

## Difference in Elementary School Students' Eye Movement according to the Process of Descriptive Concept Formation

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### Abstract

*The purpose of this study is to analyze the characteristics of eye movements in the descriptive concept construction processes of elementary school students by comparing the visual attention of a group that has constructed a descriptive concept and a group that has not constructed a descriptive concept. The participants in this study are 42 elementary school students. The Creature Card Test, which can construct knowledge without being influenced by prior knowledge, is used as the eye-tracking task. Eye movement data is collected using the Eye-Tracker X2-60 in order to compare the visual attention in descriptive concept construction processes. Retrospective Verbal Protocol (RVP) is also collected in unstructured interview form. After setting the examples, counterexamples, and options presented in the task as the Area of Interest (AOI), we extract the visit duration and visit count as eye movement data. A heatmap and gaze plot was also analyzed. Differences are observed between the two groups based on the heatmap, visit duration, and visit count. This means that the selective attention and efficient visual search processes differ depending on the concept construction. In addition, we confirm differences in the reasoning method and attribute-finding strategy, which occur in the descriptive concept construction process.*

**Keywords:** *Descriptive concept construction, Concept construction process, Visual attention, Eye movement*

### 1. Introduction

Concepts in science education can be classified into various categories. It was classified them as follows: concepts by apprehension, descriptive concepts, and theoretical concepts [1]. Descriptive concepts refer to concepts that consist of meanings that are constructed through cognitive processing about objects that can be directly observed in external situations [2]. In order to understand the descriptive concept, it is necessary to list the relationships or sequences that make up the phenomenon [1].

Previous studies have used behavioral observations and interviews to analyze the thinking processes and strategies that lead to concept construction [1][3]. However, these methods have limitations in terms of indirectly measuring students' concept construction processes. Therefore, it is necessary to use an objective approach that can reveal the visual perception processing that is involved in the concept construction process [4]. An eye tracker can be used for this purpose.

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Therefore, this study analyzes the characteristics of eye movement in elementary school students as they construct descriptive concepts using an eye tracker.

## 2. Method

### 2.1. Participants

We selected 42 sixth graders who volunteered to participate in this research among M elementary school students in Gyeonggi-do. The subjects were also excluded if they had eye problems. To increase the validity of the data, subjects were excluded when the calibration was inaccurate or the tracking ratio was less than 60%. A total of 37 students were analyzed.

### 2.2. Task

The items in the Creature Card Test [5], which analyze the concept construction process without being influenced by prior knowledge, were selected as tasks. In each task, a picture with certain properties is presented as an example on the first line, a counterexample on the second line, and an option on the third line. Example of task was illustrated in [Figure. 1]. The eye tracker experimental paradigm was presented in [Figure. 2].

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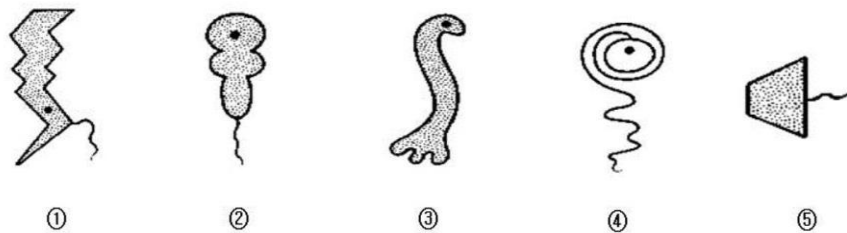


Figure 1. Example of a task

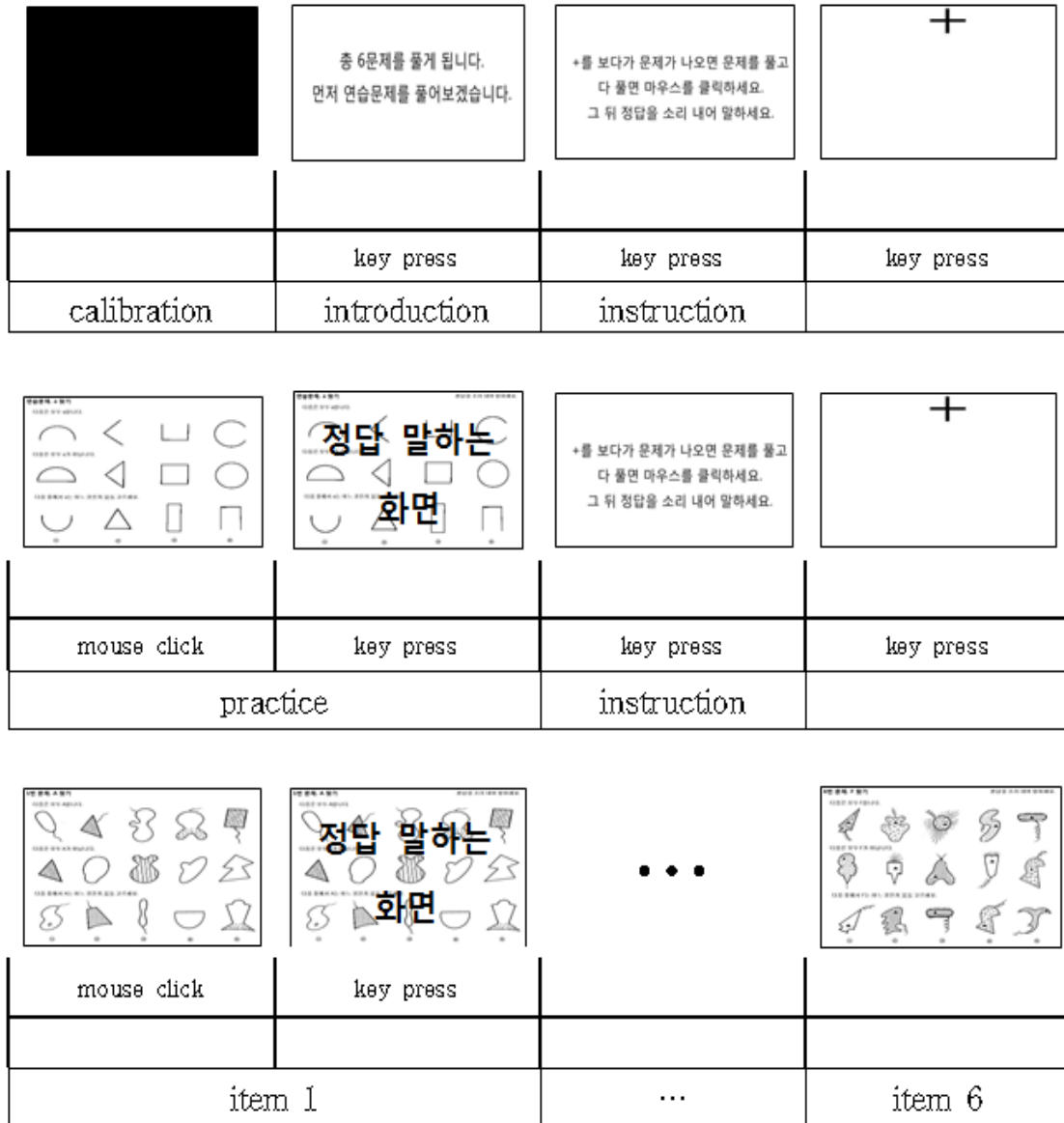


Figure 2. Experimental paradigm

### 2.3. Data Collection

The Eye-Tracker X2-60 was used to collect eye movement data during the descriptive concept construction process. A small camcorder recorded the eye-tracking process. After the eye movements were measured, the gaze plot of the eye movement data was presented to the subject, and retrospective verbal protocol (RVP) data was collected.

## 2.4. Data analysis

The collected eye movement data was analyzed using Tobii Studio 3.2.3 and IBM SPSS Statistics 22.0. The minimum fixation duration was set to 60 ms based on previous studies [6], and the area of interest (AOI) was set to three areas: examples, counter-examples, and options. The subjects were divided into two groups according to whether the concept construction was formed or not. visit duration, and visit count were also compared through independent sample t-tests.

## 3. Results and discussion

### 3.1. Heatmap

A comparison of the heatmap showed that the total fixation counts of the group that did not construct the concept was larger than that of the group that constructed the concept. A high number of fixation counts and long fixation durations in all areas indicated inefficient visual exploration [7] and difficulty with solving problems (Hyrskykari et al., 2008). The group that constructed the concept also showed uniform colors and sizes in the examples, counter-examples, and options (see [Figure. 3]) while the group that did not construct a concept showed the red color only during the examples and options (see [Figure. 4]). The counter-examples are important clues to recognize and manipulate during the process of constructing a concept [8]. Therefore, it can be said that the group that did not construct a concept had difficulty with constructing the concept because it could not use the counter-examples as important clues.

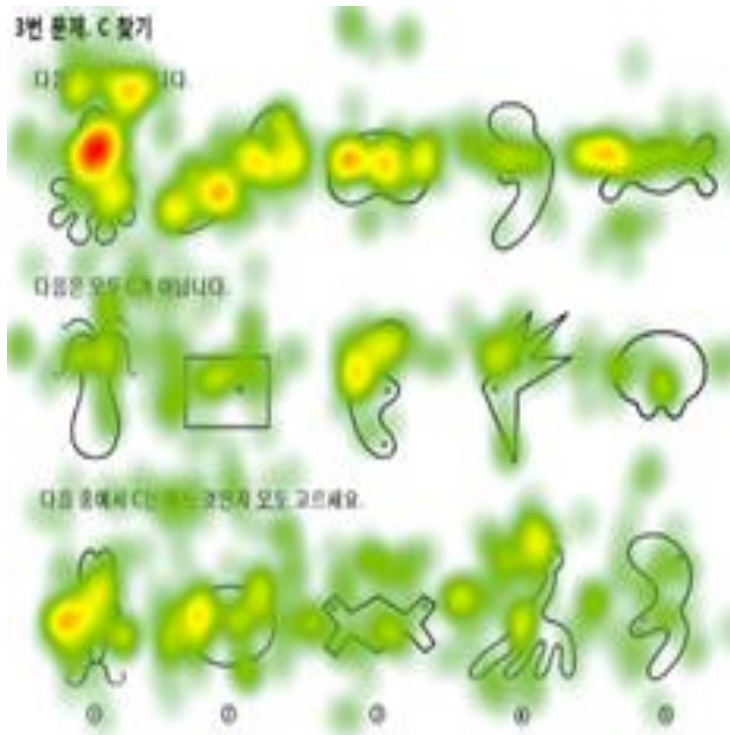


Figure 3. The heatmap for the group that constructed descriptive concept

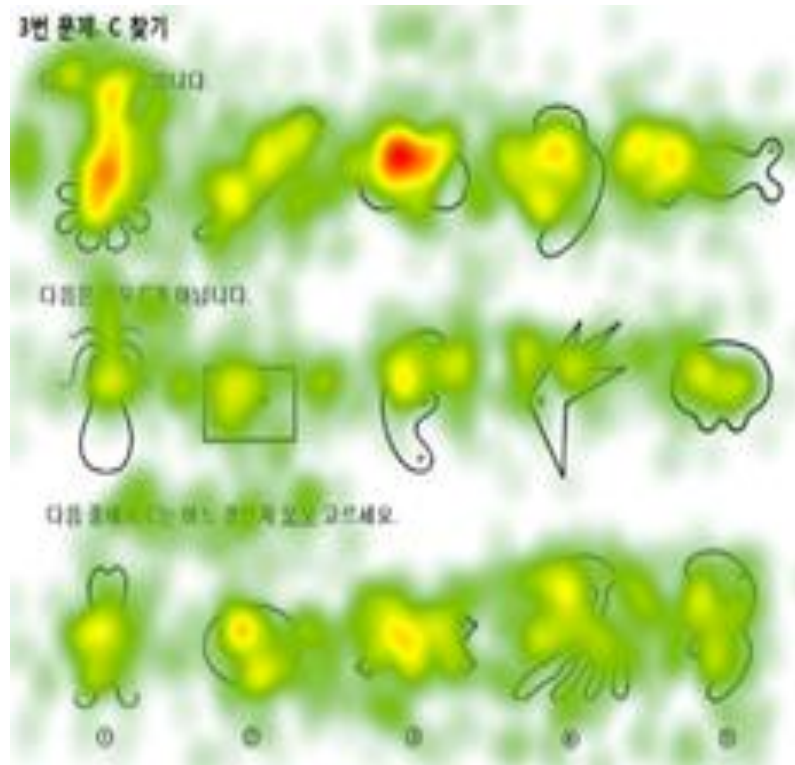


Figure 4. The heatmap for the group that did not constructed descriptive concept

### 3.2. Visit duration and Visit count

This table shows that the gaze of the group that constructed a concept stayed longer than the gaze of the group that did not construct a concept, with a statistically significant difference in the example and the counter-example areas. On the other hand, the number of visits of the group that formed a concept was smaller than the number of visits of the group that did not form a concept with a statistically significant difference.

## 4. Conclusion

The results of this study are summarized as follows. First, the heatmap, visit duration, visit count, and transitional matrix differed between the group that constructed a descriptive concept and the group that did not construct a descriptive concept. This implies that there is a difference in the efficiency of visual searches, depending on whether or not the concept is constructed. The students in the group that did not construct a descriptive concept often switched their attention to irrelevant areas and did not use counter-examples as clues.

This study empirically verifies the inductive-deductive reasoning process proposed by Lawson [2] through the analysis of eye movements during the descriptive concept construction process. Therefore, students should be instructed to experience various inference processes related to concept construction. Moreover, students who have difficulties with constructing descriptive concepts can experience better inference during the process of constructing a concept by selectively presenting the necessary clues, such as counter-examples or skipping questions related to attributes.

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