

# **EVALUATING LEARNING EXPERIENCE AND EMOTIONAL TRIGGERS OF VIRTUAL LEARNING ENVIRONMENTS (VLES) USING PSYCHOGALVANIC REFLEXES AND BEHAVIOURAL ANALYSIS**

**Abhijeet KUJUR, Sadaf H KHAN and Jyoti KUMAR**  
Department of Design, Indian Institute of Technology, Delhi, India

## **ABSTRACT**

Virtual Environments (VEs) are on the rise as an instrument in various sectors involving emotional states and educational research. Studies till date have tried to explore the effectiveness of VR in a variety of emotional health interventions, treatment of learning phobias, and providing virtual support to students worldwide. Research has demonstrated that VR immersive environments and VR experiences create a significant impact on the users' psyche. A learning experience is related to the emotional state of the person (O'Regan, K. (2003). Therefore, it would be interesting to study the influence of VR experience on the emotional states of the learners. Students around the globe were already struggling with emotional crises even before the pre-covid situation as reported by multiple agencies but now the situation has turned more grievous. Here comes the need for magnified learning experiences in virtual learning environments (VLEs). This study investigates the impact of two different VR-3D learning environments. It draws a comparison between students' emotional states, VR experience, and VR design elements using neurophysiological tools like Galvanic Skin Response (GSR) and self-reporting questionnaires. In the experiment, participants were asked to go through two different VR learning simulations and their physiological responses were recorded for analysis. The two simulations were differentiated based on space and interaction design elements. The study suggests that well-designed Virtual 3D-Environments in an educational setup can help students in reducing stress levels and ways how we can elicit positive emotions and facilitate a better learning experience.

*Keywords: VR 3D-environments, emotion, learning experiences, GSR, eye-tracking*

## **1 INTRODUCTION**

As we've seen in Covid, the global education system is changing gradually, and our academic environments must be adaptive to meet our dynamic world. It is necessary to redesign educational settings to deliver a modified or enhanced academic experience. Traditional classrooms were built with a factory-style instructional method in mind, which may have fitted the needs of the time. Therefore, they are not equipped to handle today's technological demands or to educate pupils with a variety of working methods and thinking processes [1]. Virtual learning environments (VLEs) or VR classrooms might help bridge this gap. Current research shows that teachers and students value educational learning settings [2]. Educational spaces or academic built environments have a direct influence on students' pleasant or poor experiences, and even little adjustments to their built environment may have a major impact on their day-to-day emotional states and learning results. It is not surprising that there is a visible debate about how to educate our children in the most efficient and appropriate manner [3]. In comparison to the evolutionary history of people and their learning process, the current educational system is exceedingly unnatural and confused [4]. From an academic institution's front entrance to its grounds and classrooms, every aspect of the built environment of a learning space influences brain processing and has a direct impact on how students feel and experience while they are in that area. Neurophysiology has given us a better understanding of how the brain and nervous system work and how to support effective teaching and more importantly, effective learning in an academic setting. [5]. The internal activity of the learner during learning is not limited to cognitive processing; it also involves emotional processing [6]. Neurophysiological tools like Galvanic Skin Response (GSR) provide an understanding of emotional involvement and learning [7]. Affective-cognitive learning models aim to include the

learner's emotional state throughout the learning process as part of the causal chain that leads to a learning outcome. Emotion is a strong, short-term reaction to a specific item or event like connecting a new concept to existing knowledge [8]. Understanding and supporting emotional processes in technology-based learning has become a top priority for researchers working on various types of learning environments, such as virtual learning environments (VLEs) [8]. One can employ art in designing learning environments to engage many senses which leads to improved cognition and retention. But the issue remains: what about the physical environments and layouts of our classrooms? Lighting? Sound? How can these and other physical components of the learning environment assist students in learning more effectively? Researchers now encourage everyone to think beyond the preconceived notion of school and what a school or academic space may seem like [5].

## **2 LITERATURE SURVEY**

### **2.1 Learning spaces and their relationship with emotion**

Many scholars have previously worked on generic stress-relieving designs [5]. Because perception, personality, and cultural imprints impact how learning environments affect pupils, it's hard to provide clear metrics or recommendations. Sick, elderly, and youngsters are much more attached to their living environment than others, therefore they're more affected by spatial situations [9]. In the best situation, a well-designed built environment may enhance healing processes (for example, in hospitals), increase fitness and vitality, emotional and cognitive skills, social engagement, and communication [10]. Various studies have demonstrated architecture, urban planning, and design impact humans' behaviour and emotions [11]. If learning spaces or constructed environments aren't created with a student's psychological requirements or mental health in mind, the risk of these disorders increases. These poorly planned and badly designed buildings or built environments magnify the level of negative emotion within an individual. Stress symptoms include palpitations, sweating, dry mouth, shortness of breath, fidgeting, quicker speaking, and heightened negative emotions (if present). Stress causes global adaptation syndrome. Stress contributes directly to psychological and physiological dysfunction and disease by initiating mind-body changes" [12].

### **2.2 Emotions caused by a virtual learning environment**

The virtual learning environment has a significant impact on students' learning results [13]. Open space and noise in schools, as well as the temperature, inadequate light, overcrowded classrooms, misplaced boards, and unsuitable classroom arrangements, might be distracting variables for students [14]. Emotions have a key role in technology-supported academic learning [15]. The three central research concerning emotions during learning are (i) identification of emotions generated during the interaction with the learning environment, (ii) measurement of emotional experience in the learning environment, and (iii) causes and consequences of the learner's emotional state in the learning environment [16]. The first stage is to detect learner emotions throughout a learning session. The next stage is to measure how students feel while using VLEs. Interviews, scale-based questionnaires, and neurophysiological tools like GSR are used in literature to evaluate psychogalvanic reflexes [17]. Final phase: determine causal relationships, causes, and consequences between learning environment elements and emotions. Emotional processing (e.g., emotions felt during e-learning) is linked to cognitive processing (e.g., degree of engagement and strategy use during learning) and learning outcomes. Significant positive and negative relationships were observed between positive and negative emotions and learning performance in a medical learning environment. This study establishes causal relationships between emotion and learning.

### **2.3 Emotions and their physiological measures**

Emotions are affective states that have an impact on behaviour and cognition. Physical and physiological reactions are caused by external or internal stimuli. Facial expressions, behaviour, and physiology may be utilised to distinguish emotions [18]. Emotions' onset and intensity are connected to neurophysiological, mental, and cultural factors. Emotions are produced through physiological reactions to events [19]. Since they're automatic, people don't notice changes in emotional or physiological signals. Physiological signal analysis can identify emotions accurately. Previous research [20] has shown that biosensors can detect emotions by monitoring ANS activity. This research aimed to compare 'Traditional' and 'Nature-Based' VLEs using VR design elements to analyse the psychological and





physiological effects of learning environments on individuals. This research uses the HTC Vive pro-eye VR Headset and Empatica-E4 GSR for stimulus exposure and data collection respectively. The goal was to compare participants' positive and negative emotional states and arousal while exposed to two VLEs.

### 3 METHODS AND MATERIALS

#### 3.1 Stimuli

Two virtual learning environments (VLEs) were designed for different stimuli conditions to evaluate emotional responses of the participants. VLE-1 was designed as a ‘Conventional Classroom’ setup and VLE-2 as a ‘Nature-based Classroom’ setup. Both the stimuli vary based on design elements as mentioned in table 1. These stimuli were designed using ‘Sketchup-Pro VR’ and ‘Simlab Composer-10 VR’ software. The participants were exposed to the stimuli using ‘HTC vive pro-eye VR Headset’.

Table 1. Two different VLEs and variations in their Design Elements

Design Elements	Rear View	Front View	Classification	Suitable Pedagogy	Texture	Layout	Space	Area
VLE 1			Conventional/Classic Classroom Environment	Instructor-based Approach (Formal)	Wood Concrete Steel Tile	Use of linear grid Rows and Columns	Rectangular space Four walled enclosure 4 Edged corners	24 sq.m.
VLE 2			Nature-based Classroom Environment	Suitable for multiple pedagogical approaches	Grass, Stones, Wood, Water, Steel and Concrete	Use of curvilinear forms throughout	Rectangular space Four walled enclosure Curved Corners	20 sq.m.

#### 3.2 Participants

This study was conducted on 11 participants (9 Male, 2 Females; Mean Age = 23.15 years, SD = 2.98 years). All the participants were undergraduate students of design and non-design backgrounds from IIT Delhi. All the participants were residents of urban areas and had a lesser chance of visiting natural areas frequently.

#### 3.3 Procedure

In the study, participants were instructed to wear a VR-headset, a galvanic skin response (GSR) sensor wristwatch and would be exposed to two different VLEs. They were instructed to get acquainted with HMD, observe, and get immersed into the environment. Later, they were teleported to both environments virtually one after the other for 6 minutes each. The tasks included counting chairs and the number of notebooks in VLE-1 while counting the number of trees and rocks in VLE-2. These tasks were given to engage participants completely into the respective VR environment. The experiment was performed for 20 minutes on each participant, 6 minutes for each VLE, and 8 min to prepare the participant. Their psychogalvanic data was recorded simultaneously during the experiment. After the experiment, participants filled a questionnaire and answered a few questions about the experience.



Figure 1. Participant activity during VR-Experiment

### 4 ANALYSIS AND RESULTS

There were three main ways to collect data for this study. The first way includes in-person semi-structured interviews. In VLEs, the participants stated and characterized their learning emotions and experiences. The second source of information was gathered from the questionnaire sent to participants. The third source of data was psychogalvanic reflexes which were recorded while the participants were

interacting with the VLE. Finally, the three types of data were evaluated and analysed as mentioned in this section.

#### 4.1 Interview findings

Participants reported their level of comfortability with the two different VLEs and their elements post experiment. These reports included likes and dislikes in the VLEs and how it is affecting them emotionally. Participants mentioned different VR classroom design elements that made them uncomfortable in the environment. ‘Teacher’s desk’, ‘Laminates of furniture’, ‘Open spaces’, ‘chairs’, ‘Sharp edged surfaces’, ‘Extra chairs’ and ‘Trees’ were a few elements in VR which the participants wanted to add and eliminate. However, the frequency of experiencing these VR classroom design elements varied among participants. The VR elements that were experienced and suggested by the participants are presented in Figure 2 (a) and 2 (b).

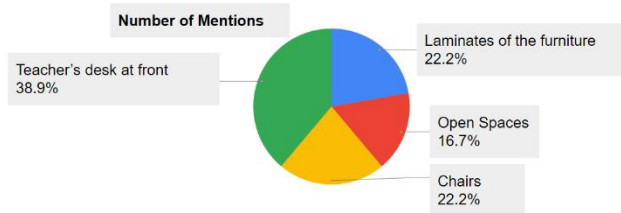


Figure 2(a). VR elements to be added

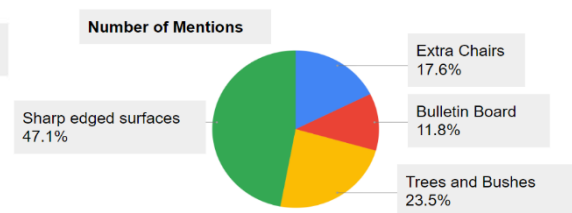
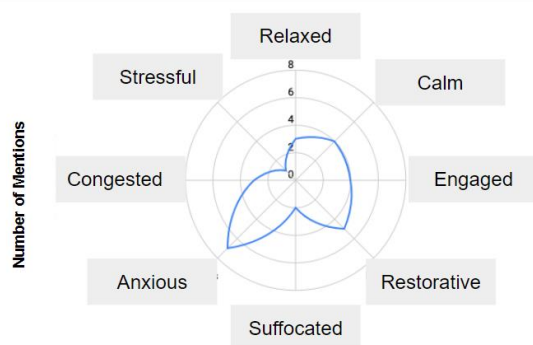


Figure 2(b). VR elements to be eliminated

#### 4.2 Questionnaire findings

From the questionnaire, it can be observed that all the participants experienced both positive and negative emotions during the interaction with the two VLEs. ‘Relaxed’, ‘comfortable’, ‘calming’, ‘fresh’, ‘spacious’, ‘congested’ and ‘suffocated’ were experienced by almost all the participants. During the activities that included engagement with the VLEs, all participants found that they experienced positive learning emotions such as feeling excited, pleased, and satisfied. It was observed that the pattern of emotions in VLE-1 and VLE-2 looks similar. However, despite VLE-1 being systematic and organized, ‘satisfaction’ was noted to be lesser in VLE-1 during the interaction with elements. The traditional model of the classroom and the congested arrangement of chairs were the two main sources of negative emotions for VLE-1. Four participants felt ‘tense’ while interacting with VLE-1, whereas eight participants felt ‘relaxed’ while interacting with VLE-2. ‘Greenery’, ‘close to nature’, and ‘peaceful’ were the reasons for VLE-2 to be more learning-oriented. Although, some participants did mention that VLE-2 is too distracting for being a classroom. The pattern of positive and negative emotions while interacting with VLE-1 and VLE-2 are shown in Figures 3 (a) and 3 (b).

Number of Mentions VS Positive and Negative Emotions



Number of Mentions VS Positive and Negative Emotions



Fig. 3(a). Positive and negative emotions in VLE1 Fig. 3(b). Positive and negative emotions in VLE2

#### 4.3 Psychogalvanic reflex findings

The electrical conductivity of skin is measured via the galvanic skin response. It changes when the activity of sweat glands regulated by the ANS changes [21]. Previous research has found that skin conductivity rises in synchrony with emotional arousal [22]. To measure the GSR signal, we employed a commercial sensor (Empatica E4 wristwatch sensor). The sensor was mounted on the wrist of the individual (Figure 1). To define the variability of the GSR signal, data was studied and analysed in the

temporal domain. Data was filtered using the normalizing techniques. Normalized data was obtained using the following equation:

$$\text{Normalized GSR} = \text{Experimental GSR} - \text{Baseline GSR}$$

The rate of change of emotional arousal [23], as measured in GSR sensors for VLE-1 and VLE-2 are as shown in Figure 4.

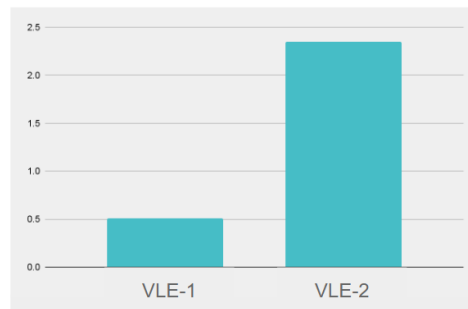


Figure 4. Rate of change of emotional arousal for VLE-1 and VLE-2

## 5 DISCUSSION AND CONCLUSION

As the two VLEs vary in design (conventional vs. nature-based), the study's data suggests a link between a learning space's built-environment and students' emotional states. These positive and negative emotional states influence learning capabilities and outcomes of the learner. Though the limited sample size is a key limitation of this research, experiment results give great insight into emotional arousal and learning. This experiment shows that interview and questionnaire data may help determine what sort of virtual design required by the learners based on their emotions. GSR helps identifying stimulating VR learning aspects. Even though techniques for identifying emotional states have improved, additional study is required to find effective VR classroom features to trigger emotions that impact learning via cognitive factors like expectancies and perceptions. Basic emotions are universal, but high-intensity VR classroom aspects must be evaluated. As a result, it is recommended that procedures should be implemented in which each participant actively and consciously participates in the selection of what elicits emotion, and is informed of the study's purpose, and hence assists in the process of evoking his or her own feeling.

## REFERENCES

- [1] Penrod D., Shaw T., Nash J., Dierkes M. and Collins S. Community college students' perspectives on online learning during COVID-19 and factors related to success, *Teaching and Learning in Nursing*. 2022. doi: 10.1016/j.teln.2022.01.012.
- [2] Fisher K. and Newton C. Transforming the twenty-first-century campus to enhance the net-generation student learning experience: using evidence-based design to determine what works and why in virtual/physical teaching spaces, *Higher Education Research & Development*, vol. 33, no. 5. pp. 903–920, 2014. doi: 10.1080/07294360.2014.890566.
- [3] National Research Council, Division of Behavioural and Social Sciences and Education, Board on Science Education, Board on Testing and Assessment, and Committee on Defining Deeper Learning and 21st Century Skills, *Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century*. National Academies Press, 2013.
- [4] Gruskin K. and Geher G. The evolved classroom: Using evolutionary theory to inform elementary pedagogy, *Evolutionary Behavioural Sciences*, vol. 12, no. 4, pp. 336–347, Oct. 2018.
- [5] Persaud N. and Eliot M. The Development and Refinement of Student Self-Regulatory Strategies in Online Learning Environments, in *Current Trends in Eye Tracking Research*, M. Horsley, M. Eliot, B. A. Knight, and R. Reilly, Eds. Cham: Springer International Publishing, 2014, pp. 317–336.
- [6] Mayer R. E. and Fiorella L. Principles for Reducing Extraneous Processing in Multimedia Learning: Coherence, Signalling, Redundancy, Spatial Contiguity, and Temporal Contiguity Principles, *The Cambridge Handbook of Multimedia Learning*. pp. 279–315. doi: 10.1017/cbo9781139547369.015.
- [7] Li J., Luo C., Zhang Q. and Shadiev R. Can emotional design really evoke emotion in

- multimedia learning?, *International Journal of Educational Technology in Higher Education*, vol. 17, no. 1, pp. 1–18, May 2020.
- [8] Smith K. G., Collins C. J. and Clark K. D. Existing knowledge, knowledge creation capability, and the rate of new product introduction in high-technology firms, *Academy of management*, 2005, [Online]. Available: <https://journals.aom.org/doi/abs/10.5465/AMJ.2005.16928421>
- [9] Vollmer T. C., Koppen G. and Kohler K. [The impact of urban architecture on health: the PAKARA model], *Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz*, vol. 63, no. 8, pp. 972–978, Aug. 2020.
- [10] Bulakh I., Didichenko M., Kozakova O., Chala O. and Kovalska G. Is the hospital-park future of the sustainable hospital architecture?, *E3S Web of Conferences*, vol. 280, p. 04014, 2021.
- [11] Higuera-Trujillo J. L., Llinares C. and Macagno E. The Cognitive-Emotional Design and Study of Architectural Space: A Scoping Review of Neuroarchitecture and Its Precursor Approaches, *Sensors*, vol. 21, no. 6, Mar. 2021, doi: 10.3390/s21062193.
- [12] Lisinski B. E. Calming chaos in the classroom: The effect of self-regulation professional training on teachers' perceptions of the classroom environment and student behaviour, Trent University (Canada) ProQuest Dissertations Publishing. [Online]. Available: <https://search.proquest.com/openview/cd4632e46f014dc54d3f44b22759164a/1?pq-origsite=gscholar&cbl=18750&diss=y>
- [13] Gilmore S. and Warren S. Themed article: Emotion online: Experiences of teaching in a virtual learning environment, *Hum. Relat.*, vol. 60, no. 4, pp. 581–608, Apr. 2007.
- [14] Gilavand A. Investigating the impact of environmental factors on learning and academic achievement of elementary students, *Health Sciences*, vol. 5, no. 7S, pp. 360–369, 2016.
- [15] Plass J. L. and Kaplan U. Emotional Design in Digital Media for Learning, *Emotions, Technology, Design, and Learning*. pp. 131–161, 2016. doi: 10.1016/b978-0-12-801856-9.00007-4.
- [16] Mayer R. E. Searching for the role of emotions in e-learning, *Learning and Instruction*, vol. 70, p. 101213, 2020.
- [17] Miller K. The experience of emotion in the workplace, *Manage. Commun. Q.*, vol. 15, no. 4, pp. 571–600, May 2002.
- [18] Ekman P. An argument for basic emotions, *Cognition and Emotion*, vol. 6, no. 3–4, pp. 169–200, May 1992.
- [19] Barrett L. F. Feeling Is Perceiving: Core Affect and Conceptualization in the Experience of Emotion, in *Emotion and consciousness*, (pp, vol. 420, L. F. Barrett, Ed. New York, NY, US: The Guilford Press, xii, 2005, pp. 255–284.
- [20] Alaoui-Ismaïli O., Robin O., Rada H., Dittmar A. and Vernet-Maury E. Basic emotions evoked by odorants: comparison between autonomic responses and self-evaluation, *Physiol. Behav.*, vol. 62, no. 4, pp. 713–720, Oct. 1997.
- [21] Collet C., Vernet-Maury E., Delhomme G. and Dittmar A. Autonomic nervous system response patterns specificity to basic emotions, *J. Auton. Nerv. Syst.*, vol. 62, no. 1–2, pp. 45–57, Jan. 1997.
- [22] Lang P. J., Bradley M. M. and Cuthbert B. N. A Motivational Analysis of Emotion: Reflex-Cortex Connections, *Psychol. Sci.*, vol. 3, no. 1, pp. 44–49, Jan. 1992.
- [23] Leiner D., Fahr A. and Früh H. EDA Positive Change: A Simple Algorithm for Electrodermal Activity to Measure General Audience Arousal During Media Exposure, *Commun. Methods Meas.*, vol. 6, no. 4, pp. 237–250, Oct. 2012.