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# Evaluating the User Experience of Virtual Learning Environments Using Biometric Data

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**Abstract:** The last two decades have seen a proliferation of virtual learning environments (VLEs) in different educational settings. The design of a VLE involves designing teaching and learning activities, the learning content, assessment activities as well as interaction design for the supporting technology platform. Given the multidisciplinary nature of designing VLEs, it can be challenging for a single teacher, or a small team to create usable VLE offering satisfying user experience from a learner's perspective. This work reports on action research investigating the user experience in an authentic virtual learning environment. A master level course is considered for user experience evaluation using eye tracking technology and galvanic skin response measurement. User testing includes participants carrying out user tasks including interacting with the learning content, interactions among peers as well as the interaction with assessments. Quantified data on user experience aspects is expected to help improve the VLE and learning content design in future systems.

**Keywords:** User Experience, Eye Tracking, Biometric Data, Virtual Learning Environment

## 1. Introduction

Virtual learning environments (VLEs) are more widely introduced into university learning and teaching [1]. VLEs can comprise of different types of learning and teaching tools, including multimedia content creation systems, assessment systems as well as communication and collaboration tools. The design of VLEs requires a multidisciplinary approach. That involves several knowledge domains such as learning theories, system design, interaction design, and user experience design.

The user experience in VLEs has to take into account the software and usability aspects of the product, but also the learning experience and the teaching or learning content, and how to make it possible for a teacher, to present it meaningfully to the students. That means in VLEs, there are two different sets of primary user groups, on the one end, there are the teachers, that have to use the platform to create their courses on, and on the other hand there are the students that consume the learning content. In this paper, we focus on the learning experience of real courses, hence also influenced by the possibilities for the teachers to create learning materials. During this particular research project, we are focusing on the usability and learnability of Canvas and moodle (MUELE), which is used at the University of Agder and at Makerere University. The following research questions are addressed:

Research questions

(1) How emotionally satisfying is the navigation in a VLE?
(2) How engaging are the students' interactions using the forum tool in a VLE?
(3) What is the relationship between the visual attention patterns and engagement in the learning materials?

The navigation of a system is central to its usability and that is why we would like to see how satisfying the navigation option in Canvas and MUELE is. This is especially interesting, since teachers can blend in our out different navigation elements and can create their own menu items to a certain extent. E.g. create their own hyperlinks and shortcuts on the navigation menus and on content pages [R1]. Another central aspect of hybrid, blended and online courses is the social communication aspect. In many VLEs, forums or discussion boards are used to give the students space to interact, discuss and get feedback on their thoughts from peers, tutors and teachers [R2]. However, it is not always a given, that students interact naturally in a discussion or forum, and it is of interest to find common problems and usability issues connected to this area to improve the learning and communication experience for future classes. VLEs can be overwhelming for students and it is crucial that visual hints guide them to their desired destinations on the page. We would like to investigate how the students' goals (to find certain information) are connected to the visual pattern, that can be analysed from different students. What is the visual path? What draws their attention? Can a common priority in visual attention be found [R3]?

## 2. Related Work

Different sensors have been used to attempt to detect and

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correlate the state of relaxing, engaging or stressful content in virtual environments [2]. GSR showed indication to be able to analyse emotion [3], attention, and stresslevels [5]. In the work of Handri et al. [6], galvic skin response (GSR) was measured for interactive and non-interactive learning materials that students engaged with, which is interesting for our research since both components will be used in the test courses as well.

Eye tracking has been used previously to detect usability issues in e-learning or virtual learning environments [7]. In the research by [7], questions similar to our research questions were formulated. One research focus was on the navigation in the e-learning environment: "What patterns of eye movement signalise difficulties of navigation within e-learning environments?". As an example, in [8] course layouts in the VLE named "Blackboard" were analysed. Another research project shows how users were given tasks to complete while engaging with the learning environment to test usability issues [9]. They targeted navigation and understandability of the course structure as well as visual attention and aesthetics. When it comes to eye tracking, it is important to note that is a method to measure usability, e.g. during the interaction of students with learning material. However, eye tracking data should be considered additional information that has to be used in conjunction with other data to cover different aspects of the problem space and add context to the analysis [8].

## 3. Methods and Experimental Setup

This research plans action research in three different courses on two different Universities: University of Agder (UiA) in Norway and Makerere University (MAK) in Uganda. In VLEs at both Universities, a test course with a module concerning a specific topic ("how to create VLEs") will be added for user testing purposes. The module has the same content but is displayed in the two different VLEs (Canvas and MUELE) following the usual structure of the given VLEs. This course module tests specific aspects of VLE design, such as presentation and perception of graphics, course structure, connection between modules, pages, discussion forum, tasks and assignments. The students are asked to perform user tasks that guide them through the module to test the aforementioned aspects.

User Survey:

(1) In which country do you live? (e.g. Norway)
(2) Where do you study (your home university)?
(3) What is your gender?
(4) What is your age?
(5) What is your course of study?
(6) How familiar are you with the use of Virtual Learning Environments (e.g. Canvas, Moodle/MUELE)?
(7) How do you mostly access a Virtual Learning Environment (VLE)?
(8) What do you usually use to open the VLE?
(9) How frequently do you use/read: Assignments, class announcements, discussion forum, chat communication, e-Mail communication ("never" to "multiple times a day", including "not relevant")
(10) How much do you agree or disagree with the following statements? ("strongly disagree" to "strongly agree")
  (a) VLE capabilities meet my requirements.
  (b) Using the VLE is a frustrating experience.
  (c) The VLE is easy to use.
  (d) I have to spend too much time searching for the items/pages I need.
  (e) The quality of courses differs from teacher to teacher (creator of the course).
  (f) The VLE adds valuable qualities to my studies (e.g. overview or routine).

Participants during the user testing sessions are asked to perform a list of user tasks, while their eye movements in the VLE are tracked. In addition to the eye tracking device, a GSR sensor is attached to the user's fingers. The list of user tasks is planned as follows:

(1) Login to VLE
(2) Find the course "Learning Environment Studies"
(3) Find the learning module for the current week
(4) Carry out the learning task for this week
(5) Do the assignment for this week and submit your answer through the VLE
(6) Go to Discussion Forum
(7) Contribute to the discussion forum on the topic "Designing VLE"
(8) Contribute to the discussion forum on the topic "How to survive pressure during the exam period"
(9) Send an individual message through the VLE to ask Renée Schulz how you could have access to the results of this user testing.
(10) Logout.

### 3.1 Tools and Setup

In this research, we want to analyse interaction and users' responses to the presented learning content beyond the usual observation based analysis. The study uses *Tobii Nano*[*1] eye tracker and *Shimmmer3 GSR+*[*2] galvic skin response sensors are used to get quantifiable data in addition to video and screen recording-based observation data.

With the Shimmmer3 GSR+ you can collect data on:

- Galvanic Skin Response (GSR)
- Optical Heart Rate

The Tobii Nano Eye Tracker allows for further analysis on:

- Advanced analytic tools for screen-based multimedia stimuli (images, videos, websites, games, software interfaces and 3D environments
- Individual and aggregate gaze replays
- Static and dynamic areas of interest (AOIs), manual and semi-automated options
- Automated metrics such as Time to First Fixation,

[*1] https://www.tobiipro.com/product-listing/nano/
[*2] https://www.shimmersensing.com/products/shimmer3-wireless-gsr-sensor

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Time Spent, Ratio, Revisits, Fixation Count, Mouse Clicks, Key Strokes etc. Static and dynamic heatmaps
- Raw data including X,Y coordinates of eye position, pupil size, and distance to the screen
- Automated gaze mapping on websites, both on screen and mobile phones for fast and automatic analysis

The Tobii Nano Eye Tracker[*3] is a screen-based eye tracker, with the following specification: model: Nano, sample rate: 60 Hz (± 2 Hz), accuracy: 0.3° at optimal conditions, precision: 0.10° RMS at optimal conditions, mount type: on screen, maximum screen size: 19" (16:9 aspect ratio), operating distance: 45-85 cm, head movement: 35 cm x 30 cm at 65 cm (at least one eye tracked), eye tracking technique: corneal reflection, dark and bright pupil combination, one camera system, dimensions: 17 x 1.8 x 1.3 cm, and weight: 59 g.

Another tool that is planned to be used for the user testing is Affectiva AFFDEX. This is an integrated solution within the iMotions platform to research human behaviour[*4]. iMotions can get objective data on actual human experiences and e.g. measure non-verbal emotional responses to understand visual attention and cognitive states. iMotions supports the collection of both eye tracking data and emotional responses. This includes the recording of face video, environment video, audio, and the stimuli. Incoming data is visualized in synchronized real-time in the software application. E.g. different foci for usage can include:

- Facial Expression Analysis - Affectiva
- Valence: Positive, negative, or neutral response
- 7 Basic emotions: Joy, Anger, Surprise, Fear, Sadness, Disgust, Contempt
- Engagement: Overall expressiveness - is respondent neutral or engaged

In this research, we are explicitly looking to find visual attention patterns that miss-match with the (learning content) design flow, including the navigation through the VLE and material in general. We expect to find areas of stress and frustration and hopefully can further analyse where these emotions stem from.

A standard video camera to support user observations can be added if necessary. The preferred test location is the usability labs at University of Agder for closed environment testing. The setup allows participants and observers to be in two different rooms for the sake of less interference. The usability labs feature a test room and an observer room, facilities to sit down and conduct user testing that can be recorded or observed from different angles if necessary.

### 3.2 Observation Points and Expected Results

Based on the research questions, there are several observation points, meaning they indicate what we look for during user testing. It splits into three different headlines: Navigation, Learner-content interaction and Emotional responses.

(1) Navigation:

[*3] https://imotions.com/hardware/tobii-nano/
[*4] https://imotions.com/platform/

**Fig. 1** Observation-room setup at one of the usability labs at University of Agder.

(a) How many times do students click a wrong interface element(s) for navigating to a particular part of the course? What are common misconceptions in the navigation menu?
(b) How easy/hard is it to find specific content? We are looking for the success/error rate and time spent by the user to carry out the user tasks during the testing.

(2) Learner-content interaction:
(a) How engaged is the learner while browsing through the learning material?
(b) Can we detect any added value for graphics and videos in terms of emotional or attention-based feedback?
(c) How do students scan the learning content page and then go to the assignments (what is their path)?
(d) Who/how many read through the entire page content and who/how many just skim read the content?

(3) Emotional responses
(a) What are common emotional responses while working on the assignments,
(b) while looking at pics/graphics/video,
(c) reading text,
(d) communicating using the internal mailing tool,
(e) and using the forum?

(4) In addition to these observation points, we also look for anomalies and unexpected user behaviour(s), meaning critical errors and frustration points (pain points).

We are expecting to find common issues during general navigation in the VLEs. In addition, there is a possibility that certain visual elements attract students attention more easily. The interesting part will be to see, if initial visual attention lasts, or if students' attention changes quickly again. E.g. do students all look at the graphic at a page first, but then quickly change to reading the text, or are students actually analysing the whole graphic first?

## 4. Summary and Future Work

This is an ongoing project in which different courses in VLEs are tested to find common user interaction problems and user experience issues in order to make improvements

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future versions of the learning content, or/and VLE design. Carrying out user studies including different types of methodologies, such as qualitative methods as well as quantitative ones, help to have different perspectives on what is observed. Different perspectives can help to find underlying issues or help the researchers to pinpoint the root of certain problems better. User experience is a highly subjective subject matter, and so far many studies rely on qualitative subjective measurements. Tools such as eye tracking and GSR sensors provide empirical data which allow to objectively quantify the user experience, with metrics including user's emotional responses and task performance. Future testing will be carried out in a usability laboratory at University of Agder, as shown in Fig1. The testing shall also be carried out in natural settings such as classrooms, where students usually interact with VLE during face-to-face learning sessions. The setup can also be transported to different locations to extend the possibilities for testing with additional participants; however such undertaking can prove to be challenging since students may not accept to be observed within their private settings.

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