from their teachers. Furthermore, teachers provided students with more hypothesize.

Within the 'Additional Question' step, teachers empowered students to come up with additional questions based on the new scientific facts, and suggested the additional questions for the added activities related with inquiry. This encourages students to think more deeply about what they have learned.

The assessment of on-site applicability of 'Water strider' Inquiry Learning Program for extending science inquiry ability

To verify the feasibility of Inquiry Learning Program, 23 elementary school teachers who oversaw science education for three or more years were evaluated through a workshop which aimed to assess the Inquiry Learning program's applicability.

During three to four workshops spanning over three days, teachers were evaluated through the assessment of the 5-step Likert scale. They were then asked to fill out a questionnaire and free-response questionnaire after their experience with each activity directly while conducting an hour free discussion on the program.

This assessment questionnaire of the on-site applicability of Inquiry Learning Program was developed and modified by Kim et al. (2005)'s evaluation questionnaire.

The goal of the program, the content of the program, and the application of the program were evaluated with three significant categorizations.

In the goal of the program, 'Does this Inquiry Learning Program challenge students to be interested in science, and improve their attitude?', 'Does this Inquiry Learning Program help students understand the scientific principles?', and 'Does this Inquiry Learning Program encourage students to improve their science inquiry ability?' were questioned. In the content of the program, 'Does this Inquiry Learning Program reflect the learning contents of the chapter, 'the little creatures' in elementary science?', and 'Is this Inquiry Learning Program appropriate for the level of elementary 5th grade?' were questioned. In the application of the program, 'Do you think this Inquiry Learning Program is useful in the current spot of an elementary school?' was questioned. The 5-step Likert scale questionnaire was used, and the free-response questionnaire was applied.

THE RESEARCH FINDING AND DISCUSSION

The development of on-site applicability of 'Water strider' Inquiry Learning Program for extending science inquiry ability

'Water strider' Inquiry Learning Program for extending science inquiry ability greatly consisted of five themes and ten small activities. In these activities, students predicted the scientific principles related to 'water strider' in advance, and observed 'a water strider' to prove this, and explained the comparison between the results of observation and their forecasting, and then questioned what they wanted to know newly through reflection.

The concrete contents of 'Water strider' Inquiry Learning Program were as follows:

Inquiry subject 1: 'comprehending the scientific principle of surface tension'

The activities of comprehending the scientific principle of surface tension related to water strider were like **Table 3**.

In the activities of comprehending the scientific principle of surface tension as previously predicted, teachers encouraged students to think about how many coins could be put in glass cups until the water overflows. Teachers allowed students to fill the cups with water and slowly drop a coin into the center of the cup. Teachers encouraged students to play a game as a group activity of how many coins could be put in glass cups until the water overflowed. Teachers then enabled students to observe the water surface at the moment of overflowing. They encouraged students to think to themselves why more coins could be put in than their prediction. They then were to describe in the Explanation step, and think about the method to put more coins as a group activity within Reflection step. Teachers led students to answer additional questions such as 'What do students want to know more of?' and 'What happens when a drop of soapy water is used instead?'

In this activity, you could see the surface of water on the cup was over the mounds, which was the force of surface tension. Water was not overflowing at first, but instead surface tension gives water its near-spherical shape. It seemed as if the water was covered with a delicate membrane.

Table 3. The activities of comprehending 'surface tension'

Activity subject	Stage	Activity Contents
The water in cups doesn't overflow	Prediction	How many coins can be put in glass cups until the water overflows?
	observation	Many coins can be put in glass cups filled with water until the water overflows. Observe the water surface at the top of glass cup.
	Explanation	What is the difference between the students' prediction and observed results and what is a new discovery for students to find out?
	Reflection	What are the problems with the control of factors in observation? Students devise alternative methods for their observations.
	Additional question	What do students want to know more of?
Clips floating in the water	Prediction	Can clips float in the water?
	Observation	Fill the cup with water and float the paper sash at first. Students gently put clips on top of the paper and observe the phenomena.
	Explanation	What is the difference between the students' predictions and the observed results? What is a new discovery that students can find out?
	Reflection	What is the problem with the control of factors in this observation? Students devise alternative method for their observations.
	additional questions	What do students want to know more of? What happen when soap is dropped in water?
Sinking the baking powder	Prediction	What happen when baking powder is dropped in water?
	observation	Sprinkle baking powder in the chalet containing water. Observe what happens in baking powder.
	Explanation	What are the difference between the students' predictions and observed results and what is a new discovery that students can find?
	Reflection	What is the problem with the control of factors in this observation? Students devise alternative methods for their observation.
	Additional questions	What do students want to know more of?

Surface tension is a property of the surface of a liquid that allows it to resist an external force. It was revealed, for example, in the floating of some objects on the surface of water, even though they were denser than water, and in the ability of some insects (e.g. water striders) to run on the water surface. This property was caused by cohesion of similar molecules, and is responsible for many of the behaviors of liquids. The cohesive forced among liquid molecules were responsible for the phenomenon of surface tension. In the bulk of the liquid, each molecule was pulled equally in every direction by neighboring liquid molecules, resulting in a net force of zero. The molecules at the surface do not have other molecules on all sides of them and therefore are pulled inwards. This creates some internal pressure and forced the liquid surfaces to contract to the minimal area.

In the second activities of comprehending surface tension, 'clips floating in the water' was to observe why clips float in the water.



Figure 2. Mesh net & Cup-induced surface tension experiment

In the 'Prediction' step, teachers enabled students to plan from the question of 'Do clips float in the water?' to the question of 'How do we make clips float in the water?' Then they are tasked to carry out the method of 'How we make clips float in the water.' Teachers enabled students to prepare one clip and a piece of paper which was a little wider than the clip. They then challenged students to fill the cup with water, and float the paper in water at first. Teachers inspired students to put the clip on top of the paper lightly and to push the paper slightly by a pencil or finger tips to sink the paper. Teachers then endorsed students to observe what happen. They suggested students induce a thorough planning because of this activity with several times trial-and-error possibility.

In the 'Reflection' step, Teachers allowed students as a group activity to think of a method to make a clip float. They then led students to answer additional questions such as 'What happens when a drop of soapy water is used?' Students could observe a clip float in the water if students put a clip carefully on the surface of water by using waters' surface tension.

In the activity of sinking baking powder, teachers encouraged students to predict what would happened if they put the baking powder in the water. Students then were told to sprinkle baking powder in chalet containing water, and observe what happen in baking powder. Moreover, in the additional activity, students made a cotton swab dipped in detergent and attached to the surface. Since baking powder's particles were much smaller and denser than water, it did not sink if it was sprinkled over the water. If students put the cotton swab dipped in detergent on the baking powder's surface floating in the water, students could see baking powder's particles sink in the water. When a drop of soapy water released in the center of the surface, it drills a hole in the middle of the water surface. The hole in the water surface was bigger because water had the pull force.

Within the 'Explanation' step, teachers encouraged students to present and describe what the scientific fact through this activity was, and reflect on what did not connect to the scientific phenomenon in some way. Teachers enabled students to ask additional questions of what is relevant with a water strider. Moreover, in additional activities as shown in **Figure 2**, teachers enabled students to fill a small cup 3/4 full of water and then cover the cup's entrance with the thick paper, put the cup upside down, and momentarily let go of the paper through

Table 4. The contents of 'collecting and raising a water rider'

Inquiry subject	Stage	Activity contents
collecting a water rider	Prediction	How could students collect a water strider?
	observation	Explore a Water Strider's habitat and how students can securely capture and collect a Water Strider. Find out what the difference between outdoor observation and direct observation through collecting and raising a Water Strider is.
	Explanation	What is the difference between the students' prediction and observation results and what is the new discovery for students to newly find out?
	reflection	Students devise alternative methods for their observation.
	additional question	What do students want to know more of? Is there alternative ways to collect Water Striders except with a scoop net?
Raising a water rider	Prediction	What is the effective way to raise Water Striders?
	observation	Students design a fit place to live in, and directly make a place, and then raise Water Striders Students directly make a place, and then raise Water Striders and sum up conspicuously the results of their observation.
	Explanation	What is the difference between students' prediction and observation results and what is the new discovery for students to newly find out?
	reflection	Students reflect the problem while raising Water Striders, and devise alternative method for solving the problem of raising them.
	additional question	What do students want to know more?

observation activity. In this activity, teachers helped students to comprehend the principles of the surface tension.

Inquiry subject 2: 'collecting and raising a water rider'

The contents of collecting and raising a water rider were like [Table 4](#).

In the activity of collecting a Water Strider, students tried to directly devise a way to collect water striders in ponds or pools. They found out the difficulty of their collection and alternative methods for their collection.

It was difficult to observe closely outside because a water striders are small. Therefore, when students grabbed and raised these water striders, they were easier to observe closely indoor than outdoor. There were lots of Water Striders in rivers with weak waves or the ponds, water holes, and rice fields. Many of them gathered in the same place, so students could easily find them. When students captured Water Striders, teachers instructed them to quietly come up to them and swiftly swing them on water by using a scoop net, and then carefully insert them in plastic box or plastic bag so as not to cut the legs of the water rider. When students collected them, teachers ordered students to put water plant with the water riders.



Figure 3. The picture of the child who is grabbing a Water Strider

Students could capture Water Striders by fishing without the use of a scoop net. Students tied dragonflies and ants to a thread as a bait and then made them float on the water. When a water strider approached, and attacked the insect, students dragged up the line and caught them. **Figure 3** is the picture of the child who is seizing a water strider.

In the activity of raising water striders, students directly brought up water striders, and saw water striders floating and feeding on the water, which was an advantage of observing the water striders' many movements. In this activity, students predicted that raising water striders in advance, and designed a way to bring up these water striders. Students reflected the problem while raising water striders, and devised alternative methods for solving the problem of how to raise them. Also, students were asked additional questions related to the water striders' lives, and answered themselves through researching documents.

For students to directly raise water striders, teachers instructed students to fill a breeding box 1/2 way full of water, and put a wooden plank or a Styrofoam as an artificial habitat on the water for water striders' rest. Water plant were used as a place to lay eggs. The plastic breeding box was covered with a lid and the length of the long side in the breeding box was 30cm. The place to put the breeding box should be lit up but without sunlight during the day. Water striders feed on mainly live flies, ants, spiders and little insects in the grass, that fall onto the water surface. So teachers instructed students to make little worms float on the water for feeding. When a film-like oily water occurs, put a piece of paper on the water which will suck the film-like oily water up. When water striders lay eggs, teachers are instructed to tell students to students to move the water striders into the other breeding boxes. Water striders go through the egg stage, five instar stages of nymphalid forms, and then the adult stage. It is not bad to raise larvae with adult insects during the larval period. Until larvae molted twice. Moulting or molting, also known as sloughing, shedding, or for some species, ecdysiast, is the way an animal routinely casts off a part of its body (often but not always an outer layer or covering), either at specific times of year, or at specific points in its life cycle. Each nymphalid stage lasts 7-10 days and the water strider's molted, shedding its and old cuticle through a Y-shaped suture dorsal to the head and thorax. Teachers instructed students to put little flies into the breeding box for feeding the water striders. Teachers enabled students to raise male water striders and female water striders for students to observe the females'

Table 5. The contents of 'the secret of a water rider's body'

Step	Activities contents
Prediction	Why do we call this insect a water strider? What kind of features makes a water strider float on the water?
observation	Students observe water striders' structural and biological features.
Explanation	What is the difference between students' prediction and observation results and what is the new discovery for students to newly find out?
reflection	What is the problem of observation? Students devise alternative method for their observation.
additional question	What do students want to know more? How do students distinguish between male and female water striders? Is there a wing in a water strider's body? Do water striders hate dirty things?

laying their eggs and larvae's molting. The autumn is a perfect time for catching and raising water striders and then observing water striders' growth in the next year.

Inquiry subject 3: 'the secret of a water rider's body'

The contents of 'the secret of a water rider's body' were like [Table 5](#).

In the 'Observation' step, teachers enabled students to start observing from the question of 'Why do we call this insect a water strider?', and 'What kind of features makes a water strider float on the water?' by capturing water striders. Water striders are called a salt merchant because the body floating on the water was like the appearance of a salt merchant's relying on a stick. The reason Water striders do not fall into the water is because a water strider's body weight is light, but the bigger secret is the water strider's legs. Water striders were able to walk on top of water due to a combination of several factors. If you looked at water striders' floating on the water carefully, water striders used the high surface tension of water and long, hydrophobic legs to help them stay above the water. Water molecules are polar and this causes them to attract to each other. The attractive nature resulted in the formation of a film-like layer at the top of water. This top layer has gravity acting downward in addition to the water molecules below pulling down the upper molecules. This combination creates a touch surface tension. Gerridae species used this surface tension to their advantage through their highly adapted legs and distributed weight. The legs of a water strider are long and slender, providing the weight of the water strider body to be distributed over a much larger surface area. Their legs are strong, but it's their flexibility that allows the water striders to keep their weight evenly distributed and flowing with the water movement.

If you looked at the foot of water striders with the magnifying glass or stereoscopic microscope, lots of hair lines the body surface of the water strider. There were several thousand hairs per square millimeter, providing the water strider with a body that prevents wetting from waves, which could inhibit their ability to keep their entire body above the water surface. The tiny hairs would trap air. Tiny air bubbles throughout the body acted as buoyancy to bring the water strider to the surface. The tiny hairs on the legs provided both a hydrophobic



Figure 4. Water striders' claws (Observed with stereoscopic microscope)

surface as well as a larger surface area to spread their weight over the water. The front legs are the shortest and have preapical adapted to puncture prey. The reason the leg does not fall into the water is because of the oily water from oil glands, or sebaceous glands, in the end of claws which prevents the hairs from wetting.

However, to float and move on the water, water striders use their legs. Claws in the end of the other insects' feet tended to fix their legs, but because water striders' claws shown in **Figure 4** are slightly bent inside from the end, they prevented the waves from spreading, providing the water strider resistance to splashes or drops of water, and keeps a water strider's entire body above the water surface.

Within the 'Explanation' step, teachers allowed students to sum up observations from the question of 'What is the difference between your predictions and observation results, and what are the new discoveries?' Teachers provided students with the opportunity to say 'what is the unsatisfied part and unsolved problem?' and 'what is the difficulty of this observation?' through a group activity discussion. Teachers could then provide students with the opportunity to reflect.

Teachers led students to answer additional questions such as 'How do students distinguish between male and female water striders?', 'Is there a wing in a water strider's body?', and 'Do water striders hate dirty things?' As water striders have the habit of keeping clean, they washed their legs as well as a body. If the legs and the body become dirty, the dirty hairs will trap the water amongst the messy hairs, and this brings the body down in water. When water striders were attached to the water plant or floating on the water, water striders cleaned their bodies with their legs. The tiny hairs on all 6 legs of the water striders act as brushes, and removed dirty things.

Female water striders lay their eggs, by submerging and attaching the eggs to stable surfaces such as plants or a log. Some water strider species will lay their eggs at the water's edge if the body of water is calm enough. The larva will be fully grown by the gradual transformation and the wings are fully formed until they become an imago, an adult insect. The adult insects fly to neighboring bodies of water and mate, resulting in the spread of genes for forming a new family.

Table 6. The contents of a water rider's floating condition

Activity	Step	Activity contents
Observation of water striders floating on top of water	Prediction	How do a water rider float and move?
	Observation	Observe that water striders walk on top of water. Observe the movement of water striders' legs.
	Explanation	What is the difference between students' prediction and observation results and what is the new discovery for students to newly find out?
	Reflection	What is the problem of observation? Students devise alternative method for their observation.
	Additional question	What do students want to know more? When a drop of soap water drops in the center of the surface, what happen?
Strange shadow	Prediction	What does the appearance of a shadow look like when water striders walk on top of water? Why does a shadow occur?
	Observation	Observe that water striders floating on top of water, and the shadow on the water.
	Explanation	What is the difference between students' prediction and observation results and what is the new discovery for students to newly find out?
	Reflection	What is the problem of observation? Students devise alternative method for their observation.
	Additional question	What do students want to know more?
Why does water striders look at the same place?	Prediction	Do water striders know the current location?
	Observation	Put water striders in a water tank, and make pictures stand circularly around the water tank. At first, observe quietly what water striders look at, and move the location of the pictures.
	Explanation	What is the difference between students' prediction and observation results and what is the new discovery for students to newly find out?
	Reflection	What is the problem of observation? Students devise alternative method for their observation.
	Additional question	What do students want to know more?

Teachers instructed students to distinguish between male and female water striders by the body size and the appearance of water strider's abdomen. The big body size is a female water strider. The appearance of male water strider's abdomen was triangular and straight.

Inquiry subject 4: 'Explore the condition of a water rider's floating'

The contents of a water rider's floating condition were like **Table 6**.

In the activity of observing the water striders walking on top of water, teachers instructed students to predict in advance what it would look like and to draw a picture of the water striders. They were then asked to observe the movement of water striders directly and annotate.

Water striders' middle legs are used for rowing are particularly well developed with fringe hairs to help increase movement through the ability to thrust. The hind pair of legs are used for steering. When the rowing stroke begins, the middle legs are quickly pressed down and backwards to create a circular surface wave in which the crest can be used to propel a forward thrust. The semicircular wave created is essential to the ability of the water strider to move rapidly since it acts as a counteracting force to push against. Thus, water striders often move at 1 meter per second or faster. Students can find out that the front legs support the water strider's body and have adapted to puncture prey.

Teachers encouraged students to tell the difference between their prediction and observation results, and to reflect on the unsatisfied parts of observation and the unsolved problems to deduce what students want to know more of. In the 'Additional questions' step, teachers enabled students to ask additional questions of what happened when a drop of soapy water placed in the center of the surface.

In the activity of 'strange shadow', teachers instructed students to predict in advance what the shadow of water striders would look like. They were then asked to draw the shadow of water striders walking on top of water, and then to observe directly the shadow of water striders on the water. Through this activity, students could solve the problem of why water striders floated on water and the reason why the shadow of water striders occurred on the water. Teachers enabled students to ask additional questions of 'what is the unsatisfied part and unsolved problem?' and 'what is the difficulty of this observation?' Teachers could provide students with the repeated opportunity to observe repeatedly to help complete the assignment in case the first observations were lacking.

Students could find that the front legs were shorter than the middle legs, and the hind legs, so the shadow of the front legs were the shortest. Students could observe the shadow of water striders on the water when water striders floated on top of shallow water. Water striders used this surface tension to their advantage through their highly adapted legs and distributed weight. The legs of a water strider were long and slender, providing the weight of the water strider body to be distributed over a much larger surface area. The surface of water was a shallow film-like layer. The legs had flexibility that allowed the water striders to keep their weight evenly distributed, and then the shadow occurred on the water surface by the legs. The shadow of water striders on the water surface occurred due to the end of the weighted legs (**Figure 5**).

In the activity of 'why do water striders look at the same place', teachers challenged students to find out the water striders' cognitive ability was, and to put a water strider in a water tank to take pictures (**Figure 6**). At first, teachers asked students to observe quietly what the water striders would look at, and then to move the location in which they take photos. Teachers instructed students to observe the movement of the water strider and the direction of the pictures. Teachers encouraged students to explain the problems of observation and to deduce a logical conclusion through repeated observation activities. Students were then instructed to recognize the difference between their predictions and the observation results. In



Figure 5. The shadow of water striders (the picture in the habit, the rice field)



Figure 6. In the activity of finding out water striders' cognitive ability

addition, Teachers provided students with the opportunity to sum up what they wanted to know about the water strider's eyes.

Inquiry subject 5: 'Making a water strider's model'

The contents of 'Making a water strider's model' were like [Table 7](#).

In the activity of 'Making a water strider's model', teachers encouraged students to design the method for making the model of a water strider by using a copper wire and a toothpick, considering the principle of a water strider floating on top of water. For the copper-wired model of a water strider to successfully float on the water, the surface area of a water strider's legs needed to be wide. In other words, prepare 2 copper wires and a toothpick. Teachers instructed students to wind 2 copper wires to a toothpick for making the model of water striders. Teachers told students to fill a water tank 3/4 full of water and then cover the water surface with a piece of shallow paper, put the copper-wired model of water striders to float on the water. Now, a piece of shallow paper slowly sinks under the water, but students would find out that the copper-wired model of a water strider floated on the water through the observation activity ([Figure 7](#)). In this activity, teachers helped students to comprehend the principles of the surface tension. If there was extra time to do the activity, teachers could

Table 7. 'Making a water strider's model'

Step	Activity Contents
Prediction	Design a method for making the model of water striders floating on top of water.
Observation	Make a model of water striders considering the water striders' characteristics by using a copper wire and a toothpick.
Explanation	What is a new discovery of the water striders' features that students found out by making the model?
Reflection	What is a problem with the first design of 'Making the model of water striders?' Students devise alternative methods for their observations.
Additional question	What do students want to know more? What do we take advantage of relating to the principle of making water striders float on the water?



Figure 7. The activity of 'Making a water strider's model'

tell the students to make a water strider's more specific model by using Styrofoam, wire, sponge.

In the additional activity, teachers allowed students to drop salt water, edible oil, soap, and so on in the water tank. Students were then asked to summarize the condition of which made water striders float on top of water (As the surface tension was getting weaker by detergent, water striders sank). In addition, teachers could provide students with the opportunity to ask 'what is the difference between the model of water striders and the real water striders?' through a group activity discussion. Teachers could provide students with the opportunity to sum up and design the method of solving these problems.

Teachers could explain a lotus leaf effect (**Figure 8**) to students for their answering of additional questions, and suggest the similar examples.

The results of on-site applicability of 'Water strider' Inquiry Learning Program for extending science inquiry ability

To verify the feasibility of Inquiry Learning Program, 23 elementary school teachers in charge of science education were evaluated through a workshop which aimed to assess the



Figure 8. A lotus leaf’s surface tension

Table 8. The result of ‘Water strider’ Inquiry Learning Program by teachers

Domain	Assessment results	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree
Goal	Does this Inquiry Learning Program empower students to be interested in science, and improve their attitude?	13 (56.5)	10 (23.7)	0 (0)	0 (0)	0 (0)
	Does this Inquiry Learning Program help students understand scientific principles?	14 (60.8)	8 (34.8)	1 (4.4)	0 (0)	0 (0)
	Does this Inquiry Learning Program encourage students to improve their science inquiry ability?	12 (52.1)	11 (47.9)	0 (0)	0 (0)	0 (0)
Contents	Does this Inquiry Learning Program reflect the learning contents of the chapter, ‘the little creatures’ in elementary science?	9 (39.1)	9 (39.1)	5 (21.8)	0 (0)	0 (0)
	Is this Inquiry Learning Program appropriate for the 5 th grade level?	7 (30.4)	10 (43.5)	6 (26.1)	0 (0)	0 (0)
feasibility	Do you think this Inquiry Learning Program is useful in its current spot of elementary curriculum?	12 (52.1)	8 (34.8)	3 (13.1)	0 (0)	0 (0)

Inquiry Learning program's applicability. The contents of ‘The result of on-site applicability of Water Strider Inquiry Learning Program for extending science inquiry ability’ are in **Table 8**.

In the question of ‘Does this Inquiry Learning Program induce students to be interested in science, and improve their attitude?’, of 23 teachers (100%) responded positively that they strongly agreed it did. In the question of ‘Does this Inquiry Learning Program help students understand the scientific principles?’, 22 teachers (95.6%) responded positively that they strongly agreed. Lastly, the question of ‘Does this Inquiry Learning Program encourage

students to improve the science inquiry ability?', all 23 teachers (100%) responded positively again that they strongly agreed.

Through these results, this Water Strider Inquiry Learning Program enabled students to comprehend the scientific principle, improve inquiry abilities, and spark interested in science. Each activity in the program helped increase the students' interest, helped them to easily comprehend scientific principle', and improved their inquiry learning abilities. Also, the Water strider' Inquiry Learning Program proved to amplify ones ability to achieve goals.

The free-response questionnaire for describing teachers' opinions was as follows:

Teacher A: In the activity of directly raising and observing the secret of water striders' body, teachers enable students to explore the scientific principle, and help students to increase their interest, and improve students' inquiry learning abilities.

Teacher I: Teachers didn't explain directly, but this inquiry activities enable students to find out the scientific principles and increase their understanding of insects. So this program is quite useful.

Teacher C: In the domain of biology, it is effective to deal with the live authentic creatures. So, this inquiry program is very meaningful because students directly raise and observe the water striders.

Teacher P: This program is suitable in the Korean elementary school curriculum. This program enables students to increase their science inquiry ability for the little creatures.

Teachers thought this inquiry program enabled students to be interested in science and improve their science inquiry ability. This program was quite useful because using real authentic creatures and considering their features in the domain of biology helped students comprehend the scientific principle. This program emphasized that it is suitable within the Korean elementary school curriculum. It was effective in stimulating students with live authentic creatures. In addition, this inquiry program was very meaningful because students comprehended the science based on inquiry while improving their knowledge of insect biology.

In the question of 'Does this Inquiry Learning Program reflect the learning contents of the chapter, 'the little creatures' in elementary science?', 18 teachers (78.2%) responded positively that it was strongly agree and agree, but 5 teachers (21.8%) responded that it was neither agree nor disagree. In the question of 'Is this Inquiry Learning Program appropriate for the level of elementary 5th grade?', 6 teachers (26.1%) responded positively that it was neither agree nor disagree.

Through these results, it was the Korean elementary school science textbook that suggested not just the specific scientific principle and structural features but the biodiversity and the importance of the little creatures. However, as shown in the free-response questionnaire, recent curriculum focused on the features of Integrated Science Process Skill

and connected with other domains. It was effective that recent curriculum enabled students to directly raise and observe and comprehend the living creatures' characteristics.

The free-response questionnaire for describing teachers' opinions was as follows:

Teacher E: In the observation activity of the chapter, 'the little creatures', there are pictures of water striders in a marshy or swampy place. Students are curious about a water strider floating on top of water. This program is useful for exploring their curiosity.

Teacher T: Somewhat difficult, but 'Water strider' Inquiry Learning Program could be useful for science club activities including science class during regular curriculum time.

Teacher F: It is difficult for a science class during regular curriculum time because there are lots of contents and activities; but some activities are very suitable for the same class, and the other activities could be used for free time activities.

Teacher D: Inquiry contents are related with the little creatures, movement and energy area. Integrated contents in science class are useful for Integrated Science Process Skills connected with other domains.

Teachers suggested their opinions that this inquiry program could be available for integrated science class due to the advanced learning in the chapter 'the little creatures', and the connection of the other domain. However, it was difficult for a science class within the regular curriculum because there was lots of content and many activities. So, this program is very suitable for extracurricular activity.

In the question of 'Do you think this Inquiry Learning Program was useful in the current spot of an elementary school?', 20 teachers (86.9%) responded positively that they strongly agreed. This meant the program was very useful in many ways.

The free-response questionnaire for describing teachers' opinions was as follows:

Teacher H: There are lots of creatures in the chapter 'the little creatures', but there is not enough content to intensively inquire about some specific creatures. There is not enough interest in some specific creatures.

Teacher S: This program enables students to comprehend the scientific principle.

Teacher G: This program gives students many opportunities to deal with the science inquiry activity. It is especially helpful in improving the ability to observe.

Teacher J: This program is very suitable for extracurricular activities. The secret of water strider's body give students a positive attitude towards science, and interest in science class.

Teacher K: I tried to provide many inquiry activities for my students in science class, but it is difficult to come up with new ideas. This program

provides new ideas for the chapter, 'the little creatures.' This workshop gives me confidence in teaching my students the chapter 'the little creatures' vividly.

Teacher R: This program is useful, but it is difficult to teach all activities due to lack of time.

Since this program enabled students to easily comprehend the scientific principle and improve their inquiry ability, this program is useful in elementary science focusing on inquiry process. Moreover, this program achieved more interest and active participating with students who had lost their interest in science. A teacher responded that this workshop gave him extended confidence in teaching his students science vividly.

CONCLUSION AND SUGGESTION

In this study, the 'Water strider' Inquiry Learning Program was developed for increasing the students' interest in science and improving their inquiry learning. So as to find out on-site applicability of 'Water strider' Inquiry Learning Program, the validity of 'Water strider' Inquiry Learning Program's goal, content, application was analyzed through the Elementary school teachers' workshop.

The following were the summarizations of the main issues of the study:

First, the 'Water strider' Inquiry Learning Program consisted of 5 subjects including 'Comprehension of surface tension', 'Collecting and raising water striders', 'The secret of water striders' body', 'The condition of floating water striders', 'Making the model of water striders' and was composed of 10 small group activities. The inquiry step included Prediction, Observation, Explanation, Reflection, and an Additional question stage. In these activities, students predicted the scientific principles that related to the 'water striders' in advance, and observed 'a water strider' to prove this. They then explained the comparison between the results of observation and their forecasting, and questioned what they wanted to know more of through reflection.

Second, in the assessment of the on-site applicability which the elementary school teachers directly implemented, each activity consisted of immediate manipulation activities that helped increase the students' interest. They easily comprehend the scientific inquiry ability including 'Water strider' Inquiry Learning Program. Also, the 'Water strider' Inquiry Learning Program could be useful for science club activities in addition to the regular curriculum time because the integrative lessons made available. Teachers thought that this program enabled students to directly catch and observe and comprehend the scientific principle related with water strider, and this program was useful when dealing with the chapter 'the little creatures'.

Given the findings of the study, there were some suggestions for this inquiry program's effectiveness with on-site applicability based on undergoing and experience:

First, it was very significant in terms of learning effects that this program led students to directly observe the little creatures. It was very difficult for students to directly observe them in the inner-city schools. Therefore, it was necessary to build a School Ecology Experience Hall through cooperation of schools for solving this problem. Also, it was essential that educational institutions supplied schools with the little creatures.

Secondly, the 'Water strider' Inquiry Learning Program was available in regular class time, but it was difficult to complete in the allotted time. This program should be considered for science club activities, science camps or in the elementary science class for scientifically gifted students.

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