Gaze Differences between Expert and Novice Teachers in Science Classes

Won-Jung Kim · Jung-Ho Byeon · Il-Sun Lee · Yong-Ju Kwon*
Korea National University of Education

Abstract: This study aims to investigate the gaze patterns of two expert and two novice teachers in one hour of lecture type class. Teachers recruited from the same middle school conducted the class each, wearing an eye-tracker. Gaze rate and gaze movement pattern were analyzed. The scene where teachers faced in the classroom was categorized into three zones; student zone, material zone, and non-teaching zone. Student zone was divided into nine areas of interest to see the gaze distribution within the student zone. Expert teachers showed focused gaze on student zone while novice teachers' gaze rate was significantly higher at the non-teaching zone, compared to expert teachers' one. Within student zone, expert teachers' gaze spread to the rear areas, but novice teachers' one was narrowly resided in the middle areas of the student zone. This difference in gaze caused different eye movement pattern: experts' T pattern and novices' I pattern. On the other hand, both teacher groups showed the least gaze rate onto the left and right front areas. Which change is required to teachers' gaze behavior and what must be considered in order to make effective teacher gaze in the classroom setting were discussed.

Key words: Expert teacher, Novice teacher, Eye movement, Eye tracking

I. Introduction

Gaze, being called eye movement, is one of nonverbal expressions to communicate with others (Duck & McMahan 2011; Huang 2011; Brooks & Rogers 1981; Hore 1976; Keith *et al.* 1974). Gaze affects the communication effectiveness since it is fundamental behavior necessary for the mutual gaze in communication (Knapp & Hall 2010). Therefore, people can reveal their mind through their eyes either emotion like fear, interest, aversion or cognition like exploration, awareness, decision making(Duck & McMahan 2011; Waxer 1974; Perry & Hore 1972; Argyle & Dean 1965).

Particularly, the interaction among members in social group have been regarded the most important factor on science class since the constructivism emerged as the main paradigm in science education(Nagowah, 2009). In this context, the measurement method of interaction scale between teacher and students were developed to various types; interview, observation, camera recording, and so on. However, most researchers could not identify the gaze interaction included mutual gaze between teacher and individual student due to the absence of instrument to detect eye movement.

In this recent, eye tracking method is being spotlighted as measuring instrument of gaze interaction among individuals(Grossberg & Vladusich, 2010). Gaze effectiveness has been discussed in a variety of research because it offers the insight on the successful communication and social behavior(Hore 1970; Kaufman-Balamuth 1996; Kaplan 1992). In addition, according to the study of gaze difference by experience level suggested that the gaze interaction can be affected by their interaction experience(Almerigogna *et al.* 2008; Duck & McMahan 2011; Knapp & Hall 2010). Furthermore, in educational research, a string of studies has been undertaken on the gaze pattern of teachers in the classroom settings. Teachers' eyes remain in the classroom where they are

*Corresponding author: Yong-Ju Kwon (kwonyju@gmail.com)
**Received on 7 August 2012, Accepted on 10 October 2012
***This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MEST) (No. KRF 327-2011-1-B00609).

orienting, hence teacher gaze moves across students, teaching materials, or classroom backgrounds continuously(Byeon *et al*. 2011; Huang. 2011).

When teachers give more eyes to students during lecture, students tend to maintain eye contact with teachers to participate more(Brooks & Rogers 1981). Teachers can take advantage of their gaze to encourage students' participation, give notices to them, and grasp their understanding to offer feedback(Huang 2011). In other words, teachers' gaze can be considered their care and attention on students because teachers will give more eyes to the direction where they are taking notice more. Therefore, investigating which gaze pattern teachers represent can account for the teaching aptitude and teacher-student communication quality. One more thing to consider is that teachers differ in the instruction experience.

The experts are generally known to possess sufficient knowledge to deal with problem features at a glance and excel at generating the optimal solution. For this reason, studies in a wide variety of research field have focused on the expert-novice comparison and have offered valuable information on the effective performance which can narrow the gap between expert and novice(Chi *et al* 1988; Lee & Kwon 2011; Lee *et al*, 2001; Savelsbergh *et al*. 2002; Verderber *et al*. 2011; Willemain & Powell 2012). Therefore, gaze of expert teacher and novice teacher may be different during lecture in classroom. Of course, there are studies on the student's gaze behavior or teacher-student gaze interaction in one-on-one teaching(Underwood & Everatt 1992; Brooks & Rogers 1981; Feldman 1978; Hore 1976; Woolfolk & Woolfolk 1974). However, comparative studies on the expert and novice teachers' gaze behavior in the real classroom setting seldom exist because of the lack of appropriate measuring method and the difficulty of gaze measurement in the classroom situation. Consequently, traditional measurement like report, interview, questionnaire, or observation which have been used in teaching behavior studies are improper to gain the objective information on teachers' gaze not only because they are mainly for analyzing verbal or perceived behaviors, but they also cannot measure the ongoing eye movement.

According to importance of gaze interaction in real class, researchers set the purpose of this study to investigate the gaze patterns of expert and novice teachers in one hour of lecture type science class wearing mobile eye tracker. The gaze distribution of teacher can be different according to teacher's subject. To identify only expert effect, researchers recruited two technology teachers whose subject is close to science. Technology is included in the same subject domain based on the 2009 curriculum.

Ⅱ. Methods and Procedure

1. Participants

Four female teachers were recruited from M middle school in Korea. All participants were right-handed and right-eye-dominant female, had normal vision, and were not color blind. Written informed consent was obtained from each participant and eye tracking process was explained.

They are all second grade subject teachers, two science teachers and two technology teachers. Expert teachers include one science teacher(E1) and one technology teacher(E2), having taught students for 23 and 25 years each. Novice teachers include one science teacher(N1) and one technology teacher(N2), both having taught students for half an year. E1 was the winner of the class teaching competition and E2 won the master title at the Korea master teacher competition; both of expert teachers were verified the professionalism and expertise in terms of class teaching. All teachers had one hour of lecture-type class each, wearing eye-tracker. Also, all of student seats were arranged 5 rows and 8 lines. Additional information on

participant teachers are shown in Table 1.

2. Procedure

1) Gaze data acquisition

Current study adopted the Viewpoint Mobile Eye-tracker(monocular system) invented by Arrington Research Co. to track subjects' eye movement. The eye-tracker has the eye camera filming where subject is watching and scene camera filming where the pupil of right eye is moving. It can measure the pupil location and diameter, so acquire data relevant to the visual attention of a subject. The location of right eye's fovea was tracked using IR LED camera at 60Hz frequency. Calibration was conducted at the beginning of every recording to modify the measurement errors caused by monocular system and subject difference. Fixation, the indicator of perceived point of interest, was set as when the eye stayed in one location at least 200ms(Henderson & Hollingsworth 1998; Kowler 2011; Slykhuis *et al.* 2005). From the definition of the fixation, the gaze was defined as the cumulative measure of all fixations(Underwood & Everatt 1992).

This study, aiming to see the difference of teacher gaze during real class setting, allowed teachers to have the class as much as usual. They could move across the classroom and exhibit their usual teaching behaviors. AOI size was set properly to tolerate possible head motion and contingent gaze motion. When gaze was located between two AOIs, the gaze was excluded from the analysis in order to reduce the ambiguity of gaze location. Likewise, the gaze when teachers moved back to the class and looked at students' backside was also excluded from the analysis.

2) Gaze data analysis

Three steps of data analysis proceeded; synchronizing scene and eye movie to gaze movie, setting areas of interest, and coding and extracting gaze data. Scene movie and eye movie were synchronized to the 'gaze movie'. Gaze movie shows where subjects fixated their right eye at every 200ms. This study adopted Byeon *et al.*(2011)'s AOI establishment because they investigated one teahcer's gaze behavior during real class teaching as this study did. That AOI categorization was proper to see the gaze distribution among student, teaching material and non teaching zone and to find the gaze difference between expert and novice teachers. Accordingly, the scene of classroom was largely categorized into three zones; student zone, teaching material zone and non-teaching zone. Teaching material zone included text book, black board and material related to instruction. Non-teaching zone encompassed teaching-irrelevant objects like window, wall, aisle, door, fluorescent light, and so on. Student zone was once more divided into nine areas of interest to further the teachers' gaze investigation within student zone(Table 2). Subsequently, gaze data were all

Table 1

Information on participant teachers and classrooms

Teacher	E1	E2	B1	B2
Teaching Subject	Science	Technology	Science	Technology
Teaching Experience(Year)	22	34	1.0	0.5
Feature	Teaching Competition Winner (2010)	Master Teacher	None	None.
Teachers' Hight(cm)	162	165	165	167

Table 2
Nine AOIs within student zone

Level Ⅰ of AOIs	Level Ⅱ of AOIs		Level Ⅲ of AOIs	
Non-teaching Zone	-		-	
Teaching Material Zone	-		-	
Student Zone	Left	Front	Left	Front
				Middle
				Rear
	Middle	Middle	Middle	Front
				Middle
				Rear
	Right	Rear	Right	Front
				Middle
				Rear

coded and calculated to gaze rate and eye movement data. Also, gaze movement frequency from one AOI to other AOIs was calculated from gaze coding data in order to see which AOIs have the active movement.

Ⅲ. Result

1. Fixation rate

Researchers could gain fixation number in each AOI and fixation rate was calculated by the fixation number per total fixation number. According to the result of fixation rate, researchers could find three results on difference of gaze rate in three zones(Table 3).

First, expert teachers' gaze fixation rate was higher on student zone than teaching material and non-teaching zone compared with novice teachers. Also, novice's gaze fixation rate was similar either non-teaching or student zone, while material zones were lower fixation rate. Second, the difference of gaze fixation rate was significant in non-teaching zone. Expert teacher's fixation rate was lower on the non-teaching zone than novice teachers. Non-teaching zone encompassed teaching-irrelevant objects like window, wall, aisle, door, fluorescent light, and so on. Then, novice teachers' average fixation rate on non-teaching zone was above two times comparing to the experts' one. Therefore, it can be said expert teachers focused on student zone and teaching material zone more than novice teachers while novice teachers' visual attention was distracted to the non teaching zone. Third, there is not the difference according to subject in gaze fixation pattern. Fixation rate of three zones were

Table 3
Fixation rate of AOIs(%)

	E1	E2	N1	N2
Student Zone	59.6	56.0	47.2	43.5
Teaching Material Zone	22.1	20.7	7.4	16.7
Non-teaching Zone	18.3	23.3	45.4	39.8
total	100	100	100	100

similar between E1 and E2, N1 and N2. Consequently, the reason of gaze distribution pattern can be the difference of teaching experience.

2. Fixation rate within student zone

Researchers could find that expert teachers focused on student zone more than other zones during class. To identify difference of fixation rate in student zone, researchers calculated fixation rate within student zone in each teacher(Fig. 1).

The result of fixation rate within student zone can show both similarity and difference in expert and novice teachers' gaze. The similarity was that four teachers showed the lowest fixation rate on SLF and SRF. However, the difference was that expert teachers showed high and sustained gaze fixation rate on marginal areas like SRM, SLF, SMR, SRR, while novice teachers' gaze fixed on these areas dropped down.

3. Gaze movement pattern

From fixation rate within student zone, researchers found that the expert teachers focused on marginal areas of class more than the novice. To identify gaze movement during class, researchers performed gaze movement analysis. Gaze movement frequency from each AOI to other AOIs was automatically calculated from gaze coding in order to see which AOIs have the active movement.

Inter-AOIs gaze movement frequency of each teacher was ordered. Of these, movement frequency more than 15 times was arranged and the most frequent four movements were visualized to the arrow graphics in order to see the pattern of dominant gaze movement of each teacher (Table. 4).

The result of gaze movement analysis revealed how frequently gaze movement occurred among 9 AOIs within student zone. Expert teachers both showed frequent movement among rear areas while novice teachers exhibited frequent and dominant movement across the middle areas. It was obviously shown at the arrow graphic (like the right side of the Table. 3) and the tendency could be patterned. Within student zone, expert teachers' gaze movement pattern is like 'T' character while novices' gaze movement pattern is similar 'I' character. According to this result, researchers suppose that two expert teachers commonly distributed their gaze to rear areas more than novice teachers.

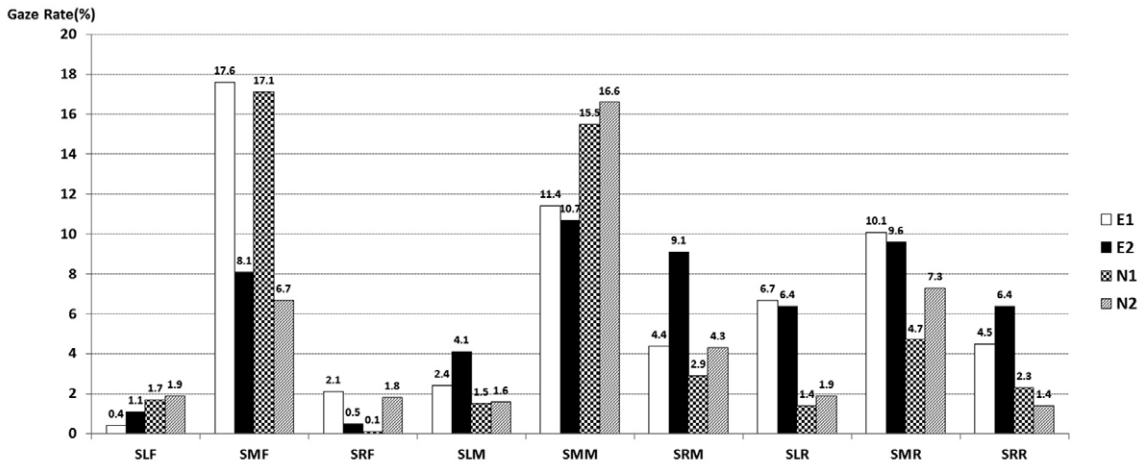
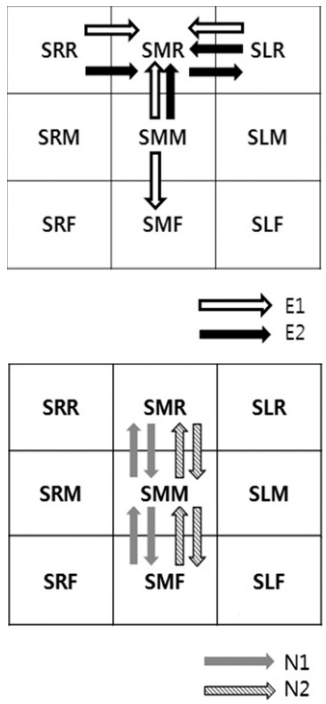


Fig. 1 *Gaze Rate on Nine AOIs within Student Zone*

Table 4

Gaze Movement Frequency among inter-AOIs (threshold >15)

Teacher	E1	E2
Movement frequency order	Direction (Frequency)	Direction (Frequency)
1	SLR→SMR (29)	SMR→SLR (49)
2	SRR→SMR (28)	SLR→SMR (37)
3	SMF→SMM (27)	SRR→SMR (32)
4	SMM→SMF (22)	SMM→SMR (26)
Teacher	N1	N2
Movement frequency order	Direction (Frequency)	Direction (Frequency)
1	SMM→SMF (45)	SMM→SMR (45)
2	SMF→SMM (39)	SMR→SMM (42)
3	SMM→SMR (31)	SMF→SMM (26)
4	SMR→SMM (31)	SMM→SMF (21)



Ⅳ. Discussion

The purpose of this study was to investigate the gaze patterns of two expert and two novice teachers in one hour of lecture type class. According to the result of this study, researchers found out three conclusions about gaze pattern between expert and novice teachers.

First, expert teachers showed more attention on student zone, especially on rear areas within student zone than novice teachers. This result corresponds to the similar studies on the experts' gaze. Expert speakers, drivers and designers showed wider gaze distribution and even gaze rate on the objects they oriented(Chi *et al* 1988; Konstantopoulos *et al.* 2010; Lucas 2007; Verderber *et al.* 2011; Willemain 1994). Experts are domain-generally reported to perceive larger patterns and more consciously monitor the process of given work. Likewise, expert teachers who participated in this study showed the wide gaze distribution within student zone. Thus, effective gaze pattern shown in expert teachers is worthy for novice teachers to emulate.

Second, novice teachers showed higher gaze rate on non-teaching zone and the middle areas within student zone than expert teachers. This propensity can be explained by the precedent studies reporting that gaze moves through the inter-space of the objects which causes the higher gaze rate on the inter-space(Byeon *et al.* 2011; Gesierich *et al.* 2008), and that gaze deviation occurs when subjects take non-visual cognitive task(Ehrlichman *et al.* 2007; Micic *et al.* 2010). When a teacher's gaze moves from one student to another, the gaze indispensably passes the inter-space mainly including classroom environment or center of the classroom. This corollary also explains why expert teachers made above-average gaze rate on the non-teaching zone and the middle areas.

Moreover, teachers operate multiple cognitive processes; they recall the effective teaching experiences and reflect them to current teaching context, utilize what they have known, and interpret students' behavior for feedback. Expert teachers have experienced and mastered this complicated task related to teaching context while paying constant attention to students. Meanwhile, novice teachers hardly have mastered this capacity, so their gaze can stray from the student zone when they undergo inner process germane to the teaching context.

Third, both expert and novice teachers showed the lowest gaze rate on the front edges of student zone. Teachers' gaze functions as the teacher-student communication channel. If teachers seldom pay visual attention to students, those students are bound to be distracted from learning process in class. Teachers must perceive this tendency and pay more intensive effort to ensure even gaze rate to each student. There would be possible causes on this gaze imbalance like seat setting style, teacher preference toward students or unconscious gaze behavior. This study only showed the gaze imbalance on the front edges regardless of the teaching experience, so it needs further study to find the reason why teachers showed this tendency.

This study raises two suggestions on the teachers' gaze behavior and relevant future research although it is hard to generalize due to the small sample size. First, multifaceted and generalizable research on teacher gaze distribution must be conducted so that teachers gain feedback about effective gaze behavior. Teachers need monitoring, analysing, and consulting on their gaze habit during class.

Second, gaze training program adapted to teaching in class is required. Even though the gaze is important variant on class teaching and learning, there hardly exists the gaze improvement program for teachers. This study showed the gaze difference related to teaching experience. Also, it introduced the possibility how eye tracker can be the teaching behavior detecting and consulting tool while excluding the subjective judgment of researchers or participants. Therefore, it is urged for teachers to train the effective gaze behavior through proper eye tracker-based gaze training program so that both teachers and students benefit from active and effective gaze interaction during class.

References

Argyle, M., & Dean, J. (1965). Eye contact, distance and affiliation. Sociometry, 28, 289-304.

Brooks, D. M., & Rogers, C. J. (1981). Researching pupil attending behavior within naturalistic classroom settings. *Anthropology & Education Quarterly*, 12(3), 201-210.

Brosch, T, Pourtois, G., Sander, D., & Vuilleumier, P. (2011). Additive effects of emotional, endogenous, and exogenous attention: behavioral and electrophysiological evidence. *Neuropsychologia*, 49(7): 1779-1787

Byeon, J. H., Lee, I. S., & Kwon, Y. J. (2011). A study on consulting of teaching behavior pattern of gaze fixation by using eye tracker; the case study. *Korea Association for Learner-Centered Curriculum and Instruction*, 11(4), 173-199.

Chi, M. T. H., Glaser, R., & Farr, M. J. (1988). The nature of expertise. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Duck, S., & McMahan, D. T. (2011). *The basics of communication: A relational perspective*. California: SAGE

Ehrlichman, H., Micic, D., Sousa, A., & Zhu, J. (2007). Looking for answers: Eye movements in non-visual cognitive tasks. *Brain and Cognition*, 64: 7-20.

Feldman, R. S. (1978). Nonverbal disclosure of teacher deception and interpersonal affect. *Journal of Educational Psychology*, 68, 807-816.

Gesierich, B., Bruzzo, A., Ottoboni, G., & Finos, L. (2008). Human gaze behavior during action execution and observation. *Acta Psychologica*, 128, 324-330.

Grossberg, S., & Vladusich, T. (2010). How do children learn to follow gaze, share joint attention, imitate their teachers, and use tools during social interactions? *Neural Networks*, 23, 940-965.

Henderson, J. M., & Hollingsworth, A. (1998). *Eye movements during scene viewing: An overview*. In G. Underwood (Ed.), Eye guidance in reading and scene perception (pp. 269-294). Oxford: Elsevier Science.

Hopfinger, J. B., & West, V. M. (2006). Interactions between endogenous and exogenous attention on cortical visual processing. *NeuroImage*, 31, 774-789.

Hore, T. (1970). Social class differences in some aspects of the nonverbal communication between mother and preschool child. *Australian Journal of Psychology*, 22, 21-27.

Hore, T. (1976). Visual behaviors: teacher pupil dyads. *American Educational Research Journal*, 13(4), 267-275.

Huang, L. (2011). Nonverbal communication in college English classroom teaching. *Journal of Language Teaching and Research*, 2(4), 903-908.

Kaplan, E. A. (1992). *Motherhood and representation*. London: Routledge.

Kaufman-Balamuth, L. (1996). *Four month mother-infant gaze contingencies as a predictor of one year infant attachment*. Adelphi University: The Institute of Advanced Psychological Studies.

Keith, L. T., Tornatzky, L. G., & Pettigrew, L. E. (1974). An analysis of verbal and nonverbal classroom teaching behaviors. *Journal of Experimental Education*, 4(2), 30-38.

Knapp, M. L. & Hall, J. A. (2010). *Nonverbal communication in human interaction* (7th edition). Wadsworth: Cengage Learning.

Konstantopoulos, P., Chapman, P., & Crundall, D. (2010). Driver's visual attention as a function of driving experience and visibility: Using a driving simulator to explore drivers' eye movements in day, night and rain driving. *Accident Analysis and Prevention*, 42, 827-834.

Kowler, E. (2011). Eye movements: The past 25 years. *Vision Research*, 51(13), 1457-1483.

Lee, J. K., & Kwon, Y. J. (2011). What neural substrates trigger the adept scientific pattern discovery by biologists? *Journal of Science Education and Technology*, 20(2), 117-122.

Lee, K. M., Kim, C. M., & Woo, S. H. (2001). fMRI comparison between expert and novice perception of dance. *NeuroImage*, 13, S907.

Lucas, S. E. (2007). *The art of public speaking* (9th edition). New York: Mcgraw-Hill.

Micic, D., Ehrlichman, H., & Chen, R. (2010). Why do we move our eyes while trying to remember? The relationship between non-visual gaze patterns and memory. *Brain and Cognition*, 74, 210-224.

Nagowah, L. (2009). A Reflection on the Dominant Learning Theories: Behaviorism, Cognitivism and Constructivism. *The International Journal of Learning*, 16(2), 279-285.

Perry, F. R., & Hore, T. (1972). Selective attention of deaf children during questioning. *The Australian Teacher of the Deaf*, 13, 88-94.

Savelsbergh, E. R., Jong, T. D., & Ferguson-Hessler, M. G. M. (2002). Situational knowledge in physics: The case of electrodynamics. *Journal of Research in Science Teaching*, 39, 928-951.

Slykhuis, D. A., Wiebe, E. N., & Annetta, L. A. (2005). Eye-tracking students' attention to powerpoint photographs in a science education setting. *Journal of Science Education and Technology*, 14(5/6), 509-520.

Underwood, G., & Everatt, J. (1992). *The role of eye movements in reading : some limitations of the eye-mind assumption*. In E. Chekaluk and K. R. Liewellyn (Eds).: The role of eye movements in perceptual process. Amsterdam: North-Holland.

Verderber, R. F., Sellnow, D. D., & Verderber, K. S. (2011). *The challenge of effective speaking* (15th edition). Wadsworth: Cengage learning.

Waxer, P. H. (1974). Therapist training in nonverbal communication: Nonverbal Cues for Depression. *Journal of Clinical Psychiatry*, 30, 215-218.

Willemain, T. R. (1994). Insights on modeling

from a dozen experts. *Operational Research*, 42, 213–222.

Willemain, T. R., & Powell, S. G. (2007). How novices formulate models. Part II: Quantitative Description of Behavior. *The Journal of the Operational Research Society*, 58(10), 1271–1283.

Woolfolk, R. L., & Woolfolk, A. E. (1974). Effects of teacher verbal and nonverbal behaviors on student perceptions and attitudes. *American Educational Research Journal*, 11, 297–303.