Understanding Learning Behaviours Though Visual Attention Analysis

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ABSTRACT
This paper presents the VAAD tool, an acronym for Visual Attention Analysis Dashboard. Its goal is to facilitate the visualization of eye movement data collected during learning sessions in an online course. The eye movement data is gathered using an eye-tracker, and subsequently processed and visualized for interpretation. The tool enables the visualization of data to identify differences and learning patterns among various learner populations. As a result, VAAD has the potential to yield insights into online learning behaviors.

CCS CONCEPTS
• Human-centered computing → Visualization. • Visualization systems and tools;

KEYWORDS
Behaviour Detection, Dashboard, Eye-tacker, e-Learning, MOOC, Multimodal Learning Analytics

ACM Reference Format:

1 INTRODUCTION
Technological advancements have contributed to innovative education in online environments, exemplified by the rising popularity of MOOCs, which are recognized by official institutions [10]. At Universidad Autónoma de Madrid (UAM), MOOCs are offered through the edX platform1. Concerns about completion rates and learning progress have led to research into Learning Analytics, resulting in systems like edX-LIMS [5–7, 11] and M2LADS [2, 3].

These approaches can be enhanced by incorporating the detection of learners’ behaviors. For this purpose, capturing and analyzing biometrical multimodal data can be an excellent and useful method to gain insights into what is occurring throughout the course and how learners are engaging with it.

Biometric multimodal data can be sourced from various devices like webcams, EEG bands for brain waves and attention levels, smartwatches for heart rate and EDA, or eye-trackers for pupil diameter and visual attention, including fixation gaze and saccades. In this article we propose the VAAD tool, with a focus on eye movement data.

Previous research has shown that utilizing eye-tracking methods is beneficial for gaining insights into students’ academic performance, irrespective of their backgrounds [4, 13]. This includes information pertaining to the cognitive processes associated with eye movement [1, 9, 12, 15], enabling the prediction of potential issues and the identification of learners’ needs, provided that correlations between learners’ performance and visual attention have been established [14].

2 OBTAINING VISUAL ATTENTION DATA
We carried out an experience where we monitored 120 learners from the School of Engineering at UAM who interacted with the same MOOC subunit during a 30-minute Learning Session (LS) [2]. The MOOC chosen was entitled “Introduction to Development of Web Applications” (WebApp). This study has received approval from the university’s ethics committee, and all biometric multimodal data are anonymized.

Before collecting multimodal data from the LS, learners take a pretest with LS-related items to gauge their initial knowledge. During the LS, learners watch videos, read materials, and complete MOOC-supported assignments, which comprise the posttest items.

All biometrical multimodal data were collected using the edBB platform, specifically designed for remote education. edBB is a multimodal acquisition framework that captures biometric and behavioral information. It utilizes software to synchronize various sensors, adapting to monitoring circumstances, and accommodating both advanced (smartwatch, eye tracker, etc.) and basic sensors (webcam, context data, etc.) [8].

3 APPROACH PROPOSED

3.1 Processing Visual Attention Data Module
During the session, eye tracking data files are generated by the eye tracker. Each learner’s data is saved in a separate file in tsv format, containing information about eye movements. For VAAD, particular focus has been placed on capturing saccade and fixation events, alongside their timestamps, to obtain four main parameters: average saccades, average fixations, average saccade time and average fixation time.
The processing tasks yield a database that contains information on the aforementioned parameters for the entire session, as well as for each different activity within the session. The database also includes data regarding the learners, such as their sex and academic background (prior knowledge of the LS topic and bachelor degree), enabling their classification into various populations for data visualization purposes. Each learner has their own identification ID, ensuring the anonymization of all data. Furthermore, their pretest and posttest scores are included in the database, allowing for a comparison before and after the session.

3.2 Visualizations and Results
VAAD’s visualization charts include a general overview of the session and individual analysis for each learner, available in English and Spanish (Figure 1).

The global session data is represented in interactive box plot charts, which can be filtered by population categories. The tool allows analysts to select specific activities or the complete session for visualization. Additionally, an ANOVA test is performed for each of the four main parameters, revealing significant differences among learners from different populations.

A second interactive chart presents data visualization for each individual learner through a heat map. Analysts can select a specific learner and choose from various options available for the learner’s visual screen heat map, such as different activities within the MOOC session. This approach allows visualization of learners’ on-screen attention, providing insights into what each learner was focusing on during each activity.

This approach is helpful for identifying which materials are more interesting and, therefore, useful for the learner and how different learning material sources can influence learners’ performance.

The data managed by the tool provide the possibility to detect the tasks performed by online learners during the learning session, which could be useful for the instructors to analyse the learning processes of their MOOC learners.

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Figure 1: An example overview of global and individual analysis visualizations

4 CONCLUSIONS
In this paper we present VAAD (an acronym for Visual Attention Analysis Dashboard), a tool that enables visualization of biometric visual attention data from online MOOC sessions. Analysts can better understand learner behavior by filtering data and visualizing different session components. It provides insights into learners’ attention through eye movements, allows filtering by various learner demographics, and facilitates ANOVA tests to identify significant differences among learners during the learning process.