Title
Retention Rates of Scientific Information Through Embodied Learning

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RETENTION RATES OF SCIENTIFIC INFORMATION THROUGH

EMBODIED LEARNING

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By

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A capstone project submitted for
Graduation with University Honors

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University Honors
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APPROVED

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Abstract

It is common for college students to forget what they had studied after a course ends due to cramming of information. This is a problem since students, particularly in STEM disciplines, take courses that integrate and build upon concepts from previous classes. How, then, can students learn the material in a way different from traditional lecturing to retain the information effectively? Previous research has shown that using embodied learning – an educational method that involves using the whole body and embodied cognition – increases the association among the material, body, and environment, which leads to a better understanding of the concepts. To further investigate how this method affects learning, college students in non-science majors will be taught a scientific concept using either the traditional passive lecture style or via active embodied learning. The control group will receive no instruction. All three groups will receive the same assessment after a predetermined interval to assess whether retention occurred. Results of study may elucidate whether embodied learning would be an effective method for not only students' course performance, but, more importantly, truly learning a concept for future applications.

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Introduction

Purpose

It is common for college students to forget what they had studied during the nights leading up to an important exam due to cramming of information. This is a problem since students, especially STEM majors, take classes that build on one another, and so require the repeated concepts to be recalled from prior classes. The question is, "How can the material be presented in a way that is different from traditional lecturing, so that they can learn and hopefully retain the information efficiently?" It has been shown that using embodied learning increases the association between the material, body, and environment, leading to a better understanding of the concepts. This study aims to show if embodied learning is useful for long-term retention of difficult concepts. The results could help students in the future study information more effectively not only for exams, but also for future classes or applications of life.

I was inspired to delve into embodied learning for my capstone while I was enrolled in Dr. Dingwall's BCH 100 class in Fall Quarter 2018. The metabolism portion of the class consists of memorizing and integrating small details of larger metabolic pathways. At the time, I was struggling to memorize the glycogen degradation and synthesis processes. As a dancer, I tend to improvise dances in my room from time to time, and for some reason, I began dancing while talking myself through the glycogen pathways. A few days later in discussion, I was surprisingly able to recall every detail easily, compared to other topics that I was quizzed on. Furthermore, when it came time to study for the final, I reviewed the glycogen pathways and was again able to recall it perfectly on the final exam. This unique retention sparked my interest in this phenomenon, and I became curious if there was research on it. After having identified it via an internet search, I found the topic of what would become my capstone project.

What is Embodied Learning?

Embodied learning is an educational method that involves using the body to learn through motor movements. Motor movements can include anything from hand gestures to dance phrases. It has been shown that using embodied learning increases the association between the material, body, and environment that leads to a better understanding of the concepts.

Horn and Wilburn proposed that the most important concepts of embodied learning are observing and self-reflecting. They claim that learners are observers, and observers self-reflect. Through self-reflection, or “turning back on [themselves]”, learners allow themselves to understand how they learn. This, then, will lead learners to broaden their understanding of their learning capabilities (747).

Johnson-Glenberg, Birchfield, Tolentino, and Koziupa go a step further by exploring the actual psychosomatic concepts behind embodied learning. They propose that “cognitive processes have deep roots in sensorimotor processing and come from the body’s interactions with its physical environment” (88). They go on to say that embodied learning should be more accurately known as a basis of cognition as it involves neuroscience, math, gestures, acting, and possibly even dance (88). Furthermore, the authors of the study developed a hierarchical scale to embodied learning that builds on the amount of motion involved in the process, and thus the amount of self-reflecting possible:

> “Fourth degree = Includes locomotion which results in a high degree of sensory-motoric engagement; gestures are consistently designed to map to content being learned; and learner perceives environment as very immersive.

Third degree = No sustained locomotion, but whole body could still be engaged while in same area; some amount of gestural relevancy; learner perceives environment as immersive.

Second degree = Learner is generally seated, there is upper body movement; interfaces should be highly interactive, but gestural relevancy is not a given; with smaller display (monitor or tablet) the learner does not perceive the environment as highly immersive.

First degree = Learner is generally seated, some upper body movement; primarily observes video/simulation—no gestural relevancy; with smaller display learner does not perceive environment as immersive" (89).

To add onto how important the amount of movement is present during the embodied learning process, Munro suggests that embodied learning is only successful if the activity's goal is "not to the engage the body willy-nilly but to foster a deep-structure and a systemic engagement within the learning process so that both a bodyminded experience and a bodyminded understanding are facilitated" (8). It is important for the instructor to carefully plan the end result of the movements in the participants' mind. If the movements are not checking off the boxes of both a "bodyminded experience" that leads to a "bodyminded understanding," then the method is not effective and therefore is a waste of time (9).

Why Cranial Nerves?

I chose the twelve cranial nerves as the subject of scientific information via embodied learning, because I could create simple movements for what has traditionally been a difficult topic to learn and students from different disciplines should be capable of understanding and memorizing them without prior knowledge.

First and foremost, I did not want to choose a topic for which movement creation and implementation would be too complicated. The movements should be simple enough to allow participants to fully immerse themselves in the experiment. Although I personally used dance, a fourth-degree movement, in my embodied learning experience, I wanted to create motions that anyone would feel comfortable doing. These involved pointing and motioning towards the specific places that each cranial nerve controls. Even though the participants studied with second-degree movements, a less immersive experience than mine, the participants seemed comfortable in using the motions in the experiment.

Additionally, I wanted a topic that was attractive to non-STEM students, as they would be my target population. The goal was that the topic be something that the potential participants may have heard of before in their everyday life and pique their interest enough to encourage them to sign-up for the study to learn more. I knew that the cranial nerves are not too complex to memorize since I first learned about them in high school. Also, learning about them could be beneficial for the participants in the long term, since they have been referenced in the news and social media. The combination of their complexity and relevancy made the cranial nerves the topic of choice.

Why Non-STEM Major Students as Participants?

The population of interest for this experiment was non-STEM students at UCR. To reduce the chances of skewing the data, I chose to draw participants from those disciplines since they would have had fewer opportunities of seeing the cranial nerves in their courses. If a participant were to have prior knowledge of the cranial nerves, the effectiveness of embodied learning as a beneficial study technique would not be accurately reported, and conclusions could not be drawn from the data. Therefore, I refrained from recruiting participants from STEM and psychology majors, since it was highly likely that they have learned about the cranial nerves in their classes.

To make the recruitment process simpler, I did not include participants outside UCR, since their participation could lead to the potential of adding variables that could skew the data, including age, location, education, etc. Additionally, the study took place at Orbach Science Library on the UCR campus, so it was convenient for UCR students to access. Finally, Google Forms was used for participants to enroll in the study, sign an electronic informed consent document, and complete the post-study questionnaire, because it was the most readily available and affordable data collection tool. Since I used my UCR email address to create these forms, the G Suite Organization exclusively allowed other R'Mail users, or those with a UCR email address, to input their information. All in all, it was not convenient for anyone other than a UCR student to participate, and excluding those populations made the data collection and conclusions simpler.

Materials and Methods

Materials Used

A 2017 11-inch Apple iPad Pro with a first-generation Apple Pencil were the main tools utilized throughout my capstone project. First, I used the Notability application to create the anatomical diagrams and visual aids for the cranial nerve video. Then, I used the iMovie application to edit and add narration to the completed movie. To ensure that I included all of the information that was going to be on the comprehensive test, I used Google Docs to write out the script that I would read out for the voiceover. Additionally, Google Docs was used to create the pre-study questionnaire that was printed on Xerox brand multipurpose printer paper with a 2016

Brother MFC-J4420DW printer**.** A paper copy of the informed consent document was also printed with the same tools. As previously mentioned, Google Forms was utilized for a plethora of logistical handlings: the document for participants to choose their preferred time to complete the first portion of the study, to read and sign an electronic copy of the informed consent document, to collect basic data, and to create and distribute the post-study questionnaire. Also, I used the Canva website and a QR code generator to create a flyer for recruitment. Finally, I used Google Sheets to record data and Microsoft Excel to perform statistical analyses.

Notability

On my Apple iPad Pro, I used my Apple Pencil and the Notability application to draw anatomically correct diagrams of the body parts that are controlled by the cranial nerves to give participants a better understanding of their relevance. I color coded each cranial nerve so that the information could be further compartmentalized. Some cranial nerves required a complex diagram that had the potential to confuse the participants, so for simplicity, I animated the word being broken down into its Latin roots to explore the nerves' function.

iMovie Editing

After I completed the diagrams, I screenshotted each of them and inserted them into the iMovie application on my Apple iPad Pro. Next, I used the narration tool to record the voiceover of the script that I had previously written out. I made sure to speak slowly and clearly so that the video was easy to follow. Then, I adjusted the timing of each diagram and added in transitions to match with the audio. My goal was for the length of the video to provide just enough information to be neither too overwhelming nor tedious for the participants. The final video was four minutes and fifteen seconds long, averaging to 21.25 seconds per cranial nerve. I required each participant to watch the video twice for comfortability and understanding, and to keep their interest piqued.

Recruitment

Participants were recruited via announcements from UCR faculty/advisors or word of mouth. I was given opportunities to make in-person and iLearn announcements to a 500-person sociology class, multiple Media and Cultural Studies classes, and the Honors program. I was able to recruit some coworkers due to a mass email sent to the Supplemental Instruction (SI) Program by the Academic Resource Center, with my flyer attached. The flyer that I distributed was made through the Canva website that included a shortened URL and a QR code, created through a QR code generator. These links would direct potential participants to the Google Form where they could read through the informed consent document that detailed the study's purpose, procedures, risks, and benefits, as well as present the schedule of available time slots to complete the study.

Pre- and Post-Study Questionnaire Writing and Distribution

I used Google Docs to generate the pre- and post-study questionnaire, which consisted of the same 27 free response, short answers, multiple choice, and matching questions. The first portion of the questionnaire was to simply name the twelve cranial nerves, and the remaining fifteen questions pertained to the functions of each cranial nerve. Due to the lack of exposure to the cranial nerves, I expected the participants to do poorly on the pre-study questionnaire since it was administered to ensure that they did not have prior knowledge of the cranial nerves and would not skew the data. However, the questions were cultivated straight from the script of the video, so participants were capable of getting a perfect score on the post-study questionnaire if they had retained the information effectively.

The pre-study questionnaire was printed on the same Xerox brand multipurpose printer paper with the same 2016 Brother MFC-J4420DW printer, as previously mentioned. Since the post-study questionnaire was administered online, I used Google Forms to create an electronic copy of the pre-study questionnaire and I distributed the link to the participants through their UCR R'mail account, in which they had agreed to provide their email addresses through the informed consent document.

Pre- and Post-Study Questionnaire

After receiving the URL or the QR code, participants would select the time slot that best fit their schedules to come into an Orbach Science Library study room and complete the in-person portion of the study. Before starting the experiment, they were required to read through both the paper and electronic copies of the informed consent documents and sign if they agreed to proceed. Then, they completed another Google Form with background questions such as their year, major, whether they are in the UCR Honors program, and their prior cranial nerve knowledge. After the logistics were complete, I gave each participant twenty minutes to complete the pre-study questionnaire.

The control group was finished with the study once they completed the pre-study questionnaire. Participants in Treatment A were shown the cranial nerve video, then given the rest of the 50-minute period to study however they wished. Participants in Treatment B were shown the cranial nerve video, I would show each participant the designated movement for each cranial nerve three times, then they were given the rest of the 50-minute period to practice the embodied learning movements for each cranial nerve and study using those. I asked that each participant not look up additional cranial nerve information on their own time before the completion of the post-study questionnaire and offered my notes if they wanted more information after the completion of the study to avoid skewing the data.

Approximately 8-10 weeks later, I sent the participants the post-study questionnaire through their UCR R'Mail address. The post-study questionnaire was an exact copy of the pre-study questionnaire, just an online version. They were required to put their email to minimize the incidence of repeat data but had been notified in the informed consent document that the identifiers will remain private until the data is deleted after the completion of my capstone.

Data Analysis

I used Microsoft Excel to perform the data analysis. My statistical analyses include the average, standard deviation, and t-tests.

Data

Null Hypothesis

The null hypothesis for this experiment is that there is no correlation between using embodied learning as a study technique and retention assessment.

Pre-Study Questionnaire

Average and Standard Deviation

The average of the scores was determined to be 4.32% with a standard deviation of 0.0395.

Participant	Observed
1	7.41%
2	0.00%
3	0.00%
4	3.70%
5	3.70%
6	11.11%

Figure 1a – Participants scores on the pre-study questionnaire.

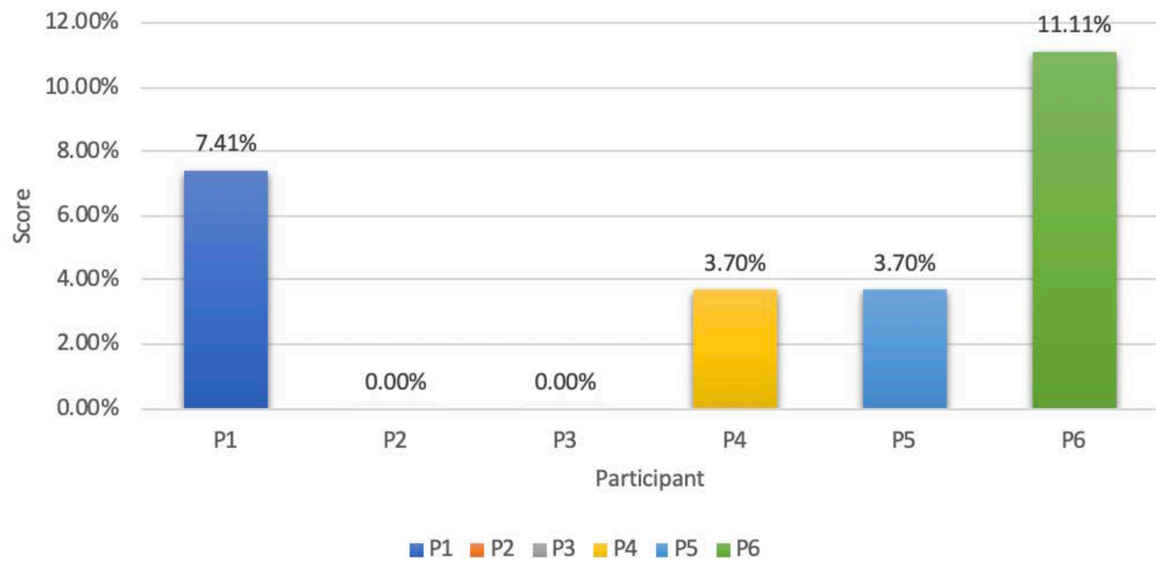

Figure 1b – Bar char of participants pre-study questionnaire scores.

Post-Study Questionnaire

Averages and Standard Deviations

The average of the scores for the control group was 5.55% with a standard deviation of 0.0261. The average of the scores for Treatment A was 14.81% with a standard deviation of 0.105. The average of the scores for Treatment B was 51.85% with a standard deviation of 0.367.

Participant	Treatment	Observed
1	Control	7.40%
4	Control	3.70%
2	A	22.22%
5	A	7.40%
3	B	25.92%
6	B	77.78%

Figure 2a – Participants scores on the post-study questionnaire.

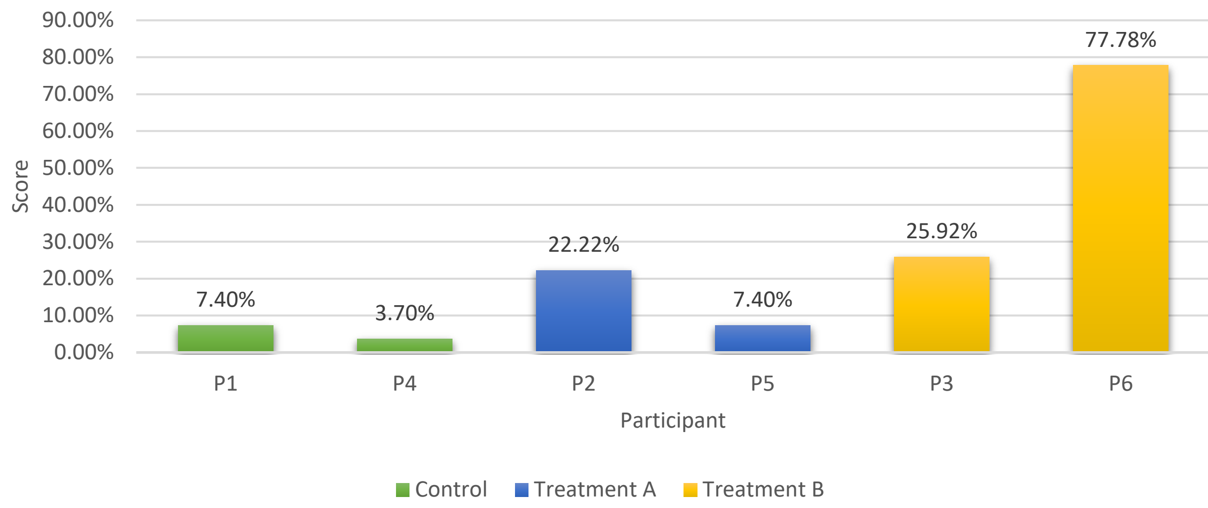

Figure 2b – Bar chart of participants post-study questionnaire scores.

T-Test with Two Independent Means for Each Treatment

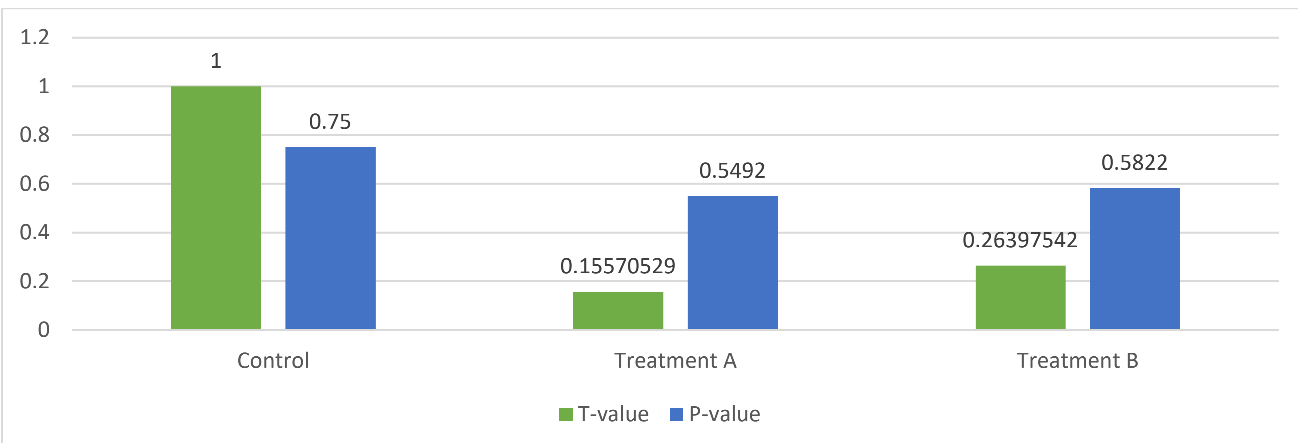

Figure 3 – Bar chart of T-values and P-values of each treatment.

Control Group (Pre-Questionnaire)

N_1: 2

Df_1: $(N_1 – 1) = 1$

Average: 5.55%

Standard Deviation: 0.02616

Control Group (Post-Questionnaire)

N_1: 2

Df_1: $(N_1 – 1) = 1$

Average: 5.55%

Standard Deviation: 0.02616

Treatment A (Pre-Questionnaire)

N_2: 2

Df_2: $(N_2 - 1) = 1$

Average: 1.85%

Standard Deviation: 0.02616

Treatment A (Post-Questionnaire)

N_2: 2

Df_2: $(N_2 - 1) = 1$

Average: 14.81%

Standard Deviation: 0.1047932

Treatment B (Pre-Questionnaire)

N_3: 2

Df_3: $(N_3 - 1) = 1$

Average: 5.56%

Standard Deviation: 0.078559563

Treatment B (Post-Questionnaire)

N_3: 2

Df_3: $(N_3 - 1) = 1$

Average: 51.85%

Standard Deviation: 0.3667056

Survey Responses

Year in School

Half of the participants were fourth year students at UCR.

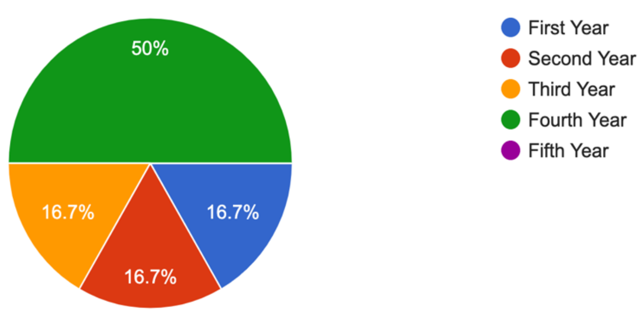

Figure 4 - Pie chart of participants year in school.

Majors

The participants consisted of English Literature, Computer Science, Finance, Linguistics, Spanish, and Undeclared CHASS majors at UCR.

Participation in the University Honors Program

One-third of the participants were in the University Honors Program and two-thirds were not.

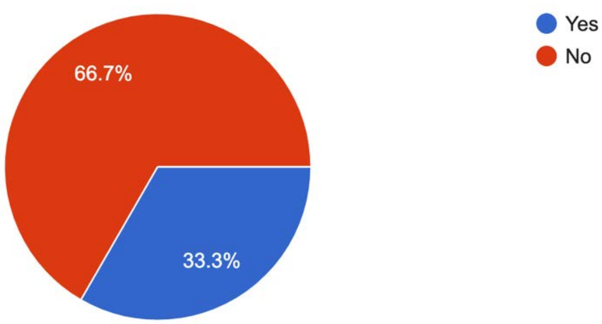

Figure 5 - Pie chart of participants involvement in the University Honors Program.

Previous Knowledge of the Cranial Nerves

Every participant rated their original knowledge of the cranial nerves, with 1 being "I have never seen them."

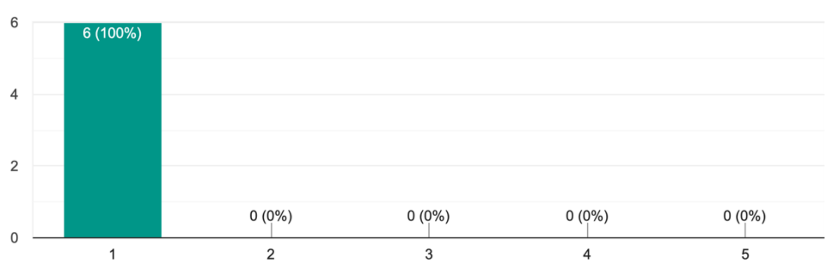

Figure 6 - Participants rated their knowledge of the cranial nerves before the study.

Data Analysis

Average Performance of Samples

A paired two-sample t-test was used to compare the means of the related groups. After calculating the t-test scores and p-value scores, referenced in Figure 3, each p-value is larger than the significance level of 0.05. Therefore, it cannot be concluded that embodied learning is a significant study technique that can enhance retention rates of information.

Discussion

Limits

Unfortunately, due to the global extenuating circumstances, I was not able to continue with recruitment in the Spring 2020 quarter and increase my sample size to complete my capstone as expected. As a consequence, I could not draw statistically significant conclusions regarding the data due to the small sample size ($n = 6$). Therefore, the performance of these participants is not conclusive as to how effective embodied learning is as a study technique that could potentially positively affect retention rates of information. Although the intention of this project was to conclude whether or not this technique could benefit students, it will be left up to further research to look into my hypothesis.

Due to my prior friendships with some of the participants, some were more eager to retain the information to get a good score on the post-questionnaire than others. For example, one participant in Treatment A, who happened to be a friend, was determined to remember the information and studied very hard in their 50-minute period, whereas one participant in Treatment B, who happened to be a stranger, was not fully invested in the embodied learning study technique. In the end, both participants scored the same on the pre-study questionnaire and increased their score by roughly the same amount for the post-study questionnaire.

I allowed variation in how the participants both received the information from the video and how they studied on their own in Treatment A. For the video, participants could take notes any way that they please, and some took them on their phone, on a piece of paper, or did not take notes at all, which could have affected the end result. Furthermore, participants in Treatment A were advised to study whatever way worked for them, which creates more variables as some students are more effective in their study techniques than others, which could also skew the data.

Additionally, there were limitations in the timing that participants took the pre- and post-study questionnaires. I was conducting my study from week four of Winter Quarter 2020 until the UCR campus was shut down during week ten of Winter Quarter 2020. Since I had to end my project prematurely, the participants towards the end of the study had a slightly shorter time frame between the pre-and post-study questionnaires, about one to two weeks, that were reflected in the post-study questionnaire scores. Therefore, the effectiveness of embodied learning cannot be concluded from the scores alone.

Future Directions

The results of this experiment cannot possibly conclude a statistical significance between the effectiveness of traditional versus embodied learning studying techniques on retention rates of scientific information due to a variety of unforeseen circumstances. In future studies, I would encourage the researchers to limit a smaller and more strict time frame between the pre- and post-study questionnaires, as well as getting a larger sample size. This will make the experiment more controlled and eliminate many of the confounded variables that I ran into. I am going to pursue a career in secondary education, so I am curious to see the results on a larger sample size when I implement embodied learning in my lesson plans. I encourage other educators of different educational levels to do the same.

References

ACE (2012). *Bodies of knowledge - embodied learning in adult education : New directions for adult and continuing education, number 134*. Retrieved from https://ebookcentral.proquest.com

Bestiary, Iconic. "Oral Cavity. Human Open Mouth Anatomy Model. Infographic Design for Educational Poster. Open Mouth Anatomy and Dentistry. Flat Style Isolated Vector Visual Aid Illustration." *Oral Cavity Human Open Mouth Anatomy Stock Vector (Royalty Free) 1125746711,* www.shutterstock.com/image-vector/oral-cavity-human-open-mouth-anatomy-1125746711.

"Cranial Nerves." *Yale Medicine*, 2016, meducation.net/resources/38141-Yale-University-Cranial-Nerves.

Helmenstine, Anne Marie. "Here's How the Human Eye Works." *ThoughtCo*, ThoughtCo, 2 Dec. 2019, www.thoughtco.com/how-the-human-eye-works-4155646.

Horn, J., & Wilburn, D. (2005). The Embodiment of Learning. *Educational Philosophy and Theory,37*(5), 745-760. doi:10.1111/j.1469-5812.2005.00154.x

Hung, I., Kinshuk, & Chen, N. (2018). Embodied interactive video lectures for improving learning comprehension and retention. *Computers & Education,117*, 116-131. doi:10.1016/j.compedu.2017.10.005

Johnson-Glenberg, M., Birchfield, D. A., Tolentino, L., & Koziupa, T. (2014). Collaborative embodied learning in mixed reality motion-capture environments: Two science studies. *Journal of Educational Psychology, 106*(1), 86-104. doi:http://dx.doi.org/10.1037/a0034008

Munro, M. (2018). Principles for embodied learning approaches. *South African Theatre Journal,31*(1), 5-14. doi:10.1080/10137548.2017.1404435

Mahon, Bradford Z. “What Is Embodied about Cognition?” *Language, Cognition and Neuroscience*, U.S. National Library of Medicine, 1 May 2015, www.ncbi.nlm.nih.gov/pmc/articles/PMC4405253.

OpenStax College. “Eye and Extraocular Muscles (Illustrations): Image.” *Radiopaedia.org*, 2016, radiopaedia.org/images/20994677.

Sanders, Katherine. “Summary of the Cranial Nerves.” *TeachMeAnatomy*, 2019, teachmeanatomy.info/head/cranial-nerves/summary/.

Seladi-Schulman, Jill. “The 12 Cranial Nerves.” *Healthline*, Healthline Media, 14 Mar. 2019, www.healthline.com/health/12-cranial-nerves.

“Test Your Cranial Nerves.” *Neuroscience for Kids - Cranial Nerves*, faculty.washington.edu/chudler/cranial.html.

Wajeh, Omar. “Digestive System Diagram Summary - HU0S007 - SouthWales.” *StuDocu*, 2017, www.studocu.com/en/document/university-of-south-wales/biology/summaries/digestive-system-diagram-summary/1804404/view.