

Improving higher education teaching with feedback of eye tracking glasses: An international and interdisciplinary study

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Abstract

The paper describes the purpose and the methods of the international project “Teaching in Higher Education Effectively via Eye-tracking” (THEE) and summarizes its findings. The project studied the eye movements of higher education teachers and students to reflect on how to improve the teaching-learning process. The participants were four professors and twelve students who wore eye tracking glasses during the lessons. The results of the study demonstrate a clear benefit of the approach based on collecting eye tracking data and teachers’ self-reflection on their own classroom practice. Concerning the analysis of gaze location and teachers and students’ behaviour, we noticed that the teachers looked mostly at the centre of the classroom and that the duration of the fixations depends on the size of the classroom and the type of subjects. Moreover, the teachers of scientific subjects seem to change their fixation duration distribution over the lessons analysed while the humanities lecturers appeared more static. The analyses also highlighted that the teachers of

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humanities subjects were found to be very focused on the cognitive processes, while teachers of scientific subjects were attentive to the way they can involve students in learning. On the other hand, students of the humanities mainly highlighted some operational factors related to the teacher's lesson and to their own subsequent study, whereas students of scientific subjects seemed to show more attention to the factors related to the lesson and to activities carried out in the classroom.

Key words: eye tracking glasses; higher education; reflection; transformative action

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1. Introduction

Eye tracking glasses are a wearable device that combines near-infrared light with high-definition cameras to map the position of the eye several times per second, thus allowing the researcher to study where the gaze of the subject wearing the glasses is focused. An eye tracker provides information and measures of visual attention (the number of times fixations are directed towards an “area of interest”; fixation duration of an “area of interest”; and so on) for examining cognitive and affective processes. Indeed, eye-tracking was identified as a promising cognitive and affective processes tracing technique that provides measures to allow inferences about cognitive effort and the level of processing (e.g., measures of gaze duration), measures that allow for inferences about information weighting (e.g., time-based indicators such as first and last fixations); also, transitions or scan paths can reveal search strategies and the relationship between specific aspects of a decision environment, and changes in affective states have been linked with pupil size increases (Rahal, Fiedler, 2019).

Technologies for tracking eye movements are also used in the field of educational research to provide quantitative data that reflect thought contents and that may be employed in numerous fields of investigation, such as attention, decision-making processes, teachers and students' behaviours, professional vision (Jarodzka *et al.*, 2021; Dagièné *et al.*, 2021; Savarese *et al.*, 2020; Faiella *et al.*, 2019; Halszka *et al.*, 2017; Lai *et al.*, 2013). For instance, they offered an interesting contribution to the field of research on teachers' professional vision (a cognitive concept that encompasses both visual perception of

classroom events and situation awareness) showing that it is different for teachers of different subjects, is influenced through various interventions, and develops with experience (Minarikova *et al.*, 2021; Huang *et al.*, 2021). As for instead novice-expert teachers' differences in gaze behaviour in classrooms, they revealed that expert teachers had overall tendencies to look at students longer while maintaining greater gaze efficiency than novices, and to prioritize students in their gaze over non-instructional areas (Minarikova *et al.*, 2021; Huang *et al.*, 2021; Faiella *et al.*, 2019).

Early research on the visual behaviour of teachers and students was conducted in a controlled laboratory set-up using fixed eye trackers to watch videos of teaching situations, in the case of teachers, and to study materials, in the case of students (Rayner, 1998). Then, the advent of wearable eye tracking glasses has allowed high portability and non-intrusiveness in research, proving to be very useful for situations where the user needs to be fully mobile without physical constraints or supplemental components (Kaakinen, 2021). So, by using eye tracking glasses, it was possible to study eye movements during classroom lessons, obtaining interesting results regarding a) the professional vision of teachers, b) the visual perception of students, and c) the visual perception in learner-teacher interaction (Jarodzka *et al.*, 2021).

2. Brief description of the project

The project “Teaching in Higher Education Effectively via Eye-tracking”, funded by the Erasmus Plus Programme (KA2 - Cooperation for Innovation and the Exchange of Good Practices KA203 - Strategic Partnerships for Higher Education), uses eye tracking glasses to study the eye movements of higher education teachers and volunteer students to reflect together – teachers, students, and researchers – on how to improve the teaching-learning process.

Interestingly the “Teaching in Higher Education Effectively via Eye-tracking” project presents several original and innovative aspects, related to the methodologies employed, i.e. (1) applying a triangulation method (Henning *et al.*, 2004) that refers to the use of a variety of data collection sources to seeking convergences and corroboration of results, (2) comparing the results obtained from the four university research teams in Turkey, Italy and Lithuania, and (3) developing an online course for university teacher training to improve teachers' visual attention skills.

In this paper we describe the purpose, the methods, and the results of the project achieved in Italy from the research team of the University of Salerno within the scope of the project “Teaching in Higher Education Effectively via Eye-tracking” (THEE).

3. The methods and the steps of the data collection

The project brings together six participants from four countries and requires the four university research teams to identify some of their courses for data collection, involving teachers and students in the practice of wearing eye tracking glasses during their lessons. For data collection in Italy, the University of Salerno identified four courses – two from the humanistic and two from the scientific area – based on the number of students attending classes, to have two large classes (with more than thirty students) and two small ones (with less than thirty students).

Data collection took place in two steps (see Fig. 1). During the first phase (lesson recordings), three lessons for each course were recorded (for a total of twelve recordings from the teacher's point of view and twelve recordings from the students' point of view). The recording system provided for the acquisition of three videos: one through the eye tracking glasses and two through the fixed cameras, one positioned at the back of the classroom and one in a corner of the front wall respectively. The captured videos were then placed side by side using the split screen technique to show the three perspectives simultaneously. During the semi-structured personalized interview (second phase) each teacher and each student watched the videos of the lesson, the heat maps, and their eye movements.

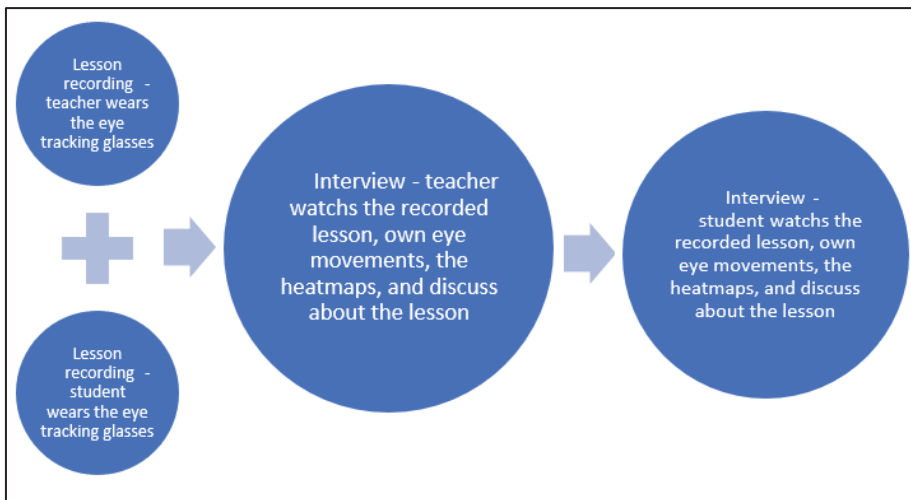


Fig. 1 - The two steps of the data collection: the lesson recording and the interviews

We addressed the following four research questions:

- How does change of gaze's location and behaviour of teachers and students in higher education classrooms vary depending on the size of the classrooms and different subjects?
- How does change of gaze's location and behaviour of teachers vary over time in higher education classrooms?
- How does teaching method change in higher education classrooms after watching video of one's own lessons and reflecting upon them?
- What do teachers and students think about their experiences with eye-tracking?

The combination of quantitative and qualitative analyses performed on the data collected through eye movements, lecture recordings and interviews will be described below.

4. Overall findings

4.1 Findings on eye movements

For eye movement data, an exploratory analysis of two measures provided by the software (fixation duration, dwell time within an area of interest) was performed.

The fixations of teachers and students in space, i.e., within the class, and in time, i.e. within the same lesson and between the three observed lessons, were analysed. The results show that the duration of the fixation time on average is greater in large classrooms than in small ones, while showing peculiarities related to the nature of the subject (scientific or humanistic). We also analysed the number of observations in each lesson, i.e., the number of times the eye moved from one point to another. This measure seems to be linked more to a characteristic of the teacher than to other factors such as the size of the classroom or the nature of the subject.

Suitable tests have shown the dependence between the duration of the fixations and both the type of subjects (scientific or humanistic) and the size of the classroom (large or small), that is, the eye, both teacher's and learners', moves in a different way depending on whether it is in a small or large classroom and whether it is of the humanistic or scientific field.

The analysis of the distribution of fixations provided, moreover, quantitative information on observation times, such as the presence of outliers, position, variability, and shape of the observed data. In particular, all the densities of fixation duration seem skewed showing several big outliers and long tails. This means that there are fixation durations that are much longer than others and this is true for all the teachers and students analysed.

A spatial analysis of the distribution of eye fixation duration is also provided by looking at the heat maps that provide a graphical representation of the observed areas in each lesson with greater intensity. Regarding this aspect, the results show that the teachers generally looked at the central part of the classroom for most of the lessons and this is even more evident in the teachers in small classrooms. However, no particular patterns are observed during the 3 lessons. As far as the students are concerned, however, different patterns are observed in the lessons analysed. This is also because students who have worn glasses during lessons are always different.

As regards the space-time dynamics of the fixations, this can be represented mathematically as a random path in the plane, thanks to which it is possible to observe how the eye moves between consecutive fixations within the classroom. In this context it is interesting to evaluate the distribution of the distances between subsequent fixations, as a measure of “eye fatigue” during each lesson.

In the latter context, a dynamic simulation of the random path has shown that the larger movements occur mainly in the first part of the observation interval, after which the gaze “stabilises” in the central part of the room making smaller movements.

4.2 Analysis of the interviews

The interviews concerned three qualitative analyses, namely Sunburst, Correspondence Analysis, and Analysis of Emerging Themes, which revealed differences in the perceptions/narratives of teachers and students, depending also on whether they pertain to humanistic or scientific subjects.

We performed a thematic content analysis using the T-Lab software. The descriptive variables were: “big classes or small ones” and “teachers of scientific subjects or humanistic ones”. First, the interviews are displayed in Sunburst graphs, the nodes of which are arranged in a radial layout and the hierarchy is defined by using labels and attributes. Then, we conducted a correspondence analysis, a type of multidimensional scaling used to integrate a standard chi-square test of independence for two categorical variables forming a contingency table. Finally, an analysis of emerging themes (THEME) was conducted on the total corpus of the interviews. The modelling of emerging themes allows us to identify, examine, and model the main themes that emerge from the texts through sets of keywords (terms or categories) co-occurring within the examined context units.

Humanities teachers were found to be very focused on the cognitive processes that link the students to their lessons; on the other hand, teachers of

scientific subjects were attentive to the lesson, but also to the person and to the way they can involve students in learning.

Students of the humanities responded to the teaching methods mainly highlighting only some operational factors related to the teacher's lesson (slides, evaluation, communication) and to their subsequent study.

Students of scientific subject lines, on the other hand, seemed to show attention to several operational factors related to the lesson (learning, attention, writing, thinking, interest, change) and to activities carried out in the classroom (taking notes, using computers).

The analysis of the correspondence of the lemmas on the total corpus of interviews with both teachers and students shows that for the former the narration was focused on the lesson to be carried out at that moment, in that area and on that topic (chi square p. 01); students, on the other hand, focused their attention on the "person", who must simultaneously look at the blackboard, write in the notebook, respond (chi square p. 0,1).

From the analysis of the Emerging Themes, we note for the teachers' themes with high significance to the test of the chi square (p. 0,1): related to didactic aspects (exam, file, image, blackboard, lesson, book), related to the student person (person, student) and related to the experience with glasses (vision). For students, instead, themes with a significant score to the chi square test (p. 0,5) are related to the study experience (notes, teacher, lesson, professor), related to their private (home), related to the experience of glasses (experience, eye, video). There were no differences to the "scientific/humanistic" variable. It is evident from our data that expectations, evaluations of the classroom experience and representations of teaching and learning processes are indeed different between teachers and students. The confirmation of this finding also appears in the article of Jarodzka *et al.* (2021), who conducted a systematic review of the diversity of perspectives of the actors involved in the university learning/teaching process. In fact, thanks to the use of eye tracking, they have highlighted many differences between teachers and students especially regarding the expectation of cultural and human interaction between the two.

4.3 Transformative action on teaching

Despite these differences, it became clear that watching videos and heat maps has effectively activated the teacher's self-reflective and critical ability with respect to the action of their teaching performance. After having watched the videos and the heat maps, the feedback received from teachers in relation to their interaction with students leads us to think that the triggering and initiation of the transformative action have occurred (Mannese, 2016; 2019; Massa, 1992). The retrospective vision of one's "relational self" in the teaching

action has allowed the activation of the awareness process, a necessary premise for the subsequent self-reflective moment with respect to the effectiveness and the possibility of improvement of the teaching-learning process. In fact, it has generated a series of questions in teachers who, in 75% of cases, revealed a clear desire for change between the first and the third recorded lesson.

The theme of the lived experience (Mortari, 2019) became central in the phase of the interviews concerning the viewing of videos and heat maps. Through the interviewer's inputs a sort of "Socratic dialogue" was triggered (Bellantoni, Lombardi, 2020), which allowed students and teachers to revise themselves, being able to see themselves in a different perspective. We refer to that "change" perceived as necessary (Mannese, 2016; Mannese, 2019). From the theoretical perspective of the Training Clinic and the studies on "Pedagogical generativity (Generatività pedagogica)" conducted by Emiliana Mannese (*Attualità pedagogiche*, from 2019 to 2022) and her research group of the "Osservatorio sui processi formativi e l'analisi territoriale", the self-narration involved the construction of new meanings, new questions, suspensions, doubts, reflections (which emerged very explicitly during the interviews) that generated reflective / generative thinking (Mannese, 2016).

The transformative action, resulting from becoming aware of the movements of one's body in the space of the classroom, first the gaze, is also confirmed by the data analysed in relation to the answers provided by the students: 75% of them said they noticed a change, an overall improvement in the degree of visual and relational interaction on the part of the teachers who had had the opportunity to deal with the feedback provided by the videos and heat maps during the interviews, as well as a greater distribution of the gaze on the audience and more attention paid to the position occupied by the body within the classroom space.

All the students declared that if the teacher's gaze meets theirs, they learn in a more meaningful way, which highlights that a decrease in their attention was mainly connected to the opposite situation.

However, even the 25% who declared that they didn't notice any significant difference in the teacher's teaching activity between the initial and the final phase of the research have found a general positive effect in terms of improving their attention and that of their colleagues, thanks to the direct and indirect experience with eye tracking.

5. Discussion and Conclusions

Concerning the analysis of gaze's location and behaviour of teachers and students in higher education classrooms we studied the fixation duration (i.e.,

the period within which the gaze is kept in one position) and the dwell time within the AOIs (i.e., the total duration of fixations in specific areas of interest), both measures considered able to give information on processing depth and effort (Rahal, Fiedler, 2019). So, we noticed that the teachers looked mostly at the centre of the classroom, showing greater variability at the beginning of the lesson and that the duration of the fixations depends on the size of the class (large-small) and the type of lesson (scientific-humanistic). As for instead the change of gaze's location and behaviour of teachers varies over time the duration of the fixations has a similar distribution over the lessons analysed of the same teacher even though the teachers of scientific subjects had fixation duration distribution which changed over the three lessons analysed. The humanities lecturers, on the other hand, seemed more static in terms of duration fixation.

The first findings of our study also highlight the fact that there is a significant benefit in using the approach based on collecting eye tracking data and qualitative interviews to stimulate teacher self-reflection on aspects of their own classroom practice. This is probably because feedback about one's own teaching was not filtered through the lens of others, leaving plenty of room for their own analysis and reflection. Watching videos and heat maps has effectively activated the teacher's self-reflective and critical ability with respect to the action of their teaching performance. After having watched the videos and the heat maps, the feedback received from teachers in relation to their interaction with students leads us to think that the transformative action has occurred. In fact, it has generated a series of questions in teachers who, in 75% of cases, revealed a clear desire for change between the first and the third recorded lesson. The transformative action is also confirmed by the data analysed in relation to the answers provided by the students. 75% of the students interviewed said they noticed a change, an overall improvement in the degree of visual and relational interaction, a greater distribution of the gaze on the audience and more attention paid to the position occupied by the body within the classroom space.

The analyses of the interviews highlighted as the teachers of humanities subjects were found to be very focused on the cognitive processes that link the students to their lessons while, on the other hand, teachers of scientific subjects were attentive to the lesson, but also to the person and to the way they can involve students in learning.

Students of the humanities responded to the teaching methods mainly highlighting only some operational factors related to the teacher's lesson (slides, evaluation, communication) and to their subsequent study. Students of scientific subjects, on the other hand, seemed to show attention to several operational factors related to the lesson (learning, attention, writing, thinking,

interest, change) and to activities carried out in the classroom (taking notes, using computers).

All the students declared that if the teacher's gaze meets theirs, they learn in a more meaningful way, which highlights that a decrease in their attention was mainly connected to the opposite situation.

The team is currently working on a book where the methods and the results of the analysis with eye tracking glasses in four classrooms of the University of Salerno will be described in detail.

Meanwhile, the results obtained by the partner universities have provided guidance to design an online training course for university teachers in four languages (English, Turkish, Italian, and Lithuanian) to contribute to university teachers' training.

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References

- Attualità pedagogiche, from 2019 to 2022. Scientific journal of the University of Salerno. Available from: <http://www.attualitapedagogiche.it/>.
- Bellantoni L., Lombardi M.G. (2020). *Relazione educativa e professionalità docente. Linee guida per l'autoformazione e l'empowerment*. Milano: FrancoAngeli.
- Dagienè V., Jasutė E. and Dolgopolovas V. (2021). Professional Development of In-Service Teachers: Use of Eye Tracking for Language Classes, Case Study. *Sustainability*, 13(22): 1-24.
- Faiella F., Mannese E., Savarese G., Plutino A. and Lombardi M.G. (2019). Eye-tracking glasses for improving teacher education: the e-Teach project. *Research on Education and Media*, 11(1): 85-92. DOI: 10.2478/rem-2019-0012.
- Halszka J., Holmqvist K. and Gruber H. (2017). Eye tracking in Educational Science: Theoretical frameworks and research agendas. *Journal of eye movement research*, 10(1): 1-18.
- Henning E., Van Rensburg W. and Smit B. (2004). *Finding your way in qualitative research*. Pretoria: Van Schaik.
- Huang Y., Miller K., Cortina K.S. and Richter D. (2021). Teachers' professional vision in action: Comparing expert and novice teacher's real-life eye movements in the classroom. *Zeitschrift für Pädagogische Psychologie*, 37(1-2): 1-18.

- Jarodzka H., Skuballa I. and Gruber H. (2021). Eye-tracking in educational practice: Investigating visual perception underlying teaching and learning in the classroom. *Educational Psychology Review*, 33(1): 1-10.
- Lai M. L., Tsai M. J., Yang F. Y., Hsu C. Y., Liu T. C., Lee S. W. Y., ... and Tsai C. C. (2013). A review of using eye-tracking technology in exploring learning from 2000 to 2012. *Educational research review*, 10: 90-115.
- Kaakinen J.K. (2021). What Can Eye Movements Tell us about Visual Perception Processes in Classroom Contexts? Commentary on a Special Issue. *Educational Psychology Review*, 33: 169-179.
- Mannese E. (2016). *Saggio breve per le nuove sfide educative*. Lecce: Pensa Multimedia.
- Mannese E. (2019). *L'orientamento efficace. Per una pedagogia del lavoro e delle organizzazioni*. Milano: FrancoAngeli.
- Massa R. (1992). *La clinica della formazione*. Un'esperienza di ricerca. Milano: FrancoAngeli.
- Minarikova E., Smidekova Z., Janik M. and Holmqvist K. (2021). Teachers' Professional Vision: Teachers' Gaze During the Act of Teaching and After the Event. *Front. Educ*, 6, 716579.
- Mortari L. (2019). *Aver cura di sé*. Milano: Raffaello Cortina Editore.
- Savarese G., Stornaiuolo G., Faiella F., Mannese E., Plutino A. and Lombardi M.G. (2020). Percezione e rappresentazione sull'uso delle tecnologie digitali in docenti esperti e novizi: analisi del contenuto delle interviste. In: G., Cecchinato, V., Grion (a cura di). *Dalle Teaching Machines al Machine Learning* (pp. 223-233). Padova: Padova University Press.
- Rahal R., Fiedler S. (2019). Understanding cognitive and affective mechanisms in social psychology through eye-tracking. *Journal of Experimental Social Psychology*, 85: 1-14.
- Rayner K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, 124(3): 372-422.