Non-traditional immersive seminar enhances learning by promoting greater physiological and psychological engagement compared to a traditional lecture format

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ABSTRACT

The purpose of this study was to determine the impact of an immersive seminar, which included moderate intensities of physical activity, on learning when compared to traditional lecture format. Twenty-six healthy participants were randomly divided into an immersive seminar or traditional lecture format group and presented material related to positive psychology and human values/beliefs over the course of two days. Physical activity was collected using a bio-harness while salivary cortisol and perceptual measures of well-being were collected over the two days. Performance on an examination related to course material was used to assess learning. Average time spent over 65% of max heart rate, energy expenditure, total bounds, mechanical and physiological load were significantly greater in the immersive seminar group when compared to traditional lecture group. In addition, cortisol levels and perceptual measures of mood, focus, energy, and well-being were significantly greater in the immersive seminar when compared to the traditional lecture format. Participants in the immersive seminar demonstrated significantly greater memory retention of course material 30-days post lecture when compared to the traditional lecture group. These findings support incorporating more physical activity and increasing arousal in order to enhance learning of lecture material.

1. Introduction

The process of memory consolidation is complex and thought to involve the transfer of fragile short-term memory into a relatively permanent long-term memory trace [1]. In addition to the well-known benefits of physical activity for health and longevity, recent studies have demonstrated benefits in the educational setting to strengthen this transfer and promote learning [2,3]. Additionally, educators have looked to enhance psychological aspects such as internal motivation, arousal, and other internal variables that promote learning.

Physical activity has been shown to benefit attention [3] and memory consolidation [4]. Physical activity also influences various aspects of psychosocial, neurobiological, and behavioral mechanisms that influence overall well-being. Exercise releases endorphins [5], improves self-efficacy, autonomy, and sleep quality [6], promotes social interaction, and provides individuals a coping mechanism [7]. Recent research has shown positive benefits of standing desks [8], bike desks [9,10], and walking treadmills [11] to further improve cognitive function and physical health. Exercise intensity appears to be a variable impacting learning as high-intensity running demonstrated a 20-percent increase in vocabulary learning compared to low-intensity running [12]. Exercise intensity is reflected by several variables including energy expenditure or metabolic equivalent [13], heart rate [14], load accumulation [15], and cortisol levels [16]. Higher levels of cortisol, which is experienced in times of stress or intense exercise, has demonstrated superior memory consolidation when compared to lower cortisol levels [17,18]. It is well

Abbreviations: IMS, immersive seminar (experimental); CON, control; BL, baseline; SE, state elevation; PreMed, pre-meditation; PostMed, post-meditation; 30DP, 30 days post; VAS, visual analog scales; T, testosterone; C, cortisol; T:C, Testosterone to Cortisol ratio; OPTIMAL, Optimizing Performance Through Intrinsic Motivation and Attention for Learning; a.u., arbitrary unit.

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documented that physical activity can improve learning [2–4], however, to date, there are limited studies that investigate moderate intensity physical activity and its impact on memory and learning.

In order to improve performance and enhance learning, the Optimizing Performance Through Intrinsic Motivation and Attention for Learning (OPTIMAL) theory was introduced as a guide to teachers and coaches looking to accelerate learning [19]. The authors discuss many variables that improve learning with two being enhancing expectancies to elicit positive experiences and providing autonomy in order to improve intrinsic motivation. Instructors often aim to enhance these variables to assist in learning through their actions and expressions. Enthusiasm and excitement while delivering information from an instructor has demonstrated greater intrinsic motivation from students [20,21]. Shoshani and Slone [22] discuss the positive emotions, engagement, positive relationships, meaning and achievement (PERMA) model in classroom settings as a method to augment learning. Classrooms where students subjectively feel encouraged, form positive relationships, and remain engaged in the material are more likely to enhance memory consolidation and learn course material. The combination of positivity, encouragement, and close relationships should strengthen an individual’s valence (if we feel positive or negative) and arousal (activation) [23] to incoming information.

In addition to physical activity and suggestions of the OPTIMAL theory, learning can also be improved through changes in various internal factors such as arousal and positive mood states. Moreover, extensive research has demonstrated that arousal increases long-term memory formation [24]. Mechanistically, arousal is thought to induce a cascade of biochemical events, which may enhance positive mood states through activating the pituitary-gonadal axis, engaging sympathetic nervous system activity, and triggering the release of adrenal hormones involved in long-term memory formation [1]. One such hormone is cortisol, which presents a complex interaction between short-term and long-term memory. For example, recent meta-analytical data demonstrates that the hormone may have negative effects on working memory in the short-term, but improves long-term memory formation (i.e., learning) [25]. Traditional classroom settings tend to consist of one lecturer relaying information to students in presentation format. This could lead to a low level of arousal from students whereas research demonstrates, increasing arousal could facilitate student learning [19,26].

Research indicates that an individual’s state (or affect) strongly impacts the strength of memory consolidation [27]. Affect is comprised of valence and arousal [23]. The affect-as-information framework posits that affect characterizes the value and importance of incoming information [24]. Pleasant or unpleasant feelings lead us to assign a corresponding value to incoming information [1,27]. Resulting judgments direct cognitive processing and regulate the ‘worthiness’ of forming long-term memories [27]. Storbeck et al. [24] suggests that when faced with incoming information, individuals not only ask “How do I feel about this (valence)?”, but “How strongly (arousal) do I feel about this?” If the information is judged positively and arousal is increased, then individuals are more likely to engage in deeper relational based processing methods [28]. Collecting subjective measures on how an individual is feeling and perceiving the information being presented could give researchers and instructors a deeper look into the relationship between state and learning.

Large scale personal development, peak performance, and business management seminars involve a central figure that is tasked with teaching and inspiring thousands of people for hours on end [29]. The goal is to inspire through a transfer of passionate language patterns, physiology, focus, and state from the presenter (Social Imitation Theory) [30] to the audience through mirroring passionate language, hyperkinetic behaviors (jumping, clapping, shouting, and fist pumping behaviors) [29], and intimate personal interactions. These are the same behaviors exhibited by instructors looking to display enthusiasm to their classroom [20]. An instructor would look to raise their heart rate through these hyperkinetic behaviors and increase arousal with hopes that their students mimic their actions. The combination of altering arousal, focus, and language patterns are thought to produce radical and permanent changes in individual’s lives (e.g., learned behavior change) [24]. However, to date, the impact of such experiences by both students and instructors on learning remains unexamined.

This study investigated the effects of an immersive seminar (Unleash the Power Within [UPW]) compared to a traditional lecture format on learning. Briefly, both interventions contained the same lecture material. The material was divided into sections focused on (1) cognitive retraining of beliefs and attitudes [31], (2) re-prioritizing need states towards those which increase intrinsic motivation and fulfillment (e.g., personal growth and contribution) [32], (3) optimal learning models for success with a focus on modeling and mentorship [33] and (4) achievement oriented imagery [34]. The lecture material was presented over two days totaling approximately 19 to 22 h. In the traditional classroom format, participants sat while the lecturer stood and presented. In the motivational seminar, the presenter engaged participants through varying tonal patterns and in the hyperkinetic activities described above. We hypothesized that those in the immersive seminar would experience improvements in learning as compared to the traditional lecture group. Secondly, we hypothesized that participants in the immersive seminar would demonstrate increased subjective measures of well-being, focus, mood, and energy when compared to the traditional lecture group.

2. Methods

2.1. Participants

A total of 50 participants were assessed for study eligibility. However, twenty-four participants were excluded from the study for various reasons (Fig. 1). Consequently, twenty-six healthy adult men and women (16 Caucasians, 5 Hispanics, 2 African-Americans, 2 Middle-Easterners, and 1 Asian-Pacific Islander) consented to enrollment for the study. All 26 participants completed all measurements throughout the study. Participants could not participate if they had any cardiovascular or neuromuscular conditions. Screening for the above criteria was obtained by phone or in person prior to any testing. Prior to the commencement of the study, participants were randomly divided by a random number generator (random.org) into immersive seminar (IMS) or traditional (control [CON]) lecture formats. The IMS group included five males and eight females (n = 13, 35.3 ± 12.2 years, 78.4 ± 20.8 kg,
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171.7 ± 11.6 cm) who attended the seminar (UPW). Control group participants included six male and seven female volunteers (n = 13, 32.1 ± 9.2 years, 78.4 ± 17.8 kg, 168.4 ± 10.7 cm) who received the tested content through a lecture in a classroom setting. The study protocol was approved by an Institutional Review Board (InteReg Review IRB, Austin, TX, USA, Protocol #1118) and in agreement with the Declaration of Helsinki. All participants were informed of the study protocol prior to the event and written informed consent was obtained from all participants prior to participation. All participants were de-identified during data collection and given a randomized subject code.

2.2. Experimental design

Participants were lectured to on two separate days separated by 24 h (i.e., Thursday and Saturday). Lecture material on day 1 consisted of a) individual discovery of human needs, b) developing effective communication, and c) processing human fears. On day 2, topics consisted of a) neuro-linguistic processing techniques, b) processing human values and beliefs, and c) practical understanding of human psychology. For the IMS group, participants were provided with a hard copy of lecture material which was presented at UPW with a combination of state elevation sessions (jumping, shouting, fist pumping, and high five behaviors) which were conducted approximately once every hour to raise arousal and to interrupt sedentary behavior, as well as mindfulness meditation that focused on a wide variety of awareness, affective states, thoughts and images [35] that were conducted once at the end of each day. The CON was provided a hard copy of lecture material which was presented via PowerPoint from a lecturer with over 15 years of undergraduate and graduate level university teaching experience.

Prior to lecturing, the participants and lecturers were fitted with a bio-harness to collect real time measurement of various physiological variables (Table 1). Participants were given an examination before, 2-days, and 30-days after exposure to the lectures containing multiple choice and essay-based questions related to the presented materials. In addition, visual analog scales were administered at baseline (BL), during state elevation (SE), and prior to (PreMed) and immediately following (PostMed) a meditation session on both days to capture perceptual changes in self-perception of mood, well-being, and energy and focus. The VAS consisted of the following questions: “How is your mood at this moment?”, “How is your personal well-being at this moment?”, “How energized are you at this moment?”, “How focused are you at this moment?” which assesses the components of mood, well-being, energy, and focus, respectively. The participants’ answers to these questions were made by placing a cross on the 100 mm lines anchored on their end with the most positive (100 mm) and the most negative (0 mm) answers for each question (I am in an awful mood/1 am in a brilliant mood, etc.). Participants were informed on how to complete the VAS by study investigators prior to the commencement of the study. Participants’ answers were recorded in millimeters and the two-day average was used for analysis (BL Day 1 + BL Day 2 / 2).

2.4. Physiological monitoring

Prior to the presentations of lecture material, participants and lecturers for both groups were fitted with a U.S. FDA-approved wireless ambulatory physiological monitoring device (Zephyr™ BioModule™ Technology, Auckland, New Zealand). The device-snaps onto an adjustable chest strap which is suitable for both men and women. The strap was held securely around the participants’ chest, with a support strap going over the right shoulder to prevent the strap from sliding up or down. The module itself was on the left side of the participant, underneath their left armpit (to be near the heart). Data by the module was collected at 100hz. Three main domains were monitored: physiological load, mechanical load, and calorific expenditure.

2.5. Salivary measures

Salivary cortisol and testosterone samples for IMS and CON were taken using IPRO Oral Fluid Collector (OFC) Kits (Soma Bioscience, Wallingford, UK). The OFC kits collect 0.5 mL of oral fluid and contain a color changing volume adequacy indicator within the swab, giving collection times typically in the range of 20–50 s [37]. Baseline levels of cortisol and testosterone were assessed in the morning prior to the seminar on Day 1 and reassessed on Day 2 at the same time of day. Saliva samples were collected on both days at SE, PreMed, and PostMed. The CON condition took measures at the same time of day as the IMS group. The samples were analyzed using an IPRO POC Lateral Flow Device (LFD), specific for cortisol and testosterone, in an IPRO LFD Reader. Two drops of saliva/buffer mix from the OFC were added to the sample window of the F. The liquid runs the length of the test strip via lateral flow, creating a control and test line visible in the test window. Ten minutes after the sample is added, the test line intensity was measured in an IPRO LFD Reader and converted to a quantitative value.

2.6. Examination

The exam given to participants contained multiple choice and essay-based questions pertaining to lecture material as well as a psychological needs-based questionnaire. The exam was administered at baseline, 2-days and 30-days following the event. The exams were graded, in a blinded manner, by an independent researcher under the guidance of a standardized answer key. A copy of the examination with the answer key is provided in Supplementary File 1.

2.7. Statistical analysis

Prior to performing statistical analysis, data was tested for normality and variance using the Shapiro-Wilk’s test and Levene’s test, respectively. The two-day averages for salivary cortisol, testosterone, testosteroneto-cortisol ratio, and visual analogue scales were used for analysis. These aforementioned variables and examination data were analyzed with a two-way mixed model analysis of variance (ANOVA) using group as a between-participants factor, time as a within-participants factor, and participants as a random factor. Whenever a significant F value was

| Variable             | Definition                                                                 |
|----------------------|-----------------------------------------------------------------------------|
| Physiological Load   | Cumulative index of cardiac output based on physiological intensity. It is a measure of total cardiovascular output when heart rate rises above 50% HR max. |
| Total Bounds         | Cumulative bounds (a movement distinguished from a step by time in the air) taken by the participants. |
| Mechanical Load      | Cumulative index of kinetic output based on mechanical intensity. It is a measure of total kinematic output. |
| Total Caloric Expenditure | Cumulative estimation of calories burned during a session. Calories were calculated in 30 s intervals according to the following equation [38]:Calorie = Gender^(- * 0.0747 * weight + 0.9774) + (1Gender)^2 * (0.02022 + 0.44722 * age) - 0.2163 + weight + 0.0747 * age) |

HR: heart rate, weight: participants’ bodyweight in kilograms, age: participants age in years, gender: male = 1 and female = 0.
obtained a post hoc test with Tukey’s adjustment was used for multiple comparisons. For physiological load, mechanical load, energy expenditure, and bounds, the two-day cumulative total was analyzed with two-tailed, unpaired *t*-test. Effect sizes for ANOVA interaction effects are reported as partial omega squared ($\omega^2_p$) using the following formula [38]: 

$$\text{df}_{AB} \times (\text{MS}_{AB} - \text{MS}_{error}) / (\text{SS}_{AB} + \text{SS}_{subject} + \text{MS}_{subject})$$

This statistic has been recommended as an unbiased alternative to partial eta squared [39]. Effect sizes using $\omega^2_p$ values of 0.01, 0.06, and 0.14 were considered small, medium, and large, respectively [40, 41]. Effect sizes for comparisons of means are reported as Cohen’s $d$ calculated using the pooled standard deviation of the means being compared (M1 – M2/SDpooled). In general, benchmarks for Cohen’s $d$ effect size were set at small (0.3), medium (0.5), and large (0.8) [42]. Additionally, we reported the mean difference, upper and lower limit values of 95% confidence intervals (95% CI) of the mean differences as this approach allows variable change due to the treatment to be investigated, rather than only the level of statistical significance. In this regard, the confidence interval includes the value range in which the true population mean of the difference is likely to be contained. The alpha level was set at 0.05 prior to analysis. Data are reported as mean and standard deviation unless otherwise stated.

![Fig. 2. Timeline of Data Collection.](image)

![Fig. 3. Visual Analogue Scale Results for Mood (A), Well-Being (B), Energy (C), and Focus (D).](image)

BL: Baseline; SE: State-Elevation; PreMed: Pre-meditation; PostMed: Post-meditation. # = significantly different than BL ($p<0.05$). * = significantly different between groups ($p<0.05$).
3. Results

3.1. Visual analogue scales

A significant group by time interaction was detected for Mood (F = 3.034, p = 0.035, ω²p = 0.05, Fig. 3A). Post hoc analysis indicated that the IMS group demonstrated elevated Mood at PreMed (mean diff = 15.3, 95% CI_diff = 3.5 to 27.1 mm, p = 0.005, d = 1.26) and PostMed (mean diff = 16.0, 95% CI_diff = 4.2 to 27.8 mm, p = 0.003, d = 1.14) relative to BL and compared to CON (PreMed: mean diff = 16.3, 95% CI_diff = 4.8 to 27.7 mm, p = 0.002, d = 1.59; PostMed: mean diff = 16.4, 95% CI_diff = 5.0 to 27.8 mm, p = 0.002, d = 1.43).

A significant group by time interaction was detected for Well-Being (F = 3.640, p = 0.017, ω²p = 0.07, Fig. 3B). Post hoc analysis indicated that the IMS group had elevated Well Being at SE (mean diff = 13.4, 95% CI_diff = 2.0 to 24.8 mm, p = 0.013, d = 1.03), PreMed (mean diff = 15.0, 95% CI_diff = 3.6 to 26.4 mm, p = 0.004, d = 1.21), and PostMed (mean diff = 17.9, 95% CI_diff = 6.4 to 29.3 mm, p = 0.001, d = 1.32) relative to BL and compared to CON (SE: mean diff = 14.1, 95% CI_diff = 3.5 to 24.7 mm, p = 0.004, d = 1.25; PreMed: mean diff = 17.3, 95% CI_diff = 6.7 to 27.9 mm, p < 0.001, d = 2.38; PostMed: mean diff = 20.6, 95% CI_diff = 10.0 to 31.2 mm, p < 0.001, d = 2.04).

A significant group by time interaction was detected for Energy (F = 12.66, p < 0.001, ω²p = 0.14, Fig. 3C). Post hoc analysis indicated that the IMS group had greater Energy at SE (mean diff = 19.4, 95% CI_diff = 10.7 to 28.0 mm, p < 0.001, d = 1.42), PreMed (mean diff = 24.5, 95% CI_diff = 15.8 to 33.1 mm, p < 0.001, d = 1.75), and PostMed (mean diff = 24.2, 95% CI_diff = 15.6 to 32.9 mm, p < 0.001, d = 1.78) relative to BL and compared to CON: SE (mean diff = 12.8, 95% CI_diff = 1.0 to 24.8 mm, p = 0.031, d = 0.99; PreMed: mean diff = 19.2, 95% CI_diff = 7.2 to 31.1 mm, p < 0.001, d = 1.70; PostMed: mean diff = 17.9, 95% CI_diff = 5.9 to 29.9 mm, p < 0.001, d = 1.46).

A significant group by time interaction was detected for Focus (F = 12.66, p < 0.001, ω²p = 0.14, Fig. 3D). Post hoc analysis indicated that the IMS group had greater Focus at SE (mean diff = 16.5, 95% CI_diff = 7.3 to 25.7 mm, p < 0.001, d = 1.55), PreMed (mean diff = 20.9, 95% CI_diff = 11.6 to 30.1 mm, p < 0.001, d = 2.52), and PostMed (mean diff = 16.6, 95% CI_diff = 7.4 to 25.8 mm, p < 0.001, d = 1.42) relative to BL and compared to CON (SE: mean diff = 20.6, 95% CI_diff = 10.5 to 30.7 mm, p < 0.001, d = 2.02; PreMed: mean diff = 25.9, 95% CI_diff = 15.7 to 36.0 mm, p < 0.001, d = 3.03; PostMed: mean diff = 20.7, 95% CI_diff = 10.6 to 30.8 mm, p < 0.001, d = 1.85).

3.2. Salivary measures

Salivary cortisol demonstrated a significant group by time interaction (F = 7.729, p < 0.001, ω²p = 0.14, Fig. 4A). Post hoc analysis indicated that the IMS group had higher salivary cortisol at SE than all other time points (BL: mean diff = 8.7, 95% CI_diff = 4.4 to 13.1 ng/dL, p < 0.001, d = 1.26; PreMed: mean diff = 7.8, 95% CI_diff = 3.4 to 12.2 ng/dL, p < 0.001, d = 1.03; PostMed: mean diff = 11.5, 95% CI_diff = 7.1 to 15.8 ng/dL, p < 0.001, d = 1.81), and PostMed was significantly lower than PreMed (mean diff = −5.5, 95% CI_diff = −9.0 to −2.0 ng/dL, p < 0.001, d = −2.20). The concentration at SE was significantly greater in IMS compared to CON (mean diff = 9.8, 95% CI_diff = 5.3 to 14.4 ng/dL, p < 0.001, d = 0.72).

No significant main effects (group: F = 7.076, p = 0.001, ω²p = 0.11, Fig. 4B). Post hoc analysis revealed that T:C levels at PostMed were higher than all other time points in the IMS group (BL: mean diff = 100.8, 95% CI_diff = 47.3 to 154.3 a.u., p < 0.001, d = 1.44; SE: mean diff = 131.3, 95% CI_diff = 77.8 to 184.8 a.u., p < 0.001, d = 1.91; PreMed: mean diff = 126.1, 95% CI_diff = 72.6 to 179.6 a.u., p < 0.001, d = 1.87). Additionally, T:C ratio was significantly lower in the IMS group compared to CON at PreMed (mean diff = −96.8, 95% CI_diff = −158.7 to −34.9 a.u., p < 0.001, d = −1.49).

3.3. Physiological monitoring

Shapiro-Wilk testing confirmed normality for physiological load (IMS p = 0.102, CON p = 0.097), mechanical load (IMS p = 0.431, CON p = 0.266), bounds (IMS p = 0.114, CON p = 0.084), and energy expenditure (IMS p = 0.606, CON p = 0.061). Data for time elapsed over HR65% violated normality (IMS p = 0.384, CON p = 0.001), therefore, the Mann-Whitney U nonparametric alternative was applied. The IMS group demonstrated greater cumulative totals for physiological load (mean diff = 419, 95% CI_diff = 159.9 to 678.8 a.u., p = 0.003, d = 1.31) (Fig. 5A), mechanical load (mean diff = 97.3, 95% CI_diff = 57.0 to 137.7 a.u., p < 0.001, d = 1.95) (Fig. 5B), bounds (mean diff = 688, 95% CI_diff = 386 to 990, p < 0.001, d = 1.85) (Fig. 5C), energy expenditure (mean diff = 2218, 95% CI_diff = 794 to 3643 kcal, p = 0.004, d = 1.26) (Fig. 5D), and a greater percentage of time over HR65% (EXP: mean rank = 19.8, median = 9.35; CON: mean rank = 0.20, median = 0.83; median 95%CI_diff = 5.2 to 12.2, p < 0.001, d = 2.59). The IMS lecturer accumulated greater physiological load (3641 vs 70 a.u.), mechanical

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**Fig. 4.** Mean and SD for Salivary Cortisol (A) and T:C Ratio (B). BL: Baseline; SE: State-Elevation; PreMed: Pre-meditation; PostMed: Post-meditation. # = significantly different from all other time points (p < 0.05). * = significantly different between groups (p < 0.001). ** = significantly different from PreMed (p < 0.01).
Fig. 5. Relative Totals for Physiological Load (A), Mechanical Load (B), Bounds (C), and Energy Expenditure (D).
BL: Baseline; SE: State-Elevation; PreMed: Pre-meditation; PostMed: Post-meditation; a.u. = arbitrary unit; kcal = kilocalorie. * = significantly greater than CON (p<0.01). Solid horizontal bar within the group’s cluster represents the mean.

Fig. 6. Mean and SD for Exam Scores.
BL: Baseline; SE: State-Elevation; PreMed: Pre-meditation; PostMed: Post-meditation. # = significantly different than BL (p<0.001). * = significantly different between groups (p<0.001). ^ = significantly different than Post and BL (p<0.01).
load (238 vs 3 a.u.), bounds (1640 vs 15 count), and energy expenditure (15,385 vs 4239 kcal) over the two days of lecturing.

3.4. Examination

A significant group by time interaction was detect for Exam Scores ($F = 39.9, p < 0.001, \omega^2_p = 0.37$, Fig. 6). Post hoc analysis indicated that both groups demonstrated greater Exam Scores at Post (EXP: mean diff = 53.7, 95% Cl$_{diff} = 45.2$ to 62.1%, $p < 0.001, d = 5.54$; CON: mean diff = 28.4, 95% Cl$_{diff} = 19.6$ to 37.2%, $p < 0.001, d = 2.47$) and Post-30D (EXP: mean diff = 59.4, 95% Cl$_{diff} = 51.0$ to 67.9%, $p < 0.001, d = 5.16$; CON: mean diff = 15.6, 95% Cl$_{diff} = 6.8$ to 24.4%, $p < 0.001, d = 1.43$) compared to baseline. In the CON group, Post-30D Exam Scores were significantly lower than Post (mean diff = −12.8, 95% Cl$_{diff} = −21.6$ to −4.0%, $p = 0.002, d = 0.86$). Additionally, the IMS group had significantly greater Exam Scores compared to CON at Post (mean diff = −27.1, 95% Cl$_{diff} = −15.9$ to 38.3%, $p < 0.001, d = 2.12$) and Post-30D (mean diff = −45.6, 95% Cl$_{diff} = −34.4$ to 56.8%, $p < 0.001, d = 3.35$).

4. Discussion

The purpose of this study was to investigate the effects of an immersive seminar compared to a traditional lecture format in a classroom setting on learning. We hypothesized that participants in the non-immersive seminar (IMS) would exhibit enhanced learning when compared to traditional lecture format (CON). The primary findings of this study were that learning was greater in the IMS compared to the CON as the increased performance on the exam was sustained 30-days post event when compared to CON, which decreased 30-days post event. Moreover, participants in the immersive seminar demonstrated greater total energy expenditure and improvements in perceptual measures. These changes were paralleled by elevations in cortisol, a hormone known to impact long-term memory consolidation.

Previous studies have shown that physical activity can promote learning in traditional classrooms [2,3]. These levels of physical activity are normally low in intensity and include walking or biking. Furthermore, a recent study demonstrated that increasing intensity of exercise promotes learning [4]. However, the study by Nanda and colleagues was constrained to a 20-min bout of exercise where it is difficult to project these results to longer duration intensive learning formats. Such formats can include weekend certification or accelerated summer courses where a semester is condensed into a matter of days. The present study mimicked these situations through two intensive days, which included several hours of lecture material given in a traditional classroom or immersive seminar format. The results of this study indicate that the IMS performed multiple bouts of higher intensity activity through jumping, clapping, and shouting behaviors which manifested in greater mechanical and physiological loads, as well as elevated total energy expenditure over the traditional lecture format. In addition, the instructor for IMS exhibited higher levels of physical activity and energy expenditure over the CON instructor which provides support to the Social Impression Theory [20] that instructor actions can be mimicked by their students and augment learning. Our results both extend and agree with Nanda et al. [4] and demonstrated greater total retention of the lecture material than was presented in the more sedentary traditional lecture format.

Several theories have been postulated that the biochemical link between physical activity and learning occurs due to alterations in the adrenal hormone cortisol. Cortisol is elevated during times of intense exercise and stress. Recent studies have shown that high levels of cortisol enhance memory consolidation as arousing experiences are well remembered, even decades after an event has occurred [1]. For example, most individuals lack recall for September 10 or 12th of 2001, but have extraordinary memory recall of the 11th. Therefore, the raised cortisol levels detected by IMS could explain their improvement in learning detected by the 30-day retention test when compared to CON. As discussed previously, acute cortisol increases from exercise can negatively impact short-term memory recall, but appear to improve long-term memory recall [25]. However, this relationship is complex as there is contrasting literature regarding the relationship between exercise-induced stress reactivity and memory recall. For example, the cross-stressor adaptation hypothesis [43] states that exercise promotes an adaptation to the stress response and develops optimal control of the response in other stress stimulating situations. Further, the hypothesis suggests long-term exercise causes a decrease in the amplitude of a stress response, meaning cortisol levels may rise due to exercise but adaptation to its response has occurred and negative influences are blunted. Unfortunately, this study did not control for exercise during the 30-day retention period and therefore cannot assess long-term cortisol response to exercise and its impact on learning. An additional intriguing finding occurred when viewing the ratio of testosterone to cortisol during the immersive seminar. In experts, this is known as an index of readiness to perform [44]. Following the seminar, individuals in the IMS robustly increased their ratio. Research indicates that experts have higher testosterone to cortisol ratios prior to demonstrating success in challenging events [44]. Though speculative, it could be proposed that the individual’s hormonal milieu at the end of the seminar reflected a signature biochemical marker of achievement. To address this question, we utilized introspective measures to sample participants’ affect and motivational state.

The OPTIMAL theory suggests that increasing motivation, autonomy, and focus will assist in learning [19]. The IMS exhibited increases in perceived focus, mood, and energy when compared to CON. These improved subjective feelings are thought to fuel an individual’s motivation and autonomy. Consequently, their overall well-being is improved, thereby augmenting their ability to learn. In addition to the OPTIMAL theory benefiting learning, the way one feels or interprets incoming information impacts their ability to learn [27]. Thus, it is plausible that the improved learning from the immersive seminar can be attributed to the improvements demonstrated in mood, focus, and energy.

The authors recognize there were some limitations to the findings in this study. While the lecture material was the same in both formats, the material was presented by two different lecturers between the two conditions. Another limitation in this study is not collecting socioeconomic status during participant recruitment. A third limitation is the inability to generalize the findings of the study to the adolescent population as the current sample of participants were adults.

In conclusion, traditional lectures are effective at improving learning. However, learning is enhanced when educational content is delivered through an arousing, mood elevating, high activity seminar. Findings from this study were similar to the “Burn 2 Learn” experiment [45] as students involved in high-intensity activity breaks during lecture improved on-task behavior and subjective well-being when compared to control. Lectures delivered in this immersive format resulted in hormonal responses that mirror experts in states of prevailing achievement and resulted in enhanced learning and memory. The benefits of physical activity on learning further support the importance of its application during lecture formats as other school-based studies have demonstrated [45,46]. These findings have broad implications for educators and lecturers who find themselves tasked with a condensed timeframe to deliver course material as occurs during weekend certification and accelerated academic summer courses.

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Declaration of Competing Interest

The authors have no conflicts of interest to report.

Supplementary materials

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