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Visual attention in mathematics classroom: use of eye-glass cameras

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Abstract: Engaging with students and building rapport is critical for teachers in order to teach classes, communicate core concepts and emotionally connect with their students. This paper reports on a study that was conducted in a primary school in Santiago, Chile where a sample of 6 selected students (3 boys and 3 girls) wore a mini video camera mounted on eyeglasses in their Mathematics and English lessons. Using google images, frames from the recordings where the classroom teacher appeared in the students' visual field were captured automatically and objectively. The results show that there was a difference in visual engagement of boys and girls at different times of the lesson. Additionally, boys and girls displayed different patterns of visual engagement in their Mathematics and English lessons. Participants paid significantly more attention in their Mathematics lessons compared to their English lessons.

Keywords: visual attention; engagement; classroom interaction; nonverbal communication; eye gaze.

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1 Introduction

With the recent rise in the use of wearable devices, practical functionalities from technology is viewed as a problem-solving process in different fields such as education that increases the efficiency of people more objectively (Genç et al., 2017). The visual communication that takes place in classrooms interactions are important social phenomenon. The ways in which a teacher interacts with his or her students are fundamental for building rapport. Classroom interaction and rapport building are important elements of patterns of social relationships, which traditionally are not considered to have an important role in educational processes. Traditionally, the notion of classroom interaction has received less attention and often ignored in educational research. However, with an increased importance of audio-visual devices for converting the projection process from real-time images and sound manipulations into a highly expressive device, the interface can be used for generating and facilitating a creative process which is not only important in technological and industrial fields, but it also involves wider and deeper implications for sectors such as education to explore teacher-student interactions within a classroom.

Traditionally patterns of classroom interaction have been explored descriptively where a camera is placed on a tripod at the back of a classroom. While descriptive analysis of visual communication can aid educators and researchers to better explore new meanings and new ideas (Morgan, 2018), the data in this method is mainly captured from a third person's perspective, which, intends to describe the interactions between the teacher and students and students themselves. The third person's perspective signifies that the data is emerging from neither the teacher's nor the students' perspectives, but from a video camera, an unanimated object whose presence is not natural in the classroom setting. In this study, we propose to incorporate a first-person perspective. To have this first person's perspective, mini video cameras were installed on students' eyeglasses to record emerging interactions within the classroom. Eyeglasses are widely used technological devices, that have recently been used in educational research.

Visual technology can provide new opportunities to detect subtle but important patterns in classrooms (Farsani et al., 2021). These eyeglasses enable researchers to record and revisit events that student observe and perceive from their own particular standpoint, which is a first person's observations. This involves activities such as what is being written on the blackboard or on the students' notebooks, gestures and nonverbal communication, and how much visual attention each student pays to the teacher or other students.

In this paper, we argue that the first-person video recording is an add-on to the regular classroom observation that can enhance interactions between the teacher and their students. As an example of such enhancement, we present results on visual attention of a female English teacher with two years of teaching experience and a male teacher with 10 years of teaching experience in a public school in Santiago, Chile. Using data obtained from mini video cameras mounted on eyeglasses worn by students, we found interesting patterns of interaction that were captured through students' eye-glass cameras. Students' visual attention throughout the 90 min lesson were displayed.

An important aspect of teaching is its multi-modal nature (O'Halloran, 2005; Flewitt, 2006). 'Mode' is a socially shaped and culturally given resource for making meanings (Kress, 2009). Different modes, such as writing, layout, gesture, and visual images, are an important part of meaning-making (Kress and Van Leeuwen, 1996). However, modes can

also be non-visual, such as speech, soundtracks, voice, and music. Furthermore, researchers have also focused on other social semiotic modes, such as colour (Kress and van Leeuwen, 2002), gesture and movement (Kress et al., 2001; Rosa and Farsani, 2021), gaze (Bezemer, 2008), and proxemics (Hall, 1966). In particular, these previous studies have looked at the importance of such modes when it comes to meaning making in different social interactions, cultural contexts and classroom practices. Visual attention is one of the most important aspects of non-verbal communication and it plays a hugely significant role in engagement and learning (Rosa et al., 2020). Nonetheless, to date very little methodological tools are developed to objectively and automatically measure visual attention in hope of measuring and assessing visual engagement.

2 Methodology

Although using video recordings in research is relatively new, visual methods have long been a part of research. Darwin (1872) was among the very first researchers to incorporate visual methods in order to explore areas of nonverbal communication. He used a still camera as a tool and method to record facial expressions in men and animals. While a video (a collection of moving images) is an extension of still images, the data captured by video recording gives the researcher a unique opportunity to understand dynamic events within their spatial-temporal context. Replaying what has been captured in a video recording has the advantage of reviewing the materials by slowing down observations which can enhance the focus on a variety of dynamic events (Webber, 2008). This can include the study of proxemics (Collier, 2001), kinesics (the study of communication and body language) (Hockings, 1995) and conversation analysis (Goodwin, 2001).

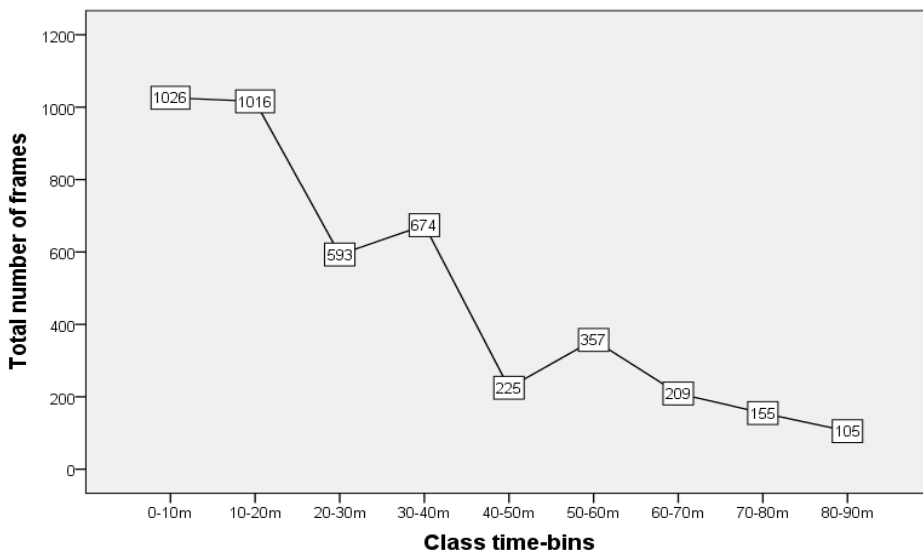
For the current research, six selected students (three boys and three girls) wore a mini video camera mounted on eyeglasses in their Mathematics and English lesson for a period of 9 h. These students had previously used the cameras on a trial basis to ensure that the experiment did not appear to them as a surprise and that the experiment took place in a natural setting. The average age of these six students was 10.5 years old. Capturing the live interactions through the mini camera mounted on students' eyeglasses allowed capturing everyday interactions and meaning-making practices from the students' own perspective. The original eyeglass lenses were removed to minimise the weight and to facilitate the original view. Each lesson lasted 90 min long and each student had to wear the eyeglasses for the full duration of the lesson. The idea of using gaze as a medium for analysing the learning processes is of interest to many researchers. In this paper, we will pay particular attention to the importance of the first person's viewpoint, something that traditionally not has been paid a great deal of attention to. By mounting cameras on students' eyeglasses, we were able to compute and obtain a better perspective of the class, as observed by the student. At the end of each day, the recordings were manually downloaded onto a computer. The video cameras had a recording quality of thirty frames per second (30 fps); for each video, a frame was sampled every second and processed in order to detect the presence of the teachers' faces. Google images were used to automatically detect teachers' faces through all the obtained frames. In total, 32,400 frames were obtained from the six students. This automatization images processing saved us time enormously in going through each frame at a time manually. Once the software had recognised teachers' face in all these frames, we then

searched for those particular frames to identify the agent (which student was looking at the teacher?), the subject matter (was it in the Mathematics or English lesson?), and the time period (was it at the beginning of the lesson or at the end?).

3 Results and discussion

Figure 1 shows students' visual attention during the 90 min lesson divided in nine consecutive 10 min period (Class time-bins). It is not surprising to note that students' visual attention tends to drop by almost 90% towards the end of the lesson. It appears that within the first 20 min, students were visually very engaged with the teachers' instructional information. What appears to be of particular interest is 40–50 min, there was a sudden fall in students' visual attention and their engagement. This is consistent with research highlighting the increase in the attention of students at the beginning of a lesson and the decrease towards the end of the lesson (Bradbury, 2016). Although students' attentional skills improve with age, little is known about the factors and strategies to develop students' ability to pay attention throughout the lesson time (Merritt et al., 2007). Further research exploring the strategies schoolteachers could use to develop students' attention span would be required to strengthen the quality of the conclusions that are drawn from these results.

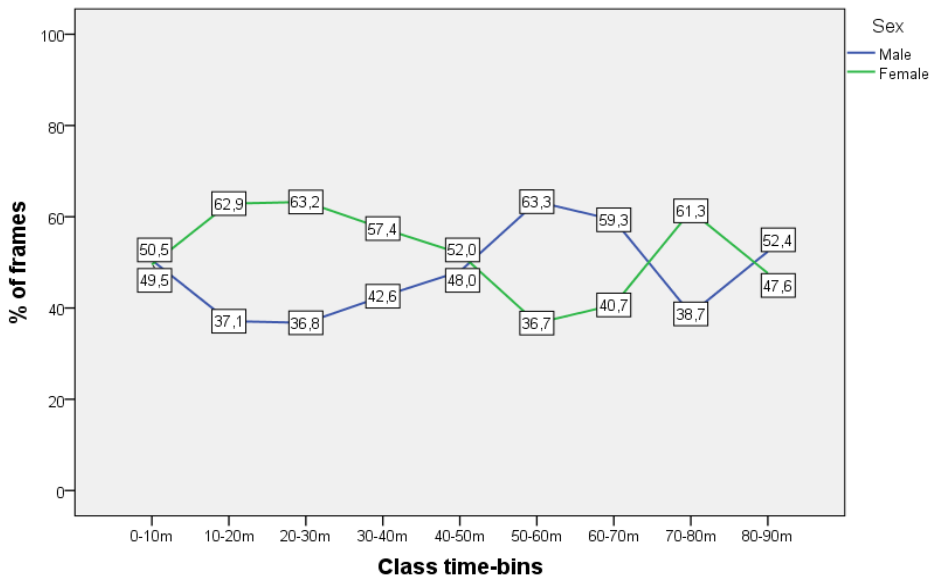
Figure 1 Students' visual attention during the 90 min lesson (see online version for colours)



We were further interested in examining to what extent gender influenced students' visual attention throughout the lesson. Figure 2 shows an interesting pattern that the visual attention of these six students are inversely proportional. It appears that in the first half of the lesson, girls are more actively engaged by paying more visual attention to the teacher. It is interesting to note that that around 40–50 min, the students reach an equilibrium point when they are equally visually engaged, one possible reason for the equilibrium point could be the type of the activity being introduced by the teacher at this

point engaging all students equally. There is much debate on gender differences in visual attention skills with females showing less sustained visual attention compared to their male counterparts (Merritt et al., 2007); however, for the current research the gender differences in visual attention could be related to the cognitive gender differences between females and males in subjects such as Mathematics (Good et al., 2008). Another possible reason for students’ lack of visual attention at parts of the lesson could be the mechanism of selective attention and students’ decision to inhibit their visual attention (Merritt et al., 2007) due to tiredness or the type of activities being presented by the class teachers.

Figure 2 Visual attention of male and female students (see online version for colours)

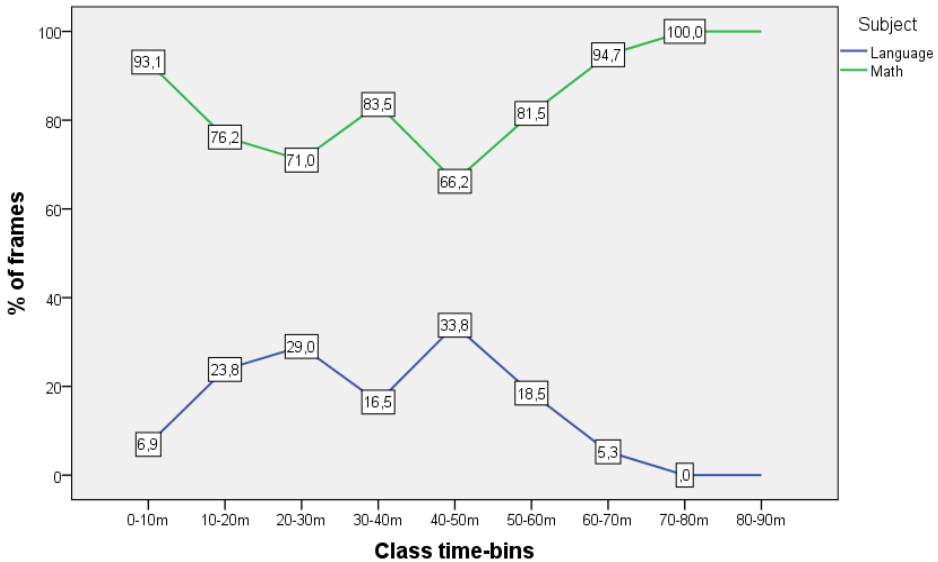


Finally, we were interested to investigate how students’ visual attention can vary depending on different subject being taught. Figure 3 illustrates different role that English vs. Mathematics have in students’ visual attention and their visual engagement in their lessons.

Results show there is a difference in the visual attention at the start of the lesson with data for the Mathematics being significantly higher at the first 10 min of the lesson; however, this trend does not continue throughout the lesson time as results fluctuate for both subjects. While 40–50 min into the lesson, the data for the Mathematics lesson reach the lowest point, the English data achieve the highest value. In contrast, the last 40–50 min of the lesson involve increase in the visual attention for the Mathematics lesson while the English data constantly decrease to reach the lowest point at the end of the lesson. The issues with attention deficit towards the end of the lesson time has already been highlighted in the study of students’ attention span (Bradbury, 2016); however, questions remain as why students’ visual attention in the Mathematics lesson does not follow this trend. While the increase in the attention could be related to the teaching methods in the Mathematics lesson improving students’ engagement towards the end of the lesson, further research will be required to investigate other factors influencing

students' visual engagement; for example, further research investigating students' attitude towards STEM subjects compared to Languages can illuminate possible causes for this variation.

Figure 3 Students' visual attention in English and mathematics lessons (see online version for colours)



4 Conclusion

This paper reports a study that was conducted in an upper primary school in Chile where a sample of six selected students wore a mini video camera mounted on eyeglass. Our results show that the ways in which students were visually engaged with the teacher was dependent on the time of the lesson (e.g., beginning vs. the end), students' gender (being a boy vs. girl) and the nature of the subject they were studying (Mathematics vs. English). There was a significant main effect of subject, where students paid particularly more visual attention to the teacher in their Mathematics lessons and not so much in the English lesson. Students were more significantly attentive and visually alert in the first 20 min of their lesson than towards the end of their lesson. Furthermore, girls and boys appeared to have distinct forms of visual patterns throughout the lesson.

Additional research is required in order to further scrutinise the visual and nonverbal multimodal exchanges that takes place not only in the Chilean classroom contexts, but in other cultural contexts with different values on e.g., STEM subjects. Furthermore, as educators, we strongly believe that regardless of a teacher's experience, it is always worth questioning the forms, styles and the quality of the messages that are conveyed verbally and nonverbally in professional teaching practice (Rosa and Farsani, 2021). We believe that optimisation of these very subtle and silent nonverbal messages can have a direct positive impact by not only visually engaging students, but also on the teaching and learning process. One recommendation and practical application is to incorporate

nonverbal training in teacher education courses both for pre-service and in-service teachers, in order to raise knowledge and awareness of the communicative function of nonverbal language.

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