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Teachers' Gaze According to Classroom Layouts: An Eye-Tracker Study

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Abstract

Social interactions between teachers and students are crucial for learning and well-being. While these interactions have been extensively studied in terms of verbal and non-verbal communication, little research has focused on how teachers' gaze behavior varies with different classroom spatial configurations.

This study aims to understand teachers' gaze behavior during class in relation to various classroom layouts, using an eye-tracking methodology. A machine learning-assisted approach was employed to analyze their gaze behavior in three distinct classroom settings. Our findings reveal the interplay between gaze behavior, teaching activities, and learning environments. This research contributes to a better understanding of how teachers'gaze behaved according to different classroom variables (as classroom layouts or activities occurred during lessons)

Keywords: eye-tracking, teachers, classroom layouts, gaze behavior

1 Introduction

Social interactions between learners and teachers have been widely studied in the literature (Dzakiria & Idrus, 2003; Hall & Walsh, 2002; Kathard, Pillay, & Pillay, 2015). Verbal and

non-verbal dimensions of teachers practices have been particularly emphasized and extensively examined (Murphy, 1999; Syarifudin, Purwanto, Irawan, Sulandra, & Fikriyah, 2019; Vincentia & Taloko, 2011) because of the relative ease of gathering information through observation or through video recordings during teaching (Smidekova, Janik, Minarikova, & Holmqvist, 2020) and surveys. Non-verbal aspects of interaction were mostly studied through gestures and body language using classroom observations (Wahyuni, 2018), questionnaires, or interviews (Ananda, Solihat, & Suryana, 2020). Nevertheless, visual interaction using eye-tracking has more recently been explored in the field of education in ecological learning environments (Tan, Ho, & Jamaludin, 2024).

Nowadays, new objective and online methods are available and bring new ways to track teachers' behaviors without relying on subjective self-reports (Beach & McConnel, 2019). For instance, eye-tracking is a method that provides quantitative data on teachers' visual perception and attention during class (Shayan, Abrahamson, Bakker, Duijzer, & van der Schaaf, 2017). In fact, the emerging field of eye-tracking offers a new way to explore how teachers behave according to different classroom layouts. In the area of education, most studies have dealt with the visual behaviors of teachers according to their level of expertise (Nuthall, 2005; Sabers, Cushing, & Berliner, 1991) or have studied students' reading processes (Al Dahhan, Kirby, & Munoz, 2016), multimedia learning (Desjarlais, 2017; Mayer, 2014), mathematics learning (Andrá et al., 2015), attention and engagement in the learning process (Haataja, 2023), or gaze distribution among students inside a classroom (Smidekova et al., 2020). Nevertheless, less is known about how teachers' gaze behaves according to different classroom layouts. In this work, we provide a new non-verbal study using eye-tracking, and we aim to explore how teachers' gaze behaves in the context of different classrooms by introducing a combined method of eye-tracking and machine learning to explore their behavior in a teaching context.

2 Analyzing teachers in their practice

2.1 Importance of Student-Teacher Interactions

Teaching is a profession that requires, among other things, interactions with students, the creation of a supportive classroom environment, classroom management, and cognitive stimulation to support student learning (Pianta & Hamre, 2009). These dimensions involve not only verbal exchanges but also non-verbal communication skills. While verbal forms of interaction have been extensively studied, non-verbal aspects, such as gestures, facial expressions, and teachers' gaze have received comparatively less attention (Bavelas, Coates, & Johnson, 2002), even though eye contact plays a key role in teacher–student relationships (Kingstone, Smilek, & Eastwood, 2008).

In fact, many studies have focused on teacher-student verbal interactions and have shown, for example, that verbal interactions often depend on some implicit beliefs and attitudes based on subconscious prejudices regarding certain student characteristics (Dovidio, 2001) (such as student gender (Drudy & Chatháin, 2002), socioeconomic status (Goddard, Tschannen-Moran, & Hoy, 2001), backgrounds (Cornbleth & Korth, 1980), or academic ability (Ilatov, Shamai, Hertz-Lazarovitz, & Mayer-Young, 1998)).

Moreover, interactions (in verbal or non-verbal forms) between teachers and learners are perceived by students as being among the most important parts of their school experience

(Alerby, 2003) and affect student interest and satisfaction with their learning (Fauth et al., 2019).

Specifically concerning gaze interaction, many studies examined the effects of eye contact on students, such as its potential to encourage them (Mitchell & Marin, 2015; Montello, 1988), control their behavior, maintain their attention (Mussard, Seyte, & Terraza, 2003), and facilitate participation in classroom activities. In addition, a positive correlation has also been demonstrated between the amount of student eye contact with the teacher and students' comprehension (Breed & Colaiuta, 1974). According to (Noddings, 2003), eye contact also influences the quality of interaction between teacher and student and affects verbal communication (Jiang, Borowiak, Tudge, Otto, & von Kriegstein, 2017).

Eye contact is also a sign of the teacher's confidence level and influences their credibility (Johnson & Miller, 2002), trustworthiness, authority (Turman & Schrodt, 2006), and validation as rated by students (Kerssen-Griep & Witt, 2012). For example, a teacher who consistently avoids eye contact may be perceived as lacking self-assurance, which can generate feelings of insecurity among students (McIntyre, Mulder, & Mainhard, 2020).

2.2 Gaze Pattern Functions

Visual attention and cognitive processing of information work almost simultaneously, allowing us to obtain information about the intentions of others or our environment (Beach & McConnel, 2019; Tatler & Land, 2016).

According to (Jefferies, Enns, & Di Lollo, 2019), selective visual attention must prioritize the location and distribution of processing, and its focus allows us to selectively process relevant information while filtering irrelevant stimuli. This process of attention needs interaction between voluntary and controlled modes of allocation of attention: exogenous factors (which are related to the physical characteristics of the stimuli) (Eimer & Kiss, 2008; Jefferies et al., 2019) and the involuntary and automatic capture of attention: endogenous factors (related to the relevance of the information for the objectives of the observer) (Eimer & Kiss, 2008).

While visual attention is essential to understanding our environment, gaze also plays a critical role in social interaction and its regulation (Pfeiffer, Vogeley, & Schilbach, 2013). In fact, numerous studies have shown that effective communication between individuals begins only when eye contact is established (McCroskey, Richmond, Sallinen, Fayer, & Barraclough, 1995; McIntyre, Jarodzka, & Klassen, 2019; McIntyre, Mainhard, & Klassen, 2017).

Nevertheless, gaze patterns may be influenced by inherent attentional biases. In fact, research has shown that humans exhibit a natural bias toward the left visual field, along with an endogenous tendency to focus on the center of space along the vertical axis (Byeon & Kwon, 2023; Guo, Meints, Hall, Hall, & Mills, 2009).

2.3 Teacher Gaze Distribution in the Context of Teaching

A teacher's gaze distribution during a teaching context corresponds to the gaze proportion across students and objects inside the classroom (Smidekova et al., 2020).

Studying gaze patterns allows us to better understand teachers' ability to process information present in the classroom environment (Van den Bogert, van Bruggen, Kostons, &

Jochems, 2014). Teachers' gaze distribution is complex to study as it is influenced by ongoing social interactions that shape visual attention (McIntyre et al., 2017; Prieto, Sharma, Kidzinski, & Dillenbourg, 2017; Van den Bogert et al., 2014).

Many studies have explored teachers' gaze distribution inside the classroom. For instance, two meta-analytic studies (Exline & Winters, 1965; Falck-Ytter, Thorup, & Bölte, 2015) reported that teachers have a tendency to look more at male students than female students. Studies also demonstrate that differences in gaze fixation exist between novice and expert teachers. In fact, expert teachers tend to look at students for a longer time than novice teachers (McIntyre et al., 2017; Van den Bogert et al., 2014). However, the complexity of the classroom environment and the number of students can cause relatively short gaze fixations (Prieto et al., 2017).

Moreover, during teaching sessions, teachers tend to direct their gaze more frequently toward students seated within an inverted "T zone". In fact, students who sit in the center of the classroom and close to the teacher tend to have more verbal interaction with the teacher than students who sit in the front area (Holland, Wolf, Looser, & Cuddy, 2017; Howe & Abedin, 2013; Huang, 2011; Smidekova et al., 2020). Nevertheless, according to (Lotfy, 2012; Wannarka & Ruhl, 2008), students sitting away from the teacher tend to display more off-task or disruptive behaviors than their peers sitting at the front of the class.

Moreover, the physical environment of the classroom has been identified as a key factor influencing both teaching and learning processes (Burruss, 2001; Oblinger, 2005) and can affect actors through their behaviors, interactions, attention, and movements inside the environment. In this context, for a few years now, the traditional classroom is evolving towards other forms of accommodation to promote more active student engagement in their learning. Today, different learning environments, such as active classroom layouts and science classrooms, are being implemented across schools to support diverse instructional approaches.

The integration and use of digital education in classrooms have also contributed to the evolution of new learning spaces (Cruz-Jesus, Vicente, Bacao, & Oliveira, 2016; Major, Haßler, & Hennessy, 2017).

Although several studies have investigated the visual activity of teachers in classroom contexts, only a few recent studies have focused on the visual activity of teachers in different class settings (including class size, course content, and instructor demographics) (Smidekova et al., 2020). To our knowledge, no study has examined teachers' gaze behavior across distinct classroom layouts.

The objective of this study is to explore how teachers' gaze behavior unfolds during pedagogical activities, in relation to classroom variables such as spatial layout and the nature of instructional tasks. Given the limited number of studies examining teachers' visual behavior during actual lessons, our approach is primarily inductive. Nevertheless, the investigation is guided by the following research questions:

- Do classroom spatial configurations influence teachers' visual behavior?
- Do teachers tend to maintain longer gaze fixations in specific areas of the classroom?
- Do the types of classroom activities affect teachers' gaze behavior?

Figure 1 Classroom layouts involved in the study (traditional classroom on the left, active classroom in the center and science classroom on the right)

3 Method

Our method is based on an eye-tracker study of teachers' gaze activities through different classroom layouts in a teaching context. Gaze data are analyzed with Deep Learning methods and present many results that allow us to better understand how teachers' gaze behaves in different classroom environments. Faces were detected with the RetinaFace DeepLearning trained package (Deng et al., 2019)

3.1 Participants and Classroom Layouts

Three teachers in secondary schools (based in France) participated in this study and gave their written informed consent. Two of them work in the same school and are science teachers, and the third one is an English teacher teaching in a different school.

The table below presents sociodemographic characteristics of participants, including gender and professional experience, categorized as early-career teacher (fewer than 5 years of experience), Mid-career (teacher) between 5 and 10 years of experience), and expert-career (more than 10 years). Number of lesson recordings per classroom layouts and field of teaching were also reported.

Table 1 Experimental sessions and sociodemographic elements of participants

Participant	Gender	Professional experience	Lessons	Classroom Layout	Field of Teaching
P1	Female	Mid-career teacher	6	3 active classrooms / 3 traditional classrooms	English
P2	Male	Early-career teacher	6	3 science classrooms / 3 active classrooms	Science
P3	Female	Mid-career teacher	4	3 active classrooms / 2 science classrooms	Science

In this study, data were collected from three participant. Each teaching multiple lessons in different classroom layouts with the same group of students. For participant 1, three lessons in an active classroom and three lessons in a traditional classroom were recorded. For participant 2, three lessons in a science classroom and three lessons in an active classroom and for participant 3, three lessons in an active classroom and two in a science classroom.

Classroom layouts where eye-tracker sessions took place are presented in the following figure.

Indeed, sessions took place in three different classroom layouts (see Figure 1): a traditional classroom (on the left of the figure), where tables are arranged one behind the other, facing the board; an active classroom (in the center), where students are grouped around tables; and a science classroom (on the right), where two long tables are arranged from the front to the back of the classroom.

3.2 Calibration of the Device

For this study, the eye-tracking device Pupil Labs was used to collect visual data from participants. Designed as a pair of wearable glasses worn by participants, the Pupil Labs eye-tracker is composed of three cameras (for left eye, right eye, and in the center) to calibrate and estimate gaze through open-source software (Adithya, Hanna, BN, & Chai, 2018). Thus, each participant wore the eye-tracker during some of their teaching sessions, in different classroom layouts. Calibration of participants' gaze was made for each participant before recording.

3.3 Description of the Method

Teacher gaze is represented by a red circle that covers the area of gaze position (see Figure 2). The duration of a glance is defined as the total duration of a concordance when a face is detected inside the red circle corresponding to the participant's viewing area.

Figure 2 Example of overlay (red circle) and face detection (blue rectangles) calculated by Machine Learning during one recording session

Subsequent Machine Learning (Deep Learning) pre-trained neural networks were used to analyze the dataset (Janiesch, Zschech, & Heinrich, 2021). These neural networks are trained to a sufficient success rate. Thanks to Machine Learning, the RetinaFace algorithm was used to detect students' faces (Deng, Guo, Ververas, Kotsia, & Zafeiriou, 2020). In fact, RetinaFace is capable of stable face detection, via 2D facial alignment and 3D facial reconstruction.

Areas of blue rectangles (surrounding the blurred student faces) were calculated from RetinaFace and then enabling the estimation of each student's face size. Thus, the face size of the student located near the participant wearing the eye-tracker (7392 pixels) is larger than the face size of the student located far from the participant (321 pixels).

This study investigates how teachers' gaze distributions vary according to different spatial classroom configurations. Given the limited research on gaze behavior in relation to physical classroom contexts, the study adopts an exploratory approach and implements a quasi-experimental protocol.

By its exploratory nature, this study does not have hypotheses but provides a combination of descriptive and inferential data that can be discussed.

4 Results

Table 2 presents the main descriptive data obtained from the analysis of gaze-to-face concordance for each recording session and according to the spatial layouts in which the experimental sessions took place, the proportion of time devoted to face-looking per session, as well as the average duration of these looks (in milliseconds) and the standard deviation of the vertical movement of the participant's gaze when the teacher looks at learners (Dev(z)).

Table 2 Participants' gaze activity: proportion and duration of face looks per session, classroom setting, and activity types

Participant	Session	Classroom	Activities†	Proportion of face looks	Average length of face looks (ms)	Dev(z)
T1 (English)	1	active	LST, SP, OAS, TSI, TD	**63.83**%	**419**	211.5
	2	active	LST, OAS, TSI, CC, TD, ISW, MSW	20.00%	281	247.6
	3	active	LST, SP, OAS, TSI, CC, TD, MSW	36.25%	264.5	211.7
	4	traditional	LST, SP, OAS, TSI, CC, ISW	**53.90**%	368	245.7
	5	traditional	LST, OAS, TSI, TD, MSW	**63.00**%	**584**	211.6
	6	traditional	LST, TSI, ISW, MSW	29.30%	386	251.7
T2 (Science)	7	science classroom	TSI, TD, ISW, MSW	25.39%	248	248.4
	8	science classroom	SP, TSI, TD, ISW, LST	44.90%	351	231.4
	9	science classroom	LST, TSI, CC, MSW	44.70%	**406**	247.2
	10	traditional	LST, TSI, CC, SGW, TD, ISW, MSW	20.50%	280	223.7
	11	traditional	LST, SP, TSI, SGW, TD, ISW, MSW, HT	39.80%	328	224.2
	12	traditional	LST, SP, TSI, CC, TD, ISW, MSW	18.39%	236	216.5
T3 (Science)	13	active	LST, OAS, TSI, MSW	12.13%	169	244.3
	14	active	LST, TSI, TD, ISW, MSW	18.30%	157	226.0
	15	science classroom	OAS, TSI, SGW, HT, TD, MSW	9.00%	227	259.5
	16	science classroom	LST, TSI, SGW, HT, TD, MSW	9.12%	202	258.9

Legend for Classroom Activities†:
LST = Lecture Style Teaching, **SP** = Student Presentation, **OAS** = Oral Assessment Situations, **TSI** = Teacher Screen Interaction, **CC** = Collective Conversation, **SGW** = Small Group Work, **HT** = Hands-on Tasks, **TD** = Teacher Demonstration, **ISW** = Individual Sit Work, **MSW** = Monitoring of Student Work

As shown in table 2, the average duration of teacher glances on students' faces is greatest in teaching session number 5 (584 ms), number 1 (419 ms), followed by number 9 (406 ms). These results seem to be independent of classroom layouts in which teaching took place, since these three teaching sessions occur respectively in the traditional classroom, in the active classroom, and in the science classroom (see Figure 1). Notably, these three teaching sessions were conducted by participant 1 (English) (for videos 5 and 1) followed by participant 2 (Science) (for video 9). These participants exhibited longer average gaze durations compared to other sessions.

Moreover, to further examine the relationship between the average duration of face glances and the proportion of time devoted to face-looking, we investigated whether a statistical correlation exists between these two variables. The analysis revealed a positive correlation ($R^2 = 0.747$) between average duration of face glances and proportion of time devoted to face-looking.

Nevertheless, proportion of face looks per and average length of face looks seems to be independent of classroom layouts. Additional calculations proposed in the study will provide further information.

4.1 How does gaze behave across activities and classroom types?

Furthermore, table 2 provides a description of all pedagogical activities carried out per session. Across the sessions, ten principal activities were mobilized by teacher and their students during sessions. To better understand the link between activities carried out and teachers' gaze distribution through students, each activity was associated to a code, presented in the following table

Classroom activities	Descriptions	Letter Code
Lecture style teaching	Teacher speaking to the whole class while students listen and take notes	LST
Student presentation	Students actively take the role of presenters in front of peers, teacher	SP
Oral Assessment situation	Students are evaluated orally, in writing or in other ways	OAS
Teacher screen/board interaction	Teacher interacting directly with board or interactive screen to write or point a concept	TSI
Collective conversation	Teacher and students engaged in a shared exchange	CC
Small group work	Students working in small groups on a task	SGW
Hands-on tasks	Students physically manipulate materials as part of the task	HT
Teacher demonstrations	Teacher models or performs a process or task	TD
Individual sit work	Students working independently at their desk	ISW
Monitoring of student work	Teacher observes or gives individual support as students work	MSW

Table 3 Typology of classroom activities

Table 3 indicates the ten main activities observed during lessons with their associated number codes. According to table 2, activities appeared to be varied and independent of classroom layouts, as they occurred across all three types of classroom layout (active, traditional, and science classroom). Nevertheless, we can observe an important presence of these 3 activities throughout each classroom layout : Learning Style Teaching (LST), Teacher Screen Interaction (TSI) and Teacher Demonstration (TD), which tend to indicate a central role for the teacher, and a traditional posture of teaching, independent of the school environment.

Small Group Work (5) activities are not present in active classroom but used in traditional and science classroom.

Nevertheless, we wonder how teachers' gaze behave according their activity. The following graph presents the standardized distribution of sizes of faces observed by teachers for each activity (with their associated code) and presents the mean gaze duration of teachers per activity.

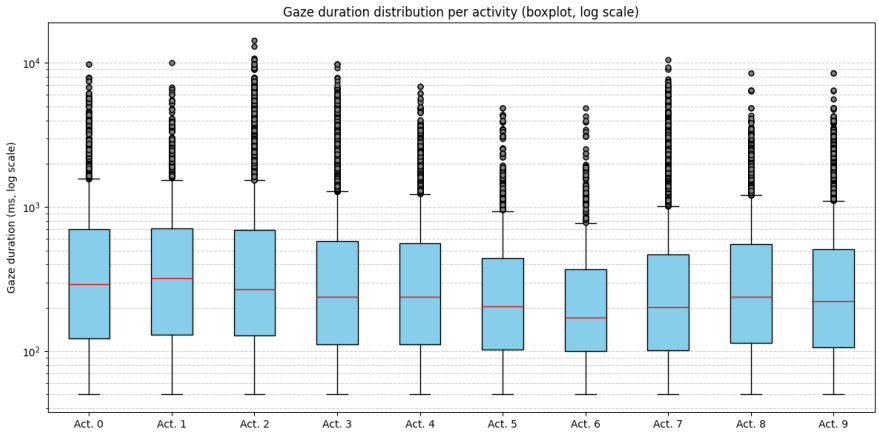

Figure 3 Teachers' gaze distribution per activity (boxplot) on a logarithmic scale. The analysis includes only gaze episodes longer than 50 milliseconds. Activity 0 = LST ; Activity 1 = SP, Activity 2 = OAS, Activity 3 = TSI, Activity 4 = CC, Activity 5 = SGW, Activity 6 = HT, Activity 7 = TD, Activity 8 = ISW, Activity 9 = MSW

Figure 3 displays the distribution of teachers' gaze durations across ten pedagogical activities observed during the study (see Table 3). The data were aggregated across all classroom layouts and participants, and visualized using boxplots on a logarithmic scale. The boxplots show that median gaze durations (indicated in red) are generally higher for activities involving a whole-class exchange or interactive formats between teachers and students as LST (0), TD (1), and OAS (3). In contrast, activities focused on individual or small group work—such as SGW (5), HT (6), or TD (7) tend to be associated with shorter gaze durations. In addition, the presence of numerous outliers (in black) in Activities 0, 1, and 2 suggests greater variability in gaze durations, including more frequent occurrences of prolonged gazes. This contrasts with activities like Activity 5 or 6, where students primarily engage with the learning task itself rather than interacting directly with the teacher or their peers.

These findings suggest that teachers' gaze behavior may vary depending on the type of pedagogical activity, at least in terms of general trends.

Additional calculations allow for a deeper understanding of teachers' gaze behavior, both in relation to specific activities and across different classroom environments.

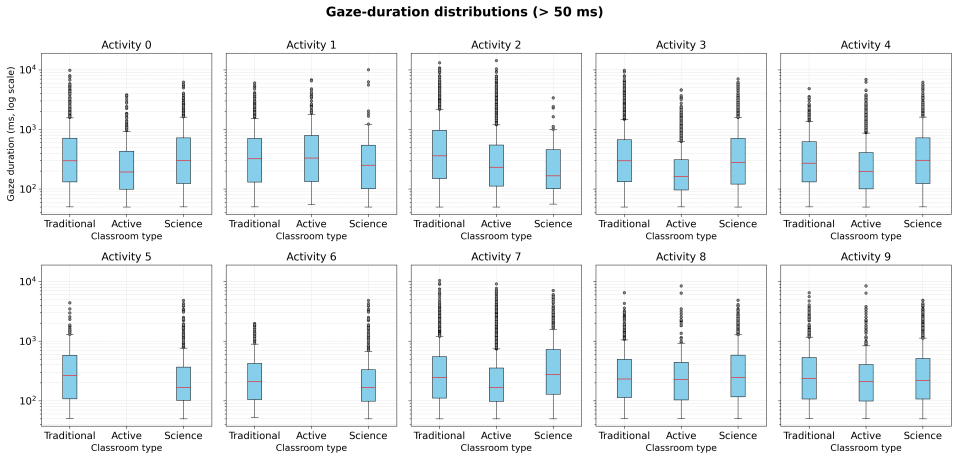

Figure 4 Teachers' gaze distribution per activity (activities 0 to 4 for the first figure and activities 5 to 9 for the second figure) and classroom layouts, on a logarithmic scale. Activity 0 = LST ; Activity 1 = SP, Activity 2 = OAS, Activity 3 = TSI, Activity 4 = CC, Activity 5 = SGW, Activity 6 = HT, Activity 7 = TD, Activity 8 = ISW, Activity 9 = MSW

The analysis includes only gaze episodes longer than 50 milliseconds. The box (interquartile range) in the boxplots contains 50% of the gaze durations. Results observed in figure 4 indicate that gaze durations in active classrooms are generally shorter, which may reflect the more decentralized and student-driven nature of interaction in such settings, but more active in activity 2 (OAS).

Science classrooms exhibit more heterogeneous patterns: for some activities (e.g., Act. 2, 4, 5, 6, 7, 8 and 9), gaze durations are comparable to traditional classrooms, possibly reflecting focused observation during experimentation or student manipulation of materials.

These results suggest that classroom layout and pedagogical activity interact to shape gaze behaviors, with traditional formats supporting more prolonged gaze episodes, especially during teacher-led activities.

4.2 How Does Gaze Behave According to Different Classroom Spaces?

With classroom layout considered as an environmental variable, this study aimed to better understand how teachers' gaze behavior varies across different classroom spaces. Each participant conducted teaching sessions in two different spaces (see Table 1). The descriptive data showed in Table 2 do not suggest a significant effect of classroom layout on participants' visual behavior; heatmaps were generated to provide a more detailed view of gaze distribution in relation to spatial configurations.

Heatmaps illustrate where the teacher was looking during the lesson, as seen from the video recording. Each dot represents a moment when the teacher's gaze was detected on screen, that is, the location in the classroom the teacher was looking at, from the camera's point of view. All gaze points were combined to generate a heatmap (with pixel-based coordinates on both the vertical and horizontal axes): yellow areas indicate zones most frequently looked at, while blue areas indicate less frequent gaze targets. To enhance readability, a smoothing technique (Gaussian kernel density estimation) was applied to highlight the most focused regions.

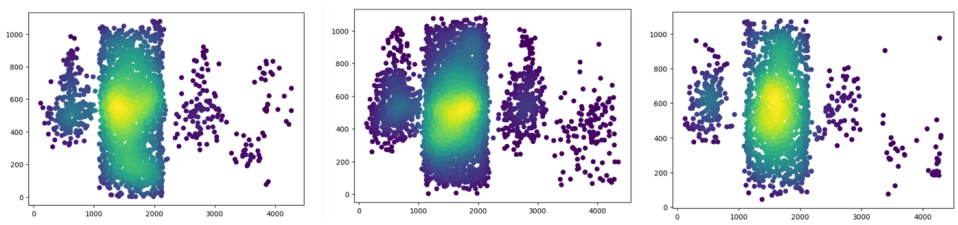

Figure 5 Some heatmaps of Gaze distribution of participants 1 (video 4 and 5) and 2 (video 10) during their teaching in traditional classrooms. Each point represents the capture of the relative position of the teacher gaze during the lesson. A Gaussian kernel density estimator was used to highlight most frequent looked regions (in yellow)

Figure 5 represents the heat maps of gaze distribution of the three participants (participant 1 on the left and middle and participant 2 on the right), during their teaching lessons in traditional classrooms.

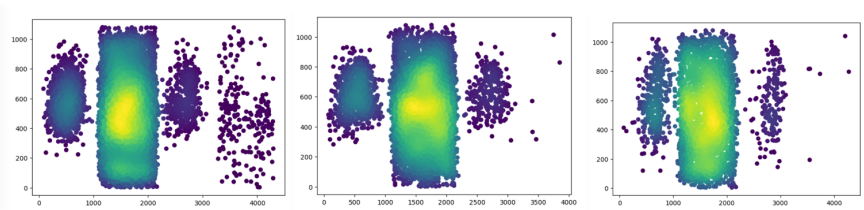

Figure 6 Some heatmaps of Gaze distribution of participants in science classroom. Each point represents the capture of the relative position of the teacher gaze during the lesson. A Gaussian kernel density estimator was used to highlight most frequent looked regions (in yellow)

Figure 6 shows gaze distribution of participant 2 (video 5, 6) and 3 in the science classroom (video 16) and indicates that most of the visual activity takes place in front of the participant, followed by activity on his left and a visual scan from close to distant looks.

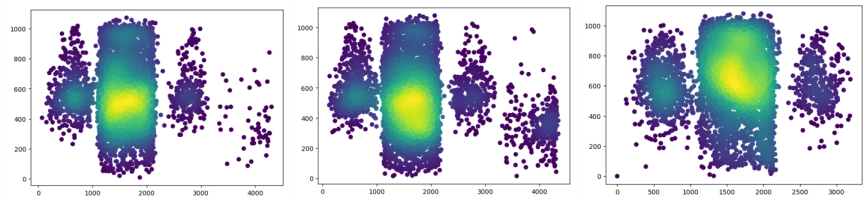

Figure 7 Some heatmaps of Gaze distribution of participants in active classrooms. Each point represents the capture of the relative position of the teacher gaze during the lesson. A Gaussian kernel density estimator was used to highlight most frequent looked regions (in yellow)

Figure 7 shows gaze activity of participant 1 (video 1 and 3) and participant 3 (video 14) in active classrooms. The data indicate that most gaze fixations tend to be concentrated in the area directly in front of the participant. Although some horizontal scanning behavior is observed, it appears to be less pronounced compared to the other two classroom layouts.

Although all participants direct their gaze primarily in front of them and slightly toward the left rather than other zones, the heat maps tell us that the active classroom involved more looks concentrated in front of the participant, while the science or traditional classroom involved more sweeping up and down. This can be explained by the different layouts of the furniture in each space. Tables in the active classroom are more centered in the space, and in the other classrooms, tables generally occupy the entire class space. Thus, as a result, these layouts may encourage broader gaze sweeps across the physical environment.

4.3 Are Participants Tended to Look More in Specific Classroom Zones During Teaching?

Heat maps only give us a general comprehension of gaze distribution according to classrooms but cannot offer a detailed understanding. To better understand how participants' gaze behaves in each classroom, we generated three graphs according to each layout. The recordings from the same spatial configurations were grouped together. Frequencies and durations of looks were determined based on the size of students' faces according to the position of teacher in the class when he is facing his students in front of the board (see Figure 2).

Sizes of students' faces were used to determine three symbolic zones inside the space (in pixels), according to their proximity with teacher:

- Close zone: 1500 (px) and more
- Middle zone: 1500 - 700 (px)
- Far zone: 700 (px) and less

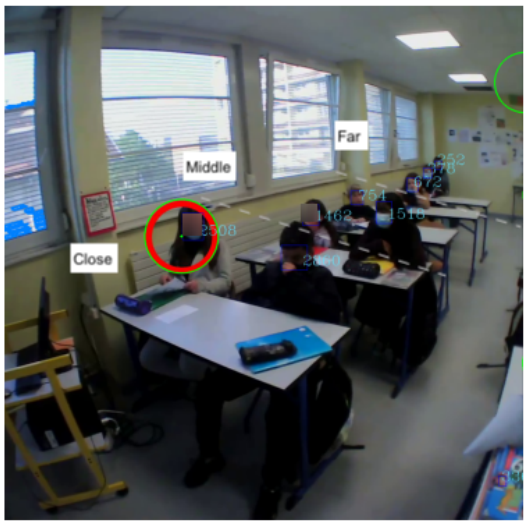

Figure 8 Three different areas determined in classrooms, Close, middle and far sections represented within dotted lines display an example of the sections used.

The following graphs show the standardized distribution of sizes of faces observed by teachers in each classroom (based on the delimitation inside the classroom proposed in Figure 8). Participants' movements were also taken into account in this analysis. In this example, teacher is close to the board, but symbolic zones are style adopted according to pixels size when teacher is moving inside classroom.

We expect teachers to tend to look further away from them, that is, in the "Far" symbolic area from them, based on (Lotfy, 2012; Wannarka & Ruhl, 2008) studies.

For each graph, the x-axis corresponds to the size of the students' faces and the y-axis to the number of faces looked at (in terms of frequency normalized to 1, on a teaching session) according to the position of teachers.

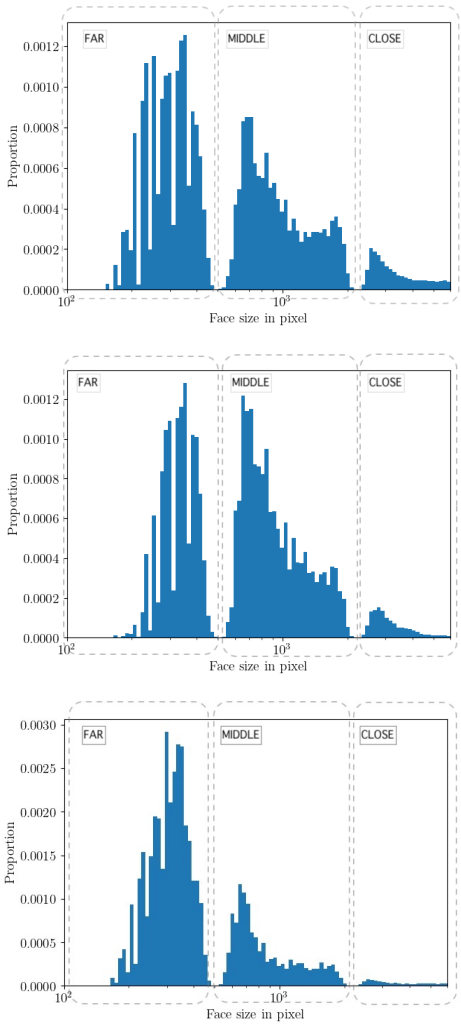

Figure 9 Classroom proportion of gaze activity represented for traditional, active, and science classrooms, the 3 regions explained before are clearly represented

Data from the different graphs indicate the presence of unequal viewing areas within each class space and allow us to distinguish three different areas of gaze activity inside classrooms. Each of these zones corresponds to one of the previously delimited areas of interest (refer to Figure 8): that is, an area close to the teacher ("Close"), a zone far from the teacher ("Far"), and an intermediate zone ("Middle"), located between the other two areas of gaze activity, according to teacher position.

Moreover, regardless of classroom layouts, participants tend to look more frequently at students' faces in the "Far" zone, followed by the "Middle" zone, compared to the "Close" zone, which includes significantly fewer views from participants. These elements indicate that

independently of classroom layouts, teachers tend to look more frequently at their students placed at a middle and far distance from them. The "Close" area involves the fewest facial looks and thus less visual interaction with students.

5 Discussion

The aim of the article was to explore how teachers' gaze behaved toward their students depending on different classroom layouts and activities occurred in these pedagogical environments. The focus of this study was to determine how variables of classroom (as classroom spaces, activities) influence teachers' gaze behavior, in real teaching situations.

Many results can be discussed in this section.

The study suggests that teachers' gaze behavior cannot be understood solely in direct relation to the physical classroom environment, but must instead be considered in interaction with multiple variables, including both spatial layout and pedagogical activity.

Indeed, the findings indicate that gaze behavior during teaching is not primarily driven by classroom configuration, but rather by the nature of the activities taking place within each setting. Specifically, teachers tend to fixate on students for longer periods during whole-class exchanges or interactive formats, such as lecture style teaching or oral assessment situations, while shorter gaze durations are observed during individual or small-group work activities. In fact, results observed indicate that teachers tend to look their students on a longer period in activities involving a whole-class exchange or interactive formats between teachers and students (as Lecture Style Teaching or Oral Assessment situations) and tend to look their students on a short period in activities where students are focused on individual or small group work. These results align with expectations on the nature of the instructional activities. The results suggests that spatial context alone does not significantly determine gaze behavior, at least with regard to the duration or frequency of face-directed gazes. However, further analysis indicate across most activity types, gaze durations tend to be longer in traditional classrooms, shorter in active classrooms, and more variable in science classrooms. These patterns are further supported by the heatmaps, which show broader vertical scanning (i.e, up-and-down gaze movements) in traditional and science classrooms, whereas gaze in active classrooms appears more concentrated in the central field of view, directly in front of the participant.
Additionally, a greater frequency of face looks is observed in traditional classrooms (a peak of looks for faces with an approximate size of 1500 px) (see 8). This peak can be explained by the arrangement of tables in rows that tend to be less centralized than those of other class arrangements. This element also joins the scan data shown in table 2 and the heat maps. Still in this area, the graphs also indicate that the traditional space and the science classroom have implied a closer look than in the active classroom (that is to say, face looks going beyond 1800 px). Indeed, the participants mainly moved within the framework of these class spaces, which involved many movements on the part of the participants and physical proximity to students.

In light of our data, the spatial layout may influence how visual attention is distributed across zones (e.g., near, middle, far) according to student position, or interact indirectly with activity type. The important part of looks in the symbolic "Far" zone from the position of the teacher, can be explained by the presence of more disruptive student behavior in this area compared to their peers sitting close to teacher (Lotfy, 2012; Wannarka & Ruhl, 2008), or

according to his position in the class. This element could be explained by the distance between teachers and students, may allow greater freedom of behavior and consequently prompt more frequent gaze checks from the teacher to maintain control and support task engagement. The symbolic "Middle" zone also received a substantial number of face-directed gazes, though less than the "Far" zone. A noticeable peak in gaze activity was observed in the transition area between the "Middle" and "Far" zones. This suggests that students seated in the central region of the classroom, typically the second or third row (depending on teacher position and room layout) were looked at less frequently than those seated farther away or at a farther distance from the teacher. Students located in the symbolic "Close" area (dependently with the teacher-student proximity) received the fewest face-directed gazes and thus less visual interaction on the part of participants. Although this result may seem counterintuitive, this area correspond to the "T zone" (Holland et al., 2017; Howe & Abedin, 2013; Huang, 2011; Jong, 2017; Smidekova et al., 2020) or the "golden zone" described by (Park & Choi, 2014). This area of the classroom space is generally preferred by students and corresponds to the zone where they are more likely to participate and engage in verbal interaction with the teacher. These students also tend to be more focused on learning tasks and exhibit fewer disruptive behaviors, which could explain the results obtained. Additionally, other interesting results indicate that teachers tend to look more in front of them and to their left. These findings is consistent with prior research on human gaze bias (Byeon & Kwon, 2023; Guo et al., 2009). A positive correlation was also observed between the frequency of face-directed gazes and their average duration, suggesting that teachers who look at their students more often also tend to sustain those gazes for longer periods. These observations resonated with works on the importance of gaze between teacher and students to support learning and the perception of a positive and quality teacher-student relationship (Jiang et al., 2017; McIntyre et al., 2017; Mitchell & Marin, 2015; Montello, 1988; Noddings, 2003; Prieto et al., 2017; Van den Bogert et al., 2014).

Nevertheless, this study has some bias that should be acknowledged. In fact, the sample of participants is not sufficient to generalize the results but allows us to have an idea of the distribution of the gaze according to different contexts, in a research area that remains relatively underexplored. Moreover, even if the majority of looks are present in the "far" and "middle" zones, it is important to note that these predefined spatial zones were established based on the physical distance between the teacher and the students' faces, and thus reflect their seating positions within the classroom. However, no element specifies whether the table layout is proportionally established in the physical space of the class (for instance, data peaks in the "Far" zone may also be part of the center of the classroom). Moreover, teachers moved during the sessions and even if we have information about teacher mobility during session, the use of an alternative methodology collecting precise distances between teachers and students during sessions could be established to analyze these movements also with regard to visual data.

Furthermore, only the distribution of participants' gaze horizontally in the space was analyzed (front to back or vice versa) while vertical gaze movements were not considered. These aspects could also provide valuable insights into how teachers' visual attention is distributed within different classroom environments. Finally, it would be interesting to also take into account verbal interactions between the teacher and students during the sessions, which would help deepen our understanding of the dynamics of visual interaction that occur during teaching.

6 Conclusion

Our work aimed to understand teachers' gaze behavior in their practice, according to different classroom layouts, through a quantifiable non-verbal method. To this end, we used eye-tracking techniques to follow their gaze behavior in a teaching context according to three different classroom layouts. Major results indicated that gaze average and duration seem not to depend only on classroom layouts but rather on the interaction between activities carried out during the lesson and the classroom environment, depending on the physical location of pupils in relation to the teacher. Nevertheless, classroom layouts may still shape how teachers' gaze attention is distributed across the classroom and should be considered in relation to the types of activities conducted, in order to promote an equitable distribution of gaze across all students.

Even if future studies should be conducted, our study tends to suggest that the physical location of pupils in relation to the teacher (inside a classroom) and activities are more decisive than the spatial organization of the class in explaining the teacher's gaze behavior during lessons. Nevertheless, classroom layouts can facilitate a more centered viewing area or a more vertical scan. Moreover, another result indicates that independently of classroom layouts, teachers tend to look more frequently to their left, which can be explained by a human gaze bias.

This study contributes to the growing field of naturalistic eye-tracking in education by showing that gaze behavior is context-sensitive, task-dependent, and partially shaped by spatial positioning but not deterministically so. It bridges cognitive theories of attention with real-world teaching practices and opens doors for designing classrooms and training teachers with a better understanding of visual engagement.

Declarations

Conflicts of interests. Authors declare no conflict of interest.

Ethics approval and consent to participate. Consent of all participants as well as pupils parents were collected before the start of the study.

Data availability. Data as well as codes used in this work are available upon request

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