



VISUAL ATTENTION IN EARLY PRIMARY SCHOOL STUDENTS DURING OBSERVATION ACTIVITIES

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Abstract. *Scientific observation is a foundational inquiry skill in early childhood science education, yet how visual attention develops during observation tasks among lower-grade primary school students remains underexplored. This study examined whether and how visual attention during science observation activities differs across Year 1, Year 2, and Year 3 primary school students and adults in Korea. A cross-sectional comparative design was employed, using eye-tracking technology to measure fixation duration, fixation count, and gaze transitions across four tasks structured according to SAPA's hierarchy of observation skills. A total of 108 participants (Year 1: n=16, Year 2: n=35, Year 3: n=33, Adults: n=24) completed the tasks, and group differences were examined using one-way ANOVA with Scheffé post hoc tests. Year 1 students consistently differed from all other groups: they showed shorter fixation durations on target areas, more frequent gaze transitions, greater attention dispersal toward irrelevant information, and weaker top-down attentional control. Year 2 and Year 3 students generally performed comparably to adults. These findings indicate that Year 1 students are at a critical developmental stage in the development of observation ability, and suggest that the design of science observation activities and curriculum materials for lower-grade students should reflect these age-related attentional characteristics.*

Keywords: *eye-tracking, visual attention, observation skills, science process skills, primary school students, science education*

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Introduction

Scientific observation is not simply a matter of looking at something. It involves selecting what deserves attention, retaining that information, and drawing meaning from what is perceived. These cognitive demands make observation a complex activity, one that develops gradually through childhood (Daston, 2008; Eberbach & Crowley, 2009). Establishing empirically how lower-grade primary school students actually observe is therefore directly relevant to science education (Ruff & Capozzoli, 2003; She & Chen, 2009).

Science education in the lower grades significantly affects later achievement in science learning (Eshach & Fried, 2005; Kaderavek et al., 2020; National Research Council (NRC), 2007). Among science activities in the lower grades, observation is a core element of early science learning (Tolmie et al., 2016), and it provides opportunities to extend to complex thinking processes such as classification, prediction, explanation, and hypothesis setting (Johnston, 2009). In addition, observation in the lower grades develops the ability to explore and form new ideas, expands understanding of objects and phenomena, and cultivates basic thinking skills applicable to a variety of problem situations (Jirout & Zimmerman, 2015). Research in science education has accordingly suggested that the observation performance of lower-grade students can be developed, and the importance of science observation education in the lower grades has been emphasized (Crowley et al., 2001; Johnston, 2009).

Despite the importance of systematic observation education in the lower grades, Korea's science curriculum begins at Year 3 in primary school (ages 8–9), unlike other countries (Department for Education, 2013; Korean Ministry of Education, 2015, 2022; National Research Council, 2012; NGSS Lead States, 2013). As a result, Korean Year 1 and Year 2 students have limited opportunities for systematic observation education within the formal curriculum. In order to provide systematic observation education for the lower grades, the observational characteristics of younger students need to be considered (Buck et al., 2014; National Research Council, 2007). Therefore, research on the observational characteristics of younger Korean students has important implications for observation education in the lower grades in Korea.

Although the importance of systematic observation education in the lower grades has been emphasized, studies of observation involving Korean primary school students have generally been conducted with Year 3 students and above (Kwon & Kwon, 2009; Park & Kim, 1999; Park et al., 2005; Song & Han, 1995), whereas research abroad has examined the observational



characteristics of children in early childhood (aged 5–7) (Harlen & Symington, 1985; Johnson & Tunnicliffe, 2000; Johnston, 2009; Kos & Jerman, 2015). However, because these studies rely on language-based methods such as interviews and worksheets, they are limited in objectively identifying the actual observation process of younger students whose language ability is still developing (Kwon & Pae, 2006).

Eye-tracking is gaining attention as a tool that can compensate for the limitations of previous research methods, in that it can objectively measure the characteristics of learners' gaze movement in observation situations (She & Chen, 2009) and directly explore the information-processing process during the performance of observation tasks. Studies analyzing visual attention in observation situations using eye-tracking have been conducted (Yang et al., 2013), but in Korea, such studies have mainly targeted upper-grade students, and research on the visual attention characteristics of younger students is lacking. Abroad, studies on visual attention in early childhood have been conducted (Betts et al., 2006; Lewis et al., 2017; Mahone & Schneider, 2012), but these do not deal with the specific context of scientific 'observation', and, because they were conducted with children in different learning environments and educational cultures, their results alone are insufficient to fully explain the visual attention characteristics of younger Korean students in actual observation activities.

Three critical gaps, therefore, remain in the existing literature. First, Korean observational studies have focused predominantly on Year 3 students and above, leaving the observational characteristics of Years 1 and 2 largely unexplored. Second, existing studies of younger children's observation have relied on language-based methods that are inherently limited when applied to children whose verbal ability is still developing. Third, while eye-tracking studies have begun to address visual attention in early childhood, none has examined visual attention within the specific framework of SAPA's hierarchy of observation or within the distinctive context of the Korean curriculum. The present study addresses these three gaps by applying eye-tracking technology to compare visual attention patterns during structured science observation tasks. Research on visual attention commonly distinguishes between two types of attentional processes. One is stimulus-driven, meaning that certain features of the environment, such as movement or sudden change, draw the eye without deliberate intent. The other is goal-directed, meaning that the observer attends to something because a task requires it (Matlin, 1994). This distinction is used in the present study to interpret the age-related differences observed across the four tasks.

Accordingly, the purpose of this study was to analyze the characteristics of visual attention shown during the performance of observation tasks by comparing the visual attention of lower-grade primary school students in Korea (Years 1, 2, and 3) with that of adults. The specific research question was:

What differences in eye movement do primary school students in Years 1, 2, and 3 and adults show when performing observation tasks?

Research Methodology

Design

This study employed a cross-sectional comparative design to examine visual attention patterns during science observation tasks across four age groups: Year 1, Year 2, and Year 3 primary school students, and university-aged adults (aged 19–24). A quantitative approach was adopted, using eye-tracking technology to obtain objective behavioral measures of visual attention. University students were selected as the adult comparison group, not because they represent scientific expertise, but because they provide a developmental reference point representing a mature attentional control system, consistent with established practice in developmental eye-tracking research (Colombo, 2001; Lewis et al., 2017; Mahone & Schneider, 2012). Data were collected from April to June 2025 at a single primary school located in a large metropolitan city in Korea.

Participants

Four groups of participants were recruited: students in Years 1, 2, and 3 from a primary school in Korea, and university-aged adults. Students were selected by random sampling within each year group. The sample comprised 137 students attending a primary school located in a large city in Korea (31 in Year 1, 51 in Year 2, and 55 in Year 3), and 44 adults were recruited from a university. In the case of primary school students, consent to participate in the study was obtained from both the students and their parents, and in the case of adults, only those who voluntarily indicated their agreement to participate were selected.



To ensure the reliability of the data, the proportion of the gaze sample was taken into consideration. Gaze sample refers to the proportion of valid gaze data points captured by the eye-tracking device (Holmqvist et al., 2011). The higher this proportion, the more accurate fixation and saccade detection become, and the more reliable the resulting eye-movement indices (Salvucci & Goldberg, 2000). Based on previous studies, a gaze sample of 80% was set as the minimum criterion (Andersson et al., 2010; Kim et al., 2015), and cases with a gaze sample below 80%, failed calibration, or inability to track owing to excessive body movement were excluded. As a result, 73 of the initial 181 participants were excluded, and data from a final total of 108 participants (16 in Year 1, 35 in Year 2, 33 in Year 3, and 24 adults) were used for analysis. The Year 1 group was most affected by this screening. Younger children tend to move their heads and bodies more frequently during measurement, and their shorter attention spans make it harder to maintain the level of gaze capture the criterion requires. Excluding participants whose data fell below the threshold improved the precision of the fixation estimates for those who remained. The exclusion process was a standard quality control procedure, not an arbitrary reduction of the sample. Readers should nonetheless be aware that statistical power was lower for the Year 1 group than for the others, and the Year 1 findings are best understood as indicative of a developmental pattern rather than as a fully representative account of all children at this age.

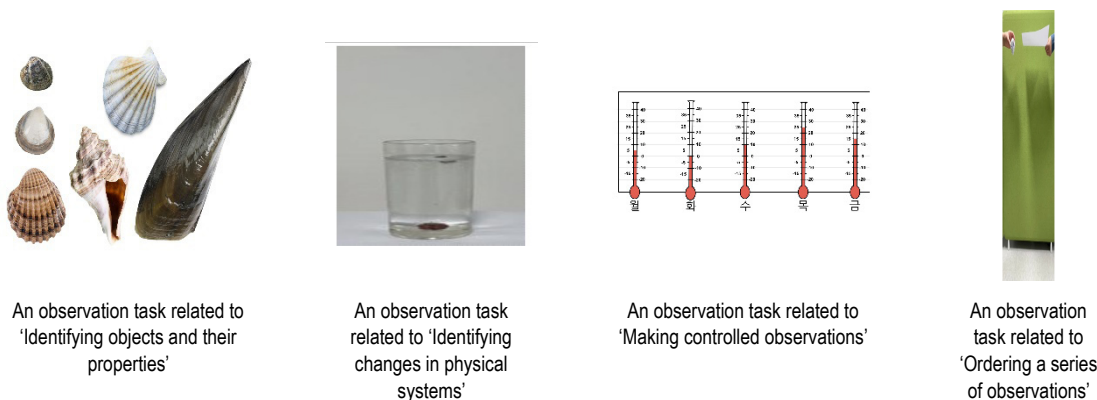
Instruments and Observation Tasks

In order to measure visual attention shown during the performance of observation tasks by lower-grade primary school students and adults, the eye-tracking device Tobii Pro Spectrum (Tobii AB, Stockholm, Sweden) was used. Gaze data of this kind have been used to examine how people process and respond to visual information (Kim, 2008). According to previous eye-tracking studies (Harris & Christliff, 1980; Friedman & Liebelt, 1981), people tend to fixate longer on objects that are perceptually demanding, informationally dense, or personally relevant, suggesting that fixation duration reflects cognitive importance and processing load (Kim, 2001). Eye-tracking is, therefore, a well-established method for objectively examining the visual attention students direct toward observation materials. To examine differences in observational characteristics across age groups, four tasks were developed according to SAPA's hierarchy of observation (Figure 1).

The developed tasks were revised and supplemented after their validity was reviewed by an expert group consisting of two science education specialists and one science field education specialist with experience in eye-tracking research. The final content validity index (CVI) values of the expert group for the developed tasks ranged from 0.87 to 0.95, indicating acceptable validity (Task 1 = 0.95, Task 2 = 0.90, Task 3 = 0.87, Task 4 = 0.90).

Figure 1

Observation Tasks for Research

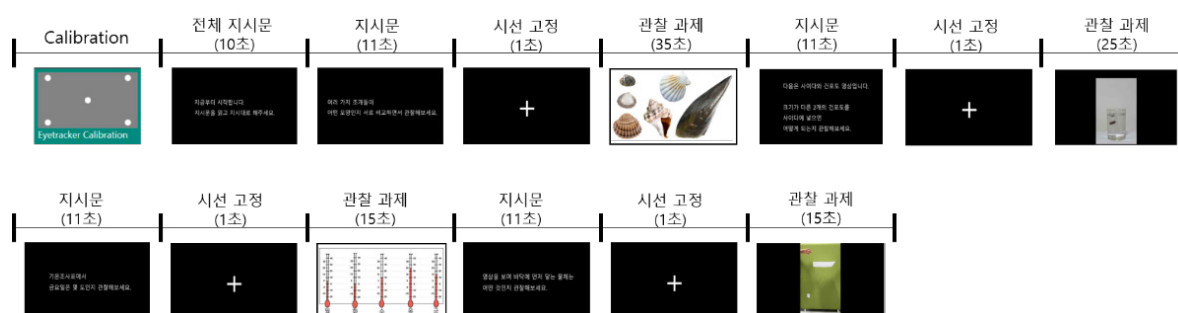


A presentation paradigm was also developed and reviewed for validity by the same expert group. The criteria used to assess content validity were as follows.

1. Do the distribution, transitions, and fixation time of gaze reflect the hierarchy of observation?
2. Can children understand and perform the task instructions?
3. Can the order and method of presenting the materials be understood without confusion?
4. Do the instructions encourage natural observation while also allowing performance to be assessed according to the observation hierarchy?
5. Are the instructions designed so that students can observe autonomously, without implying a specific direction of observation or a particular answer?

The final task paradigm is shown in Figure 2. The content validity index (CVI) for each paradigm ranged from 0.89 to 0.95.

Figure 2
The Final Revised Task Paradigm



Data Collection

Gaze data were recorded using the Tobii Pro Spectrum eye-tracker and extracted using Tobii Pro Lab (version 1.116). The sampling rate of Tobii Pro Spectrum was 150 Hz, and binocular tracking was possible. The device is also largely unaffected by the handedness of participants. Statistical analyses were performed using SPSS (version 24.0). Data collection took place in a quiet room with external noise minimized. Each session began as soon as the participant completed calibration, at which point the observation task was presented and recording commenced.

Data Analysis

Group differences in eye-movement indices were examined using one-way analysis of variance (ANOVA) with Scheffé post hoc tests. Following Holmqvist et al. (2011) and Cullipher et al. (2018), participants who fixated on the target AOI two or more times were classified as having successfully identified the target information.

Specifically, for eye-tracking data analysis, the Velocity-Threshold Identification (I-VT) filter algorithm (Salvucci & Goldberg, 2000) was applied to distinguish fixations from saccades on the basis of the speed of eye movement. In accordance with standards commonly used in previous studies (Kooiker et al., 2016; Negi & Mitra, 2020), the threshold was set at 30°/s with a minimum fixation duration of 200 ms. Only fixations satisfying both criteria were retained for analysis, thereby excluding accidental or transient gaze pauses.

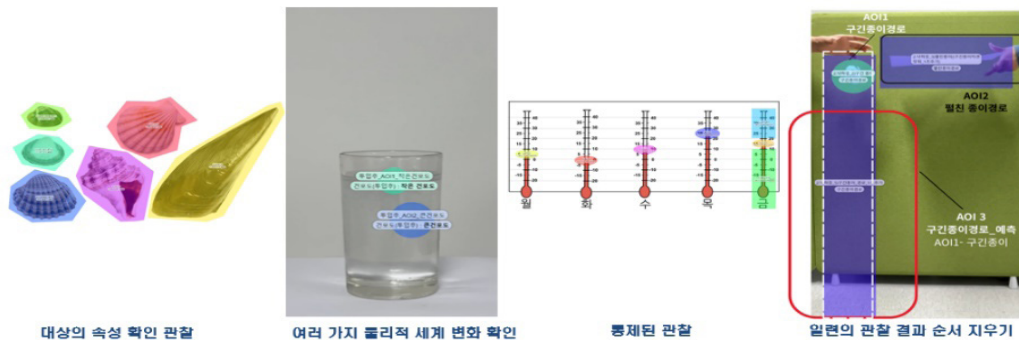
Quantitative indices including fixation count, fixation duration, and AOI hit rate were collected, along with visualization data in the form of heat maps and gaze plots. Transition count between AOIs was also calculated to examine how gaze moved across different areas during task performance. Transition count refers to the number of times the gaze moved from one AOI to another (Blascheck et al., 2017). Because transition count is not provided by default in Tobii Pro Lab, raw AOI hit data were extracted, and only transitions between different AOIs were calculated by using Tobii's Python API, with re-fixation within the same AOI excluded.

In general, for video analysis, it is necessary to set an analysis segment. In order to analyze the observation activity related to 'Identifying changes in physical systems', the analysis segment was set from the point at which

the two raisins began to float simultaneously after being placed in cider to the end of the video. The segment was divided into a total of eight parts based on the ascent and descent of the larger raisin. To analyze the observation activity related to 'Ordering a series of observations', the analysis segment was set from the point at which the two pieces of paper began to fall until the crumpled paper touched the floor.

In order to derive quantitative data such as fixation duration and fixation count, Areas of Interest (AOIs) were established (Hessels et al., 2016; Rim et al., 2021). The AOIs used are illustrated in Figure 3.

Figure 3
AOI by Task(Area of Interest)



Research Results

Visual Attention Shown by Lower-Grade Primary School Students in the Observation Activity 'Identifying Objects and Their Properties'

Observation is the use of the senses to gather information about objects and phenomena (AAAS, 1990a). In other words, observation activity at this level centers on identifying the properties of objects. 'Identifying objects and their properties' is the most basic stage in the hierarchy of observation activities (Park, 2012). In order to identify the visual attention shown by lower-grade primary school students in the observation activity related to 'Identifying objects and their properties', this study employed a task in which participants observed various shells with different characteristics. Both quantitative data (fixation duration, transition count between AOIs) and qualitative data (heat map) were used in the analysis.

First, in order to compare the characteristics of visual attention according to group (Year 1, Year 2, Year 3, adults), fixation duration values for each shell observation area were obtained, and one-way ANOVA was conducted. The results are shown in Table 1. The analysis showed a significant difference in fixation duration according to age ($F = 5.18, p < .001$), and the post-hoc test confirmed a significant difference between the Year 1 group and the adult group.

Table 1
Comparison of Visual Attention by Group for the Exploration of Shell Properties

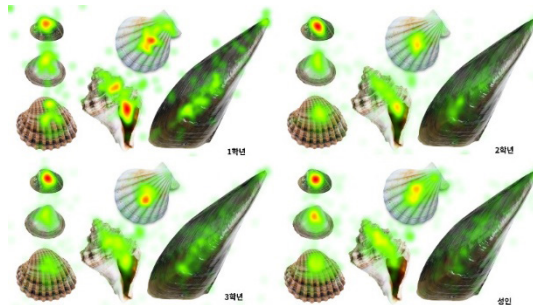
Group	Fixation duration				<i>p</i>	Scheffé
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>F</i>		
A G E	Year1 ^a	16	19.58	5.18	< .001***	a<d
	Year2 ^b	35	21.68			
	Year3 ^c	33	21.67			
	Adults ^d	24	24.26			

*** $p < .001$

The heat map data shown in Figure 4 indicate that the Year 2, Year 3, and adult groups directed their gaze primarily toward the shells, whereas Year 1 students also fixated on empty spaces outside the shell areas. This suggests that Year 1 students' gaze was more dispersed across the display than that of the other groups.

Figure 4

Heat Map Results for the Shell Observation Task by Group



Because the observation task required participants to observe several kinds of shells, the difference in transition occurring during the process of observing the shells was also analyzed. On the basis of the analyzed results, one-way ANOVA was conducted to examine group differences, and the results are shown in Table 2. The results showed that the difference in transition according to group was statistically significant ($F = 3.17, p = .03$). In the post-hoc test, the Year 1 and Year 2 groups showed significant differences from the adult group. In other words, compared with the adult group, Year 1 and Year 2 students moved more frequently among the shells while observing them.

Table 2

Comparison of Transition by Area According to Group

Group	Transition Shells AOI					
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>F</i>	<i>p</i>	Scheffé
Age	Year1 ^a	16	25.56	3.17	.03*	a,b<d
	Year2 ^b	35	27.57			
	Year3 ^c	33	23.09			
	Adult ^d	24	21.46			

* $p < .05$

*Visual Attention Shown by Lower-Grade Primary School Students in the Observation
Activity 'Identifying Changes in Physical Systems'*

In order to identify the visual attention shown in the process of 'Identifying changes in physical systems' for each group, fixation duration and transition between AOIs were analyzed. The observation task was presented as a video showing two raisins of different sizes placed in a carbonated drink (cider), in which participants observed the bubble activity on the raisin surfaces and the changes in their vertical positions. To this end, differences in fixation duration for the small raisin by group were first tested by using one-way ANOVA (Table 3). The small raisin was selected for this comparison because it moved repeatedly within the cider as bubbles formed and dissolved around it. In other words, as the position of the raisin changed, it provided a cause for bottom-up attentional capture (Kim, 2008; Mowen, 1995; Wickens & Hollands, 1999). The fixation duration result values for the position-changing small raisin according to group did not show a statistically significant difference ($F = 2.24, p = .09$). All four groups looked at the moving raisin for comparable durations.

Table3*Comparison of Visual Attention by Group for the Observation Task of Identifying Physical Changes*

Group	Fixation duration _Small Raisin				
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>F</i>	<i>p</i>
A g e	Year1 ^a	16	4.13	2.24	.09
	Year2 ^b	35	4.70		
	Year3 ^c	33	3.57		
	Adult ^d	24	4.72		

As shown in Table 3, although there was no significant difference among the groups, the fixation duration value for the small raisin was shortest in Year 3 and longest in adults. In other words, this indicates that adults observed the changing raisin more than the other groups. In addition, no significant difference among groups appeared in fixation duration for the large raisin, whose positional change was smaller than that of the small raisin. The visual movement between the small raisin, whose positional change was frequent, and the large raisin, whose positional change was less frequent, was analyzed by using the transition value indicating between-area shifts. One-way ANOVA was conducted using the number of transitions between the two raisins as the dependent variable (Table 4). The analysis showed a significant group difference ($F = 10.78, p < .001$). Year 1 showed the highest transition value, whereas Year 3 showed the lowest. Year 1 students shifted their gaze between the two raisins more frequently than any other group. This result indicates that Year 1 students showed a pattern of observing by comparing the small raisin, which showed greater positional change, with the large raisin, which showed less. In addition, although there were differences in the mean values among the Year 2, Year 3, and adult groups, these differences were not statistically significant. That is, compared with the other groups, Year 1 alternated observation between the two raisins more frequently.

Table 4*Comparison of Transition Between the Two Raisins of Different Sizes According to Group*

Group	Gaze Transitions Between the Two Raisins					
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>F</i>	<i>p</i>	Scheffé
A g e	Year1 ^a	16	4.63	10.78	< .001***	b,c,d<a
	Year2 ^b	35	2.63			
	Year3 ^c	33	1.97			
	Adult ^d	24	2.50			

*** $p < .001$

*Visual Attention Shown by Lower-Grade Primary School Students in the Observation
Activity 'Making Controlled Observations'*

According to SAPA II (AAAS, 1990b), controlled observation is a higher-level inquiry skill that builds on lower-level skills such as basic observation, measurement, and variable control. It involves time-series observation, the collection of quantitative data, and attention to the relationship between variables. In order to identify the visual attention shown by each group in activities related to such controlled observation, fixation count and fixation duration were analyzed.

In 'Making controlled observations', the first observation activity was: 'Please observe what the temperature is on Friday in the temperature chart.' In other words, participants had to identify the temperature on Friday. In the presented figure, the Friday temperature instruction area was set as the AOI. The number of students in each group whose gaze reached the Friday temperature area is shown in Table 5. Compared with the other groups, in the case of Year 1, only 50.0% of the students reached the task target with their gaze, whereas the figures were 94.3% for Year 2, 93.9% for Year 3, and 100.0% for adults. In other words, compared with the other groups, Year 1 did not accurately observe the AOI, that is, Friday's temperature.

Table 5*Visual Attention in the Observation Activity Related to ‘Making Controlled Observations’ (Fixation Count)*

Age	Reached (persons)	Not reached (persons)	Total (persons)	Success rate (%)
Year1	8	8	16	50.0
Year2	33	2	35	94.3
Year3	31	2	33	93.9
Adults	24	0	24	100.0
Total	96	12	108	88.9

Fixation duration for the temperature-chart observation area according to group was also collected and analyzed by using one-way ANOVA (Table 6). The analysis showed a significant difference in fixation duration according to group ($F = 3.21$, $p = .03$), and the post-hoc test confirmed significant differences between the Year 1 and Year 3 groups, and between the Year 1 and adult groups. This result, taken together with the fixation count data above, confirms that Year 1 students directed less visual attention to the target area than the other groups.

Table 6*One-Way ANOVA and Post-Hoc Results for Fixation Duration in the Temperature-Chart Observation Area According to Group*

Group	Fixation Duration_ Temperature-chart Observation Area				<i>p</i>	Scheffé
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>F</i>		
A g e	Year1 ^a	16	5.57	3.84	3.21	a<c,d
	Year2 ^b	35	7.64	2.50		
	Year3 ^c	33	8.03	3.06		
	Adult ^d	24	8.31	2.81		

* $p < .05$

*Visual Attention Shown by Lower-Grade Primary School Students in the Observation
Activity ‘Ordering a Series of Observations’*

SAPA II (AAAS, 1990b) presents activities related to ‘Ordering a series of observations’ as tasks that are structured to observe continuous change, such as observing plant growth or falling objects. In this study, a video showing a crumpled sheet of paper and a flat sheet of paper dropped from the same height was presented to the participants. In order to identify the results related to the task, three types of quantitative data were analyzed: fixation duration for the crumpled paper, fixation duration for the flat paper, and fixation duration for the predicted path of the crumpled paper.

First, visual attention by group to the process in which the crumpled paper fell was analyzed by collecting fixation duration values and conducting one-way ANOVA (Table 7). The analysis showed a significant difference in fixation duration for the AOI of the crumpled paper path according to group ($F = 6.31$, $p < .001$). In addition, the post-hoc test showed significant differences between the Year 1 and adult groups, and between the Year 3 and adult groups. In other words, it was confirmed that adults observed the process of the crumpled paper falling more attentively than the other groups.



Table 7*One-Way ANOVA and Post-Hoc Results for Fixation Duration in the Observation Area of the Crumpled Paper Path According to School Year*

Group	Fixation Duration _ Path of the Crumpled Paper					
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>F</i>	<i>p</i>	Scheffé
A g e	Year1 ^a	16	1.66	6.31	< .001***	a,c<d
	Year2 ^b	35	2.06			
	Year3 ^c	33	1.84			
	Adult ^d	24	2.79			

****p* < .001

Table 8 shows that fixation duration for the flat paper did not differ significantly across groups ($F = 2.42$, $p = .07$). In the post-hoc test, the adult group showed a tendency for significantly shorter gaze duration than the Year 1 group. Unlike the crumpled paper, the flat paper produced no clear group difference in fixation duration. Although no statistically significant difference was confirmed, Table 8 shows that adults displayed less visual attention to the flat paper than the other groups. This indicates that adults paid more visual attention to the crumpled paper, in which change occurred more rapidly, and less visual attention to the flat paper, in which change occurred more slowly.

Table 8*One-Way ANOVA and Post-Hoc Results for Fixation Duration in the Observation Area of the Flat Paper According to School Year*

Group	Fixation Duration _ Flat Paper					
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>F</i>	<i>p</i>	Scheffé
A g e	Year1 ^a	16	.83	2.42	.07	d<a
	Year2 ^b	35	.64			
	Year3 ^c	33	.67			
	Adult ^d	24	.36			

Fixation duration was also used to examine where participants directed their gaze in anticipation of the falling object's path. When observing a moving object, people often shift their gaze not only toward the object itself but also toward where it is likely to go next. The analysis was conducted using the crumpled paper, which had shown a significant difference among groups. One-way ANOVA was conducted using the fixation duration value for the predicted path of the crumpled paper according to group (Table 9). The results showed that fixation duration for the AOI of the predicted path of the crumpled paper differed significantly according to group ($F = 8.74$, $p < .001$), and the post-hoc test confirmed significant differences between the adult group and the other groups. In other words, adults checked the predicted path of the crumpled paper, whereas the other groups did so relatively less.

Table 9*One-Way ANOVA and Post-Hoc Results for Fixation Duration in the Observation Area of the Predicted Path of the Crumpled Paper According to School Year*

Group	Fixation Duration _ Predicted Path of the Crumpled Paper					
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>F</i>	<i>p</i>	Scheffé
A g e	Year1 ^a	16	.46	8.74	< .001***	a,b,c<d
	Year2 ^b	35	.54			
	Year3 ^c	33	.55			
	Adult ^d	24	1.07			

****p* < .001

Discussion

Inquiry process skills, including observation, are organized descriptions of the skills that scientists use in problem-solving (Padilla et al., 1985). In science education, such skills have long been taught and valued as core methods of scientific practice. In particular, observation is the beginning and the core function of science (Kwon et al., 2005; Park & Kim, 1999; Lawson, 1995), and its importance needs no further elaboration here. As revealed in the study by Park (2011), observation improves significantly as the school year rises within primary school. However, in addition to the quantitative approach of improvement in observation skill, there is also a need to examine together the qualitative characteristics of what kinds of observational features are shown. Specifically, it is important to understand what observational characteristics appear at each year level and whether the differences between year groups are educationally meaningful. The present study used eye-tracking to address this question.

In the Korean curriculum, the subject 'Science' does not begin from Year 1 in primary school, but from Year 3. In other words, Year 1 and Year 2 students do not study the subject 'Science', but instead engage in the integrated subject activity '슬기로운 생활' (Smart Life). As a result, formal assessments of science learning in Korea typically begin from Year 3. Tests or assessments targeting Year 1 and Year 2 students are rare. As a result, it may be said that the organization of the 'Science' curriculum applying the hierarchy of 'observation' ability, which can be regarded as the core and starting point of scientific inquiry (Tolmie et al., 2016), is discontinuous. This study represents an attempt to address this curricular gap. It was designed to compare the observation abilities of students in Years 1, 2, and 3 with those of adults, with the aim of providing evidence to inform the design of inquiry activities and the development of science textbooks for the lower grades.

As also presented in the results above, the observation behaviors shown by primary school students in Years 1, 2, and 3 in this study generally differed significantly from those of the adult group. In particular, Year 1 students showed significant differences from the other groups, namely Year 2, Year 3, and the adult group, on several items. These results indicate that observation activities for Year 1 students need to be structured differently from those for higher year groups.

In particular, looking at the result of the first task in this study, the observation activity 'Identifying objects and their properties', findings similar to those of previous studies appeared. The Year 1 group showed lower values than the other groups in identifying objects and properties, and showed a significant difference from adults. Johnston (2009) reported that children aged 5–7 quickly grasp the general impression, but have difficulty paying attention to specific properties and analyzing them in detail. In addition, Harlen and Symington (1985) revealed that from the age of 8–9, that is, from approximately Year 2 in primary school, the ability of selective attention to filter out task-irrelevant information effectively and focus on important information improves. In the light of these findings, it may be inferred that Year 1 in primary school is a period in which observation ability and the characteristics shown in observation activity are distinct from those of the other groups.

In this study, the number of gaze transitions, which may be seen as an activity of comparing the properties of shells with different shapes, was also investigated and compared. The analysis showed that Years 1 and 2 had significantly higher values than the adult group. A higher transition count may reflect active comparative observation, but it may equally indicate difficulty in processing visual information across multiple objects, leading to repeated shifts of gaze. However, considering that the previous study of Buck et al. (2014) showed that students aged 6–8 had difficulty deriving commonalities and differences after observing shells, the findings of this study may be interpreted as meaning that Year 1 and Year 2 students experienced difficulty in comparing the properties of shells. This aspect requires further study.

Year 2 and Year 3 students performed at levels close to those of the adult group on most tasks (Tables 1 and 3). This rapid developmental improvement between Year 1 and Year 2 aligns with evidence that the period of 6–8 years is characterized by substantial growth in inhibitory control and sustained attention (Lewis et al., 2017; Jones et al., 2003), and that selective attention begins to stabilize functionally around ages 7–8 (Malegiannaki & Metallidou, 2017). In the Korean curriculum context, Year 2 students engage in inquiry-like observational activities through the integrated subject 'Smart Life' (슬기로운 생활), and it is plausible that this informal observational exposure contributes to the accelerated maturation of visual attention. These findings suggest that structured science observation activities can be introduced effectively from Year 2.

According to the hierarchy of observation activities presented in SAPA II (AAAS, 1990b), the observation activity following 'Identifying objects and their properties' is 'Identifying changes in physical systems'. That is, students should be guided to observe, with visual attention, objects that undergo physical changes. This was also the second task in the present study. The analysis showed no significant group difference in fixation duration for the small raisin, which repeatedly rose and fell in the cider. The allocation of visual attention in observation can be broadly divided into bottom-up attentional capture and top-down attentional capture, depending on the cause that leads students to direct their visual attention (Matlin, 1994). Bottom-up attentional capture refers to the concentration of visual attention in response to

stimuli such as size, color, position, distinctiveness, and movement, whereas top-down attentional capture refers to the concentration of visual attention according to internal factors such as individual needs and preferences (Kim, 2008). The small raisin, therefore, had properties more likely to attract gaze than the large raisin, which moved relatively little. This suggests that the small raisin captured attention through bottom-up processes similarly across all groups.

The fixation duration result for the moving raisin showed no significant group difference, whereas the key measures in the other three tasks did. Where a stimulus moved continuously and visibly, all four groups attended to it for similar durations. When completing the task, students were required to locate specific information or follow a particular target. Year 1 students spent less time on the relevant area than the other groups. This contrast is consistent with the distinction between stimulus-driven attention and goal-directed attention (Matlin, 1994). Responding to the raisin's movement is a type of visual behavior that occurs without deliberate choice. Attending to a temperature value on a chart, or tracking a falling object's predicted path, requires the observer to decide where to look based on what the task demands. The results suggest that this capacity for goal-directed visual attention is still at an early stage of development in Year 1 students (Jones et al., 2003).

The third task observed by the participants in this study concerned 'Making controlled observations'. According to the hierarchy of observation presented in SAPA II (AAAS, 1990b), this is the third observation activity that students should learn. The task used in this study was the temperature chart, also presented in SAPA II (AAAS, 1990b), and the goal was to identify the temperature for a particular day of the week. Year 1 students spent significantly less time than the other groups fixating on the specific temperature value the task required. Their fixation duration on that area was notably shorter. The study of Malegiannaki and Metallidou (2017) reported that selective attention develops slowly but gradually between the ages of 6 and 10. In addition, it reported that ages 7–8 correspond to the early stage of this gradual development, in which the ability to select task-relevant information improves but is still inconsistent, whereas between ages 8 and 10 basic attentional functions develop significantly and selective attention stabilizes. In the light of the findings of Malegiannaki and Metallidou (2017), the fact that Year 1 students allocated shorter visual attention to the temperature of a particular day than the other groups may be interpreted as resulting from an immature ability to select relevant information during the age period corresponding to 7–8 years. Furthermore, Jones et al. (2003), in a study of children aged 6–10, reported that ages 8–9 are a period during which executive attention grows rapidly, goal-directed attentional control develops, and by around age 10, goal-directed attentional control becomes established. The pattern of differences between Year 1 and the older groups is consistent with what prior research has reported about the age-related development of selective and goal-directed attention. In relation to observation, Park (2012) also noted that, as school year increases and cognitive development progresses, observation ability likewise increases, pointing out that this is consistent with the theory of Pascual-Leone (1987), which explains cognitive development as the development of mental capacity.

According to the hierarchy of observation activities presented in SAPA II (AAAS, 1990b), the fourth activity is 'Ordering a series of observations'. For this task, participants watched a video showing a flat sheet of paper and a crumpled sheet of paper being dropped from the same height simultaneously. The results confirmed that adults observed the process of the crumpled paper falling more attentively than the other groups. In particular, in this observation task as well, Year 1 students showed a significant difference from adults. That is, Year 1 students did not show sustained attention to the crumpled paper, which fell more quickly than the flat paper. This result is consistent with the finding of Lewis et al. (2017), who reported that children aged 6–7 have greater difficulty sustaining attention for long periods than other groups. As with the previous three tasks, this finding is likely related to developmental differences in attentional capacity. Year 1 corresponds to an age group in which selective attention has not yet fully matured (Colombo, 2001; Harlen & Symington, 1985; Jones et al., 2003; Mahone & Schneider, 2012; Malegiannaki & Metallidou, 2017), and owing to this developmental characteristic, they may have experienced difficulty selectively concentrating attention on the crumpled-paper stimulus.

The findings of this study suggest that curriculum design should take into account both the developmental level of learners and the hierarchical structure of inquiry skills. In particular, because science subject activities are not conducted in Years 1 and 2 in Korea, it is necessary, when writing science textbooks for Year 3 or planning inquiry activities, to structure inquiry activities in accordance with the hierarchy of inquiry activities. When learning activities are designed to match learners' developmental level, they are more likely to be effective and to support the growth of inquiry skills.

Conclusions and Implications

This study compared visual attention during science observation tasks across students in Years 1, 2, and 3 and adults, with the aim of establishing where lower-grade primary school students stand in relation to other age groups on the observation hierarchy.



First, lower-grade primary school students showed lower observation ability than Year 3 students or adults, as measured through visual attention indices. In particular, according to the hierarchy of observation presented in SAPA II, Year 1 students were found to have lower observation ability than the other groups. These findings suggest that future research should examine the qualitative characteristics of observation, and that these characteristics should be considered when designing observation-related learning activities.

Second, the observation abilities of students in Years 1, 2, and 3 were broadly in line with age-related expectations. Students in Years 2 and 3 performed at levels close to those of the adult group on most tasks, while Year 1 students differed consistently from the other groups across all four tasks. This pattern suggests that the transition from Year 1 to Year 2 marks a meaningful point in the development of visual attention during observation. The finding that Year 2 students already perform similarly to adults has a practical implication: structured science observation activities are likely to be developmentally appropriate from Year 2, even in a curriculum context where formal science instruction begins later.

Third, when a stimulus moved visibly and continuously, all age groups directed their gaze toward it in comparable ways. However, where tasks required students to locate or attend to a specific target, clear differences emerged, with Year 1 students spending less time on the relevant area. The attentional difficulty Year 1 students show during observation is therefore not general. It becomes apparent when the task requires them to decide where to look rather than simply react to what is moving. Consequently, observation activities for younger students are likely to be more effective when the target of observation is made visually distinct and when the teacher provides clear direction about what to attend to.

By providing empirical data on the observational characteristics of lower-grade primary school students in Korea, this study contributes to a better understanding of how younger students approach science observation tasks. First, through the analysis of the visual attention of lower-grade primary school students, especially Year 1 students, it was confirmed that this period may be a critical stage in which the foundations of observation ability are formed, and this provides empirical support for the need for systematic observation education in the lower grades. Therefore, the differences in gaze-movement patterns by school year shown in this study can provide concrete grounds for designing observation tasks and teaching-learning strategies appropriate to students' developmental levels. Second, by using the eye-tracking method, this study presented empirical evidence that visual attention in observation activities appears differently according to age. In this respect, it has methodological significance in suggesting the possibility and necessity of gaze-movement analysis in observation research. Third, by situating the developmental assessment of visual attention within the specific framework of SAPA's hierarchy of observation skills, and by addressing the unique curriculum context in which formal science instruction is absent in Years 1 and 2 in Korea, this study provides direct empirical evidence relevant to curriculum design and science textbook development for the lower grades.

Limitations

Several limitations of this study should be considered when interpreting the findings. First, participants were drawn from a single elementary school in one metropolitan city in Korea, which limits the generalizability of the findings to other regions and school contexts. Future research should seek to replicate these findings with samples from diverse geographical regions and socioeconomic backgrounds. Second, university-aged adults served as a developmental reference baseline for mature visual attention rather than as domain experts; future research may benefit from including science teachers or older primary students as additional comparison groups to examine domain-specific observational expertise.

Declaration of Interests

The author(s) declared no conflicts of interests.

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