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Difference between the Types of Visual Materials Preferred by Students and Those Presented in the Science Textbooks

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Abstract

The purpose of this study is to examine whether the visual materials presented in the science textbooks coincide with those visual materials that are preferred the most by students. After analyzing the visual materials presented in the unit "Molecular Motion and Change of State" of science textbooks for the first grade of middle school, questionnaires by teaching-learning process are made. Thereafter, students are requested to select those types of visual materials that were preferred by them by process and describe their reasons for the selection. According to the results of the survey of students' perception, students at the high science achievement level prefer those visual materials that were presented conceptually and implicatively, while students at the low science achievement level prefer concrete and detailed visual materials. Except for the learning motivation process, the proportion of non-preferred visual materials is higher in the remaining processes and those visual materials that were presented in the science textbooks are much different from those visual materials that were preferred by students.

Keywords: *visual materials, science achievement level of students, preference for visual materials, survey of the students' perception of visual materials*

1. INTRODUCTION

In the case of science subjects, using more visual materials for realistic delivery of the concepts of natural phenomena is more effective for understanding of scientific contents[1]. In comparison between science textbooks where visual materials were presented and those where no visual material was presented, it was found that students' learning was improved when the science textbooks where visual materials were presented were used because additional information was provided by the visual materials[2]. On the other hand, it is said that in cases where the expression of the visual materials presented is not effective or beyond the cognitive level of learners, the learners experience difficulties in understanding the visual information on scientific contents[3].

Each unit of science textbooks is composed of teaching-learning processes such as motivation for learning, learning material provision, inquiry experiment carrying out, and summarization of inquiry results and concepts. The role of visual materials in the process of motivation for learning is to stimulate learner's will to learn and strengthen their attention thereby activating teaching-learning[4]. In order to express scientific phenomena and changes in the process of providing learning materials, various materials (natural, scientific, and living) are introduced into visual materials[5]. In terms of contents, abstract concepts or microscopic phenomena are concretely and macroscopically visualized in order to improve students' understanding[6]. Since the inquiry method guidance process has procedural natures, inquiry process flowcharts, graphs that cannot be

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easily expressed in written explanations can be effectively expressed through visual materials[7]. In the process of summarization of inquiry results and concepts, visual materials play the role of interpreting the regularity obtained from experimental results and organizing concepts based on the results of interpretation. Therefore, visual materials appropriate for each teaching-learning process should be presented.

Visual materials in science textbooks represent phenomena that cannot be directly observed or abstract concepts mainly in microscopic, macroscopic, or symbolic expressions[5]. Cartoons not only can motivate learners for learning in humorous ways, but also can stimulate the imagination and creativity of learners[8]. Mixed visual materials (visual materials+written explanations) are more effective for understanding scientific concepts because they concurrently provide visual information and descriptive information[9]. On the other hand, complex or decentralized multidimensional visual materials are said to be less concrete in their expression or to involve difficulties in understanding scientific contents[10]. Since conflicting study findings regarding the effects of visual materials are being published, visual materials preferred by students should be presented by teaching-learning process, and more studies on such visual materials are necessary.

Familiar materials that can serve as cognitive bridges to scientific concepts are effective as visual materials, and prior knowledge of them can be an important factor in understanding scientific contents[11]. Without prior knowledge of the visual materials, it is difficult to understand the visual information implied by the visual materials. On the other hand, when students have enough prior knowledge as much as experts have, they can more easily recognize broader visual information[12]. Therefore, familiar materials of which learners have prior knowledge or those visual materials that are preferred by learners (that fit the learners' cognitive level) should be presented extensively.

According to the results of studies on cognitive levels[13], whereas students at the formal operation stage understand presented visual materials with various extended related concepts, students at the concrete operation stage understand the presented visual materials focusing on the relevant concept. Higher level students spent more time in getting appropriate information from the visual materials, and made more effort to integrate written explanations and visual materials thereby showing positive learning outcomes[14]. Low level students, on the other hand, preferred uncomplicated simple visual materials[15]. Since students' science achievement levels are closely related to their understanding of visual materials, studies on the degrees of understanding of visual materials by science achievement level are acutely necessary. Therefore, in this study, the visual materials preferred the most by students' science achievement level were investigated.

The overall frequency of visual materials presented in the unit analyzed in this study, the frequencies of visual materials by teaching-learning process, and the frequencies of visual materials by type in each process were analyzed, respectively. Questionnaires were made based on the analyzed visual materials and students were requested to select those types of visual materials that were preferred by them and describe the reasons why they selected the types of visual materials. Based on the questionnaire survey, this study was intended to find highly effective types of visual materials by teaching-learning process and those visual materials that enhance the degree of understanding of scientific contents by science achievement level. In order to achieve the study purpose as such, the following research problems were set up.

First, how are the visual materials by teaching-learning process and the types of visual materials by process distributed?

Second, what visual materials do students prefer in each teaching-learning process?

Third, do the visual materials preferred by students by science achievement level coincide with the visual materials presented in the science textbook?

2. METHODLOGY

Selection of study unit

The unit 'Molecular Motion and State Change' consists of molecules and molecular motion, evaporation and

diffusion phenomena appearing in real life, changes of the states of matter, and the entry and exit of thermal energy according to the changes. Individual subunits relatively well divided teaching-learning processes such as motivation for learning, provision of learning materials, inquiry experiment carrying out, and summarization of inquiry results and concepts and diverse visual materials are presented for each process. In order to explain the concepts and phenomena effectively, various types of visual materials expressed concretely, macroscopically and symbolically are presented, which are photos, figures, diagrams, cartoons, charts, and mixtures. This unit was selected as the study unit because this unit was judged appropriate for studies of the appropriateness of visual materials presented by teaching-learning process and preference for visual materials based on the teaching-learning processes and diverse types of visual materials.

Analysis method and judgment criteria by item

The classification of visual materials by teaching-learning process based on the previous classification framework[4] was revised to fit the present study unit. Visual materials for individual processes were defined as follows; visual materials for the process of motivation for learning as those that present visual information to induce motives and curiosity in the introduction stage; visual materials for the process of providing learning materials as those that present visual information to explain scientific contents and concepts in the developmental stage; visual materials for the process of guiding inquiry method as those that present visual information on the processes, methods, result processing, etc. in the experimental stage; and visual materials for the process of summarization of inquiry results and concepts as those that present visual information on the interpretation of experimental results, the elaboration of contents, etc. and the frequencies of visual materials were classified.

The types of visual materials were divided into photos, figures, diagrams, cartoons, charts, and mixed visual materials presented in the study unit. Photos are those visual materials that show the actual shapes of objects taken by cameras, figures are pictorial visual materials that show scientific phenomena and activities drawn in totality and realistically, diagrams are those visual materials that show abstract phenomena drawn concretely and macroscopically and include written explanations such as scientific models, cartoons are those visual materials that show the characteristics of things or phenomena drawn humorously and exaggeratedly together with writings in the form of dialogues, charts are tables or graphs that show the relationships between many variables determined by analyzing the quantities of the variables, and mixed visual materials are those that include two or more types of multidimensional visual materials. After defining the types of visual materials as such, the frequencies of the types of visual materials were analyzed.

Criteria for division of visual materials

Each visual material independently presented was classified as one visual materials. Two or more visual materials presented with the same background or content or many visual materials presented consecutively by stage (arrows, flowcharts) or by time zone (continuous changes of time) were classified as one visual material.

In teaching-learning processes, the types of visual materials were primarily classified firsthand by the researcher and visual materials that could not be easily classified were secondarily classified through discussion among study group members. The classification of visual materials was finalized through consulting other experts.

Survey of perception of visual materials

Students' perception of visual materials was surveyed with the entire 192 first grade students of **Q** middle school. The relevant middle school is located in a region where about middle levels of life and education are maintained in a densely populated large city.

As for the science achievement levels, the 192 students were divided (randomly) into three groups, higher, middle, and lower groups based on the students' science grades for one year. The three groups were divided so that the numbers of members in the three groups were equally 64. The grades of the higher group were at least 69 points out of the full score of 100 points, those of the middle group were 68-46 points, and those of the lower group were not higher than 45 points.

For rational surveys of perception, each subunit was divided into four teaching-learning processes and the frequencies of visual materials for individual processes were calculated. Four subunits with relatively high frequencies of visual materials for individual processes were selected. Using the visual materials presented for the process of motivation for learning in the unit 'Change of state that emits thermal energy', the process of providing learning materials in the unit 'Evaporation and Diffusion', the process of guiding inquiry methods in the unit 'Change of the volume of gases according to pressure', and the process of summarization of inquiry results and concepts in the unit 'Change of state that absorbs thermal energy', the questionnaire was constructed with a total of four questions, one question for each process.

The visual materials for the questionnaire questions were selected differentially so that they range from easy and simple ones to complicated ones, from concrete ones to abstract ones, from one-dimensional ones to the multi-dimensional ones. The questionnaire questions were primarily made by the researcher based on the previous classification[13], and were finalized after consulting two experts regarding whether they are valid based on the selection criteria. The content and number of questions constructed as such are shown in Supplementary 1.

Survey method and period

As for the questionnaire survey method, the respondents were requested to select those visual materials that could be the most effectively recognized in understanding scientific concepts for each of the four teaching-learning processes, and then describe the reasons for selection. The survey period was a total of three days (February 5 to February 7, 2018) after completely learning the present unit at the end of the school year. After the questionnaire sheets were distributed, the respondents were asked to complete the questionnaire for one hour (45 minutes), and the completed questionnaire sheets were collected immediately thereafter. All 192 respondents answered the questions faithfully, and all the questionnaire sheets were included in the survey statistics.

As for the process of analysis of the questionnaire, the questionnaire sheets of 192 students were collected and classified by teaching-learning process, by type of visual materials, and by academic achievement level (64 sheets each of upper, middle, and lower levels), and the frequencies of individual categories were calculated. The ratios of distribution of the categories were shown in a graph and compared and analyzed.

Reasons for selection of questionnaire items

The reasons for selection of questionnaire items were classified into those that were related to scientific contents, those that were related to the roles of visual materials in teaching-learning processes, those that were related to the types of visual materials, familiar materials that could play the role of cognitive bridges to scientific concepts, and other reasons. As such, those contents that were closely related with the roles of visual materials in each teaching-learning process and the understanding of scientific contents, were meaningful, and were commonly described frequently were classified and contained in the manuscript.

3. RESULTS AND DISCUSSION

Analysis of the visual materials presented in the study unit

To study students' preference for visual materials, the overall frequency of visual materials, the frequencies of visual materials by teaching-learning process, the frequencies of visual materials by type according to the processes, and the tendency of the frequencies were investigated and analyzed. According to the results of analysis, the average frequency of visual materials per page was 1.76, and the ratios of visual materials for individual teaching-learning processes were shown to be; learning material provision 59.7%, guiding inquiry methods 14.9%, motivation for learning 14.7%, and summarization of inquiry results and concepts 10.7%. The ratios of individual types of visual materials were presented as; photos 61.7%, mixed visual materials 16.3%, and cartoons 8.3%.

The reason why the ratio of visual materials for the process of providing learning materials is that relatively

more visual materials are necessary to explain scientific facts, changes, and phenomena[6]. The reason why the frequency of photos is high is that photos are the best tools to show scientific facts and phenomena that exist in nature as they are[16]. On the other hand, the frequency of cartoons preferred by students was shown to be relatively the lowest. According to the results of a previous study of visual materials in South Korean science textbooks[4], the ratio of visual materials presented in the process of providing learning materials was relatively high at 68% and the ratio of photos was low at 42%.

Survey of perceptions of visual materials by science achievement level in the process of motivation for learning

According to the results of analysis of visual materials for the process of motivation for learning in the unit 'Change of state that emits thermal energy', the ratios of the types of visual materials were shown to be; photos 58.2%, cartoons 31.8%, and mixed visual materials 9.0%. The frequency of cartoons is relatively high. In particular, it is higher than the average frequency (8.3%) of cartoons presented in the entire unit. This is consistent with previous study findings indicating that cartoons are more effective for motivation for learning[4].

In this unit, visual materials that induce diverse learning motives are presented, and learners' interests and attention are induced in the form of questioning in order to enhance the intensity of motivation. Questionnaire items were constructed using these visual materials, and investigation was carried out to find which of the visual materials were the most effective in inducing learning motives. The results of selection by the students are shown in Figure 1.

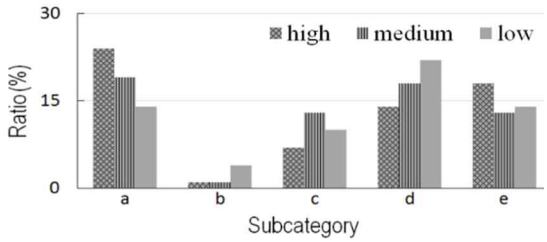

Figure 1. Graph showing a study of students' awareness for learning motivation (%). **a**: Cartoons depicting the use of hand-warmers. **b**: Photo representing a scene of molten metal. **c**: Photos showing a hot pack series. **d**: Diagrams showing the principle of a cooling system. **e**: Mixed visual material of (photo+cartoon) depicting the scene of an igloo.

According to the results of questionnaire surveys of those visual materials that induce learning motives, the students relatively frequently selected item **a** (cartoons), item **d** (diagrams), and item **e** (photo+cartoon), while hardly selecting item **b** (photo). Whereas students at the **high** or **middle** science achievement level selected item **a** the most frequently, students at the **low** science achievement level selected item **d** the most frequently. With regard to the reasons why these items were selected, characteristic contents by science achievement level are as follows.

Student A (High): *"The thoughts we frequently have in daily life are expressed in cartoons, so the situation can be easily understood and it is interesting. The dialogic sentences accurately present the process that arouses curiosity and problems that must be solved."*

Student B (Middle): *"In cases where a phenomenon that can happen in everyday life is expressed in cartoons, it will look more interesting and attract more attention and the degree of understanding will be enhanced because the pictures are presented together with writings."*

Student C (Low): *"Although photos and cartoons are difficult to understand due to a lack of content, this enables easy understanding of the principle because it showed an air conditioner frequently used in everyday in a diagram and it can be seen at a glance even though it is simple."*

The students at the **high** or **middle** science achievement level preferred cartoons among the types of visual materials, those that are familiar to them among the subject matters, and those visual materials that are composed in the form of questioning. On the other hand, students at the **low** science achievement level preferred those visual materials that depicted what they had been curious about at normal times in detail. As

such, the targets of students' attention among the contents of science vary with students' science achievement levels[17] and students want different visual materials in terms of the types, subject matters, and the degree of motivation. Meanwhile, item **b** presents only a photo of a scene that cannot be easily experienced by students and this is judged to be the reason why students' preference for item **b** was shown to be low because not only it can hardly motivate students for learning but also its role is limited[8].

Survey of perceptions of visual materials by science achievement level in the process of providing of learning materials

According to the results of analysis of visual materials for the process of providing learning materials in the unit 'evaporation and diffusion', the ratios of the types of visual materials were shown to be; photos (63.2%), mixed visual materials (19.2%), diagrams (6.3%), and cartoons (6.0%). The reason why the relative frequency of mixed visual materials is high is that mixed visual materials are suitable for provision of learning materials because they can express two concepts consecutively from microscopic concepts to macroscopic concepts.

Since surveys of students' perceptions were judged to be important for the degrees of students' understanding by science achievement level in this process, a questionnaire was made using the visual materials presented here. While providing the learning materials, the students were asked to select visual materials that are effective for understanding scientific concepts from the questionnaire. The results of selection are shown in Figure 2.

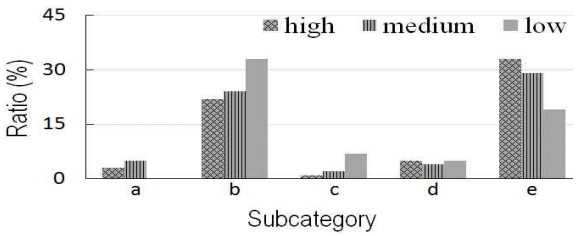

Figure 2. Graph showing study of students' awareness for provision of visual materials (%).**a**: Photo showing a scene of drying laundry. **b**: Photos representing sequential experimental procedures. **c**: Figures depicting the diffusion of ammonia water (sequential experimental procedures). **d**: Magnified figures (figures+diagrams) showing the vaporization of acetone molecules. **e**: Figure series (figures+diagrams) showing the diffusion of ink in water.

According to the results of the survey, students at the **high** or **middle** level selected item **e** the most frequently while students at the **low** level selected item **b** the most frequently. Both item **b** and item **e** are visual materials, which are stepwise and concrete, and added with written explanations. Items **a**, **c**, and **d** were hardly selected. As for the reasons why those items were selected, characteristic contents by level are as follows.

Student A (High): *"Since not only is the inquiry process shown step-by-step, but also molecular models are expressed together, the cause of such a result can be easily understood in linkage with molecular motions."*

Student B (Middle): *"Since the diffusion of ink is presented step-by-step with molecular models, molecular motions are more easily understood."*

Student C (Low): *"Since the process of ink diffusion over time is shown step-by-step, it is helpful for understanding the phenomenon of diffusion."*

Students at the **high** or **middle** level preferred mixed visual materials among the types of visual materials, those that were experienced by the learners among the subject matters, and those in which macroscopic phenomena and microscopic movements were presented step-by-step among the contents. It can be seen that while those types of visual materials that are described step by step in detail and composed of materials experienced greatly contribute to the provision of learning materials, items **2-a**, **c**, and **d**, which are not much preferred by students not only involve limitations for learners to understand scientific concepts but also cause difficulties for learners to obtain concrete information by themselves. Visual materials that merely express scientific contents without considering students' science achievement levels[14] may play a minor role in providing learning materials. Meanwhile, a study conducted with teachers presented a study finding indicating

that teachers frequently utilize visual materials outside of the science textbooks[3]. Therefore, it can be seen that many visual materials that do not fit the eye-level of students or are not preferred by students are presented.

Survey of perceptions of visual materials by science achievement level in the process of guiding inquiry methods

According to the results of analysis of the types of visual materials for the process of guiding inquiry methods in the unit 'Change of the volume of gases according to pressure', the ratio of 'Photos that contain an inquiry device (tool) and inquiry processes in sequence' was the highest at 34.8 % followed by 'Photos that contain only one scene of a major part inquired by students' at 33.9 %, and the ratios of distribution of the remaining visual materials were low.

The visual materials presented for this process are relatively simple. Since simple visual materials may pose difficulties in understanding inquiry processes, the questionnaire items were composed so that the aspect of students' understanding of inquiry method guidance can be reflected. The students were requested to select those visual materials that are the most effective for understanding of concepts while guiding inquiry methods. The results are shown in Figure 3.

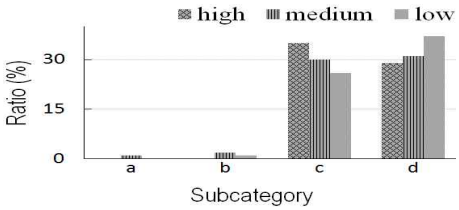

Figure 3. Graph showing study of students' awareness for guide to inquiry procedure (%). **a**: Photo that contain only one scene of a completed major experimental device (tool). **b**: Photo that contain only one scene of a major part inquired by students. **c**: Photos that contain an inquiry device (tool) and inquiry processes in sequence. **d**: Photos that contain an inquiry device (tool) and inquiry processes in sequence including explanations of individual processes.

According to the results of the questionnaire survey, most students preferred items **c** and **d** that showed processes by stage in detail. Students at the **high** science achievement level relatively more frequently selected item **c** while students at the **middle** or **low** science achievement level relatively more frequently selected item **d**. The students at each level described reasons for their selection as follows.

Student A (High): *"Item **d** is inefficient because it explained too much in detail, and the visual materials in item **c**, presented sequentially, enable easy understanding of the inquiry procedure guidance."*

Student B (Middle): *"Since the photo containing the scene of inquiring activity is accompanied by explanations, the inquiry method guidance can be easily followed."*

Student C (Low): *"Since photos and writings about the inquiry process are presented together, it seems easiest to follow the inquiry process in sequence. The description of the inquiry process in writing is the most detailed.*

Whereas students at the **high** science achievement level preferred photos (item **c)** that contain only those pieces of information that are the most central to the process of guiding inquiry methods, students at the **middle** or **low** science achievement level preferred photos (item **d)** in which detailed inquiry processes and explanations by stage are presented more. These students wanted not only the concept of volume changes according to pressure changes, but also the preliminary preparation processes such as the processes of constructing experimental devices and measuring. In particular, low level students are judged to obtain more information through detailed written explanations[4] presented in visual materials.

As shown in Figure 3, the photos **a** and **b**, which are photos of one scene, were hardly selected by students.

Since students' preferences were shown to be very low, it can be seen that quite a few visual materials not preferred by students are presented for the process of guiding inquiry methods.

Survey of perceptions of visual materials by science achievement level in the process of summarization of inquiry results and concepts.

According to the results of analysis of the types of visual materials for the process of summarization of inquiry results and concepts in the unit 'Change of state that absorbs thermal energy', the ratio of 'Visual materials that presented tables and graphs to be completed using the results of experiments conducted and summarized concepts with mixed visual materials (graphs+diagrams)' was the highest at 32.6 % followed by the ratio of 'Visual materials that presented tables and graphs to be completed using the results of experiments conducted and summarized concepts with mixed visual materials (graphs+figures)' at 30.2 %.

Since this process is a stage of to organize the scientific contents of the subunit based on the interpretation of the inquiry results, visual materials centered on scientific contents can be presented[18]. Therefore, questionnaire items were constructed to reflect diverse types of visual materials. The students were requested to select those visual materials that are judged to be the most effective for the summarization of inquiry results and concepts. The results are shown in Figure **4**.

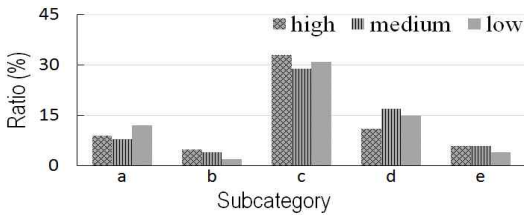

Figure 4. Visual materials that present graphs to be completed using the results of experiments conducted and summarized concepts with mixed visual materials (graph+photos). **a**: Graph completion using the results of the experiment performed, and the last summary is represented with a graph including figures. **b**: Table and graph completion using the results of the experiment performed, and the last summary is represented with a graph including figures. **c**: Table and graph completion using the results of the experiment performed, and the last summary is represented with a graph including diagrams and explanations. **d**: Table and graph completion using the results of the experiment performed, and the last summary is represented with a graph including figures and explanations. **e**: Table and graph completion using the results of the experiment performed, and the last summary is represented with a graph.

According to the results of the questionnaire survey, all the students selected item **c** the most frequently. The students preferred those mixed visual materials that are concrete by process as well as expressing state changes and arrangement changes at the molecular level following thermal energy changes together as such the most. Reasons for selection of item **c** are as follows.

Student A (High): *"It is easy to comprehend because it also shows the molecular model according to state changes, and since the written explanations of the temperature changes and molecular motions in each state are detailed, the concepts can be easily organized even when I read it alone."*

Student B (Middle): *"I could more easily understand the content while I was completing the tables and graphs, and I could better understand state changes over time and molecular arrangements because the completed inquiry results were linked to the diagrams (molecule arrangement)."*

Student C (Low): *"I could concentrate more while I completed the tables and graphs, and I could easily understand state changes over time and molecular arrangements because there were diagrams (molecular arrangements)."*

Questionnaire item **c** is judged to have been selected because it can be easily understood by students at all levels since it presents the macroscopic phenomena and the microscopic concepts together. In particular, item **c** preferred the most by students showed the highest distribution ratio in the results of analysis of visual

materials presented in this unit too.

As shown in Figure 4, other items excluding item **c** were selected relatively rarely. This means that the visual information obtained from the remaining items is relatively insufficient or not suitable for students' levels materials[9]. Although the visual materials under item **b** are presented in the process of summarization of inquiry results and concepts at a relatively high ratio (30.2%), students' preference was very low. The results as such indicate that the visual materials presented for this process are far from the visual materials preferred by students.

4. CONCLUSIONS AND REMARKS

Conclusions

This study aims to provide customized visual materials by level in order to enhance the degree of students' understanding of scientific contents by science achievement level. To carry out this study, the unit 'Molecular Motion and State Change' was selected and the types of visual materials by teaching-learning process in this unit were classified. A questionnaire was made based on the classified visual materials, the students were asked to select those types of visual materials that were thought to be the most effective for understanding scientific concepts, and the results were compared and analyzed.

First, the visual materials presented in this unit of science textbooks were analyzed and according to the results, although the ratios of visual materials presented by teaching-learning process and by type of visual materials were different, generally similar tendencies were shown. As for the frequencies of visual materials by teaching-learning process, the frequency of provision of visual materials (59.7%) was the highest followed by inquiry method guidance (14.9%). Among the types of visual materials, the frequency of photos (61.7%) was the highest followed by mixed visual materials (16.3%) and cartoons (8.3%).

Second, preference for the types of visual materials by teaching-learning process was surveyed and the results indicated that 'Cartoons depicting the use of hand-warmers' [cartoons that depicted phenomena] were preferred the most for the process of motivation for learning, and 'Figure series (figures+diagrams) showing the diffusion of ink in water' [mixed visual materials (figures+diagrams) that showed phenomena step by step] were preferred the most for the process of providing learning materials. 'Photos that contain an inquiry device (tool) and inquiry processes in sequence including explanations of individual processes' were selected the most frequently for the process of guiding inquiry procedures, and those 'Table and graph completion using the results of the experiment performed, and the last summary is represented with a graph including diagrams and explanations' were selected the most frequently for the process of summarization of inquiry results and concepts.

In the case of the process of motivation for learning, the students preferred those visual materials that would stimulate interest and curiosity such as scientific contents about which the students are curious at normal times[19] and subject matters that are familiar or experienced[20]. In the case of the process of providing learning materials, mixed visual materials were preferred among the types of visual materials, those that are familiar and have been experienced among the subject matters, and those that are continuous and concrete ranging from microscopic concepts to macroscopic phenomena among the contents of visual materials[6]. In the case of the process of guiding inquiry methods, the students wanted those visual materials that clearly expressed inquiry processes and methods in terms of procedures and those with high degree of understanding of contents in terms of contents. The students preferred those types of visual materials that give visual information concretely and in detail because their anxiety about failure of inquiry experiments may be heightened[7]. In the case of the process of summarization of inquiry results and concepts, students wanted systematic visual materials that fit the eye-level of them in the process of interpreting and elaborating inquiry results[10].

Third, students' preferences according to their science achievement levels were investigated and the results indicated that the targets of scientific interests were different according to the levels, and the degrees of understanding of contents were also different. In the case of the process of motivation for learning, preference for four items (items **1-a**, **c**, **d**, and **e**), which considered empirical contents, was high, but preference for item

1-b was low. In the process of providing learning materials, the students preferred the two items (items **2-b**, **e**) that were detailed step by step and experienced, but not the three items (**2-a**, **c**, **d**) that required assistants' help. In the case of the process of guiding inquiry methods, students selected implicit and concrete visual materials (items **3-c** and **d**), but hardly selected **3-a** and **b**. In the case of the process of summarization of inquiry results and concepts, students at all levels preferred mixed visual materials (item **4-c**), which comprehensively summarized scientific content and concepts. Meanwhile, the remaining terms (items **4-a**, **b**, **d**) were not much preferred. This suggests that the visual materials preferred by students at all levels should be presented in science textbooks as with item **4-c**.

For each teaching-learning process, the ratio of selected preferred visual materials is quite low. This means that many visual materials not preferred by students are presented in the science textbooks.

Remarks

According to the results of questionnaire surveys of the visual materials presented in the study unit, preferred visual materials were concentrated in one or two items, and the preference of the remaining items was quite low. According to the results of surveys of visual materials for the process of motivation for learning and the process of providing learning materials, the students wanted visual materials of familiar and empirical subject matters, concrete and sequential visual materials, and those visual materials that enable them to understand visual information by themselves without any help of assistant. On the other hand, visual materials not preferred by students are judged to be beyond the cognitive development level of the students so that students' understanding of scientific contents (role of scaffolding) is low[8]. Therefore, this suggests that the science textbooks require many visual materials that fit students' science achievement levels.

According to the results of surveys of preference for visual materials for the process of guiding inquiry methods, students wanted visual materials that could contribute to the clarity of procedural flows in inquiry experiments and their understanding of guidance of inquiry experiments. According to the results of surveys of preference for visual materials for the process of summarization of inquiry results and concepts, students at all levels selected only one item. This means that the remaining visual materials are beyond the levels of students or poorly understood by the students[15].

In conclusion, the types of visual materials thought to be the most effective by students were different from those visual materials that were presented the most frequently in this unit. It can be inferred that students do not like many of the visual materials presented in the science textbooks, and that the visual materials not preferred do not provide much visual information on scientific contents. Therefore, more optimal types of visual materials should be presented in terms of teaching-learning processes, and more customized visual materials by level that can be understood by first graders of middle school in South Korea by themselves and can greatly contribute to the development of creativity should be presented in terms of science achievement levels[11].

The fact that this study showed the possibility of existence of visual materials preferred by students at all levels as with those under item **4-c** can be regarded to be the biggest outcome of this study. These study findings will not only contribute to the maximization of the effectiveness of teaching-learning of individual learners, but also be of great help to curriculum designers and textbook writers.

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