# Analysis of Concept's Diversity and Proximity for Photosynthesis in Grade 7 Students

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**Abstract:** Concepts of science have been developed by occupying 'ecological niche' within conceptual ecology. The ecological niche is determined from the mutual effect between intellectual environmental of the learner and new concept, which few studies have been conducted. This study examined how the ecological niche of the concept of photosynthesis in 7th grade is changed by instruction. The ecological niche was analyzed using 2 methods: (1) the change in the diversity of concepts, and (2) the change in the proximity of concepts based on the frequency and the relativeness score of the concepts. The concept of photosynthesis was analyzed in the 4 domains in the place of photosynthesis, products of photosynthesis, reactants of photosynthesis, and environmental factors. The results of this study are as follows: (1) reduced diversity of concepts, (2) increased frequency and relativeness score of the scientific concepts, and (3) increased proximity of the scientific concepts by instruction. With these results, the mutual effects of the concepts within the conceptual ecology have become active by class to differentiate the relationships between the concepts, which accordingly displayed their changes in status.

**Key words:** ecological niche, conceptual ecology, diversity of concepts, relativeness, frequency rate, proximity of concepts

## Introduction

Scientific knowledge is obtained through the composition of concepts (Riemeier and Gropengieber 2008), whereby a concept does not exist independently but forms a relationship with other concepts. Therefore, the conceptual ecology of the learner must be considered to accurately understand the concept of the learner (Park 1995).

Species in ecology have niche. Ecological niche is relationships between species of the ecology. The learners' intellectual environment has been compared to ecology, that is, conceptual ecology. Conceptual ecology is the relationship between the intellectual environments of the individual learners (Toulmin 1972, p. 95). This refers to the intellectual environment that provides the context of a conceptual change (Park 1995), and the learner is educated through the mutual effects of the conceptual ecology (Demastes *et al.* 1995). Many studies have examined the factors that influence the study of concepts (Song and Chung 2001) and on the common factors of conceptual ecology to investigate the mutual effects of different concepts and the changes in concepts within the cognitive environment of the learner (Park 1995). Several studies have examined the conceptual ecology of students but they did not consider many important aspects. First, most conceptual ecology studies failed to analyze the ecological niche. It is natural to think that concept in learners' conceptual ecology has niche as species in ecology have niche. Scientific concepts have been developed by occupying an 'ecological niche' within the conceptual ecology (Toulmin 1972, p. 300). The ecological niche is determined from the mutual effect between the intellectual environment of the learner and a new concept, onto which few studies have been conducted. Second, previous studies were lacking to explain the relationship between concepts within the conceptual ecology and other concepts. Accordingly, this study

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examined the ecological niche, how to know relationship between concept in intellectual environment that students have.

Since the unit of distribution of a certain species that occupy the community of that species is defined as the ecological niche, the ecological niche is currently positioned at the center of the ecological competitive theory (Slagsvold and Wiebe 2007). The ecological niche was used as an approach not only in ecology, but also in other fields. Several studies have examined the anthropology (Thomas 1977), marketing (Milne and Mason 1989) as well general and specialized organizations (Carroll 1985) as factors of the ecological niche, but few studies examined the ecological niche concerning concepts in the field of science education. Accordingly, this study examined how the ecological niche of the concepts held by a learner changes due to instruction. The ecological niche was analyzed based on the proximity of concepts that employ multidimensional scaling (MDS) and conceptual diversity index.

The concept of photosynthesis is a field wherein misconceptions can easily manifest from invisible phenomena (Wood-Robinson 1991). It is the basic concept behind the metabolism (Canal 1999), and is widely presented as the main subject in biology in elementary, middle, and high schools (Moon and Kim 2008). This study examined the ecological niche of the concept of photosynthesis in 7$^{th}$ grade changes due to instruction.

## Materials and Methods

### Subjects

Questionnaires were distributed to the subjects of this study, who consisted of 92 7$^{th}$ grade students in regions with a population less than one hundred thousand, 148 students in cities with a population less than one million, and 317 students in cities with a population more than one million. 82 students were excluded because they were judged as being inattentive, and showed such cases where only the concept was suggested with the suggestion of a relativeness score, or presented the same relativeness score for all different concepts. Among the 557 study subjects, 255 were male and 302 were female.

### Questionnaire

The 4 domains of the photosynthesis unit cover the following important concepts of the Korean science curriculum: the place of photosynthesis, products of photosynthesis, reactants of photosynthesis, and environmental factors, as proposed by Chung *et al.* (2005). The questionnaire presents illustrations related to the 4 domains, and asks questions on the concepts related to each domain and the degree of relativeness of that concept with its domain in the form of the given relativeness score. This relativeness score was indicated according to the degree of relativeness with each domain, as judged by the students, on a scale of 1 to 30. The developed questionnaire was given a content validity rating of 0.83 by 3 biology education researchers and 2 teachers with more than 15 years experience.

### Data Collection and Analysis

A questionnaire was conducted among students and biology teachers from schools that had agreed to participate. The questionnaire explained the purpose of the study and gave instructions on how to compose it. The supervisors were composed of biology teachers. The questionnaire was administered 2 weeks before and after instruction on the photosynthesis unit. The subjects were given sufficient time (20-30 minutes) to answer the questionnaire.

The change in the ecological niche of the concept of photosynthesis in 7$^{th}$ grade based on instruction was analyzed by examining the following aspects: (1) the diversity of concepts change, and (2) the proximity change between the concepts based on the positioning map using MDS.

First, the diversity of concept enabled the examination of frequency and conceptual diversity index using the species diversity index formula of Shannon (2001), which is a concept that includes richness and evenness of species.

$$H' = -\sum_{i=1}^{s} Pi \log Pi$$

$H'$ = Conceptual Diversity index
$Pi$ = Frequency of the ith concept
= Frequency of the ith concept / Frequency of all the concepts
$s$ = Total number of concepts in each domain

Second, PASW statistics 18 was used for the proximity of concepts, which examined the positioning map using MDS. The positioning map based on MDS is a method that allows easy apprehension of the overall relationship structure that cannot be deduced solely from the numerical data from a series of statistical methods that indicate the place of the subjects in multidimensional space by processing the numerical data related to the objective or subjective relationships between various subjects through spatial illustrations. The relationships between the subjects are called 'proximity'. Subjects with high proximity are located close to each other in multidimensional space, and subjects with low proximity are located far away from each other (Richardson, 1938). Concerning the change in the frequency rate and relativeness of the concepts, the relativeness of the concepts was first determined through a questionnaire on the relativeness score of each domain with the concepts that the students presented. The frequency is the percentage value of Pi, which displays the frequency of each concept, among the frequencies of all concepts. This was deduced by examining the proportion of concepts that the students understood. The concepts selected were those with a frequency of more than 5% to extract representative subjects among the species that were dispersed in the vegetation analysis method based on a corresponding method of a study that selects only subjects with a frequency of more than 5% (Lee *et al.* 1998). Also, students were provided instruction, general lecture based on national curriculum. Therefore we failed to find difference of ecological niche students have by different type of instruction.

## Results

This study examined the changes in the ecological niche of concepts by instruction with focus on 7$^{th}$ grade photosynthesis. To achieve this, this study examined the changes in proximity between concepts through the positioning map and conceptual diversity index based on the 4 domains of photosynthesis, which consist of the place of photosynthesis, products of photosynthesis, reactants of photosynthesis, and environmental factors.

### Diversity of Concepts

The analysis of the conceptual diversity index change in each domain of the photosynthesis unit is discussed below.

The domain, 'place of photosynthesis', presented 47 concepts before the instruction and 50 concepts after the instruction. This domain displays a higher conceptual diversity index than the other domains, and delt not only with the structure and functions of the substances that compose plant cells, as presented in a previous unit on 'structure and function of cells', but it also mistakes the concept of place for a region. Therefore, it resulted in a recording of the place of plants. Despite the increase in the richness of the entire concept as suggested by the students after the instruction on this domain, the conceptual diversity index decreased. This is because the evenness also decreased, which

**Table 2**

*Conceptual diversity index change in each domain of the photosynthesis unit*

| Domain | Concept | Pre-test | Post-test |
|---|---|---|---|
| place of photosynthesis | chloroplast | 0.115 | 0.119 |
| | leaf | 0.111 | 0.118 |
| | light | 0.087 | 0.076 |
| | Water | 0.065 | 0.057 |
| | carbon dioxide | 0.064 | 0.066 |
| | palisade parenchyma | 0.058 | 0.085 |
| | spongy parenchyma | 0.055 | 0.075 |
| | guard cell | 0.055 | 0.067 |
| | oxygen | 0.055 | 0.053 |
| | chlorophyll | 0.055 | 0.062 |
| | stem | 0.054 | 0.051 |
| | root | 0.050 | 0.041 |
| | others | 0.560 | 0.461 |
| **sub total** | | **1.384** | **1.331** |
| products of photosynthesis | oxygen | 0.136 | 0.138 |
| | glucose | 0.130 | 0.143 |
| | starch | 0.128 | 0.134 |
| | carbon dioxide | 0.084 | 0.079 |
| | water | 0.073 | 0.056 |
| | light | 0.072 | 0.069 |
| | nutrient | 0.054 | 0.037 |
| | chloroplast | 0.048 | 0.046 |
| | leaf | 0.040 | 0.031 |
| | energy | 0.030 | 0.035 |
| | others | 0.390 | 0.327 |
| **sub total** | | **1.185** | **1.095** |
| reactants of photosynthesis | light | 0.145 | 0.141 |
| | carbon dioxide | 0.135 | 0.143 |
| | water | 0.129 | 0.128 |
| | oxygen | 0.092 | 0.086 |
| | chloroplast | 0.071 | 0.064 |
| | temperature | 0.051 | 0.051 |
| | glucose | 0.040 | 0.036 |
| | leaf | 0.035 | 0.029 |
| | bromothymol blue | 0.031 | 0.044 |
| | respiration | 0.030 | 0.031 |
| | others | 0.339 | 0.371 |
| **sub total** | | **1.098** | **1.124** |
| environmental factors | light | 0.140 | 0.134 |
| | water | 0.119 | 0.106 |
| | carbon dioxide | 0.112 | 0.136 |
| | temperature | 0.112 | 0.133 |
| | light intensity | 0.076 | 0.103 |
| | oxygen | 0.075 | 0.072 |
| | wind | 0.045 | 0.016 |
| | chloroplast | 0.041 | 0.037 |
| | sodium hydrogen carbonate | 0.037 | 0.028 |
| | leaf | 0.034 | 0.015 |
| | others | 0.380 | 0.281 |
| **sub total** | | **1.171** | **1.061** |

signifies its recognition by the students with focus on specific concepts. This leads to the prediction that dispersed preconceptions are concentrated as specific scientific concepts by instruction.

The domain, 'products of photosynthesis', showed a decrease in the total number of concepts presented by the students, from 49 before the instruction to 39 after the instruction. The conceptual diversity index also decreased. This shows that the concepts recognized by students are concentrated as specific concepts after the instruction. This is because the goal of this domain is clearly proposed in the curriculum, and is presented repeatedly in other sub-units, such as 'function of roots and stem,' 'conversion and transference of nutrients,' and 'leaf,' wherein photosynthesis is presented directly. In addition, this concept is deemed to have a high level of concentration as a scientific concept due to instruction because the concept is taught in the 5$^{th}$ grade elementary curriculum through experiments that examine the products of photosynthesis of photosynthesis. This coincides with previous studies, which concluded that prior knowledge has a positively affect of the studies (Carrier and Jonassen 1988).

The domain on 'reactants of photosynthesis' showed an increase in the concept diversity index from 32 before the instruction to 39 after the instruction, which is unlike the other domains. This is the result of many cases, wherein the elements required in the growth of plants are listed. Because experience related to elements is rarely experienced, and is a domain that is newly learned, the divergent thinking of the students is predicted to be stimulated and causes an increase in the specific conceptual diversity index. Through this, the conceptual diversity index displays the convergence effects of dispersed preconceptions as scientific concepts after instruction, if there had been many routes of approach. On the other hand, for newly learned concepts, such as elements, a term exists that signifies the increase in the recognition of a concept before the display of the convergence effect.

The domain, 'environmental factors', showed a decrease in the number of concepts from 42 before the instruction to 35 after the instruction; the conceptual diversity index decreased substantially unlike the other domains. Because this presents the experimental methods in the curriculum, most 7$^{th}$ grade textbooks present experiments on temperature, carbon dioxide concentration and light intensity in photosynthesis, along with graphs on each factor. The use of the most powerful and universal communication tool in science, a graph, displays an increase in the degree of concentration of scientific concepts after the instruction (Wavering 1989). Furthermore, this coincides with previous studies, which concluded that the most focal method for achieving the educational goal of science is experimentation that provides opportunities for scientific observation (Chinn and Malhotra 2002).

The direction and goal of instruction are determined by the curriculum, which influences significantly the change in the conceptual diversity index of students. A larger decrease in the conceptual diversity index is displayed when a goal is proposed in the curriculum than when it is not because most teachers instruct using contents based on the curriculum, and there are few cases where the goal of the class is established by extending the contents (Lee and Kim 2008). Furthermore, the domains with many preconceptions due to previous experience has displayed decreased the conceptual diversity indices with the instruction, which is predicted to be the result of converging dispersed concepts as misconceptions and as scientific concepts through studies. On the other hand, the newly approached domains with low preconceptions showed increased recognition of concepts through studies, and the conceptual diversity index also increased. Despite showing convergence effects of dispersed preconceptions as scientific concepts, partial preconceptions

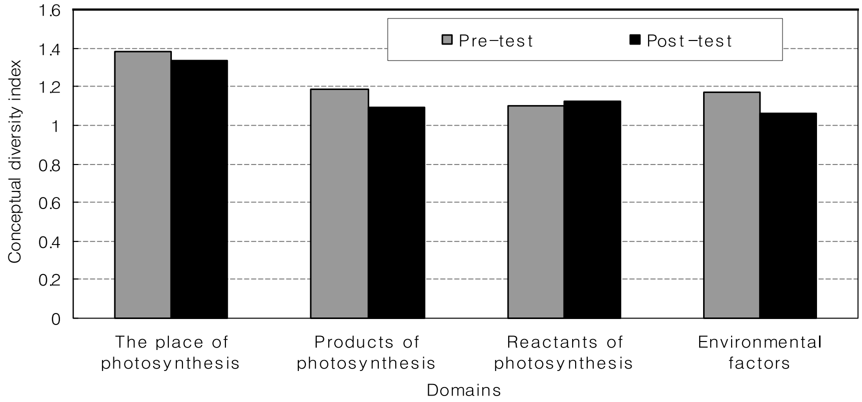


**Fig. 1** *Conceptual diversity index change of each domain based on instruction*

firmly remained in the cognition of students (Trundle *et al.* 2007).

## Proximity of Concepts

The proximity of concepts in multidimensional space based on MDS was indicated using the frequency and mean relativeness score of the concepts proposed by the students as numerical data. Through them, the changes in the proximity of concepts were examined based on instruction.

Table 3 shows the changes in the frequency and relativeness score of the concepts in each domain based on instruction. In the domain, 'place of photosynthesis', chloroplast, leaves and light showed a high frequency with no relationship with the instruction. Most of the students knew that the leaf is the place of photosynthesis, as with previous studies (Wood-Robinson 1991).

The frequency of the concepts of palisade parenchyma, spongy parenchyma, and guard cell increased after the instruction. This suggests that the students developed a more segmented concept after the instruction. This is because the curriculum is established with the specific goal of teaching students the existence of palisade parenchyma and spongy parenchyma within the chloroplasts by observing the cross- domain view of the leaf, and with the goal of observing guard cell related to the gas movement route and transpiration by emphasizing the concept that the guard cell, as a transformed form of epidermal cell, specifically has chloroplasts (Ministry of Education, Science and Technology 2008, p.162).

In the ‘products of photosynthesis’ domain, a frequency of more than 5% is presented with no relationship with the instruction on oxygen, glucose, starch, carbon dioxide and light, with the exclusion of water. Light and starch are deemed to display a high frequency because an experiment that investigates starch with an $I_2$-KI solution after exposing a leaf wrapped with foil and a leaf that is not to light is presented in $5^{th}$ grade, and is also presented in most middle school textbooks. Furthermore, the form of the nutrient that is initially produced in photosynthesis is not starch but glucose, which is converted to starch for storage. The frequency rates of glucose and starch increased after the goal of understanding the conversion and transference of the nutrients produced in photosynthesis was realized (Ministry of Education, Science and Technology 2008, p. 162). This is because the concepts of carbon dioxide and oxygen are understood from the aspect of gas exchange in photosynthesis (Ozay and Oztas 2003).

**Table 3**

*The changes in the frequency and the relativeness score of the concepts in each domain based on instruction (frequency of more than 5%)*

| Domain | Concept | Pre-test | | Post-test | |
|---|---|---|---|---|---|
| | | Relativeness score | Frequency rate(%) | Relativeness score | Frequency rate(%) |
| place of photosynthesis | chloroplast | 25.08 | 13.0 | 25.36 | 13.9 |
| | leaf | 21.61 | 12.2 | 23.71 | 13.7 |
| | light | 22.69 | 7.8 | 22.13 | 6.3 |
| | water | 18.87 | 5.1 | 18.75 | 4.1* |
| | palisade parenchyma | 22.12 | 4.2* | 22.64 | 7.6 |
| | spongy parenchyma | 20.52 | 3.9* | 20.48 | 6.2 |
| | guard cell | 18.73 | 3.9* | 19.38 | 5.3 |
| | carbon dioxide | 19.47 | 4.9* | 18.65 | 5.1 |
| products of photosynthesis | oxygen | 23.39 | 18.5 | 23.61 | 19.3 |
| | glucose | 24.47 | 16.7 | 24.75 | 21.1 |
| | starch | 23.42 | 16.1 | 23.29 | 18.1 |
| | carbon dioxide | 18.84 | 7.4 | 17.29 | 6.8 |
| | water | 17.52 | 6.0 | 18.75 | 4.0* |
| | light | 19.39 | 5.8 | 19.28 | 5.5 |
| reactants of photosynthesis | light | 25.27 | 22.3 | 24.63 | 20.5 |
| | carbon dioxide | 22.11 | 18.4 | 23.48 | 21.1 |
| | water | 21.79 | 16.4 | 23.45 | 16.1 |
| | oxygen | 21.22 | 8.7 | 22.05 | 7.8 |
| | chloroplast | 22.58 | 5.7 | 23.06 | 4.9* |
| environmental factors | light | 24.26 | 20.2 | 23.94 | 17.9 |
| | water | 20.48 | 13.8 | 20.63 | 11.2 |
| | carbon dioxide | 22.33 | 12.3 | 23.41 | 18.7 |
| | temperature | 23.26 | 12.2 | 24.60 | 17.5 |
| | light intensity | 24.14 | 6.3 | 24.57 | 10.6 |
| | oxygen | 18.64 | 6.2 | 21.77 | 5.8 |

* frequency of less than 5%

In the domain, 'reactants of photosynthesis,' the concepts that had a frequency of more than 5% remained the same before and after the instruction, except for those instruction that presented the concept of chloroplasts. The relativeness scores for the scientific concepts of carbon dioxide, light, and water increased due to the instruction, and the frequency of students who presented the concept of carbon dioxide increased after the instruction. On the other hand, the frequency of oxygen decreased, from which it is understood that many students appreciate photosynthesis in terms of gas exchange that produces oxygen using carbon dioxide (Ozay and Oztas 2003).

In the domain, 'environmental factors,' the concepts with a frequency of more than 5% before and after the instruction were light, water, carbon dioxide, temperature, light intensity and oxygen. Light has been divided into light and light intensity because it has been deemed that students in 7th grade can already grasp the two differentiated concepts due to the use of the concept of the external entry of gas following light intensity to explain the relationship between photosynthesis and respiration in the curriculum.

The frequency based on the concepts of carbon dioxide, temperature, and light intensity increased due to the instruction. This presents the goal of examining the factors that influence photosynthesis through experiments in the curriculum, and that experiments based on the three factors, carbon dioxide, temperature and light intensity, in most textbooks manifest in the cognition of many students as they are examined on the graphs.

Figure 2 presents the positioning map related to the changes in the proximity of concepts in each domain based on instruction. In the domain, 'place of photosynthesis,' the students recognized each concept independently before the instruction as the concepts of leaf, water, light, and chloroplast exist separately. After the instruction, however, the students recognized the concepts of palisade parenchyma and light, leaf and chloroplast, and guard cell and spongy parenchyma as communities, showing a high recognition of proximity of the concepts within a single community. The concepts with a frequency of more than 5% manifested differently before and after the instruction. Therefore, comparisons are difficult. Nevertheless, the proximity is also increasing because the distance between the simultaneously presented leaf and chloroplast is becoming closer. Furthermore, the distance between light and chloroplast is receding. On the other hand, palisade parenchyma was displayed as gradually approaching light. Hence, the proximity of light to the palisade parenchyma, which is a segmented concept of chloroplast, is believed to have increased due to the instruction.

The domain, 'products of photosynthesis', displayed the least changes before and after the instruction, among all 4 domains. Light, water and carbon dioxide all formed a single community before and after the instruction, and glucose and starch formed another community. Their differences included the shrinking distance between starch, oxygen and glucose due to the instruction, in both dimensions 1 and 2. This demonstrates the increased proximity of scientific concepts related to the products of photosynthesis, as presented in the curriculum. Furthermore, the products of photosynthesis, starch, glucose and oxygen, as well as the environmental factors, carbon dioxide and light, are clearly categorized with the boundary of dimension 1. This shows that students have segmented recognition of environmental factors and products of photosynthesis.

The domain, 'reactants of photosynthesis' was divided into the concepts of oxygen and chloroplasts, water, light and carbon dioxide based on dimension 1 with no relationship to the instruction. The 'reactants of photosynthesis' domain, which was presented in the curriculum, maintained a high degree of proximity among the scientific concepts of light, water and carbon dioxide. Changes based on the instruction included a decreased proximity of water and carbon dioxide and an increased proximity of water and light. This suggests that students most closely recognize water and light among all the scientific concepts as a result of the instruction.

The domain, 'environmental factors', initially showed close proximity between water, carbon dioxide and temperature, but showed a change after the instruction for light, which led to its close proximity with temperature and carbon

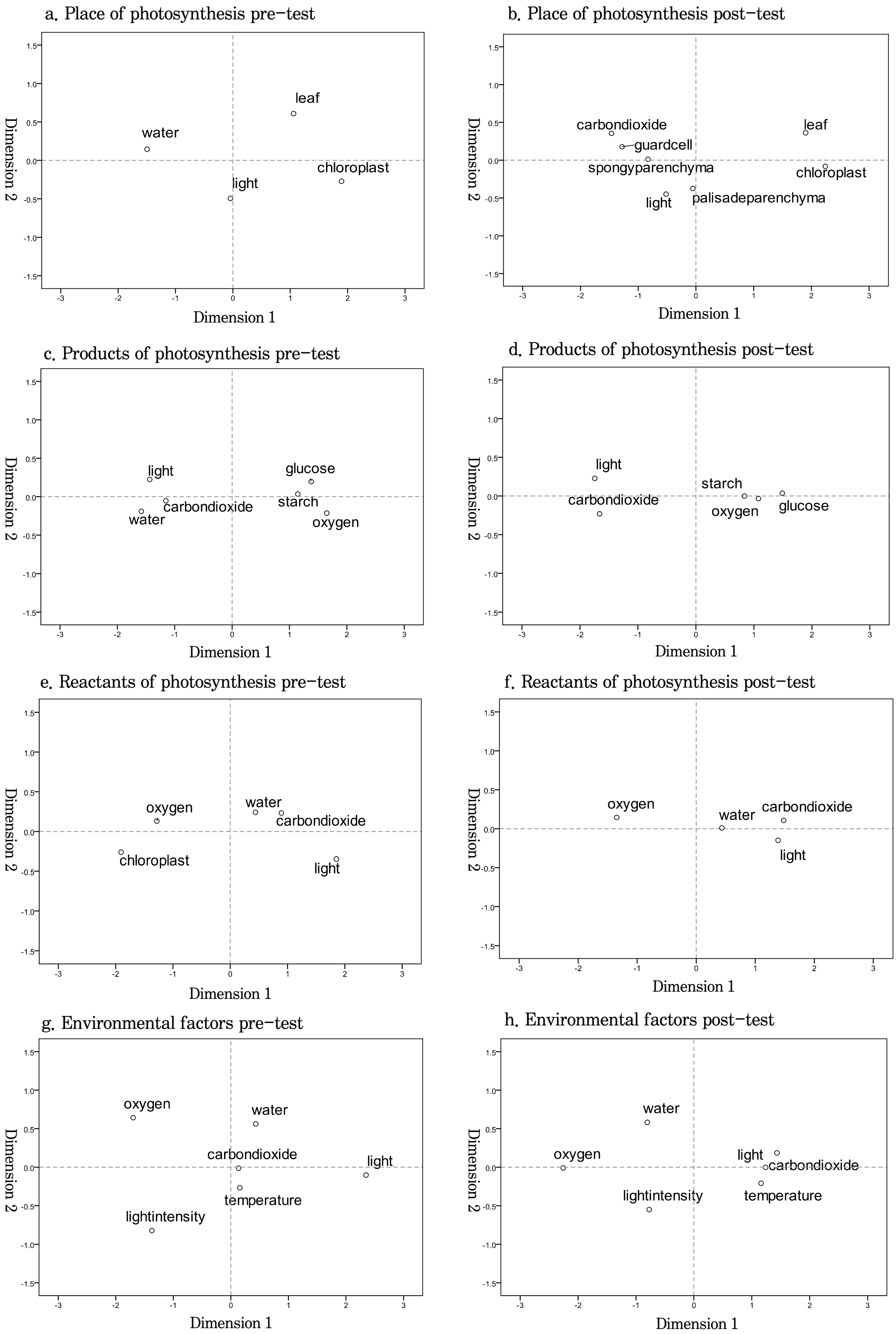


**Fig. 2** *The changes in the proximity of concepts in each domain based on instruction*

dioxide. The amount of light, carbon dioxide concentration and temperature are scientific concepts related to environmental factors as presented in the curriculum. The close recognition of temperature and carbon dioxide with light instead of water shows that the proximity of these scientific concepts is increasing.

## Discussion

This study examined the changes in the ecological niche of the concepts based on the 4 domains related to photosynthesis in 7th grade students after instruction. The results are as follows: (a) reduction of the conceptual diversity index, (b) increase in the frequency and relativeness of the scientific concepts by the instruction, and (c) the changes towards increased proximity between these concepts.

The examination of the detailed conceptual diversity index of the individual domains showed that the 'place of photosynthesis' domain had a higher conceptual diversity index than the other domains. This was attributed to many misconceptions due to the confusion between the scientific concept of 'place' and ordinary concept of 'region' (Williams 1999), and the existence of many preceding conceptions due to the study of plant cells in the previous unit on 'structure and function of cells'. In the 'products of photosynthesis' domain, the products of photosynthesis are taught in relation to the transference of nutrients in the sub-units of 'roots' and 'stems,' and directly in the sub-unit on 'leaf'; and it is repeated in the sub-unit on 'the conversion and transference of nutrients formed as a result of photosynthesis', thereby reinforcing the student's knowledge through repeated education on the content. This coincides with previous studies that concluded that an elaborate knowledge structure related to the subject of a class simplifies the learner's acquisition of knowledge with a greater amount of prior knowledge through repeated studies (Carrier and Jonassen 1988).

In the 'environmental factors' domain, an experimental method, which examined the factors that affect photosynthesis, was presented under the observation activities in the curriculum. Because most textbooks explain the effects of the 3 factors of temperature, concentration of carbon dioxide, and light intensity in the form of a graph, significant positive effects of the studies are shown, which greatly reduce the conceptual diversity index. This suggests that instruction consisting of experiments have a positive effect on the teaching of concepts to students (O' Connell 2008).

All the domains, except for the 'reactants of photosynthesis' domain, showed a decrease in the conceptual diversity index based on the instruction. This is because students already have many preconceptions of the subject as this is a domain that is taught in the 'photosynthesis' domain in 5th grade, and can be approached easily through experience. As such, the conceptual diversity index is deemed to decrease with the convergence of dispersed preconceptions as scientific concepts due to the instruction. Because the student first approaches the periodical table of the elements in the domain on 'reactants of photosynthesis', the conceptual diversity index is believed to increase with the stimulation of dispersed thinking, unlike that in the other 3 domains.

The goal and direction of the instruction are determined by the curriculum as such. Therefore, the curriculum has a great effect on the conceptual diversity index, as presented by the students. The currently executed 7th grade curriculum presents a detailed level of content that must be taught. Hence, the conceptual diversity index decreases due to the instruction. This is because of the convergence of the dispersed preconceptions as scientific concepts in instruction, as this unit deals with content learned in many previous instruction. The curriculum that was presented in detail had significant effect in decreasing the conceptual diversity index. This coincides with the results of previous studies, in which teachers taught content based on the curriculum and very few teachers established class goals by expanding such content (Lee and Kim 2008).

The changes in the proximity between concepts based on the relativeness and frequency were analyzed by selecting the concepts with a frequency of more than 5% among the concepts presented by the students before and after the instruction. The common existence of some concepts with no relation to the instruction was observed (Table 4).

In the domain, 'place of photosynthesis,' chloroplast, leaf, light are commonly presented; and in the 'products of photosynthesis' domain, oxygen, glucose, starch, carbon dioxide, and light are presented. In the 'reactants of photosynthesis' domain, light, water, carbon dioxide, and oxygen are presented; and in the 'environmental factors' domain, light, water, carbon dioxide, oxygen, temperature, and light intensity are presented.

Among these common concepts, the scientific concepts in each domain showed increased frequency rates, and with a decrease in the frequency of misconceptions, which indicates that students recognized scientific concepts more after the instruction. The frequency of misconceptions decreased but continued within the cognition of students (Trundle *et al*. 2007).

Furthermore, the concepts presented by the students in the instruction were further segmented, and the frequency of the segmented concepts increased. For example, there was an increase in the frequency of segmented concepts on the existence of chloroplast, such as palisade parenchyma, spongy parenchyma, and guard cell, concerning the place of photosynthesis. With regard to the increase in the frequency among students who understood light intensity by segmenting light as an influencing factor, the segmentation of concepts within the cognition of students was identified (Kim 2009).

The proximity between the palisade parenchyma, spongy parenchyma, guard cell and light, which are segmented concepts of chloroplasts, and the place of photosynthesis increased, as did the proximity between the products-oxygen, starch, and glucose. Furthermore, with regard to the increase in the proximity between the factors that affect temperature, light, and carbon dioxide, it was concluded that the proximity between scientific concepts also increases with mutual effects between the concepts due to the influence of instruction.

## Implications

There is a need to examine whether or not a concept develops by occupying a given ecological niche between concepts within the conceptual ecology. Accordingly, this study examined how instruction change the ecological niche of the concept of photosynthesis by targeting 557 7$^{th}$ grade students. The conclusions were as follows.

First, the relationships between concepts were differentiated by the mutual effects between

**Table 4**

*Common concepts with a frequency of more than 5% among the concepts presented by the students before and after the instruction*

| Domain | Common Concepts |
|---|---|
| place of photosynthesis | chloroplast, leaf, light |
| products of photosynthesis | oxygen, glucose, starch, carbon dioxide, light |
| reactants of photosynthesis | light, water, carbon dioxide, oxygen |
| environmental factors | light, water, carbon dioxide, oxygen, temperature, light intensity |

concepts within the conceptual ecology based on instruction. When the curriculum was presented in detail, conceptual diversity index based on instruction showed a tendency to decrease. The conceptual diversity index is deemed to decrease because the concepts that had been dispersed as preconceptions are collected as scientific concepts in instruction in those domains that establish many preconceptions through experience such as photosynthesis. Similar the form of succession in ecology, the concepts within the conceptual ecology of the students changed dramatically as dispersed scientific concepts. In this process, the concepts dispersed as preconceptions converged as scientific concepts. Therefore, concepts within the conceptual ecology are initially dispersed with an increase in related concepts, and are then due to mutual effects that occur within the conceptual ecology due to these studies. As a result, the scientific concepts remain and the number of misconceptions decreases. In addition, the students' establishment of segmented concepts after the instruction suggests that the relationships between concepts can be differentiated. Through this, the teacher needs to clearly explain each concept in relation to the preceding concepts, rather than to present various concepts dispersively when teaching the photosynthesis domain.

Second, the status of concepts within the conceptual ecology changes according to the relationship between concepts that changes due to the instruction. Regarding the positioning map, the proximity between scientific concepts increased after the instruction. Furthermore, more than 5% of students displayed a decreased frequency of misconceptions in commonly presented concepts, and an increased frequency of scientific concepts. Therefore, the concepts change with the increased status of scientific concepts as a result of the instruction, unlike in the case of misconceptions. There is a need to teach scientific concepts in relation to misconceptions that students generally have to help promote conceptual changes towards a desirable direction (Alparslan *et al.* 2003).

This study examined the conceptual change from the aspect of the ecological niche in the state wherein the situation of specific instruction has not been presented. Depending on the class situation, students may absorb the education content differently. Hence, there is a need to examine the effects displayed in different situations. In addition, there is a need to examine the effects of the different methods of instruction by analyzing the effects displayed upon the presentation of special class models, instead of standard lecture-type instruction.

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