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Non-Verbal Interaction and Students' Visual Engagement in Mathematics and English classes

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ABSTRACT

Background: The interactions in the classroom are of particular interest to the teaching and learning processes. **Objectives**: This study examines nonverbal interaction in mathematics classrooms, and how different modes of nonverbal behaviour, contributed to the engagement in lessons. **Design**: A quantitative study. **Setting and Participants**: 30 randomly selected students wore mini camera-mounted eyeglasses in their mathematics and English lessons. Approximately 45 hours of video recording were made from these cameras (from a first-person's perspective) to analyse and compare the nonverbal interaction in mathematics and English lessons. **Data collection and analysis**: In Google Images, we objectively searched and statistically analysed frames in which the class teachers appeared within the students' visual field. **Results**: The results show that how students are visually engaged with the teacher depends on a set of proxemics. Differences were found related to visual attention both regarding the subject matter and the different proxemics of the student in relation to the teacher, pointing out that students are more visually involved with the teachers' instructions when at a proxemic of 1.20 to 3.70 meters. Furthermore, we report differences between boys and girls and how they are visually engaged in their mathematics classrooms. **Conclusions**: Finally, we report how teachers pointing gestures can serve as a tool to recapture students' visual attention in mathematics classrooms.

Keywords: Non-verbal interaction; Visual engagement; pProxemics; Math and English classes; Mini camera.

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Interação Não-Verbal e Envolvimento Visual dos Estudantes nas Aulas de Matemática e Inglês

RESUMO

Contexto: As interações em sala de aula são de particular interesse para os processos de ensino e aprendizagem. **Objetivo**: analisar como os diferentes modos de interação não-verbal contribuíram para o envolvimento visual dos alunos nas aulas de matemática e inglês. **Design:** estudo quantitativo. **Ambiente e participantes**: selecionou-se, aleatoriamente, quinze alunos do sexo masculino e quinze do sexo feminino, os quais, usavam uma minicâmara acoplada em óculos de lente que gravou quarenta e cinco horas de videoaula. **Coleta e análise de dados**: usando o *Google Images*, buscou-se de forma automática e objetiva registros das gravações em que os professores da turma apareceram no campo visual dos alunos, as quais foram analisadas estatisticamente. **Resultados**: os resultados mostram que a maneira pela qual os alunos estão visualmente envolvidos com o professor depende de um conjunto de proxêmicas. Por um lado, encontraram-se diferenças relacionadas à atenção visual tanto em relação à disciplina que os alunos estão aprendendo quanto às diferentes proxêmicas do aluno em relação ao professor, apontando que os alunos estão mais envolvidos visualmente com as instruções dos professores a uma proxêmica de 1,20 a 3,70 metros. Por outro lado, relatam-se diferenças entre meninos e meninas e como eles estão visualmente envolvidos em suas aulas de matemática e inglês. **Conclusões**: conclui-se que os gestos de apontar realizados pelos professores podem servir como uma ferramenta para recuperar a atenção visual dos alunos nas aulas de matemática e inglês.

Palavras-chave: interação não-verbal; atenção visual; proxêmica; aula de matemática e inglês; minicâmara de vídeo.

INTRODUCTION

Classroom interactions are particularly interesting, especially in science, technology, engineering, and mathematics teaching and learning (STEM) (O'Halloran, 2005; Rosa & Farsani, 2021). Studies carried out by Planas and Iranzo (2009) and Falsetti and Rodríguez (2005) focused on analysing how interactive processes occur in mathematics classes. In this article, we examine different dimensions of interaction, particularly those of non-verbal nature, such as proxemics, which traditionally receive less attention in educational research. Albert Mehrabian, an Iranian-American of Armenian descent, was the first theorist to study the meaning of non-verbal characteristics of communication in an interactive process. During the 1960s and 1970s, Mehrabian (1971) examined verbal (what is said), vocal (how something is said), and visual (gestures, space, and other nonverbal characteristics) communication and how each of these aspects contributed to creating meaning between interlocutors.

Over the past two decades, researchers have focused on classroom interactions, particularly on social semiotic modes such as writing, drawing (Kress & Van Leeuwen, 1996), and colour (Kress & Van Leeuwen, 2002). Special attention was given to the non-verbal aspects of communication in the processes of meaning creation, including examining multimodal processes (Adami & Swanwick, 2019) of gestures and movements (Farsani, 2015a; Radford, Edwards, & Arzarello, 2009; Kress et al., 2001), posture (Brey & Shutts, 2015; Inagaki, Shimizu & Sakairi, 2018; Zahry & Besley, 2019), gaze (Araya, Farsani, & Hernández, 2016; Farsani & Villa-Ochoa, 2022; Holsanova, Rahm, & Holmqvist, 2006), nod (Smith-Hanen, 1977), and shoulder orientation (LaCrosse, 1975). However, few studies have focused on proxemics in classroom research (Collier, 1983), particularly in mathematics classes (Farsani, Breda, & Sala, 2020). Furthermore, few methodological tools have been developed to measure and evaluate students' visual engagement objectively. This article will pay special attention to the importance of the first-person point of view. By installing micro cameras in the students' glasses (Figure 1), we can calculate and obtain a better perspective of the interaction in the classroom from students' direct observation.

Figure 1

Mini camera mounted on students' glasses.

This article explores the subtle changes in teachers' non-verbal behaviours that affect students' visual engagement. In particular, we propose to examine where in the classroom and at what specific distance students are likely to be more or less visually engaged with the teacher. We also want to explore the differences between these variables for boys and girls and math and English classes. Finally, we examined how teachers' instructions using pointing gestures affect student engagement in math classes. To our understanding, there is a gap in the literature. Zahry and Besley (2019) recently noted that future research needs to respond to identifying visual cues (e.g., gaze and space) that most attract students' attention.

LITERATURE REVIEW

In the following subsections, we present the literature on gestures — mainly pointing gestures— and the notion of proxemics, the personal space of individuals in a social environment.

2.1. Pointing gesture

Gestures were categorised into four groups: iconic, metaphorical, tapping, and pointing. Each form of gesture has a different function in human communication (see McNeill, 1992; Khatin-Zadeh, 2022a; 2022b). Pointing or performing deictic gestures are one of the basic categories defined by McNeill (1992) that are manifested by the spatiotemporal movements of the body. Pointing gestures are used when interlocutors connect the verbal to the visual, indicating objects, locations, and inscriptions that are present or not in the environment. These gestures do not convey perceptual or action information and can be produced independently of their speech unit (Norris, 2011). Pointing can be performed in different ways and use different types of materials. For example, pointing gestures are often made with an extended index finger, whereas they can sometimes be made using an object (for example, a pen or a laser pointer).

Interestingly, different body parts can also be used for pointing, such as the head, lips (Enfield, 2001), and eyes (Wilkins, 1999). The pointing gesture can also be made using an open hand gesture, with the hands up or with a vertical palm. In all cases, each gesture has a distinct meaning in speech (Kendon & Versante, 2003; Kendon, 2004). The open-hand gesture and palm-up are perceived as non-threatening (Givens, 2016), while pointing is often considered threatening and seen as "highlighted" (Andersen, 1999). Pointing fingers are often used to "command or accuse"; in contrast, palm-up open hand gesture "constitutes a surface rather than a line, a gift or an offering. They are polite rather than imperative designations" (Calbris, 1990, p. 128).

Teachers also use pointing gestures in class as a pedagogical tool. In a study, Azaoui (2015) reported two French teachers' pointing gestures to organise the classroom environment. In another study, Farsani (2015b) examined students' verbal answers when a teacher used pointing gestures and compared them to when the teacher used hands-up open hand gestures. The students' answers were longer when the teacher used the open hand gesture, while students' answers were reduced to a simple "yes" or "no" (or even a shrug) when the teacher pointed with his finger.

In recent years, there has been increasing attention to deictic gestures concerning spoken language, both outside (Norris, 2011) and inside the classrooms (Farsani, 2015a). For example, Farsani (2015a) studied two mathematics teachers working with first and second-generation British-Iranians in the UK. He observed how interlocutors made mathematical sense in multilingual classrooms using deictic gestures. For example, when imparting the mathematical concept of "isosceles" triangles to students with limited English proficiency, teachers pointed both index fingers toward the eyes while saying "isosceles". Therefore, his pointing gestures served as a mnemonic device, not only to help remember the technical mathematical term 'isosceles' but also to reinforce the concept that there are two equal sides and two identical angles (just like the eyes) in an isosceles triangle. Therefore, the teachers' use of deictic gestures in the instruction not only added clarification and richness to the spoken discourse but also promoted the memory of a mathematics record in the English language.

Because pointing gestures are ubiquitous and we interpret them so easily, pointing can be considered a trivial phenomenon (Kita, 2003). Therefore, this article aims to pay special attention to the teachers' pointing gestures. In particular, we will see how students react to these non-verbal messages. To our knowledge, no previous studies have reported how a math and English teacher's pointing gestures can affect students' visual engagement. Therefore, this study will explore the teachers' use of pointing gestures in different proxemic categories. We will now discuss what proxemics is and its four categories.

2.2. Proxemics

Proxemics, the silent study of communication, is often defined as "the science of using human space" (Hockings, 1995, p. 509) or how "people regulate themselves in space and how they move in space" (Collier, 1995, p. 235). The field of proxemics encompasses the perception, use, and framing of space. Historically, E.T. Hall (1963, 1966, 1973) and Sommer (1959, 1961) were the first to study proxemics and personal space, and their ideas reflect their theoretical background. This concept has attracted many contemporary anthropologists, psychologists, and educators. The term proxemics was coined by the American anthropologist Edward T. Hall (1963), who examined the proxemics of interpersonal communication in different cultures. He classified people's use of space and the distance they maintain with others into four categories: intimate space (up to 45 cm), personal space (up to 1.20 m), social/professional space (up to 3.70 m) and public space (more than 3.70 m). Araya and Farsani (2020) renamed them private, personal, professional, and public spaces because they refer to interactions in professional educational contexts. In this article, we will examine and raise awareness of which of the four spaces has the most significant effect on students' visual engagement in their math and English classes.

The intimate space (mothers and babies; lovers) is usually inhabited by the intimate distance presented by Hall (1963), from zero to 30 cm, where touch, smell, body heat and even faint sounds are perceived, but vision is distorted. Hall (1963) made an interesting observation regarding personal, professional, and public space. He realised not only that "space speaks" but also that people from different cultures use space in different ways in their social communicative encounters. As verbal language varies from culture to culture (Farsani, 2022), the use of space between social dyads also changes. For example, one of the authors of this article lived in three very different countries, each on a different continent (Iran, the United Kingdom, and Chile), with diametrically opposed sociocultural norms and mentalities. He immediately realised that the British, Iranians, and Chileans have fundamentally different systems of proxemics in their social and communicative encounters. What is considered a socially acceptable personal distance between social dyads in the UK may be seen as rude or even offensive in Chile.

In England, for example, it is socially acceptable to be approximately one meter (90 cm or approximately an arm's length) away from other interlocutors. In Iran, this distance is somewhat smaller (Mehrabian, 1972), while in Chile, interlocutors are even closer during their interpersonal communication. In England, the closeness between interlocutors and any gestural performance, from the "crossing of arms" to the verbal expression "turn your face away from mine", can cause individuals to show signs of discomfort. It is possible to state that the sociocultural norm of proxemic behaviour varies considerably in Iran and Chile compared to the United Kingdom. In Iran, as the interpersonal space between social dyads increases, many Iranians express their discomfort through phrases such as "I cannot feel the scent" or "I cannot feel your scent". This simply means, "I cannot feel your scent, and you cannot feel mine, so let us get closer". Due to sociocultural norms and warm Latin American culture, personal space is closer in Chile than in Iran. In Chile, it is socially rude and bad practice to keep your distance between social dyads. In such circumstances, Chileans become more aware and show discomfort when saying, “I don’t bite!”. This phrase probably reflects how close Chilean interlocutors expect each other to behave in social interactions. Interestingly, the notion of proxemics varies not only across cultures but also across individuals and situations. For example, people worldwide tend to be closer to each other on underground trains or elevators. Interlocutors also tend to get closer in noisy environments.

Particular attention has been paid not only to the role of cross-cultural communication but also to how proxemics is used in diverse public settings: transportation terminals (Remland et al., 1995), outdoor benches (Leibman, 1970), playgrounds (Scherer, 1974), sidewalks (Sobel & Lillith, 1975), queues for movie theatres and banks (Kaya & Erkíp, 1999) and shopping centres (Brown, 1981). However, there are few studies on the notion of proxemics in the school environment, which can raise important questions to think about teacher/student interactions and the role of those interactions in teaching and learning processes.

Proxemics can be seen as a resource that teachers can use as a form of disciplinary observations of unconscious and non-verbal behaviour (Farsani et al., 2021). Other researchers have examined the effects of different languages spoken by bilingual learners and the subsequent changes in their proxemics and nonverbal behaviour (Collier, 1983; Farsani, 2015a). For example, Collier (1983) showed a proxemic study demonstrating that interpersonal distance is a significant factor in classroom interaction. His detailed analysis of a video recording of a Chinese-American class showed that the medium of instruction determined particular patterns of proxemics and interpersonal space. Cantonese not only provoked a closer proxemic space between the interlocutors but also allowed significantly more turning angles (body orientation) between the students and the teacher. This created a more engaging atmosphere and increased students’ attention. Students were also more likely to communicate about class-related topics.

Farsani (2015a) took this idea a step further and analysed proxemic behaviour among boys and girls of Persian descent in the UK. He looked into the multimodal mathematical messages that British-Iranian students subconsciously send and receive. In addition, he examined the ways different languages (English and Persian) affected students’ body orientation and proxemic behaviour in classroom interaction. Students often employed English to advance the task and spoke in Persian to make jokes, manage behaviour, and engage emotionally. Therefore, Persian was a verbal trigger to increase the turning angle among students. It is possible to think about how proxemics vary according to the different roles of language in interaction. These proxemics can also be observed in relation to cultural differences between the sexes. In this regard, Farsani (2015a) observed that the girls kept closer, with a greater turning angle, while discussing ideas/tasks. The boys, in turn, maintained greater personal distance, less turning angle and less eye contact with each other. Although previous studies have shown the different effects of non-verbal language, no studies have examined so far which categories of space are likely to have the most significant influence and the strongest effects on students' visual engagement in math classrooms. Furthermore, in this article, we want to explore the differences between those variables between boys and girls and compare how they engage visually in their math classes.

METHODOLOGY

In the next subsections, we present the instruments and methodological tools used for data collection and analysis.

3.1 Instruments and methodological tools

While video recordings are relatively new in research, visual methods have been a part of it for a long time. Darwin (1872) was one of the first researchers to incorporate visual methods to explore areas of non-verbal communication. He used a photographic camera as a tool and method for registering 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 offers the researcher a unique opportunity to understand dynamic events in a spatio–temporal context. In addition, reproduction of what was captured in a video recording has the advantage of reviewing materials, slowing down observations, features that can improve focus on a variety of dynamic events (Webber, 2008). This may include the study of proxemics (Collier, 1983; 2001), kinesics —the study of communication and body language— (Hockings, 1995), and conversation analysis (Goodwin, 2001).

Recent research has shown special attention to new methods for studying visual communication and multimodal integration (Holsanova, 2012). For example, the use of eye tracking devices from the readers' real interaction with a newspaper (Holsanova, Rahm & Holmqvist, 2006). However, these studies point to disadvantages in the use of eye tracking devices. To perform medium–large samples, eye tracking devices can be expensive. For the current research, 30 selected students (15 girls and 15 boys) used mini glasses-mounted video cameras in math and English classes. In total, we obtained 45 hours of interactive recordings. It is worth mentioning that these mini video cameras mounted on students' glasses do not have the same effect as eye tracking (Boeriis & Holsanova, 2012). However, as the glasses are inexpensive and accessible, they are ideal for survey implementations, especially for medium-large sample sizes.

Those students had already used the cameras as a test to ensure that the experiment did not seem strange to them and, therefore, could occur naturally. The participants were 10.5 years old on average. Capturing live interactions through the mini camera mounted on the students' glasses allowed capturing their routine interactions and meaning-making practices from their perspectives. The original lenses have been removed to reduce weight and facilitate the original vision. Each class lasted 90 minutes, and each student had to wear glasses throughout the class.

Using the gaze to analyse learning processes interests many researchers (Araya, Farsani & Hernández, 2016). In particular, previous studies have analysed the relevance of such a method when it comes to creating meaning in different social interactions, cultural contexts, and classroom practices. Visual attention is one of the most critical aspects of non-verbal communication and plays an extremely significant role in student engagement and learning (Araya & Farsani, 2020). However, to date, few methodological tools have been developed to objectively and automatically measure visual attention to measure and evaluate students' visual engagement. In this article, we will pay special attention to the importance of the first-person point of view, which is not traditionally done. By mounting cameras on the students' eye-glasses, we could calculate and obtain a better perspective of the lesson interaction directly through the eyes of the students themselves (Araya, Farsani & Hernández, 2016).

The recordings were downloaded to a computer manually at the end of each day. Video cameras had a recording quality of thirty frames per second (30 fps); for each video, one frame was sampled every second and processed to detect the presence of the teachers' faces. In total, the 30 students produced 162,000 frames. In this article, each frame represents a second. In other words, each frame represents a photo, a "reality impression" (Jewitt, 1999, p. 21), which allows us to participate in specific moments from the students' perspective in their interaction in the mathematics and English classrooms. Of the 162,000 frames, only 6,278 contained the teachers' faces or closeness in the frames. Some frames were rejected for poor quality, but mainly because they did not include the teachers' faces (as we wanted to explore who was looking at the teacher and visually engaged). In this article, we considered only 6,278 frames for analysis.

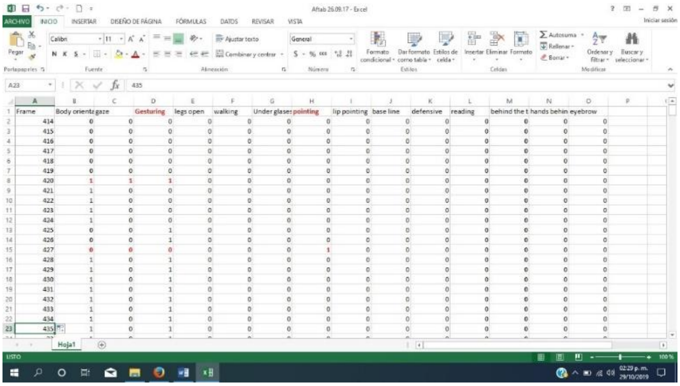
All sampled frames (each representing a second) were sent via the Google Images software. The photos on Google were used to detect the presence of faces. We have inserted photos of the classroom teacher, and Google Images automatically and objectively identified all frames that showed a teacher's image captured by the students.

We were primarily interested in cases where students kept visually engaged with the teacher. Sometimes, there were more than two faces in the same frame, for example, the teacher and another person who had just arrived late to class, in which case, we decided to discard the frame, as the student's visual attention may have been engaged elsewhere. Other times, we deliberately discarded the frames, not analysing them mainly where the frames were not very accurate or blurred, making it impossible to discern whether the teacher was looking at the student. Implementing all these stringent measures has made our interpretation of frame analysis more effective.

After Google Images detected a teacher's face on a frame —captured by the students' glasses— this board received a unique identification number. Next, it was manually examined through Excel to observe some non-verbal variables (Figure 2).

Figure 2

Examining non-verbal variables with the aid of Excel.



Frame	Body orienta	gaze	Gesturing	legs open	walking	Under glases	pointing	lip pointing	base line	defensive	reading	behind the t	hands behin	eyebrow
414	0	0	0	0	0	0	0	0	0	0	0	0	0	0
415	0	0	0	0	0	0	0	0	0	0	0	0	0	0
416	0	0	0	0	0	0	0	0	0	0	0	0	0	0
417	0	0	0	0	0	0	0	0	0	0	0	0	0	0
418	0	0	0	0	0	0	0	0	0	0	0	0	0	0
419	0	0	0	0	0	0	0	0	0	0	0	0	0	0
420	1	1	1	0	0	0	0	0	0	0	0	0	0	0
421	1	0	0	0	0	0	0	0	0	0	0	0	0	0
422	1	0	0	0	0	0	0	0	0	0	0	0	0	0
423	1	0	0	0	0	0	0	0	0	0	0	0	0	0
424	1	0	0	0	0	0	0	0	0	0	0	0	0	0
425	0	0	1	0	0	0	0	0	0	0	0	0	0	0
426	0	0	1	0	0	0	0	0	0	0	0	0	0	0
427	0	0	0	0	0	0	1	0	0	0	0	0	0	0
428	1	0	1	0	0	0	0	0	0	0	0	0	0	0
429	1	0	1	0	0	0	0	0	0	0	0	0	0	0
430	1	0	1	0	0	0	0	0	0	0	0	0	0	0
431	1	0	1	0	0	0	0	0	0	0	0	0	0	0
432	1	0	1	0	0	0	0	0	0	0	0	0	0	0
433	1	0	1	0	0	0	0	0	0	0	0	0	0	0
434	1	0	1	0	0	0	0	0	0	0	0	0	0	0
435	1	0	1	0	0	0	0	0	0	0	0	0	0	0

This manual process was performed in Excel, entering 0s and 1s (whether it did not happen versus whether it did happen), and then statistical analysis was performed to measure its importance. Besides the non-verbal variables mentioned, we also considered other non-verbal variables such as whether the teacher was using the desk as a barrier between him and the students, writing on the board, walking or standing still in the classroom. For example, we looked at frame numbers 420 and 427 taken from one student.

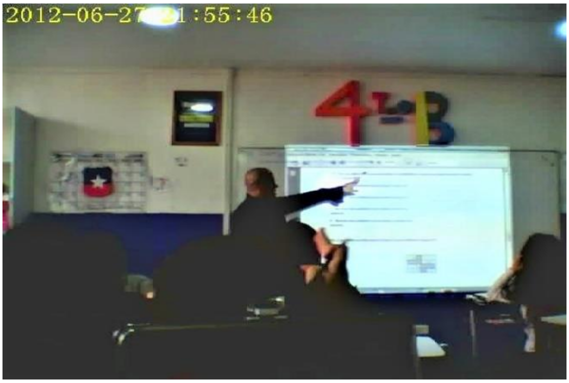
Figure 3

Watching the teacher while gesturing.

Figure 3 represents the quantitative description of frame 420 and Figure 4 of frame 427. In frame 420, we see that the teacher a) turns his body toward a specific student, b) looks at the student and c) makes gestures. In frame 427, the teacher does not seem to be looking straight at the student or leaning toward the student but pointing at something. In this work, we analysed and wrote descriptive reports of 6,278 frames, taking into account that the data gathered is primarily from a first-person perspective.

Figure 4

Watching the teacher while pointing.



We concluded the analysis by searching those specific frames to identify the agent (which student was looking at the teacher), the proximity (distance between the student and the teacher), and the period (the minute it occurred during the lesson). All those data based on the students' gaze toward the teacher were then put in binary format into Excel for quantitative analysis.

3.2. Measuring the proxemic space of the classroom

Traditionally, in the study of proxemics, Hall's proxemic scales are used to estimate distances between interlocutors in different social spaces. For example, to measure the distance between participants in environments such as playgrounds (Aiello & Jones, 1971) or doctors' surgery rooms (Noesjirwan, 1977). Video recordings allow for greater accuracy in distance measurement using predetermined calculations; for example, the distance between participants' heads and torsos was estimated at three-inch intervals (Remland, Jones, & Brinkman 1995). Other methods, such as calibrated grids, have been used in several studies to code the settlement of distances (Madden, 1999). Likewise, photographs taken in environments such as shopping malls and sidewalks were projected onto a calibrated grid to estimate the distance between people (Burgess, 1983). While slow motion video recordings and digital counters provide more accurate distance estimates than paper and pencil registers, other problems can occur when measuring distances (e.g., angle of participants in relation to the camera). Scherer (1974) developed photogrammetry, a mathematical formula to explain coding errors in relation to distance measurement, resulting from the angle of participants in relation to the camera. Recently, proxemic studies have been conducted with robots (Mumm and Mutlu, 2011; Van Oosterhout & Visser, 2008) and in virtual environments (Llobera et al., 2010).

To the best of our knowledge, there are no reports of any empirical studies measuring proxemics in real-time classroom contexts. In the proxemics analysis, we measured how far from the observer the teacher was standing or sitting (student participant). Our approach was to go back to the classroom and physically measure the distance between the side and sagittal tables (left to right and front to back, respectively). As a result, we observed that the tables were one meter apart (left to right) and 90 cm between each row (front to back). Sitting at their desks, each student used approximately 1.10 meters of space in total (front to back). Therefore, if the observer (student) were seated in the second row, in the same column as the teacher, the distance between the observer and the teacher would be approximately 2.20 m. The Pythagorean theorem was used to identify the distance between the observer (student) and the teacher and whether the teacher was standing (or sitting) in a different column than where the observer (student) was sitting. Having obtained a rough estimate of how far the observer was from the teacher, we classified each frame in terms of proxemics: private, personal, professional, and public space (Figure 5).

Figure 5

Measuring proxemics in the classroom.

ANALYSES AND RESULTS

Figure 5, presented in the previous section, shows the students' visual engagement in different categories of space. Although the students were expected to engage more in the class, from a visual perspective, when they are closer to the teacher, the results were quite different. As Farsani et al. (2020) observed, the students pay more visual attention to the professional space (P3), followed by the public space (P4), then the personal space (P2), and the private space (P1), respectively. It may not be surprising that students' visual engagement tends to decline because they may feel uncomfortable about their location in the classroom environment. Of the 6,278 frames, 3847 came from P3, which represents 61.3% of all frames. Subsequently, 1,624 frames appeared in P4, representing 25.9% of all frames. P2 and P1 were responsible for 597 and 210 frames, constituting 9.5% and 3.3% visual engagement, respectively (Figure 6).

Although students' engagement span improves with age, little is known about the factors and strategies for developing their competence to engage during classes (Merritt et al., 2007). In addition to the result presented in Figure 6, we were also interested in examining the extent to which the student's gender influenced their visual attention across all categories of space. Figure 7 shows an interesting pattern of visual engagement from these 30 students. It seems that, regardless of gender, boys and girls are equally and actively engaged, watching the teacher in the professional (P3) and public (P4) spaces. Notably, 13 frames showed that, in the professional space (P3), boys were more engaged than girls. Oddly enough, this graph also shows that girls were more engaged in closer proxemic spaces with their teachers than boys. Boys seem to be better involved visually in spaces larger than 1.20 meters.

Figure 6

Students' visual engagement in different categories of space.

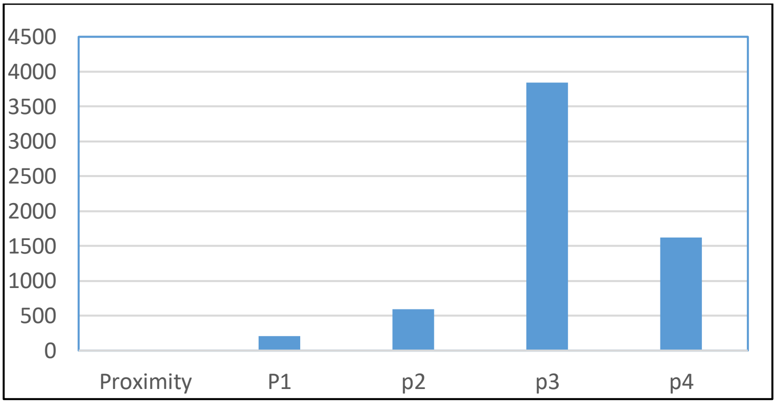
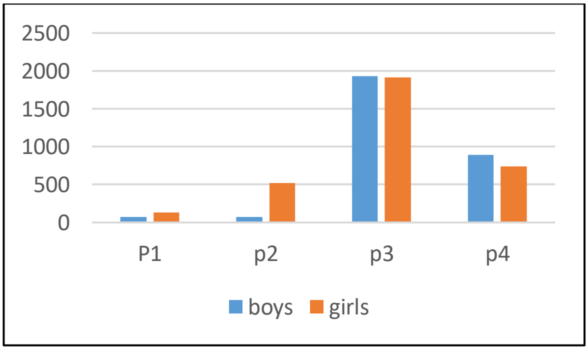


Figure 7

Differences between boys' and girls' visual engagement.



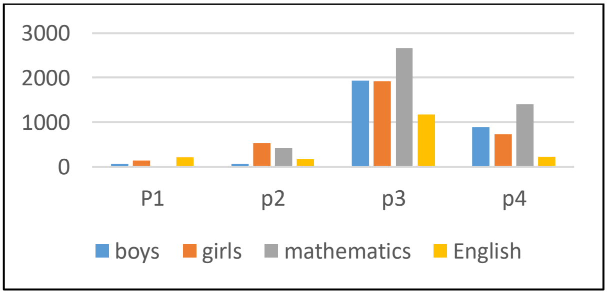
There is much debate about gender differences in visual attention skills, with women showing less visual engagement than men (Merritt et al., 2007). In this research, gender differences in visual attention have been shown to be related to cognitive gender differences between women and men in subjects such as mathematics (Good, Aronson, & Harder, 2008). However, our results do not show a significant difference in visual engagement between boys and girls.

Now, we want to focus on the extent to which the nature of the discipline (mathematics versus English) affects students' visual attention (or visual engagement). Figure 8 illustrates boys' and girls' visual engagement in different subjects (English and Mathematics), each in different categories of space. Students seem to be more visually engaged with the math teacher in more proxemics than with the English teacher. Overall, more students were visually engaged in math class than in English class. Of the 6,278 frames, 4,504 (71.7%) were taken in math classes, while only 1,774 frames (28.3%) were generated in English classes.

Interestingly, in private space (P1), only 1% and 99% of the frames were taken in mathematics and English, respectively. In personal space (P2), 71.5% and 28.5% of the frames emerged from mathematics and English, respectively. In the professional space (P3), 69.5% and 30.5% of the frames emerged from mathematics and English, respectively. Finally, in the public space (P4), 86.3% and 13.7% of the frames were from mathematics and English, respectively (Figure 8).

Figure 8

The effects of subject matter on students' visual engagement.

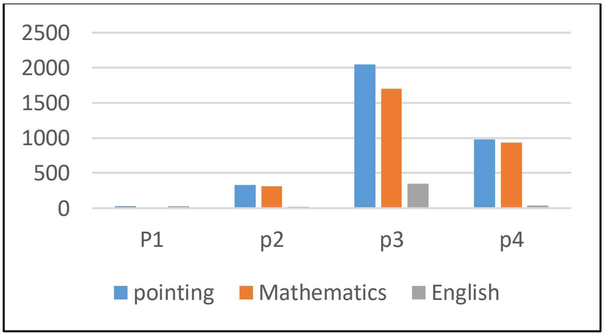


Lastly, we want to discuss the extent to which the teacher's pointing gestures attracted the students' visual attention in mathematics classrooms. Furthermore, we ask: are there critical distances at which students can benefit from the pointing gestures performed by mathematics and English teachers?

Figure 9 illustrates teachers' execution of the finger-pointing gesture in different proxemic categories, both in mathematics and English classes. In P1, there are only 32 frames with pointing gestures, all in English classes. In P2, of the 334 frames that show the teacher is pointing, 312 were in mathematics and 22 in English classes. In P3, 1,702 of the 2,048 pointing gestures (83.1%) captured engaged students visually in their math classes. Finally, in the P4 space, 938 of the 981 pointing gestures (95.6%) captured students' visual engagement in their math classes. It seems that teachers' pointing gestures can be a tool to increase students' visual engagement in math classes, particularly at a distance of 1.20 m or more.

Figure 9

Teachers' pointing gesture and its proximity to students' visual engagement.



CONCLUSIONS

This article describes a study carried out in a primary school in Chile, where a sample of 30 students (15 girls and 15 boys) attended specific classes wearing glasses with a mini video camera mounted on them to verify their visual engagement and compare them based on the teachers' gestures. Our results show that students' visual engagement with the teacher depended on a collection of proxemics. We also found differences in students' visual engagement between specific variables both in the subject matter (English versus mathematics) and the different proxemics between the students and the teacher. We conclude that there are prominent visual engagement patterns, particularly at student-teacher distances of 1.20 meters or more. We also analysed how teachers' pointing gestures could affect a student's visual engagement. Apparently, in math classes, students learn more with the teacher's pointing gestures, especially in professional (P3) and public (P4) spaces. These results corroborate the results found in Farsani, Breda, and Sala (2020) and Farsani and Villa-Ochoa (2022).

As educators, we firmly believe that, regardless of a teacher's experience, it is always worth questioning the forms, styles, and quality of messages conveyed verbally and non-verbally during teaching processes. We believe that optimising these very subtle and silent non-verbal messages can positively impact students' visual engagement and the teaching and learning process. One recommendation and practical application is to incorporate non-verbal training in teacher training courses, both for future teachers and in-service teachers. The training of teachers in this perspective can increase knowledge and skills to reflect on the communicative function of non-verbal language in interaction in the classroom and, consequently, lead to the improvement of mathematical instruction processes. (Breda, 2020; Breda, Pino-Fan & Font, 2017).

This study has a limitation due to its realtively small smaple size (30 students) and the specific context (Santiago de Chile). Therefore, we understand that it is necessary to foster more cross-cultural research on multimodal non-verbal interaction to examine the multimodal visual and non-verbal exchanges in the classroom more deeply.

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DATA AVAILABILITY STATEMENT

The data supporting the results of this study will be made available by the corresponding author, [D. F.], upon reasonable request.

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