Title

Measuring the effectiveness of active learning environments using physiological measures of arousal

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OVERVIEW

Lecturing is still the dominant mode of instruction at Universities and has been used for years to transfer knowledge in a form of information (Boyer, 1990). Because of this students passively receive information and retain it through memorisation (Stewart-Wingfield & Black, 2005). Students do not have enough opportunities to learn through discussion or experiential exercises and thus do not retain much information after class (Gallagher, 1997). However, this traditional method is being challenged by learning theories that emphasize the need for students to become more active in the learning environment which would improve their attention and hence learning. Research has found students' attention during lectures tends to be high during the first minutes then flat and near the end it increases, and that their processing of information is dependent upon their motivation (Bligh, 2001; Sousa, 2006). Hence, many lecturers are now looking at more active approaches to teaching so that it will improve student engagement and, ultimately, learning. Varying initiatives are being implemented within Higher Educational Institutions (HEIs) to promote student engagement including interactive pedagogic approaches such as, experiential and problem based learning.

Central to these approaches is the student's ability to retain attention which in turn influences working memory (Pashler, 1998). To examine this, we need to be able to measure it and thus examine the effectiveness of methods that look to improve attention. Researchers have done this by looking at different indicators of attention, for example note taking, observation, retention, self- report and physiological measures (Wilson & Korn, 2007). Physiological arousal is one component of attention and physiological states of arousal are maintained by activity within the nervous system (Wilson & Korn, 2007; Poh, 2010). These measures include heart rate (HR) and Galvanic Skin Response (GSR). Despite advances in the development of electrodermal measures, much of the research is still done in laboratory settings (Poh, 2010). With this in mind, the study sought to expand on this pedagogic evidence base by examining students' physiological arousal and mood during a lecture in a standard lecture theatre, in a standard experimental room while watching a non-emotional video of birds roosting and while using a Problem based learning (PBL) activity in an active learning classroom. .

Overview, Aims and Context

Modern learning environments promote collaborative interactive learning, which is associated with improved performance (Freeman, et al. 2014). The aim of this project was to measure physiological arousal and mood during learning in a modern learning environment in comparison with learning in a traditional lecture theatre environment.

In this repeated measures design, we aim to assess levels of physiological arousal (GSR) and mood during teaching activities in different environments. It is expected that physiological arousal will be higher during an active learning session (PBL) than during a standard lecture. On both occasions, the topics will involve Psychology Research Methods.

Description

The PSY109 research methods module has adopted Problem-based learning (PBL) as one of the main approaches to learning. This is a student-centered pedagogy during which they learn about a topic by gaining experience of solving a problem. In the study we used one of the new learning rooms (U113) so that students could work in a better defined learning space. The PBL session used for the study was several weeks into the class project that had been assigned. Some initial material had been provided by the facilitator, and the students had to find their own resources inside and outside of the classroom setting. During the sessions, they worked collaboratively in small groups. The PBL approach is focused on reflection and reasoning so that students develop their own learning.

One week later, the participants attended their regular lecture class on Research Methods where the lecturer used a standard powerpoint presentation.

Before and after both sessions short measures of positive affect and negative affect were completed and GSR was measured continuously during both sessions.

Design

Method

Design

This was an experiment, which used a repeated measures design. The independent variable (IV) was the different learning environments (traditional lecture theatre, active learning environment and a standard experimental room). The dependent variable (DV) was the physiological response to the different environments measured by Galvanic Skin Response (GSR).

Materials

The experiment used a number of different pieces of equipment and materials. The 20-item Positive and Negative Affect Schedule (PANAS; Watson, Clark & Tellegen, 1988) was used to measure mood. The NEXUS – 10EH Neuro-feedback equipment and Biotrace software along with purpose built, cost effective, BITalino equipment and BioSignals software were used to measure GSR. Each device communicated via Bluetooth to a laptop, which recorded the data.

Participants

The study used a sample of 1st year undergraduate Psychology students enrolled on the research methods module PSY109. The study involved 10 participants (2 males and 8 females) aged over 18. Participation was voluntary. A sample of ten participants were recruited due to the limited number of physiological devices.

Procedure

Each participant (individually) first watched a video, with sound, of birds flying and resting on phone lines, this was conducted in an experimental room located in the School of Psychology. Secondly, they attended a Problem Based Learning (PBL) class in the purposely designed rooms for small group learning in the new teaching block (U113). This was their regularly timetabled class shared with other students. Thirdly, they attended their regular timetabled PSY109 lecture in U123 with the whole class. Before and after each session the participants were asked to fill out the PANAS mood questionnaire and during each session they were attached to the physiological equipment to record their GSR. For the NEXUS physiological equipment, two Skin Conductance electrodes were placed on two fingertips of the nondominant hand, at the palmar side of the fingers and for the BITalino, 2 electrodes were placed on the nondominant hand, at the palmar side of the thumb. There is no standard that defines which fingers to use. From these electrodes a cable runs to the equipment which is then calibrated to the participant using the software. Data were recorded during a baseline period (before each session started) and during each session.

Analysis

The resulting GSR data were submitted to analysis of variance (ANOVA) with repeated measures and pairwise comparisons using a general statistical package (SPSS). Where the criterion for homogeneity of variances was not met, Greenhouse-Geisser correction was used for that analysis. One participant was dropped before final analysis because of equipment failure and non-attendance at one session.

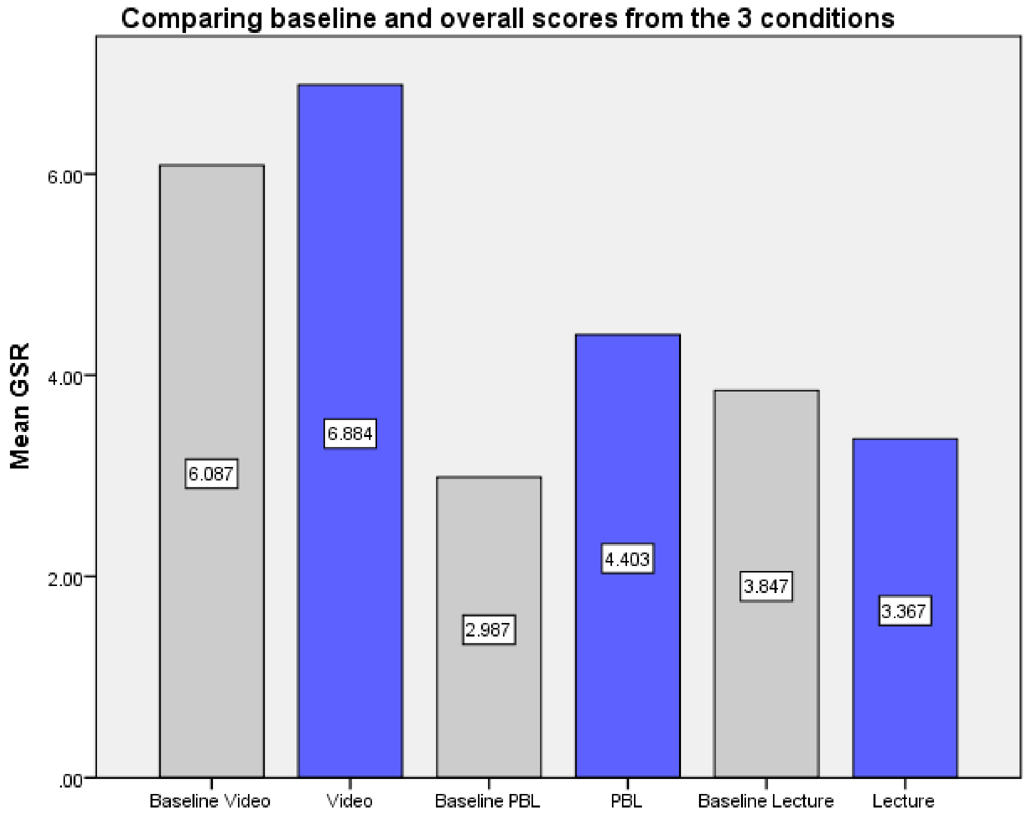
Ethics

The project was approved by the Psychology Ethics Filter Committee

RESULTS

The repeated measures ANOVA result shows a significant main effect across sessions $F(2,16) = 6.54$, $p < .05$. Post hoc analysis shows that the mean GSR score for the video session is significantly higher than the lecture GSR mean ($p<.05$). Importantly, there is no significant difference in GSR based on the pairwise comparison between the PBL mean and lecture mean. In addition, no significant difference was found between video GSR mean and PBL mean. Figure 1 shows the GSR for the PBL is higher than the GSR for the lecture. Whilst this favours the role of active learning, there is no convincing evidence here that arousal or attention is significantly influenced by the learning environment.

Figure 1



Comparing each baseline mean GSR against its pair (for example baseline video V mean GSR for the video session; baseline PBL V mean GSR for the PBL session; baseline lecture V mean GSR for the lecture session) there are no significant differences. Thus, neither student-centred nor teacher-centred approaches, as defined here, altered arousal appreciably.

Figures 2 and 3 show baseline and session means for positive affect and negative affect. These figures indicate moderate levels of positive affect and low levels of negative affect, suggesting that the levels of arousal shown in the GSR are unlikely to be a function of the background moods of the participants.

Figure 2

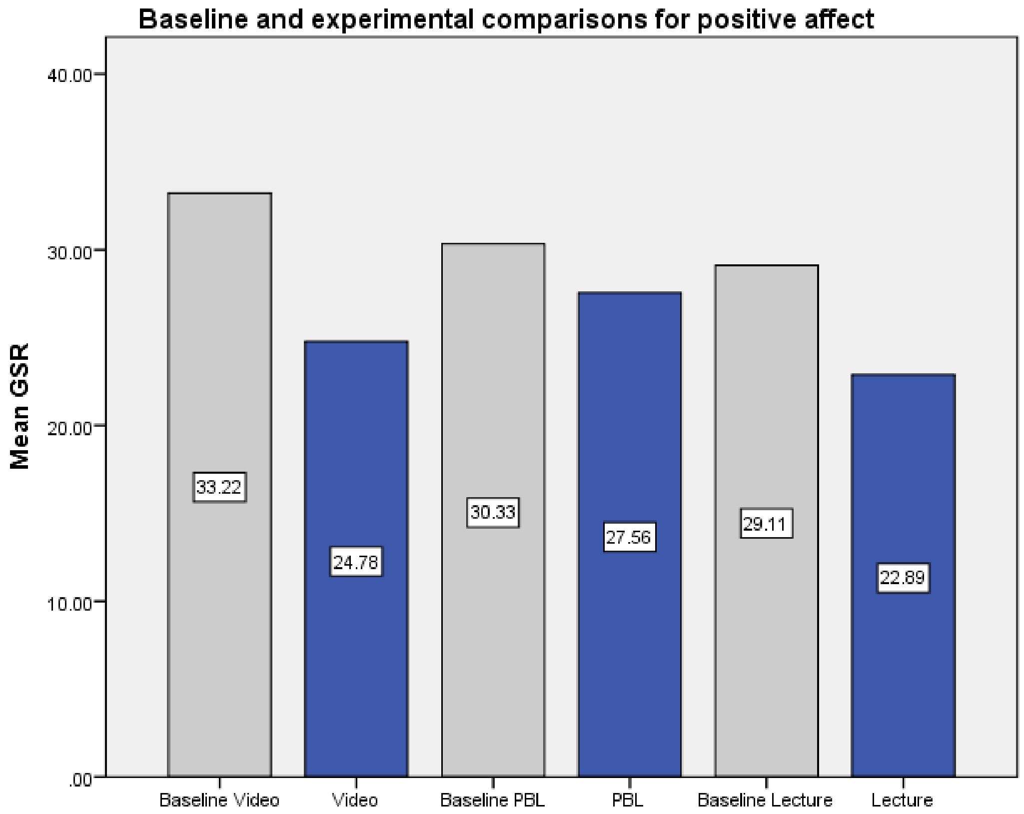
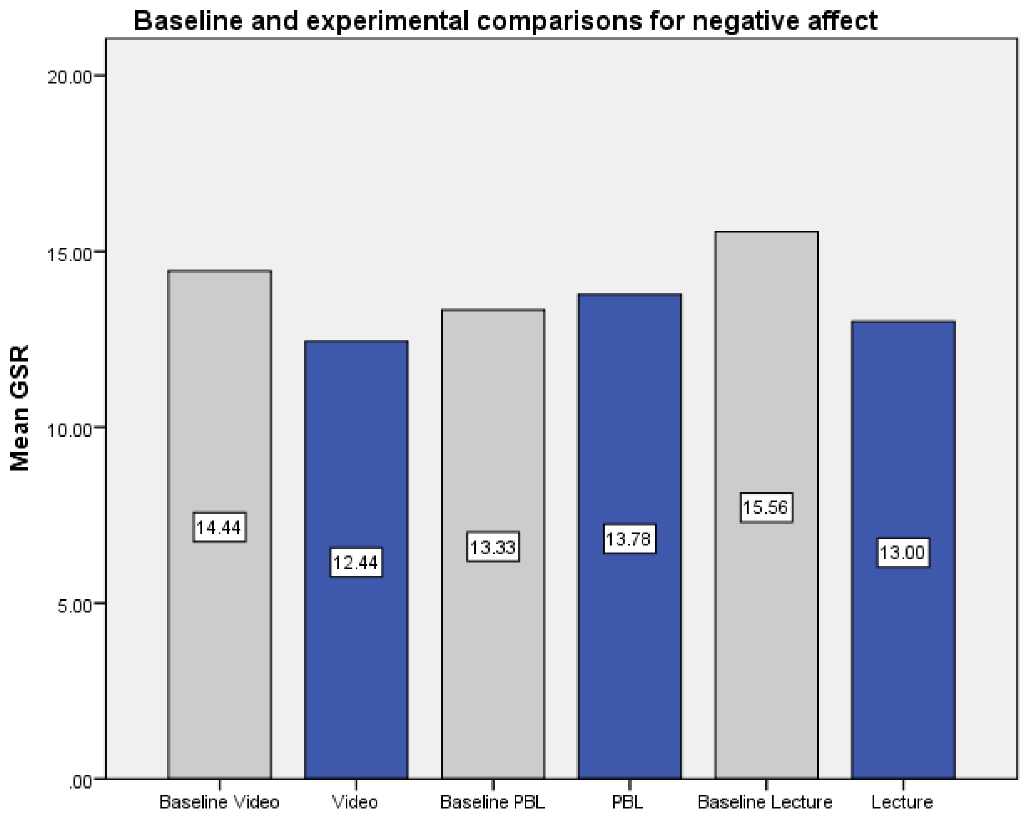


Figure 3



Reflective Commentary (this should draw from your experience and identify what worked well and what were the key challenges ;)

There were a number of issues with which we did find a challenge. The first one being Equipment. Physiological equipment can be expensive and complicated to run. We ran 10 machines in each session, which was extremely difficult for one experimenter, so on reflection more experimenters are needed to run this type of study. Because of the expense of the NEXUS – 10EH Neurofeedback machines, we also built our own more mobile and cost effective units to measure GSR, using BITalino hardware and BioSignals software. These seemed to work well in terms of connecting to the laptops via Bluetooth. The challenge came in terms of connecting a switch to the equipment, which enabled a marker to be added to indicate where baseline ended and the class began. Because this involved the participant operating the switch when instructed by the experimenter, human error was introduced. On reflection, this procedure would need to be reconsidered. Issues in terms of battery life of the laptops would need to be fixed along with the computers going into standby or the Bluetooth failing. A second challenge relating to the equipment was data extraction. More reliable extraction will require a new algorithm to be written. How often the equipment takes a GSR reading would need to be addressed. For example, the built equipment was gathering so much raw data that we ended up with 600000 data points for every 10mins. A third issue was recruiting participants who would attend all three sessions, because if they missed a class then a participant would not have a full profile of data. This happened for one participant. A more obvious problem was because of only having ten machines we ended up with a small number of participants, which then has an effect on our statistics. We ran inferential statistics but we are very cautious about extracting anything meaningful from such a small sample. A larger study with more participants is needed. More consideration is needed at the design stage concerning potential threats to the validity. Whilst the equipment is measuring arousal, is this being affected by the participant's attention or could it be anxiety or even some other extraneous variable that needs to be controlled? These could include age, gender, time of day, individual differences, general health and even food and substance use before the experimental sessions. With better recording of time intervals, we would be able to look at particular segments of the lecture and PBL. Participants may require a longer period of habituation to being monitored by physiological equipment.

Student Engagement (to be completed by the student partner):

The results of the mood analysis showed that all of the participants displayed low levels of negative affect and moderate positive affect throughout the study and afterwards indicated that they enjoyed the experience.

Learning Environment and Engagement: your views on the appropriateness and effectiveness of physical spaces for engagement and virtual spaces to enhance learning**.**

We looked at learning and teaching in two different spaces, the normal lecture theatre (U123) and one of the new learning rooms (U113). We found that students' engaged more in the smaller learning space and you could form more of a relationship with them (U113). This was evident in them asking and answering more questions during PBL sessions. Effective spaces can improve student learning but we do think these open flexible spaces need longer sessions than a teacher-centered transmission pedagogy.

Impact

This experiment used physiological arousal as an indicator of attention and while we found no significant difference between an active learning environment (PBL) and a didactic lecture, we did find the GSR means to be in a favourable direction for the PBL with a slightly higher mean for GSR scores.

STRATEGIC DEVELOPMENT

Transferability (consider how this activity might be used by colleagues in other schools/faculties and if it could be developed for a further Faculty interdisciplinary learning project)

If a real difference exists in attention/arousal favouring PBL over lecture environments, then a replication with greater power and better controls, would find it. In such a scenario, there could be real benefits in expanding the use of PBL.

Dissemination (internal and external) (School and Faculty briefings, workshops, resources developed)

A talk to the school is planned to showcase the equipment used.

SUPPORTING INFORMATION

References (using Harvard style, list literature and other resources that influenced your work)

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Attachments List and attach relevant documents/images in support of project activities

N/A