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TEACHER'S GAZE BLIND SPOT IN SCIENCE LECTURE CLASS

Jung-Ho Byeon,
Yong-Ju Kwon

Abstract. *The teacher's gaze attention can trigger interaction with the student. So if the teacher fails to equal attention during class, students may be alienated from the interaction. According to this perspective, this study aimed to establish the pattern of the teacher's gaze during science lecture classes and whether the change of the gaze when the student's seat as an external factor changed. Eye tracking was conducted on six teachers during class, and the teacher's gaze fixation and movement were also analyzed after changing the student seat. According to the results, teachers mainly focused on the center of student seats, and the gaze blind spot was mainly biased forward. Even if the student's seat was changed, the gaze was focused on the center of the classroom, and the gaze blind spot differs within the individual, and the teacher tends to be unaware of it himself. Consequently, the teacher's gaze concentration pattern is generally similar, but the gaze blind spot varies depending on the teacher and can be affected by external factors. Therefore, it is necessary to develop a system and retrain program for diagnosis and feedback of teachers' attention to provide proper and high-quality education to students.*

Keywords: *science class; science teacher; blind spot; eye tracking; gaze attention; teaching behavior*

Jung-Ho Byeon
BukPyeong Girls' High School & Korea National University of Education, South Korea
Yong-Ju Kwon
Korea National University of Education, South Korea

Introduction

In a life that requires social interaction, human beings constantly perform interactions called social communication with others and respond appropriately by analyzing and processing external information or signals. The fact that humans can perceive and deal with numerous pieces of information through the eyes among various sensory organs means social interaction with others is very important for survival. Humans continuously deal with external information through intentional and unintentional attention at every moment, and their attention could increase when they give an interested or detailed observation of an object or event. In particular, eye contact and watching face is a powerful visual cue to build social connections between communicating persons and affects various cognitive processes of communication (Madipakkam et al., 2015; Schilbach, 2015). In addition, looking at the other person is a primary behavior to send intention for communication because it is an essential means of non-verbal communication and also affects verbal communication (Jiang et al., 2017).

The teacher should confront a heavy load for external information processing during class, and they must continuously interact with many students as long as the class. From a pedagogical perspective, social interaction between teachers and students should emphasize for efficient learning, and teachers need to provide interaction and attention evenly to a large number of students. Actually, can teachers pay equal attention to students in actual classroom situations?

Attention

Visual attention and cognitive processing of information occur almost simultaneously, and measurement results of attention provide information about the subject's intentions and objectives in a specific situation (Beach & McConnel, 2019; Tatler & Land, 2015). In particular, human attention takes place by the interaction between endogenous and exogenous attention factors, and exogenous attention could be induced by signals or information encouraging visual attention to be continuously interpreted by following gaze and repeatedly affect (Tatlet & Land, 2015; Veneri et al., 2012). According to the theory of mind, humans respond more efficiently in processing the other person's facial information than detectible other information. Humans have

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a cognitive tendency called social attention to predict and recognize the other person's feelings or thoughts by interpreting various information such as the gaze and facial expressions of others. Social attention is a tendency and interpretative process to focus one's gaze on the eyes of others to understand their cognitive and emotional state (Emery, 2000; Jiang et al., 2017; Senju & Johnson, 2009).

The teacher's attention-related teaching behavior in class can explain in the context of social attention. Social attention can be explained through developmental psychological elements such as mutual gaze, following gaze, joint attention, shared attention, and theory of mind (Emery, 2000; Jiang et al., 2017; Senju & Johnson, 2009). In social attention, eye contact results from an interaction between teacher and student caused by the teacher's attention toward the student as instruction behavior (Emery, 2000; Jiang et al., 2017; Senju & Johnson, 2009). The cognitive psychological process from eye contact to the theory of mind is to infer the psychological state of the other person by judging extrinsic response signals such as facial expressions and reactions when eye contact between students and teachers occurs.

Teaching Competency and Attention

Teachers' teaching skill in class is a factor of the teachers' professional competency, which individually controls the learning of students participating in the class and is essential in student development (Baumenrt & Kunter, 2013). In general, the teacher professionally expresses the quality of teaching in class, and it can be divided into the efficiency of class management, supportive class atmosphere, and cognitive encouragement (Kliem et al., 2009; Pianta & Hamre, 2009). Positive interactions between teachers and students are the main component of a supportive atmosphere and are known to be related to the development of student's intrinsic motivation and interest from the perspective of sociocultural constructivism (Fauth et al., 2019; Kunter et al., 2013; Lazarides et al., 2018).

Teachers' professional competence can reveal through teaching behavior and teacher-student interaction, and it can mediate by teachers' interactive behavior during class (Mahler et al., 2017). According to a recent study, the interaction between teacher and student during class affects student interest and satisfaction with their learning (Fauth et al., 2019). Because teachers decide which information and signals to pay attention to, the learner's participation is determined by the teacher's behavior and response during class (Wolff et al., 2016). Therefore, during class, teachers should constantly find clues in students' behavior about their participation and whether they focus on learning (Goldberg et al., 2021). Teachers' professional competence is an essential functions instruction factor in all subject classes. Particularly science teachers should ask for not only concept learning but also the additional operation of scientific inquiry that includes experimental activity (Furtak et al., 2012). However, conducting scientific inquiry in class requires teachers to have high science literacy and challenging performance. For this reason, teachers generally practice lecture-style teaching focused on concept learning more than inquiry learning. Teachers' teaching style is mainly lecture type due to a lack of experience or confidence in professional knowledge for inquiry learning (Brobst et al., 2017; Johnston & Ahtee, 2006).

The social interaction between teachers and students, including the professional competency of the teacher, should be set as the main factor of their class to provide students with meaningful learning in a science lecture class. The relationship between teacher and student can connect through teaching behavior and learning behavior at every moment in a class, and it can be represented through social attention by gaze fixation (Pennings et al., 2018). From this perspective, measuring teachers' teaching behavior during class is necessary to analyze teachers' eye movements, class interactions, and students' satisfaction with teachers' professional development and feedback (Cortina et al., 2015). It could measure the difference in attention tendency as each teacher by eye tracking, and it could suitably analyze teachers' interactive attention during class (King et al., 2019; Wolff et al., 2016).

Eye-tracking

In the context of cognition, eye tracking can provide quantitative data on the cognitive process that regulates human behavior so that it can provide objective information about teachers' visual perception and attention during class (Shayan et al., 2017). Because instruction is composed through complex interactions between teachers and students in real-time, studies on the attention of teachers have mainly focused on specific activities such as language reading, math problem-solving, and multimedia instruction (Haataja et al., 2019; Hunt et al., 2015; Norqvist et al., 2019; Rayner 2009). Some studies present analysis results on attention focused in class according to the teacher's career (van den Bogert et al., 2014; McIntyre et al., 2017; Wolff et al., 2016).

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The distribution of teacher's gazes to students is uneven because teachers communicate through gaze, and social interactions during class repeatedly affect teacher's visual attention (van den Bogert et al., 2014; Dessus et al., 2016; McIntyre et al., 2017; Prieto et al., 2017). In addition, experienced teachers mainly use top-down perceptual mechanisms, and there is an attention tendency to enhance students' learning by consciously focusing on information relevant to the lesson (Wolff et al., 2016). Therefore, the result of measurement on social interaction between students and teachers can be able to use quantitative data for comparison of individual differences by the analysis of where the teacher focuses his attention during class. Not only does the analysis result of where the gaze is direct but also the fixation time of the gaze reflects the teacher's cognitive process during class. In related studies, professional teachers pay attention to students for a long time compared to less experienced teachers, and a short fixation time on students means that their eyes move to other objects rather than interaction or their attention is dispersed (van der Boget et al., 2014; Mclyntyre et al., 2017). On the other hand, the increased complexity and student number make it more difficult for teachers to manage classes and cause relatively short fixation times for students (Prieto et al., 2017).

The visual attention of the teacher can be measured using the number of times the gaze fixation, the duration of the gaze fixation, and the consistency of the pattern during the learning process, which can be used as an efficient scale to explain the cognitive process (Haataja et al., 2019; Hunt et al., 2015). Gaze fixation provides information about what the teacher is paying attention to during the class, and the consistency pattern shows the teacher's tendency to focus on methods. Teachers encourage students' learning participation by communicating through eye contact and inducing learning-related behaviors during class (Dessus et al., 2016; Korthagen et al., 2014). Therefore, in this study, we will investigate the teacher's gaze concentration and consistency during class to understand what the teacher's gaze focuses on and is distributed during science class.

Research Hypotheses

Research on teachers' visual attention during classes mainly investigates the differences in attention patterns between expert and novice teachers (Dougusoy-Taylan & Cagiltay, 2014; Korthagen et al., 2014). However, in many research, the number of teachers who participated in eye-tracking is limited to 1 to 4, so it tends to perform quantitative analysis to complement the difficulty of generalization the findings (Dagiené et al., 2021). The measurement data of teachers' attention during class enables quantitative analysis of teaching behavior because it can provide microscopic and sequential information on interactive teaching behavior (Magnussen et al., 2017). Therefore, two hypotheses were set to investigate the teacher's attention pattern and the student's perception of the class in an actual science lecture class situation. In general, science inquiry learning requires behavioral interactions such as student individual activity guidance, experiment performance assistance, and feedback. However, in science lecture classes where behavioral interactions are minimized, the primary interaction method between teachers and students may be limited to visual attention and speaking.

For this reason, teachers should focus on students as evenly as possible by using their professional class management capabilities during class. However, humans have individually non-intentional endogenous attention tendencies and intentional exogenous attention strategies (Fernández et al., 2021; Ogmen et al., 2016). Therefore, if the intervention of unintentional endogenous attention mainly affects to teacher's attention, the teacher could be challenged to pay attention to all students evenly during class. On the other hand, if the intentional attention strategy is mainly a teaching behavior, they can pay attention equally to all students. Therefore, researchers established the first hypothesis to confirm as follows.

Hypothesis I: There are differences in teachers' gaze attention to students in science lecture classes.

Exogenous attention is a response triggered by a signal or cue that arouses attention and corresponds to an intentional action to acquire information (Goldberg et al., 2021). Teachers process and respond to various information and signals discovered from students in instruction situations in class. The generated reactions immediately act as a feedback factor that induces attention and can affect the teacher's attention. In this context, students with higher levels of academic achievement perform more actively in class than students who do not, and students with high-level confidence in their abilities participate in more discussions (Böheim et al., 2020; Goldberg et al., 2021). In general, one of the student factors that induce a teacher's attention is the existence of students with excellent academic ability or students who attract attention, whether positive or negative (Stahnke & Blömeke, 2021). If

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the presence or absence of a specific student corresponding to the extrinsic attention factor affects the teacher's attention pattern, the teacher's attention will lateralize depending on where the student is present. Conversely, if whether or not an outstanding student does not affect the teacher's attention pattern, the teacher's attention will appear constant regardless of the presence or absence of an interested student. Therefore, researchers established the second hypothesis to confirm as follows.

Hypothesis II: The presence or absence of students who arouse gaze attention affects the attention pattern of teachers.

Research Methodology

General Background

Intrinsic tendencies and external stimuli induce the human gaze, and the relationship between teachers and students is formed by interactive processes that occur every moment in class (Pennings et al., 2018; Tatler & Land, 2015). In addition, social interaction with students in class affects teachers' gaze attention, and individual teachers' teaching behavior could differ depending on relationship orientation (Dessus et al., 2016; McIntyre et al., 2017; Prieto et al., 2017). This study set up two hypotheses to clarify the effect of endogenous and exogenous variables on teachers' gaze attention distribution as teaching behavior. Mainly, it is necessary to control the student variable and investigate only the characteristics caused by the teacher variable to clarify the relationship between the teacher's gaze distribution and teaching behavior in science lecture classes. For this condition, analyzing the teacher-specific gaze concentration areas and gaze distribution tendencies measured several times when different science teachers teach in the same classroom with the same students is essential. While most schools and teachers do not agree to continue recording classes with an eye tracker, six science teachers working at school A in South Korea participated in this study. The researcher received the school's official permission and the voluntary research participation of 6 teachers and 63 students. Therefore, two classes in that school were recruited as teaching places to investigate teachers' gaze attention.

Participants

All six science teachers graduated from a university providing preservice teacher training courses in Korea and possessed teacher licenses certified by the state (Table 1). All participants underwent a gaze test and had uncorrected visual acuity of 1.0 or better or corrected visual acuity of 1.0 or better. This study was conducted in compliance with the declaration of Helsinki and followed a protocol approved by the Ethics Committee of KNUE, and all participants gave their written informed consent. All participants had normal or corrected to normal visual acuity but had no history of psychiatric disorder and Strabismus. Also, participants made sure of right-handedness according to the Edinburgh handedness inventory.

Table 1
Participants

Class(N)	Teacher	Major of university	Age	Education career
A (30)	A1	Physics education	34	5 years
	A2	Chemical education	27	0.5 years
	A3	Biology education	30	2 years
B (33)	B4	Chemical education	29	3 years
	B5	Earth science education	57	30 years
	B6	Biology education	36	10 years

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The students were divided into A and B groups through their teaching class name and school curriculum to maintain regular learning courses in school. The eye tracking was performed on six high school science teachers to investigate the teacher's attention and movement patterns during science class. The eye movement data were acquired by mobile eye tracker during each science class and analyzed gaze fixation and movement on all AOIs. The AOI set for three higher AOIs and the thirteen sub-AOIs (nine student areas, three teaching and learning material areas, and a non-teaching area) to investigate whether or not the blind spots in science lectures.

Teachers wore the eye tracker until they felt no discomfort from wearing the eye tracker during class. Teachers who participated in this study could intentionally adjust gaze distribution due to the self-recognition that they are tracking eye movement, and students can also show unusual interactions by expressing curiosity and interest in teachers wearing eye trackers. A double-blind test was conducted on all teachers and students to offset this interference and test the first hypothesis. In two classrooms, three teachers each wore eye trackers in the same classroom and conducted several lessons, and both teachers and students answered that the eye trackers caused no curiosity effect or discomfort, and then the eye tracking data was used for analysis. The researcher randomly changed the student seat to verify the second hypothesis between the class used by measuring the actual gaze tracking data and the next class and measurement. The teacher was unaware of the unexpected change of student seats in advance, and the students' positions in the student area divided into nine were randomly adjusted by researchers so that they did not match before and after the seat change. The second gaze data collection was conducted during the next class without the teacher's prior recognition of how the student's position changed for the blind test.

Eye-tracking

The eye movements of subjects were recorded using a goggle-type eye tracker (ViewPoint Eye Tracker®, Arrinton Research, Inc.) to collect the teacher's attention data during class. The eye tracker consists of a head camera (56°, horizontal FOV) that captures the scene where the subject is looking and an infrared camera that records the position of the pupil and cornea. The head position was monitored through the display screen of the tracker body and checked whether or not is tracking the pupil. In addition, the spatial resolution of the eye tracker is 0.15 °, the tracking signal generation unit is 60 Hz, and the accuracy is 0.25 ° - 1.0 °. According to the dominant eye test, the eye-mount camera position changed before the eye movement data collection. The foveal coordination was obtained through pupil tracking by infrared projection extracted in two-dimensional plane coordinates. A calibration to compensate for eye torsion was performed every time before recording each subject. The calibration was performed according to nine points while the teachers' heads stabilized to eliminate measurement errors by position distortion that could occur driven by individual eye differences. After eye tracking, all participants reported their actual thinking of each task through an in-depth interview.

Data Analysis

The data analysis was performed through the Viewpoint program, and the area of interest (AOI) was set up and defined for analyzing fixation and saccade. The areas of interest for eye movement analysis were set as student area, teaching and learning material area, and non-teaching area. The student area is where students are sitting from the teacher's point of view, and the teaching and learning material area means the teacher's focus on teaching activities, such as textbooks, TV monitors connected to computers, and blackboards. Also, the areas unrelated to teaching and learning, such as walls and windows, were divided into non-teaching areas, and gaze movements were analyzed. After the definition of AOI, post-process was performed on individual eye movement data to extract data such as frequency of attention, gaze movement, and gaze path. The gaze fixation threshold was set at 200 ms to conduct the analysis and to minimize intentional attention to the AOI.

The coordinate matrix is constructed based on the scene template, and the two-dimensional coordinate is calculated from gaze data extracted eye camera using MatLab R2016b (9.1). After data computation, gaze data synchronized to the scene template. According to the purpose of this study, in the next step, gaze fixation was defined as the amount of continuous time (200 milliseconds) spent looking within an AOI. The total time spent fixation of the main task was calculated as the sum of fixations within each AOIs. The total number of gaze fixations for each AOI is defined as the total number of gaze fixations, and the gaze fixation ratio was calculated by calculating the number of gaze fixations of lower AOIs for all AOIs. Fixation ratio means fixed gaze number rate of total gaze

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fixation number within AOI. The time-series information of moving to another AOI after fixing the gaze on an AOI was extracted and used for cross-analysis on the gaze path. In addition, gaze movement analysis utilized data extracted from the degree of gaze movement to another AOI immediately after gaze fixation on one AOI for 200 ms.

The teacher's gaze movement pattern was confirmed within the student area to analyze what strategies implied in the teacher's teaching behavior that distributes attention during class. After gaze fixation and movement occurred in one of the nine student areas was divided into four attention types 'induced attention by behavior,' 'exploratory attention for knowledge,' 'exploratory attention for interaction,' and 'social attention for interaction,' depending on where the subsequent eye fixation occurs. Induced attention by behavior is a case where the subsequent gaze fixation moves to the non-teaching area immediately after the gaze fixation occurs in the teaching and learning material or the student area. It occurs when the teacher moves, or the attention is unrelated to teaching and learning. Exploratory attention for knowledge was determined as a movement to the teaching and learning material area after gaze fixation occurs in the non-teaching or student areas, and continuous gaze fixation occurs in the same area within the teaching and learning material area. Exploratory attention for interaction determined to move to a different student area from the first one after gaze fixation occurred in one of the student areas. Social attention for interaction means subsequent fixation in the same place after gaze fixation occurred in the student area. The analysis of gaze movement and attention interpreted how the teacher's teaching behavior strategy changed by comparing changes before and after replacing students' seats. Since the number of gaze fixations obtained from 12 times gaze trace from 6 people differed, it needs to relative rate value for teacher comparison. The relative ratio was calculated as a percentage based on the total number of gaze fixations shown in individual measurements.

Research Results

Verification of Hypothesis I

Researchers used eye trackers to collect eye movement data from 6 science teachers in two classes. Eye tracking was performed during a science lecture class to analyze differences in attention distribution as teaching behavior for social communication with students. In addition, after eye-tracking measurement, the difference between the attention distribution pattern shown in the eye-tracking result and the attention pattern recognized by the individual teachers was compared using the survey response results on their teaching and learning behavior tendencies individual teachers thought (Table 2).

Table 2
Gaze Fixation Rate of Teachers on AOIs during Lecture Class

Teacher	Student area %	Teaching and learning area %	Non-teaching area %
A1	39.59	56.97	3.44
A2	28.24	36.61	35.16
A3	49.68	36.94	13.38
B4	40.12	53.09	6.79
B5	43.04	47.17	9.78
B6	42.36	48.00	9.65

In the case of class A, some teachers paid more attention to the comparison area, others paid more attention to the student area, and the rest of the teachers paid the most attention to the teaching and learning material area. In the case of class B, most of the teachers' eyes were mainly distributed in the teaching and learning material area,

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but much attention was also happening in the student area. Therefore, it can be seen that there are individual differences in the distribution of eyes in the student area, teaching and learning material area, and non-teaching area. In addition, it was confirmed that there is a tendency for more attention to be paid to the teaching and learning material area than the student area. Table 3 shows the results of dividing the student area into three horizontal and vertical sections from the teacher's point of view to confirm the tendency of attention to the student area.

Table 3
Average Rate of Gaze Fixation of Teachers on Student Area

Teacher	LF %	LC %	LR %	CF %	CC %	CR %	RF %	RC %	RR %
A1	0.65^{m}	2.65	3.81	2.01	10.45^{M}	9.64	1.61	4.04	4.73
A2	1.93	2.15	2.53	6.22	6.23^{M}	3.21	0.86^{m}	2.80	2.30
A3	1.61	1.52	6.45	2.67	14.52^{M}	9.89	1.27^{m}	7.04	4.71
B4	1.78	3.24	2.65	3.89	8.28	10.55^{M}	1.41^{m}	3.93	4.40
B5	1.37^{m}	2.93	3.17	8.06	15.23^{M}	3.69	2.25	3.90	2.45
B6	2.05	2.85	1.49^{m}	9.63	10.15^{M}	4.33	4.82	4.74	2.30

Note. The gaze fixation ratio of nine AOIs on the student area was calculated, and areas with maximum and minimum values were indicated within the student area (LF: Left-Front, LC: Left-Center, LR: Left-Rear, CF: Center-Front, CC: Center-Center, CR: Center-Rear, RF: Right-Front, RC: Right-Center, and RR: Right-Rear).
^{M} Maximum value of average fixation rate on student area.
^{m} Minimum value of average fixation rate on student area.

On a horizontal basis, the teacher's gaze on the left, center, and right student areas mainly focused on the center. On the other hand, on a vertical basis, there were individual differences among teachers and differences according to the number of measurements for the front, center, and rear areas. These results mean that teachers' gazes during class have similar tendencies regarding horizontal lines, and differences may exist depending on individual classes regarding vertical lines. Since the human gaze moves around the linkage point when focusing on an object (Gesierich et al., 2008), the most attention can appear in the center based on the horizontal line. On the other hand, the differences in the vertical line standard can be attributed to differences in the internal disposition of individual teachers or differences in external signals by class.

After completing the gaze tracking, it compared to the self-report and gaze tracking results where they did not usually focus their attention during science classes. Six teachers answered that the eyes were relatively not focused on the left side based on the horizontal line and were relatively not distributed to the front for A1, A2, and B6 teachers and A3, B4, and B5 teachers. In this study, the area of interest where the teacher's attention is relatively low during class will call as the term 'blind spot.' Comparing the blind spots identified through eye tracking and the blind spots presented by the teacher through the survey, the other five, except teacher A, did not match the actual eye concentration results and self-report results (Table 4). This result means that in terms of teaching and learning, gaze control, which is purposeful behavior, may not be accurately recognized by the teacher. In other words, the teacher may not accurately remember how achieved the adjustment of gaze concentration is related to social interaction during class. Therefore, since it is challenging to self-discover the bias of gaze control that appeared in the class, it is necessary to receive professional measurement and feedback to discover and improve the problem of teaching behavior.

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Table 4
Result of Gaze Tracking and Survey about Blind Spots on Student Area

Teacher	Blind spot of horizontal standard			Blind spot of vertical standard		
	Gaze tracking	Survey	Match	Gaze tracking	Survey	Match
A1	Left	Left	○	Front	Front	○
A2	Right	Left	×	Rear	Front	×
A3	Left	Left	○	Front	Rear	×
B4	Left	Left	○	Front	Rear	×
B5	Left	Left	○	Rear	Rear	○
B6	Left	Left	○	Rear	Front	×

Note. ○ = match between gaze tracking and survey , × = mismatch between gaze tracking and survey.

The above results showed individual differences and general tendency in the opening of the teacher's attention pattern on the student area during the lecture class presented in the first hypothesis. In addition, it was confirmed that blind spots that occur in the actual focus of attention and blind spots that teachers perceive themselves might be different. Therefore, professional consulting and feedback from a teaching behavior perspective would need rather than self-diagnosis to strengthen the interaction between student and teacher.

Verification of Hypothesis II

The second hypothesis was verified by checking whether there was a change in the gaze concentration pattern before and after changing the seat where students were sitting. If a teacher focuses relatively more attention on students with outstanding academic achievement or response, the pattern of attention before and after the change of student seat will be different because the external attention signal strongly affects them. On the contrary, if the gaze concentration before and after the change of seat is the same or similar, the internal attention tendency is stronger than the external attention signal provided to the teacher. Table 5 shows the minimum and maximum gaze rate of the nine student areas in the total gaze concentration of the class before and after replacing the student position.

Table 5
Gaze Fixation Rate of Teachers within Student Area

Teacher	Time	LF %	LC %	LR %	CF %	CC %	CR %	RF %	RC %	RR %
A1	Pre	2.05m	7.42	7.48	4.89	19.32	28.88 M	5.28	13.78	10.91
	Post	1.05m	5.65	12.71	5.37	36.61M	17.83	2.32	5.02	13.44
A2	Pre	8.99	7.54	6.62	24.88M	17.98	13.68	2.05m	9.95	8.31
	Post	4.53	7.70	11.53	18.93	26.53M	8.82	4.10m	9.91	7.96
A3	Pre	5.02	2.88	3.23	6.16	50.12M	15.49	1.94m	10.18	4.99
	Post	1.20m	3.28	24.16	4.48	5.29	24.97 M	3.28	18.73	14.61
B4	Pre	6.71	8.71	4.86	7.07	19.62	28.70 M	3.72m	10.40	10.21
	Post	2.34m	7.48	8.22	12.09	21.56	24.07 M	3.34	9.23	11.68

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Teacher	Time	LF %	LC %	LR %	CF %	CC %	CR %	RF %	RC %	RR %
B5	Pre	4.89	2.72	6.29	20.38	41.83M	3.80	1.68m	11.30	7.10
	Post	01.53m	10.76	8.42	17.10	29.10M	13.22	8.68	6.88	4.31
B6	Pre	08.03	12.47	6.41	9.41	26.39M	17.55	3.35m	9.18	7.22
	Post	01.63	0.90	0.60 m	36.22M	21.52	2.83	19.49	13.20	3.62

Note. The gaze fixation ratio of nine AOIs on the student area was calculated, and areas with maximum and minimum values were indicated within the student area (LF: Left-Front, LC: Left-Center, LR: Left-Rear, CF: Center-Front, CC: Center-Center, CR: Center-Rear, RF: Right-Front, RC: Right-Center, and RR: Right-Rear).
[M] Maximum value of average fixation rate on student area.
[m] Minimum value of average fixation rate on student area.

In teachers A1, A2, A3, and B6, the highest attention area slightly changed before and after the seat change of students, but there was a tendency to focus on the center based on the horizontal line. Teachers B4 and B5 focused the most on the same area before and after the change of student seats and focused on the center based on the horizontal line. On the other hand, there were differences between individuals and classes in the concentration of attention based on the vertical line within the center area.

As a result of confirming the blind spot within the student area, teacher A1 had the lowest fixation ratio in the LF area, and A2 had the lowest value in the RF area. Teachers A3, B4, and B5 showed the lowest gaze fixation on the LF and RF area, but teacher B6 was the lowest value on the LR and RF area. Since teachers A1 and A2 had the lowest fixation rate in the same area in all classes, they seemed to be affected by the intrinsic factor of the teacher having a significant influence on the formation of blind spots rather than the influence of external signals. On the other hand, Teacher A3, B4, and B5 are partially affected by changes in external factors but tend to be biased toward the front area. However, teacher B6 seems to have a pattern of attention distribution dependent on changes in external factors like the change of student seat. This result is because there is an individual difference in the tendency of gaze concentration to form blind spots in a specific area based on the horizontal or vertical axis. However, most areas with relatively large gaze distribution were the center areas, with no significant individual difference. Therefore, an individual's tendency to concentrate may differ between internal and external factors. In addition, the blind spot for the location of the student area from the teacher's point of view is mainly formed on the left and right sides compared to the center based on the horizontal line. Therefore, during class, the blind spot of the horizontal standard is formed on the left or right side due to the influence of internal and external factors and mainly provides relatively more attention to the center of the classroom.

It was confirmed whether the individual patterns of where the teachers who participated in the study focused their attention during the class and in what order they focused their attention were consistent and similar. Cross-analysis was conducted by extracting time series data on where attention was sequentially focused before and after student position replacement from the teacher's attention data obtained during science lecture classes. As a result of performing the chi-square test on the gaze path for each teacher before and after the student seat replacement, a significant difference was not found in most teachers but found in one teacher (Table 6).

Teacher A1 ($\chi^2 = 149.923$, $df = 132$, $p = .136$), A3 ($\chi^2 = 106.318$, $df = 132$, $p = .951$), B4 ($\chi^2 = 131.411$, $df = 121$, $p = .244$), B5 ($\chi^2 = 137.191$, $df = 120$, $p = .135$) and B6 ($\chi^2 = 151.723$, $df = 132$, $p = .115$), no statistical difference was found in the gaze path before and after the student seat change, but teacher A2 ($\chi^2 = 155.986$, $df = 121$, $p = .018$) showed differences at a statistically significant level. In other words, five teachers have no difference in gaze path, but there is a difference in 1teacher. These results mean that most teachers have a similarity and a specific regular pattern in the order of gaze distribution in classes. Therefore, to confirm the attention strategy implied in the gaze distribution as a teaching action, four types of gaze movement patterns were classified by analyzing the case where the gaze continuously moved from one specific area of interest to another. The movement of attention to the non-teaching area due to the teacher's behavior or head movement was defined as induced attention by behavior. The gaze movement at the teaching and learning material area or stayed continuously was defined as exploration attention for knowledge. Also, when the gaze moves from one AOI to another within the student area, it is defined as exploratory attention for interaction, and continuous attention in the same area within the student area is defined as social attention for interaction.

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Teachers A1, B4, B5, and B6 showed the most exploratory attention for knowledge occurred, and social attention for interaction was the second significant gaze movement. However, the second rank in B5 differed in the pre-post measurement, but both were related to the interaction. In the case of teacher A2, induced attention by behavior and exploratory attention for knowledge were crossed in the first and second places in each class. Except for A2, five teachers mainly showed exploratory attention for knowledge and social attention for interaction in all classes (Table 6). Therefore, it could interpret that a specific knowledge transfer-oriented lecture class is being conducted, with the majority of attention related to teaching and learning materials to check the contents of science knowledge and present them to students. In addition, researchers found that the teacher constantly monitors whether the contents are delivered according to the goal by implementing interactive attention to check whether the students understand the science contents during the knowledge delivery lecture.

On the other hand, in the case of A2 teachers, there was a different type of attention pattern from other teachers, but the teacher had less than one year of experience in classroom instruction than other teachers. In particular, as a beginner teacher, it shows a distracting type of attention that shows a relatively large amount of close attention caused by other behaviors in class compared to interactive activities.

Table 6

Attention Type of Science Teachers during Science Lecture Class

Teacher	Time	IAB %	EAK %	EAI %	SAI %
A1	Pre	5.09	48.11	19.22	27.57
	Post	1.78	65.84	12.96	19.42
A2	Pre	39.41	31.17	10.57	18.85
	Post	30.89	42.05	10.58	16.47
A3	Pre	15.48	31.46	16.12	36.94
	Post	11.28	42.44	12.76	33.53
B4	Pre	3.24	58.32	15.43	23.01
	Post	10.35	47.86	17.10	24.70
B5	Pre	16.08	41.94	36.53	5.45
	Post	3.76	52.59	12.83	30.82
B6	Pre	11.22	46.19	11.49	31.10
	Post	8.07	49.82	14.90	27.21

Note. IAB: induced attention by behavior, EAK: exploratory attention for knowledge, EAI: exploratory attention for interaction, SAI: social attention for interaction.

From the teacher's point of view, the distribution of attention to students was concentrated in the center based on the horizontal line, and the attention area before and after differed by individual and class in vertical standard. In addition, except for one case, 11 blind spots focused on gaze were also found to be biased in the front area. In other words, the teacher's attention during class was mainly at the center position, and the blind spot was mainly at the front. Therefore, it can be said that the individual difference in the location of the blind spot on the horizontal line or the concentration area on the vertical line can partially affect the distribution of attention by exogenous factors related to some student or class. In addition, there was no statistical difference in the analysis of the gaze path before and after the student seat replacement, and the gaze movement pattern was consistent with the other experienced teachers except for the case of one novice teacher. Therefore, the teacher's focus area during science lecture classes does not change much even if the student's seat changes, but the concentration and blindness based on the horizontal line can be affected.

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Discussion

Development for students in the educational context is possible when realizing universal primary and secondary education, so it is necessary to ensure that all students receive equal and quality education effectively in classroom instruction. Quality education requires various goals and measures, and the development and support of teachers' professional teaching competencies are particularly essential topics. Providing an adequate diagnosis and feedback system for appropriate education and professional development for teachers can positively affect teachers who significantly influence students' learning outcomes (Fauth et al., 2019; Kleickman et al., 2016; Lazarides et al., 2018). In this context, gaze distribution related to interaction skills with students during class is a professional competency held by teachers, and appropriate diagnosis and feedback are essential for effective student learning outcomes. However, the focus and distribution of teachers' attention during actual classes are challenging to diagnose and provide feedback, and there are few opportunities for professional advice or education.

Eye contact, the starting point of social attention, triggers teacher and student interaction and corresponds to teaching behavior essential to all classes, including lecture-style and activity-oriented classes (Goldberg et al., 2021; Pennings et al., 2018). For accurate diagnosis and feedback for teachers, measurement results suitable for individuals should be provided based on quantitative data, so this study challenged using a gaze tracking method. Some case studies have been presented on how teachers' gaze in class, known as common sense, takes place in the actual class, but most studies focus on what context novice and expert teachers concentrate on while watching class videos (van den Bogert et al., 2014; McIntyre et al., 2017; Wolff et al., 2016). In this study, we analyzed the concentration and movement of teachers in the process of actual classes for students and whether the teacher's gaze distribution pattern changed before and after students changed their seats in the same class.

We investigated the attentional patterns of teachers during science lecture classes, where linguistic expressions play a leading role in contrast to active learning activities such as inquiry-based learning. The result of gaze concentration analysis revealed individual differences or group-level general tendencies within the gaze data into student, teaching and learning material, and non-teaching areas. These differences could be related to variations in the degree of reliance on teaching and learning materials among teachers during the class. In particular, most teachers showed high levels of gaze concentration on the teaching and learning material area, which can be explained by the characteristic of lecture classes that continuously confirm and review scientific concepts conveyed to students (Leuchter et al., 2014). Creating a positive atmosphere and maintaining cognitive activity is essential for teachers conducting classes as part of their teaching abilities (Fauth et al., 2014). Therefore, teachers make continuous efforts to monitor their students and verify the content of the course during class. As a result, teachers would generally focus more on teaching and learning materials and students during the class.

On the other hand, the level of gaze concentration in the student area showed significant individual differences along with a general tendency. Humans do not jump instantly to a distant object when switching their gaze from one object to another. Instead, there is a tendency to focus on the existing object during the gaze shift and use it as an intermediate point to shift attention to the next object (Gesierich et al., 2008). Therefore, regardless of whether teachers move their gaze to the left or right of the vertical line, they tend to focus on the students in the center as the midpoint. In contrast, individual teacher differences were evident for the front, middle, and rear positions based on the vertical line. Moreover, vertical line-based differences were observed differently depending on the class, even for the same teacher. The correlation analysis was performed to determine whether these differences were related to age or educational experience, but statistical significance with age or educational experience was not identified.

In conclusion, the concentration of gaze on a particular student area during class is mainly due to humans' endogenous attentional bias towards the center. On the other hand, blind spots in gaze are more dependent on individual differences and mainly affected by changes in student seating, especially along the vertical axis. Therefore, when conducting science lecture classes, the position where teachers and students can interact most frequently through social attention is in the center of the classroom, and front seats on both sides are likely to be excluded from interaction with teachers. Furthermore, while most teachers know where their gaze is primarily focused along the horizontal axis, only a few properly recognize their focus along the vertical axis.

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Conclusions and Implications

To achieve equal and high-quality education and assistance for students in the field of education through classroom instruction, teachers have to possess teaching and learning competencies that allow for personalized interaction with students and management of the classroom. However, this research reveals variations in teachers' gaze distribution tendency during science lecture classes, despite the general similarity of teachers. Teachers' gaze concentration was mainly focused on the center of the classroom, and gaze blind spots occurred mainly at the front left and right sides. Therefore, students are relatively excluded from social interaction opportunities with teachers during classes, and recognition and improvement by self is a challenging problem for teachers. Consequently, the concentration of gaze on a particular student area during class is mainly due to humans' endogenous attentional bias towards the center.

On the other hand, blind spots in gaze are more dependent on individual differences and mainly affected by changes in student seating, especially along the vertical axis. Therefore, when conducting science lecture classes, the position where teachers and students can interact most frequently through social attention is in the center of the classroom, and front seats on both sides are likely to be excluded from interaction with teachers. Furthermore, while most teachers know where their gaze is primarily focused along the horizontal axis, only a few properly recognize their focus along the vertical axis. As a result, in science lecture classes, it is difficult for teachers to distribute their attention to students regarding social interaction evenly. It is challenging to expect voluntary correction as they may not be aware of the possibility of exclusion. Therefore, there is a need to provide a feedback system that can diagnose and correct teaching behaviors related to teaching competency for interaction with the student. Just as gaze tracking simulation and feedback systems are utilized to maintain pilots' operation skills at a high level, a solution system and program for enhancing teaching behaviors need to propose. In addition, efforts must establish the scientific infrastructure and education program for developing and training related to teaching behaviors in teacher training and re-education institutions.

Declaration of Interest

The authors declare no competing interest.

References

Baumert, J., & Kunter, M. (2013). The COACTIV model of teachers' professional competence. In Kunter, M., Baumert, J., Blum, W., Klusmann, U., Krauss, S., Neubrand, M. (Eds.), *Cognitive activation in the mathematics classroom and professional competence of teachers* (MTEN, volume 8, pp. 25-48). Springer. https://doi.org/10.1007/978-1-4614-5149-5_2

Beach, P., & McConnel, J. (2019). Eye tracking methodology for studying teacher learning: a review of the research. *International Journal of Research & Method in Education, 42*, 485-501. https://doi.org/10.1080/1743727X.2018.1496415

Böheim, R., Knogler, M., Kosel, C., & Seidel, T. (2020). Exploring student hand-raising across two school subjects using mixed methods: An investigation of an everyday classroom behavior from a motivational perspective. *Learning and Instruction, 65*, Article 101250. https://doi.org/10.1016/j.learninstruc.2019.101250

Brobst, J., Markworth, K. A., Tasker, T., & Ohana, C. (2017). Comparing the preparedness, content knowledge, and instructional quality of elementary science specialists and self-contained teachers. *Journal of Research in Science Teaching, 54*(10), 1302-1321. https://doi.org/10.1002/TEA.21406

van den Bogert, N., van Bruggen, J., Kostons, D., & Jochems, W. (2014). First steps into understanding teachers' visual perception of classroom events. *Teaching and Teacher Education, 37*, 208-216. https://doi.org/10.1016/J.TATE.2013.09.001

Cortina, K. S., Miller, K. F., McKenzie, R., & Epstein, A. (2015). Where low high inference data converge: Validation of CLASS assessment of mathematics instruction using mobile eye-tracking with expert and novice teachers. *International Journal of Science and Mathematics Education, 13*, 389-403. https://doi.org/10.1007/s10763-014-9610-5

Dagienė, V., Jasutė, E., & Dolgopolovas, V. (2021). Professional development of in-service teachers: use of eye tracking for language classes, case study. *Sustainability, 13*(22), Article 12504. https://doi.org/10.3390/su132212504

Dessus, P., Cosnefroy, O., & Luengo, V. (2016). "Keep your eyes on 'em all!": A mobile eye-tracking analysis of teachers' sensitivity to students. In Verbert, K., Sharples, M., & Klobucar, T. (Eds.), *Proceedings of the 11th European conference on technology enhanced learning* (pp. 72-84). Springer. https://doi.org/10.1007/978-3-319-45153-4_6

Dougusoy-Taylan, B., & Cagiltay, K. (2014). Cognitive analysis of experts' and novices' concept mapping processes: An eye-tracking study. *Computer in Human Behavior, 36*, 82-93. https://doi.org/10.1016/j.chb.2014.03.036

Emery, N. J. (2000). The eyes have it: the neuroethology, function and evolution of social gaze. *Neuroscience & Biobehavioral Reviews, 24*(6), 581-604. https://doi.org/10.1016/S0149-7634(00)00025-7

https://doi.org/10.33225/jbse/23.22.413

Fauth, B., Decristan, J., Decker, A., Buttner, G., Hardy, I., Klieme, E., & Kunter, M. (2019). The effects of teacher competence on student outcomes in elementary science education: The mediating role of teaching quality. *Teaching and Teacher Education, 86*, Article 102882. https://doi.org/10.1016/j.tate.2019.102882

Fauth, B., Decristan, J., Rieser, S., Klieme, E., & Büttner, G. (2014). Student ratings of teaching quality in primary school: Dimensions and prediction of student outcomes. *Learning and Instruction, 29*, 1-9. https://doi.org/10.1016/J.LEARNINSTRUC.2013.07.001

Fernández, A., Okun, S., & Carrasco, M. (2021). Differential effects of endogenous and exogenous attention on sensory tuning. *The Journal of Neuroscience, 42*(7), 1316-1327. https://doi.org/10.1523/JNEUROSCI.0892-21.2021

Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (2012). Experimental and quasi-experimental studies of inquiry-based science teaching: A meta-analysis. *Review of Educational Research, 82*(3), 300-329. https://doi.org/10.3102/0034654312457206

Gesierich, B., Bruzzo, A.A., Ottoboni, G., & Finos, L. (2008). Human gaze behaviour during action execution and observation. *Acta psychologica, 128*(2), 324-30. https://doi.org/10.1016/j.actpsy.2008.03.006

Goldberg, P., Schwerter, J., Seidel, T., Müller, K., & Stürmer, K. (2021). How does learners' behavior attract preservice teachers' attention during teaching? *Teaching and Teacher Education, 97*, Article 103213. https://doi.org/10.1016/j.tate.2020.103213

Haataja, E., Moreno-Esteva, E. G., Salonen, V., Laine, A., Toivanen, M., & Hannula, M. S. (2019). Teacher's visual attention when scaffolding collaborative mathematical problem solving. *Teaching and Teacher Education, 86*, Article 102877. https://doi.org/10.1016/J.TATE.2019.102877

Hunt, T. E., Clark-Carter, D., & Sheffield, D. (2015). Exploring the relationship between mathematics anxiety and performance: an eye-tracking approach. *Applied Cognitive Psychology, 29*(2), 226-231. https://doi.org/10.1002/ACP.3099

Jiang, J., Borowiak, K., Tudge, L., Otto, C., & von Kriegstein, K. (2016). Neural mechanisms of eye contact when listening to another person talking. *Social Cognitive and Affective Neuroscience, 12*(2), 319–328. https://doi.org/10.1093/scan/nsw127

Johnston, J., & Ahtee, M. (2006). Comparing primary student teachers' attitudes, subject knowledge and pedagogical content knowledge needs in a physics activity. *Teaching and Teacher Education, 22*(4), 503-512. https://doi.org/10.1016/J.TATE.2005.11.015

King, A.J., Bol, N., Cummins, R.G., & John, K.K. (2019). Improving visual behavior research in communication science: An overview, review, and reporting recommendations for using eye-tracking methods. *Communication Methods and Measures, 13*(3), 149-177. https://doi.org/10.1080/19312458.2018.1558194

Kleickmann, T., Richter, D., Kunter, M., Elsner, J., Besser, M., Krauss, S., Cheo, M., & Baumert, J. (2015). Content knowledge and pedagogical content knowledge in Taiwanese and German mathematics teachers. *Teaching and Teacher Education, 46*, 115-126. https://doi.org/10.1016/J.TATE.2014.11.004

Klieme, E., Pauli, C., & Reusser, K. (2009). The Pythagoras study: Investigating effects of teaching and learning in Swiss and German mathematics classrooms. In Janik, T., & Seidel, T. (Eds.), *The power of video studies in investigating teaching and learning in the classroom* (pp. 137-160). Waxmann.

Korthagen, F.A., Attema-Noordewier, S., & Zwart, R.C. (2014). Teacher–student contact: Exploring a basic but complicated concept. *Teaching and Teacher Education, 40*, 22-32. https://doi.org/10.1016/J.TATE.2014.01.006

Kunter, M., Klusmann, U., Baumert, J., Richeter, D., Voss, T., & Hachfeld, A. (2013). Professional competence of teacher: Effects on instructional quality and student development. *Journal of Educational Psychology, 105*(3), 805-820. https://doi.org/10.1037/a0032583

Lazarides, R., Buchholz, J., & Rubach, C. (2018). Teacher enthusiasm and self-efficacy, student-perceived mastery goal orientation, and student motivation in mathematics classrooms. *Teaching and Teacher Education, 69*, 1-10. https://doi.org/10.1016/j.tate.2017.08.017

Leuchter, M., Saalbach, H., & Hardy, I. (2014). Designing science learning in the first years of schooling. An intervention study with sequenced learning material on the topic of 'floating and sinking'. *International Journal of Science Education, 36*(10), 1751-1771. https://doi.org/10.1080/09500693.2013.878482

Madipakkam, A.R., Rothkirch, M., Guggenmos, M., Heinz, A., & Sterzer, P. (2015). Gaze direction modulates the relation between neural responses to faces and visual awareness. *The Journal of Neuroscience, 35*(39), 13287–13299. https://doi.org/10.1523/JNEUROSCI.0815-15.2015

Magnussen, R., Zachariassen, M., Kharlamov, N., & Larsen, B. (2017). Mobile eye tracking methodology in informal e-learning in social groups in technology enhanced science centres. *Electronic Journal of e-Learning, 15*(1), 46-58. http://files.eric.ed.gov/fulltext/EJ1140126.pdf

Mahler, D.G., Großschedl, J., & Harms, U. (2017). Opportunities to learn for teachers' self-efficacy and enthusiasm. *Education Research International*, *2017*, 1-17. https://doi.org/10.1155/2017/4698371

McIntyre, N. A., Mainhard, T., & Klassen, R. M. (2017). Are you looking to teach? Cultural, temporal and dynamic insights into expert teacher gaze. *Learning and Instruction, 49*, 41-53. https://doi.org/10.1016/j.learninstruc.2016.12.005

Norqvist, M., Jonsson, B., Lithner, J., Qwillbard, T., & Holm, L. (2019). Investigating algorithmic and creative reasoning strategies by eye tracking. *Journal of Mathematical Behavior, 55*, Article 100701. https://doi.org/10.1016/j.jmathb.2019.03.008

Ogmen, H., Agaoglu, S., & Breitmeyer, B.G. (2016). How do endogenous attention, exogenous attention and metacontrast masking operate in controlling stimulus visibility? *Journal of Vision, 16*(12), 898-898. https://doi.org/10.1167/16.12.898

Pennings, H. J. M., Brekelmans, M., Sadler, P., Claessens, L. C. A., van der Want, A. C., & van Tartwijk, J. (2018). Interpersonal adaptation in teacher-student interaction. *Learning and Instruction, 55*, 41-57. https://doi.org/10.1016/j.learninstruc.2017.09.005

Pianta, R. C., & Hamre, B. K. (2009). Conceptualization, measurement, and improvement of classroom processes: Standardized observation can leverage capacity. *Educational Researcher, 38*, 109-119. https://doi.org/10.3102/0013189X09332

Prieto, L. P., Sharma, K., Kidzinski, L., & Dillenbourg, P. (2017). Orchestration load indicators and patterns: In-the-wild studies using mobile eye-tracking. *IEEE Transactions on Learning Technologies, 11*(2), 216-229. https://doi.org/10.1109/TLT.2017.2690687

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Rayner, K. (2009). Eye movement and attention in reading, scene perception, and visual search. *The Quarterly Journal of Experimental Psychology, 62*(8), 1457-1506. https://doi.org/10.1080/17470210902816461

Schilbach, L. (2015). Eye to eye, face to face and brain to brain: Novel approaches to study the behavioral dynamics and neural mechanisms of social interactions. *Current Opinion in Behavioral Sciences, 3*, 130-135. https://doi.org/10.1016/j.cobeha.2015.03.006

Senju, A., & Johnson, M. H. (2009). The eye contact effect: mechanisms and development. *Trends in Cognitive Sciences, 13*(3), 127-134. https://doi.org/10.1016/j.tics.2008.11.009

Shayan, S., Bakker, A., Abrahamson, D., Duijzer, C., & van der Schaaf, M. (2017). Eye tracking the emergence of attentional anchors in a mathematics learning tablet activity. In Was, C., Sansosti, F., & Morris, B. (Eds.). *Eye-tracking technology applications in educational research* (pp. 166-194). IGI Global. https://doi.org/10.4018/978-1-5225-1005-5.CH009

Stahnke, R., & Blömeke, S. (2021). Novice and expert teachers' situation-specific skills regarding classroom management: What do they perceive, interpret and suggest? *Teaching and Teacher Education, 98*, Article 103243. https://doi.org/10.1016/j.tate.2020.103243

Tatler, B., & Land, M. (2015). Everyday visual attention. In Fawsett, J., Risko, E., & Kingstone, A. (Eds.), *The handbook of attention* (pp. 391-421). MIT Press. https://doi.org/10.7551/mitpress/10033.003.0020

Veneri, G., Rosini, F., Federighi, P., Federico, A., & Rufa, A. (2012). Evaluating gaze control on a multi-target sequencing task: The distribution of fixation is evidence of exploration optimization. *Computers in Biology and Medicine, 42*(2), 235-244. https://doi.org/10.1016/j.compbiomed.2011.11.013

Wolff, C. E., Jarodzka, H., van den Bogert, N., & Boshuizen, H. P. A. (2016). Teacher vision: Expert and novice teachers' perception of problematic classroom management scenes. *Instructional Science, 44*, 243-265. https://doi.org/10.1007/s11251-016-9367-z

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Jung-Ho Byeon BukPyeong Girls' High School & Korea National University of Education, South Korea.
E-mail: jhbyeon77@gmail.com
ORCID: https://orcid.org/0000-0002-0109-7866

Yong-Ju Kwon *(Corresponding author)* PhD, Professor of Biology Education, Editor-in-Chief of the journal Brain, Digital, & Learning, Korea National University of Education, South Korea.
E-mail: kwonyj@knue.ac.kr
ORCID: https://orcid.org/0000-0002-8232-1574