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# Analyzing Korean Elementary School Teachers' Arm Muscle Models as Scientific Models

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## ABSTRACT

The aim of this study was to analyze pre-service elementary school teachers' Arm Muscle models and elementary school teachers' evaluation viewpoints of their Arm Muscle models as scientific models. The sample of this study consisted of 24 pre-service elementary school and 12 elementary school teachers. Pre-service elementary school teachers, who were divided into three groups, directly developed 3 Arm Muscle models. 12 elementary school teachers evaluated their developed 3 Arm Muscle models as scientific models. Most of elementary school teachers suggested that three models helped pre-service elementary school teachers conceptually understand the relationship between muscles and bone. Also, the results indicated that pre-service elementary school teachers made three models by visually imitating the shapes of real bone and muscle tendons. Further, elementary school teachers evaluated pre-service elementary school teachers' efforts given visual similarities between actual bone and muscle tendons Most of elementary school teachers addressed that these 3 Arm Muscle models were practically good at acting as an automatic model. The current study recommends that modifying these models may increase their scientific values in the future.

**Keywords:** Arm Muscle models, elementary teachers, science education, scientific models.

## INTRODUCTION

Today's scientific education purposes to examine how social interaction influences scientific knowledge, how to evaluate newly constructed knowledge, and how learners have an opportunity for exploring themselves. For this reason, a traditional science class should be changed with a new one.

To effectively participate in scientific researches, teachers and students need to develop learning materials of scientific concepts inquiries. To accomplish meaningful learning at elementary schools, pre-service elementary school teachers or elementary teachers should develop and explore scientific models that promote their scientific understanding (Schwarz *et al.,* 2009).

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The word "model" describes a physical copy of the phenomenon or an object. For example; a plastic molecular model, a solar system model with a bulb and many balls. Also, maps, tables and mathematical algorithms and formulas can be called models (Cartier, Rudolph & Stewart, 2001). The term "model" means a system, or an object, or a science concept. Therefore, science education studies have widely used various meanings and definitions of models (Taber, 2011).

The value of a model depends on how a phenomenon works or its conceptual meaning. Science education studies exploit models to understand and explore any scientific knowledge. For instance, a model could be used to make a very small object observable (e.g., cells) or to illustrate a solar system in a science class. In some cases a model could be utilized to understand such directly invisible phenomena as force or electricity current (Aktan, 2013**;** Güneş**,** Gülçiçek, & Bağcı, 2004).

Scientific models explain a system (e.g., respiratory organs of the body, the solar system, the electrical circuit) or a scientific phenomenon (i.e., a seasonal change and a food chain) (National Science Foundation [NSF], 2013). This model employs paintings, tables, flow charts, and three-dimensional graphs to explain a system or a scientific phenomenon. A scientific model clearly simplifies reveals and visualizes the central features of the phenomenon. In addition, scientific models, which play an important role in science curriculum, serve as important learning tools to help students understand scientific phenomena. Students-generated models enable students to build and evaluate conceptual understanding, and scientific knowledge (Coll & Lajium, 2011; Jung & Kim, 2016; Schwarz & White, 2005). Similarly scientific models, which are easily accessible for scientific phenomena, help teachers understand modeling and its features.

Because majority of science teachers has limited knowledge of model and modeling, they have difficulties in using inappropriate models in their classes or integrating them into science teaching (Danusso, Testa & Vicentini, 2010). Unfortunately, teachers' limited experiences of scientific models restrict students' ideas of scientific models (Kim, Moon & Son, 2006). Even though some teachers find models useful to teach science content, they do not think that models are worthy to instruct the nature of science (Henze, Van Driel & Verloop, 2007; Justi & Gilbert, 2002).In addition, Oh (2007) found that trained teachers did not explain the nature of the scientific model and provide an opportunity for students to think about it. Also, lots of experienced teachers tend to limit models to an imitation or a copy of awareness (Harlow *et al.*, 2013; Justi & Gilbert, 2003). Indeed, science teachers' skills and knowledge of models and modeling are essential for improving their pedagogical content knowledge (PCK). Schwarz *et al.* (2009) claimed that teachers' limited knowledge of scientific models, and modeling might threaten their effectively use in science classes. Therefore, science textbooks should introduce inquiry-based science activities that include attributes of scientific models or modeling. To help students comprehend a scientific system or a phenomenon, better models need to be actively developed and disseminated to schools for teachers and students.

Fostering teachers to directly make their own models and evaluate them practically enhances their capacities of scientific models and their effectiveness (Kim & Kim, 2009).

If teachers have a chance to explore how models explain scientific phenomena, they can really know the characteristics of scientific models (Kim, Moon & Son, 2006). In this study, pre-service elementary school teachers developed modeling activities as their projects, and elementary school teachers evaluated them in regard to the characteristics of the scientific model.

The Korean Elementary School Biology Science Textbook contain a chapter entitled 'The body's structure and function' at grade 5 and stresses understanding the agencies of our body through a variety of inquiry activities. Especially the principles of the arm movement require students to make arm muscle models. Therefore, the aim of this study was to analyze pre-service elementary school teachers' arm muscle models and elementary school teachers' evaluation viewpoints of their arm muscle models as scientific models. It was also expected that the results of the current study would offer an effective model strategy for pre-service and in-service education.

## METHODS

### a) Participants

The participants of this study, who attended science curriculum materials and a guide method in a national education university in a Korean Metropolitan City, consisted of 24 pre-service elementary school teachers and 12 elementary school teachers. The elementary school teachers evaluated 3 highly efficient Arm Muscle models developed by pre-service elementary school teachers (see Table 1). 12 elementary teachers studied the same courses "research and development of primary science materials in the third semester of graduate school (see Table 2).

**Table 1.** *Types of pre-service elementary school teachers' Arm Muscle models*

| Features | A | B | C |
|---|---|---|---|
| Gender | Two females and one male | Two females and one male | Two females and one male |
| Selecting evidence (excellence) | Model simplicity | Real issues and models, visual similarities | Model automatism |

**Table 2.** *Demographic features of elementary school teachers evaluating pre-service elementary school teachers' Arm Muscle models*

| Teachers | Gender | Teaching experiences | Semester in graduate School | Teachers | Gender | Teaching experiences | Semester in graduate school |
|---|---|---|---|---|---|---|---|
| A | Female | 3 years | Third semester | G | Female | 3 years and 5 month | Third semester |
| B | Female | 4 years | Third semester | H | Male | 7 years and 5 month | Third semester |
| C | Female | 6 years | Third semester | I | Male | 4 years | Third semester |
| D | Male | 10 years | Third semester | J | Female | 8 years and 5 month | Third semester |
| E | Female | 4 years | Third semester | K | Female | 12 years and 5 month | Third semester |
| F | Female | 5 years | Third semester | L | Female | 1 year | Third semester |

### b) Evaluating the Arm Muscle Models

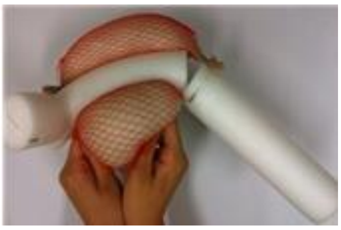
'The body's structure and function' in the Korean Elementary School Biology Science Textbook has an activity asking students for building Arm Muscle models to understand arm muscle. Pre-service elementary school teachers followed science textbooks revised in 2007 and 2009 (see Table 3). Table 4 presents the developmental process of some selected arm muscle models.

**Table 3.** *Science textbook's basic Arm Muscle models*

| | Science textbook revised in 2007 (p. 29) | Science textbook revised in 2009 (p. 109) |
|---|---|---|
| Picture |  |  |
| Materials | A tape measure, three boxes, two stockings, thick cottonseed, knives, scissors, a cellophane tape | Ttwo thick straws, wrinkle straw, a pin, a plastic bag, scissors, an awl, a cellophane tape, picture |
| Learning Objectives | • Students are able to identify the features of bones and muscles.<br>• Students are able to create a model of bones and muscles.<br>• Students are able to explain what bones and muscles do. | • Students are able to build and explain the model of bones and muscles.<br>• Students are able to explain the relationship between bones and muscles and their functions. |

**Table 1.** *Some of pre-service elementary school teachers' Arm Muscle models*

| Types | Materials and Building procedures |
|---|---|
| Type A | 1. Materials- a white cardboard, a orange cardboard, a snap fastener, wooden chopsticks, tape, string, thread, scissors, knives.<br>2. Building procedures included to:<br>1) Draw and cut the upper arm bones (a humerus) and the lower arm bones (a radius and an ulna) in a white cardboard.<br>2) Draw and cut two biceps and two triceps in an orange cardboard.<br>3) Connect the upper arm bones (a humerus) and the lower arm bones (a radius and an ulna) by using a snap fastener.<br>4) Connect the tail end of two biceps by using a snap fastener.<br>5) Connect the right part of two biceps and the upper and right parts of the upper arm bones (a humerus) by using a snap fastener.<br>6) Connect the left part of two triceps and the lower and left parts of the upper arm bones (a humerus) by using a snap fastener.<br>7) Just cut 4cm down in the middle of the upper arm bones (a humerus) and pull out the end of the biceps' left part.<br>8) Just cut 4cm up in the middle of the upper arm bones (a humerus) and pull out the end of the triceps' right part.<br>9) Tightly connect 90 degrees of the upper arm bones (a humerus) and the biceps by a thread.<br>10) After cutting one third of wooden chopsticks, connect the upper arm bones (a humerus) muscles by tape with each other.<br>  |

| | |
|---|---|
| | <Fully completed models> |
| B | 1. Materials- a ruler, a backup stick, stockings, an egg net, cotton wool, thick cottonseed, knives, scissors,<br>2. Building procedures included to:<br>1) Make 36cm arm bones and 5cm shoulder blades by a backup stick. Then, stick arm bones and shoulder blades by a tape.<br>2) Cut the upper arm bones (a humerus) and the lower arm bones (a radius and an ulna) to a depth of two thirds in the middle to divide them. (Note: One third of them is the role of the joint).<br>3) Cut a backup stick for shoulder blades and the lower arm bones (a radius and an ulna).<br>4) Add two stocking in the cotton ball. Put more the cotton ball and tie up the end of stockings in the upper arm bones (a humerus). Cut the front and back of an egg net, and put the egg net on top of the stockings with the cotton ball.<br>5) Put the upper part and lower part of the upper arm bones (a humerus) to the stockings, pull it tightly (4 threads, each 30cm).<br>6) Pull and release tied part of stockings by observing the movement of the model, bones and muscles.<br><br><Fully completed models> |
| C | 1. Materials- 2 syringes, 3 toothpaste boxes, wrapping paper, knives, Scotch tape, thread, magnets, cardboard<br>2. Building procedures included to:<br>1) Connect 2 syringes via a tube.<br>2) Connect the upper arm bones (a humerus) and the lower arm bones (a radius and an ulna) via a tape<br>3) Cut in the middle of the upper arm bone (a humerus) bones.<br>4) Connect it by syringes and fasten it by a tape.<br>5) Tie syringes by thread.<br>6) Cut the lower arm bones (a radius and an ulna) to 5cm.<br>7) Connect a thread in the end of syringes to the lower arm bones (a radius and an ulna) and fasten it tightly.<br>8) Cut in the middle of the lower arm bones (a radius and an ulna).<br>9) Fasten the cutting part in the upper arm bones (a humerus) and the lower arm bones (a radius and an ulna) to a cardboard box that represents the muscle fibers. (Stick a joint tensely. Two cardboards represent the biceps.)<br>10) Connect the back of the cardboard that represents the muscle fibers in the same way. (Stick loosely a flexed joint at this time. Three cardboards represent the triceps.)<br>11) Connect magnets between the upper arm bones (a humerus) and the lower arm bones (a radius and an ulna) boxes (joints). (Stick the magnets because syringes are a little weak when a joint stretches.)<br><br><Fully completed models> |

### c) Data Collection and Analysis

12 elementary school teachers, who studied the first week of "Research and Development of Elementary Science Materials" course in graduate school, directly evaluated 3 Arm Muscle models as a scientific model and compared them with the basic model in the science textbook. They were asked to freely write (called open questionnaires) the features of the Arm Muscle models as a scientific model.

Because open questionnaires only express the results via, the researcher found them incomplete and inappropriate for an in-depth analysis. To overcome these shortcomings, discussions were conducted with 12 elementary teachers to clarify unclear or missing issues in any open questionnaire. During discussion sessions, the researcher took notes their views since they did not allow to video-record their responses to discussion sessions. Open questionnaires and discussions lasted about two hours. Even though 12 elementary teachers freely wrote many features of 3 Arm Muscle models as a scientific model, analysis procedure only concentrated on the nature of the model by using four criteria: (a) scientific conceptual context, (b) visual context, (c) practical context, and (d) dynamic context. A group of experts (a scientist and a science educator with PhD) analyzed and categorized elementary school teachers' views.

Their viewpoints about the attributes of the Arm Muscle models as scientific models were presented and exemplified in the results.

## FINDINGS and DISCUSSION

### a) The Context of Conceptual Understanding: Models Should Promote to Understand Science Concepts

The science models, which purpose to support the context of conceptual understanding improve students' scientific knowledge and remedy their misconceptions or incomplete knowledge. For this reason, a scientific model should lead to explain the scientific concepts through research activities. In other words, a well-designed model should imitate and interpret any scientific phenomenon or applicability of scientific knowledge.

12 elementary school teachers' views of the conceptual understanding context at the Arm Muscle models are as follows:

> An evaluation for 'model A':
> In this model, a change in muscle thickness is unclear. This model leads misconceptions because muscles cannot be a shorter and longer form. However, it seems that there is no problem in understanding the relationship between muscle and bone (Teacher J).
>
> An evaluation for 'model B':
> This bone and muscle model more effective in explaining science concepts than the basic model in the science textbook. A great advantage of this model is that bone shapes are similar with actual bones ; and the contraction and relaxation of muscles is well expressed. This model makes me easily understand a change in muscle thickness (Teacher C).
> I think the model as a guide material, effectively achieves learning goals. When learning the bone structures of our bodies, students do not understand many muscles, and interactions between bones and muscles through this model. Teachers should let

students know the limitations of this model and handle carefully main scientific contents (Teacher D).

An evaluation for 'model C':
Many students just memorize the meanings of biceps and triceps, this model enables students to understand well the meanings of biceps and triceps muscles. But expressing the tendon within this model is incomplete. Nevertheless, reaching a learning objective about the relationship between muscle and bone is not difficult (Teacher F).
This model is used to understand and explain a difficult phenomenon. Students directly operate this model to understand muscles and bones (Teacher I).

12 elementary school teachers wrote commonly that the model C helped students understand the relationship between the muscle and bone. In particular, 5 of them mentioned that the model C afforded students to understand the meanings of triceps and biceps. They also depicted that the model A had a problem at the activity 'measuring a thickness of muscle' in science textbooks, while the model B involved in this activity. Even though the model C enabled them to comprehend the meanings of triceps and biceps, it had a difficulty in expressing a change in muscle thickness. In addition, although the model B explained the role of the tendons, the model C had a trouble at explaining its meaning (see Table 5).

**Table 2.** *Elementary school teachers' model evaluation results of the conceptual understanding context*

| The features of science models | Model Types | Frequencies | Sample views |
|---|---|---|---|
| The context of conceptual understanding | A | 2 | It helps to understand the relationship between the muscle and bone. |
| | | 2 | It has problems at expressing a change in muscle thickness. |
| | | 1 | It expresses the external features of the muscle and bone. |
| | B | 2 | It helps to understand the relationship between the muscle and bone. |
| | | 2 | It helps to understand a change in muscle thickness. |
| | | 1 | It explains the role of the tendons |
| | | 1 | It has a trouble at expressing many muscles and misconceptions. |
| | C | 5 | It helps to understand the meanings of the triceps and biceps. |
| | | 2 | It helps to understand the relationship between the muscle and bone. |
| | | 2 | It cannot explain the role of the tendons. |
| | | 1 | It leads to do a new prediction. |

A scientific model represents or exemplifies something, which is hard to reach or understand. Hence, the scientific models should be consistent with the collected data of the phenomenon. The model's components, relations, interaction, and rules are created through several observations of any real phenomenon. A scientific model also explains and predicts natural phenomena (Schwarz *et al*, 2009). A scientific model not only explains why the phenomenon happens but also predicts a new component or relation or interaction or rule by comparing the data derived from the phenomenon. In other words, a scientific model should implement the properties of mechanism, causation and function in order to example, describe, and predict the phenomena as a specialized expression.

Consequently, teachers need to develop basic and existing scientific models or a new scientific model for explaining scientific phenomena or predicting new phenomena. This allows to increase their own students conceptual understanding.

### b) The Visual Context: A Model Should be Similar to a Phenomenon and Possess a Good Appearance

Students in a science class use model to find an example or similarity of a phenomenon. Students compare and assess various models to accurately describe and explain the pattern of phenomena. But students tend to reject the use of scientific models, which are complex and coarse (Schwarz *et al.*, 2009). The academic excellence of the scientific model is dependent on clearly expressing how scientific phenomena happen. However, the scientific models, which do not view the visual context as a barrier, may have pitfalls at clarifying and understanding the scientific phenomena.

In particular, elementary school students understand and use the models, which do not have visual estrangement phenomena to explain them as a productive tool. Elementary school students define a model as a visual similarity. The younger students, who prefer defining models by using the model similarity, and similarities between models, tend to use the 'model' term as an example (Aktan, 2013).

12 elementary school teachers' views of the visual context at the Arm Muscle models are as follows:

> An evaluation for 'model A':
> The biggest problem of the Arm Muscle models is a visual discrepancy. The visual discrepancy can be solved using materials similar to the real bones and muscles. However, this model does not have a visual effect for the bones and muscles (Teacher L).
> Models are similar to real objects, but they do not need to illustrate everything. If a model shows a very small fraction, the model should actually enlarge it. If a model shows a very big object, the model should actually minimize it. This model is smaller than the actual arm muscles. But the real shape has differences. If teachers explain the differences between models and the real object, this model runs effectively (Teacher J).
>
> An evaluation for 'model B':
> In this model, the bones are round, white, while muscles are red. This enables students to visually identify bones and muscles. The biggest problem of the textbook is that its visual estrangement is shortened (Teacher K).
>
> An evaluation for 'model C':
> It facilitates student's expression on stretching their arms automatically. Most of them looks neat rather than using plastic bags or stockings in the textbook model. The feature of this model utilizes the syringe for the automation of the model and to entertain their eyes (Teacher D).

As seen from Table 6, elementary school teachers assessed models B and C positively in terms of the visual context (Table 6). Especially, the model, which was similar to the one shown in the science textbook, was very easy for students to understand the body colors. This model has an advantage at completing the model-making process. That is, the neat feature of the model emphasized that students could gain access to it without any protest. Elementary school teachers were generally worried about safety rules at their schools. For example, students might identify the messy parts of the model in case of an incomplete model. Hence, they may be confused with the function of the model. The model C was praised with its resemblance of the biceps and the triceps, as the main points of this model, and with its automation making students' eyes pleasant.

Some teachers argued that mentioning the idea "models are smaller than the actual arm muscles" might result in effectively teaching the topic to the students. Therefore, teachers could teach their lessons to the students by extending the structure of the human body, or reducing scientific phenomenon by time and space.

**Table 6.** *Elementary teachers' model evaluation results of the visual context*

| The features of science model | Model Types | Frequencies | Sample responses |
|---|---|---|---|
| The Aesthetic context | A | 3 | It is visually inconsistent with the arm muscles. |
| | | 2 | It expresses the bones and muscles with paper in fragments. |
| | | 1 | It does not make a neatly connection to the bones and muscles. |
| | | 1 | It is smaller than the actual size. |
| | B | 3 | It is similar to the bones and muscles in the visual context. |
| | | 3 | It is neat and tidy. |
| | | 2 | Completing a model-making process is good for manufacturing. |
| | C | 2 | It is good for students. |
| | | 2 | It is similar to the biceps and triceps. |
| | | 2 | Its automation makes the students' eyes pleasant. |

For the visual context, some teachers saw the scientific model as a sign focusing on explaining and simplifying the system (Goo & Oh, 2014).This means that teachers should deploy models to facilitate students' understanding of the scientific phenomena by means of a visually simple-oriented manner (or example; the Bohr atomic model, the molecular model of the matter, a light beam model, Hydrologic cycle model, and the food web model).

First of all, visually modifying the students-generated models gives an opportunity for students to learn a new scientific concept and infer new concepts from the evidence. These advantages of the use of the models need to be integrated into science classes.

### c) The Practical Context: Models Should be Easily Operated and Used

A scientific model acts as a practical model since it, as a real model, is easily manipulated in a science class (Aktan, 2013). Similarly, because of such features of the model as size, materials, environment, and representative complexity, it may be limited to the use of teachers. Thus, considering the practicality of a good science model may be a shortcut for approaching a variety of scientific phenomena.

A good model helps students learn an obvious reason of any phenomenon. Therefore, using models is easier for students and positively and effectively stimulates their conceptual understanding and interests.

12 elementary teachers' views of the practical contexts at the Arm Muscle models are as follows:

An evaluation for 'model A':
When students pull up wooden chopsticks, the biceps model is contracted, and then the triceps model is loose, so the lower part of the arm connected by a thread moves up. Also, this model means that bones move through muscles because the muscles must firstly move (teacher B).

An evaluation for 'model B':
Since the bone is made of the material of the backup stick, it is easy to manipulate and move freely. It is regrettable that the muscle does not move automatically (Teacher E).

An evaluation for 'model C':
It has an advantage at operating comfortably via the syringe. Holding and releasing the tied portion of the stockings in the model suggested by the science textbook are very hard for students to operate, and observe the movements of the bones and the muscles (Teacher G).
The flexibility of the model should play an important role in allowing students to easily operate it. This model includes easily accessible and easily operable. In particular, inducing its applicability gives an opportunity for them to trigger creative thinking that can easily be converted into a re-making process (Teacher K).

Most of the elementary school teachers thought that the three models were easier to operate than the models in the science textbooks. In particular, they depicted that model C was more convenient to operate than models A and B.

Some teachers pointed out that model C's automation system might lead a misconception "the operation of the syringe move bones instead of the muscle movement." Also, model C had a potential to encourage students to re-make and induce its applicability by using their creative thinking skills (see Table 7).

**Table 7.** *Elementary school teachers' model evaluation results of the practical context*

| The features of science model | Model Types | Frequencies | Sample responses |
|---|---|---|---|
| The practical context | A | 3 | It is easy to manipulate. |
| | | 2 | Students can easily understand the relationship between the muscles and bones. |
| | | 1 | It is light. |
| | B | 2 | It is easy to manipulate. |
| | | 2 | It is regrettable that it is not moving automatically. |
| | | 1 | The material is soft and pleasant to the touch. |
| | C | 2 | It is easy to operate with automation. |
| | | 2 | It is a bit hard to hold up because of its heaviness. |
| | | 2 | It is made from easily accessible material. |
| | | 1 | Pressure adjustment of the syringe is troublesome. |

The practical context should give opportunities for students to get firsthand experiences with the characteristics of the model. The model should be easily operable for directly experiencing.

A model acts as a communication tool to convey knowledge. Models can also be used to promote a new conceptual understanding by predicting new properties of any scientific phenomenon. Given these advantages of the model, its practical use is a pre-requisite for directly experiencing. Thereby, students understand the roles of the models and modeling in science.

Modeling in science affords students to understand how science works, what science does, how science produces knowledge. Further, they learn the reasons, advantages and limitations of the use of models (Lederman, 2007).

On the other hand, model materials should be supplied for students to produce in their classes. This may be seen as a requirement for the practical context. Students may get them from their homes to re-make or deepen the models.

**d) The Dynamic Context: Models are Modified to Improve Student's Conceptual Understanding.**

The dynamic properties of the model contain its modification evaluation, re-construction, and improvement. Thus, considering a dynamic modeling approach identifies students' modeling processes and their understanding of the inferences. Moreover, these dimensions, which are positive aspects of a model, make to produce a more scientific model through modification process. Also, they help students understand the characteristics of the model by enhancing student-student interactions.

Elementary school teachers' views of the dynamic contexts at the Arm Muscle models are as follows:

> An evaluation for 'model A':
> Pulling up wooden chopsticks results in biceps contraction and triceps stretch, which pulls up the lower part of the arm bones connected with a thread. Pulling down wooden chopsticks results in biceps stretch and triceps contraction, which lowers the lower part of the arm bones connected with a thread. The limitation of the model is that when the wooden chopstick is lifted up and down, a cardboard is too thin. Also, the lower part of the arm bones is ringing out. The triceps is not shrunk or loosened. However, these ideas facilitate to understand the relationship between the muscles and the bones. If teachers continue to correct this part, it will be a better model (Teacher H).

> An evaluation for 'model B':
> Considering the modeling process, a wad of cotton is firstly used into an egg net in the first place. But a wad of cotton is not flexible, and the muscles did not show the muscle contractions. A way to put a wad of cotton into the stockings through cutting the front and back of the egg net is needed to complement this issue. This process supports that pre-service teachers understand the arms and muscles. However, the way to move the muscles automatically is still problematic (Teacher I).

> An evaluation for 'model C':
> The model linked the two needles to move the piston, use the internal pressure change, and move the muscle of the arm. In addition, because the syringes are insufficient to express muscle, using a corrugated cardboard presents a muscular fiber. When connecting the upper and lower parts of the arms by scotch tape pushes the adjustable piston, the upper part of the arms is completely pushed and the arms are not fully extended. For complementing this model, magnets can be utilized to jointly connect the

upper and lower parts of the arms. Thereby, it fully extends the arms to better describe the movements of the arms. To better understand the arm muscles, the model needs a continuous revision (Teacher A).

In order to define any change in the models, elementary school teachers gave some explanations for pre-service teachers to evaluate and modify their models. They addressed that modifying the basic models in the science textbooks through new ideas would result in understanding the relationships between the arms and muscles (see Table 8). So, elementary school teachers suggested that pre-service teachers were supposed to modify their models by collecting new evidences and elaborating their learning of the phenomenon. Further, they recommended them to evolve the model based on understanding the scientific phenomenon and its causes.

**Table 8.** *Elementary school teachers' model evaluation results of the dynamic context*

| The features of science model | Model Types | Frequencies | Sample responses |
|---|---|---|---|
| The dynamic context | A | 4 | New ideas come from understanding relationships between the muscle and bone. |
| | | 3 | If the model continues to be modified, the better model will be completed. |
| | B | 3 | This model is completed based on understanding the muscles of the arm. |
| | | 3 | This model needs to be modified by considering its automation. |
| | C | 3 | The use of syringes and cardboards is an indicator on the understanding of the arm muscle. |
| | | 3 | This model can be improved through continuous modifications. |

Changing the model to get a better understanding of scientific knowledge means the dynamic feature of the model.

As a scientific knowledge changes with new discoveries, a scientific model also changes. Scientists often re-construct models to disseminate scientific knowledge to more people. In other words, improving scientific models usually incorporates new and old scientific evidences (NSF, 2013). Thus, the model is used to create a new understanding of the scientific phenomenon and give a correct message for its comprehensibility. Therefore, a model, as a dynamic learning process, promotes students to acquire the advanced learning while revising the model (Kim, Moon & Son, 2006). Therefore, they need to undergo a model modification process in order to understand the facts and improve its mechanisms better. In other words, an interactive modeling process helps students understand their acquired knowledge while exploring or changing their models.

## CONCLUSIONS and SUGGESTIONS

The aim of this study was to analyze pre-service elementary school teachers' Arm Muscle models developed from the basic models of 'The body's structure and function' in the Korea Elementary School Biology Science Textbook. Further, this study aimed to evaluate elementary school teachers' assessments of the Arm Muscle models developed by pre-service elementary school teachers.

The elementary school teachers evaluated these Arm Muscle models as a scientific model in terms of conceptual, visual, practical, and dynamic context.

First, most of them evaluated that all models under investigation helped to understand the relationships between the muscles and bones. This means that elementary school teachers emphasized the importance of the scientific concepts as the nature of scientific models.

Secondly, to involve the visual context in their models, pre-service elementary school teachers studied the shapes of the real bone and muscle tendons. Elementary school teachers appreciated their efforts on imitating the real bone and muscle tendons as the visual aspects of the model. Also, they viewed these models as well-designed for neat and simple expressions.

Thirdly, most of elementary school teachers implied that the models under investigation were easy to automatically operate. Also, they viewed these issues as practical characteristics of the scientific model.

Finally, the dynamic nature of the scientific model improve pre-service elementary school teachers' conceptual understanding of the bones and muscles. Elementary teachers stated that pre-service teachers modified the basic models in the science textbooks to understand related scientific knowledge. Further, they stressed that new models needed to be modified in order to increase their scientific values in the future.

Elementary school teachers thought that scientific models helped scientists understand, express, explain, or predict any phenomena. Also, they suggested that scientific models were supposed to have and show a clear conceptual view of the scientific phenomenon. For this reason, elementary school teachers mentioned that the scientific model should have considered visual, practical, modified aspects of scientific knowledge.

Despite the fact that an actual science textbook presents various models, unfortunately, few teachers use them in their classes. Given the idea "The model is strong enough to explain the concept of science," teachers should be trained about varied models in science education. Hence, in-service teachers have an opportunity to systematically understand the characteristics of the model.

Even though elementary school teachers evaluated pre-service teachers' models, someone may criticize a lack of field experience in the current study. However, it is believed that pre-service teachers will be able to develop more meaningful scientific models if they have opportunities.

Because the current study examined elementary school teachers' evaluations of the muscle models, future studies should directly handle and assesse various models in the Korea Elementary School Biology Science Textbook.

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